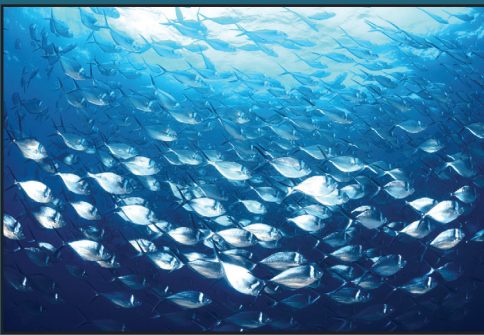


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Latin American & Caribbean Aquaculture 2023



Sustainable Aquaculture for Two Oceans

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Dear All:

¡Bienvenidos!

Welcome to LACQUA23 in Panama City, Panama.

From our Board of Directors to our Conferences' locations, in our Latin American and Caribbean Chapter we always seek for the proper representation of aquaculture from all countries and regions in the American Continent. After Mérida, Mexico (2021) and before Medellín, Colombia (2024), we are delighted to have this time the opportunity of gathering in Central America, where aquaculture is also established and growing, giving us the opportunity to impulse its sustainable development for the benefit of Food and Nutrition Security. Our last WAS-LACC Central American Conference in Costa Rica (2019), was all success and a wonderful meeting. I am sure we will repeat the experience.

“Sustainable Aquaculture for two Oceans” reflects the opportunity and vision of Panama, and our region. Panama, with an optimal location in the Continent, is actively seeking the development of commercial aquaculture based on a multi-species effort. Its geographical location and crucial role for global commerce, gives the country a unique opportunity.

We have for you a trade show and Scientific Program that I am sure will give the opportunity for analysis, discussion, establishing links and commercial deals. The format of our Scientific Program is well known by all of you and are important opportunities to share knowledge and ideas. We all have developed networks by the opportunity given during our Conferences.

I want to thank Panama's Government through the Autoridad de Recursos Acuáticos ARAP for their support and main sponsorship, and all our other sponsors. Also acknowledge the support of the National Association of Aquaculture (ASPAC). Our Home Office (Carolina Amezquita), the WAS-LACC Board of Directors, and the Steering, Program and National Committees have worked hard to offer you what you will experience.

Please enjoy LACQUA23 and contribute with the World Aquaculture Society in making aquaculture in the Latin American and Caribbean region, a continuous effort towards Human Sustainable Development, inclusive and just. And approach me during the Conference to share your ideas, comments and observations. We all are the Latin American and Caribbean Chapter.



Francisco Javier Martínez Cordero
President
Latin American and Caribbean Chapter
World Aquaculture Society

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LAQUA 23

ABSTRACTS

GASLIFT PUMPING TECHNOLOGY FOR COMMERCIAL AQUACULTURE SYSTEMS

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Increasing the use of sustainable practices in the aquaculture industry is vital to meeting increasing global demands for seafood products. One suggested approach to reduce environmental impacts on wild ecosystems and improve the sustainability of the aquaculture industry is to remove fish production systems from natural bodies of water and relocate them to land-based facilities. Moving fish production systems to land based-tanks however, increases the demand for freshwater resources and increases energy costs due to the requirement to run pumps, aerators and lighting systems.

To overcome these challenges, this study presents a gaslift pump technology designed to handle heavy fluids or liquid-solid mixtures with high mass transfer capabilities and with minimal energy requirements. This design was created using fundamental knowledge of multiphase flow in which the mixture takes on different patterns when the gas, liquid and solid phases are moving together in the same passage at different velocities. The pump's gas injector was designed while considering the ratio between the density of the liquid/solid and the gas phases, utilizing the buoyancy forces for optimal pump operation. This pump does not require any mechanical or moving parts or lubrication and uses much less energy to operate with negligible noise and vibration. It offers the end users (fish farmers and food processing facilities) the advantage of a simple design that can be easily integrated in existing piping systems with minimal installation costs. It has lower operating costs (at least 40%), lower capital investments (70 to 80% less) and requires minimal maintenance compared to conventional mechanical pumps. It is easy to use for pumping liquid-solid mixtures or non-Newtonian fluids, such as transferring fish/shrimp in aquaculture farms, moving nutrient solutions/solid mixtures in hydroponics or moving waste in food processing applications. Field tests of these pump were carried out at the Ontario Aquaculture Research Centre - Alma (previously known as the Alma Aquaculture Research Station established by OMAFRA and the University of Guelph to assist the commercial fish farming industry in Ontario).

The objective of these tests were to quantify the effects of the gaslift pump technology on the water quality parameters and fish productivity in a commercial aquaculture setting compared to traditional aeration devices. Five thousand Arctic char (*Salvelinus alpinus*) sourced from the Ontario Aquaculture Research Centre were distributed amongst two grow-out tanks, one utilizing a standard aeration device and the other utilizing the gaslift pumps. Over a 3-month period, fish growth and performance were monitored and measured along with the dissolved oxygen concentration, total suspended solids, temperature, turbidity and surface velocity in comparison between the two tank systems. Results showed an increase in dissolved oxygen in the tank containing the gaslift pumps as well a reduced number of suspended solids due to the recirculating motion created by the pumps, allowing for better solid filtration within the tank. This recirculation was captured using surface velocity distributions mapped out to fully analyze the effects of the gaslift pump on the fish tank. It can be shown that higher velocity can be attained utilizing the gas lift pump while maintaining consistent air injection flow rates, when comparing it to velocities reached with the standard aeration device. Overall, it is observed that the gas lift pump offers sufficient water circulation and increased aeration, which can ultimately improve the quality of fish farms.

OVERVIEW OF AN INTEGRATED OFFSHORE COBIA FARM IN PANAMA'S CARIBBEAN SEA

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Open Blue is a new-generation, submersible offshore farm dedicated to the sustainable production of Cobia, *Rachycentron canadum*, off the Caribbean coast of Panama. Since starting operations in 2010, the company has worked to vertically integrate by incorporating hatchery, land-based nursery, dedicated R&D department, primary processing, value-added processing, and lately a rendering plant to become a zero-waste operation focused in sustainable production, environmental health, and positive social impact. Open Blue believes fish belong in their natural habitat in the open oceans.

This overview will tour the company and cover hatchery production, nursery procedures, offshore pen technology and processes, as well as current status and future prospects as we grew to become a well-established farming platform proven to have very limited impact in the surrounding environment while generating long-term meaningful employment in remote areas where few other alternatives are available.

From year-round volitional spawning, to challenging offshore growout conditions, Open Blue is dedicated to proof the sustainable culture of marine species in exposed locations as a viable production alternative with reduced environmental impact and consistent water quality which translates into premium white-meat marine fish protein products.

VACUNACION EN TILAPIA COMO PREVENCION DE ENFERMEDADES DE ORIGEN BACTERIANO EN LATINO AMERICA, PERIODO DEL AÑO 2005 AL 2022

Mario Aguirre Plaza¹

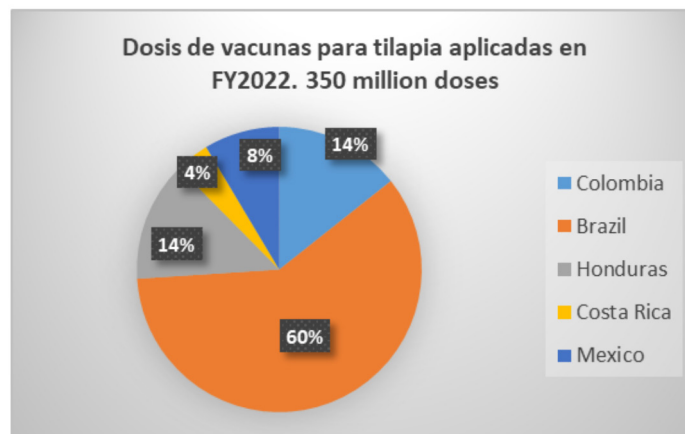
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Estreptocosis es la principal enfermedad de origen bacteriano que afecta el cultivo de tilapia globalmente. En los países de Latino América (LATAM), los patógenos *Streptococcus agalactiae* serotipo Ib y *Streptococcus iniae* son endémicos y fueron los más importantes hasta hace poco tiempo. Hoy en día, nuevas cepas de *Streptococcus* y cocos Gram-positivos han surgido en diferentes países y han tenido un impacto significativo (Leal, 2022). Las primeras vacunas comerciales usadas en tilapia para prevención de estreptocosis, en LATAM, fueron de inmersión y orales; las cuales solo incluían dos antígenos *Lactococcus garviaea* y *Streptococcus iniae*, los resultados no fueron satisfactorios.

La primera vacuna comercial aplicada vía intraperitoneal en tilapia, a nivel comercial, fue contra *Streptococcus agalactiae* serotipo Ib en Brasil y Honduras en el año 2010 y 2011 respectivamente (Zanolo,2011). Desde el año 2012 han aparecido nuevas cepas de *Streptococcus* en la región, lo cual ha impulsado a la oferta de nuevas vacunas comerciales multi antígenos. La implementación de vacunación intraperitoneal en la región ha crecido progresivamente, reportándose la aplicación de 340 millones de dosis en el FY 2022. En el mismo sentido, la oferta de autovacunas ha tomado auge en Brasil y en otros países de la región, donde la regulación sanitaria permite su uso.

El productor de tilapia debe incrementar estrategias sanitarias, tales como: multi-sitios y descansos de zonas de producción, exclusión de peces portadores y evitar su ingreso a los sitios de producción, vacunación estratégica como inversión y no gasto. En el mismo sentido, el productor requiere soluciones que faciliten una primo protección, como vacunas orales e inmersión. En la misma forma, el desarrollo de vacunas antivirales. El modelo salmón tiene validez en el aspecto sanitario, productivo y en incrementar el valor de la tilapia.



PRODUCCIÓN SEMI-INTENSIVA DEL CLADÓCERO *Daphnia magna*

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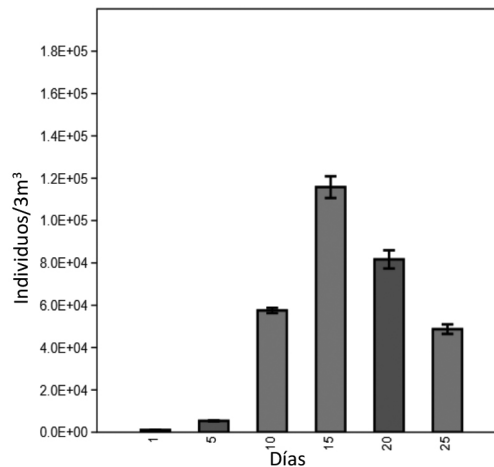
La producción del microcrustáceo *Daphnia magna* Straus, 1820 tiene un gran potencial para la piscicultura de peces de agua dulce, debido a que puede ser ofertado al inicio de la alimentación exógena en la larvicultura de peces destinados para el consumo humano o como suplementación en juveniles y reproductores de peces ornamentales. Estos microorganismos acuáticos además de tener un alto valor nutritivo, poseen una reproducción partenogénica, que logra un aumento exponencial de la población en un corto periodo de tiempo. A pesar de la importancia de este tipo de alimento vivo, son limitados los estudios de producción de biomasa. El objetivo del presente estudio fue evaluar el crecimiento poblacional de *D. magna* en condiciones semi-intensivas.

Se utilizaron 5 piscinas de 3000 litros, que fueron fertilizadas con 13,8% de melaza, 2,3% de cal, 80,9% gallinaza, 1,73% de sulfato de amonio y 1,15% fertilizante líquido para cultivos hidropónicos. A partir del cuarto día después de la fertilización se colocó aireación y diariamente se observó microscópicamente una muestra del agua hasta observar la presencia de infusorios, momento en que se realizó la inoculación con aproximadamente 1000 individuos/litro. Se realizaron mediciones de la biomasa a los días 1, 5, 10, 15, 20 y 25, colectando por medio de una malla de zooplancton. Durante el periodo de estudio no se realizaron cambio de agua. El fotoperiodo fue de 12 horas luz :12 horas oscuridad y se midieron los parámetros de temperatura y pH. Para evaluación del crecimiento de la población se realizó un análisis de una ANOVA de una vía.

Los resultados muestran un aumento en el tamaño poblacional entre los días 1 y 5, aunque no es estadísticamente significativo ($p > 0,05$), entre los días 5, 10 y 15, se evidencia un fuerte aumento altamente significativo ($p < 0,05$). Al día 15 se observa el mayor aumento de la densidad con una media de 115796 individuos/m³ como se aprecia en la gráfica 1. El pH y la temperatura tuvieron una media de $6,34 \pm 0,48$ y $23,4 \pm 1,4$ respectivamente para los 25 días de experimentación.

Con los datos del presente estudio se logró determinar que bajo las condiciones de cultivo, en el día 15 se obtiene la mayor densidad de biomasa que podría indicar el periodo en que deben ser sembradas las larvas de peces o el tiempo donde debe cosechada la *D. magna*.

Gráfica 1. Crecimiento poblacional de *Daphnia magna* en condiciones controladas.



REPRODUCCIÓN Y PRODUCCIÓN DE JUVENILES DEL CICLIDO ENANO *Apistogramma macmasteri*

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Apistogramma macmasteri es una especie de ciclido enano endémico de la cuenca de la Orinoquia colombiana. Debido a sus características de color, tamaño y facilidad de manutención en acuario, ha sido ampliamente comercializado en el mercado ornamental local y también exportado a varios continentes. Sin embargo, los ejemplares destinados al mercado ornamental son capturados principalmente en estado silvestre y los estudios científicos relacionados con su biología, reproducción y aspectos fundamentales de su cría en condiciones controladas son limitados. El objetivo del presente trabajo fue estandarizar un protocolo de producción de esta especie en cautividad.

Como materiales y métodos se utilizaron nueve parejas preformadas y manejadas individualmente en tanques de 45 litros, fueron alimentados diariamente con concentrado comercial 48% de proteína bruta, 6.5% extracto etéreo y suplementados con *Daphnia magna*. Los acuarios fueron mantenidos en condiciones controladas, con fotoperiodo 12 horas luz :12 horas oscuridad, temperatura media de $26\pm 1,25^{\circ}\text{C}$ y pH de $6,0\pm 0,5$. Las parejas fueron sometidas a dos tratamientos, tratamiento 1 donde se dejaron los desoves para cuidado parental de huevos y larvas hasta el día 30 después de la eclosión. Para el tratamiento 2 se retiraron los desoves y se hizo cuidado de estos de manera artificial. Para los dos tratamientos se obtuvieron datos para indicadores reproductivos y productivos por un periodo de 12 meses. Se realizaron biometrías hasta el día 90 después de la eclosión donde fueron analizados el crecimiento de los machos y las hembras. Para evaluación de los aspectos reproductivos se realizó análisis de T-Student y para evaluación del crecimiento de los juveniles una ANOVA de una vía.

Los datos de aspectos reproductivos, larvicultura y producción de juveniles están en la tabla 1. El único parámetro afectado por los diferentes tratamientos fue el intervalo entre desoves, el cual tuvo mayor tiempo cuando se mantuvo bajo el cuidado parental. A 90 días post eclosión, se observa el dimorfismo sexual. La longitud total media para las hembras en el tratamiento 1 fue de $2,60\pm 0,17\text{cm}$, para el tratamiento 2 fue de $2,64\pm 0,04\text{cm}$ y para los machos en la longitud total fue de $4,21\pm 0,18\text{cm}$ y de $4,36\pm 0,43\text{cm}$ respectivamente, resultados que no mostraron diferencias significativas entre los tratamientos.

Con los datos del presente estudio se logró cerrar el ciclo productivo de *A. macmasteri* en cautiverio.

Tabla 1. Indicadores productivos *Apistogramma macmasteri*

	MEDIA T1	MEDIA T2	P
INTERVALO ENTRE DESOVES (DIAS)	28.62	24.68	0.02*
# HUEVOS	82.51	72.47	0.11
# ECLOSION DE HUEVOS	42.62	38.74	0.35
TASA DE ECLOSION	51.87	51.22	0.78
% SOBREVIVENCIA 30 DIAS	94.68	80.17	0.60
% SOBREVIVENCIA EN 90 DIAS	67.58	65.04	0.31
# HEMBRAS	17.65	15.55	0.24
# MACHOS	10.03	94.68	0.62

IPRS, OPPORTUNITY FOR INTENSIVE, SUSTAINABLE AND PROFITABLE PRODUCTION: FROM INITIATIVE TO REALITY!

Jairo Amezquita

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The In Pond Raceways System (IPRS) is an advanced approach to pond aquaculture that combines the management benefits of confining fish to a small portion of the pond with the production capacity of a water system. stream. IPRS creates a flowing “river in the pond” and allows water to mix and move as it would in a river system. This flowing water significantly increases the production potential of the pond. To create the flowing water, the IPRS uses components that, when combined, mix, and move the water in a circular pattern around a baffle in the pond, effectively recycling and cooling the water and preventing the download in the local environment. This system reduces production costs per unit, reduces risk and significantly improves performance.

IPRS operates simply and in harmony with nature to offer greater predictability and profit potential than conventionally operated ponds. IPRS technology offers the opportunity to double, or even triple, yields beyond the expectations of traditional ponds (up to 70-80 tons per hectare in tropical climates) without discharging water or waste into local waterways. IPRS

it is a more manageable and controllable approach that allows for high yields and reduced environmental impact. However, to achieve the expected success for the investment made, it must be executed following the principles and guides that are recommended by the creator experts.

Since the United States Soybean Export Council (USSEC) introduced IPRS to China in 2013, nearly 9,000 systems have been developed in 18 countries. This advanced, sustainable aquaculture production technology, based on principles and guidelines, is evolving throughout the world as a new alternative to increasing costs and improving profitability. Latin America also sees it as a great potential for sustainability, respectful of the environment. environment, more productive and profitable than traditional pond fish farming.

As consumer demand for aquaculture products continues to grow, the opportunity for soy grows as well. To support that growth, we believe a reliable raw material is necessary. And what is more consistent and reliable than the nutritional quality of American soybeans? As farmers search for new solutions to meet aquaculture demand, our support for sustainable and efficient farming practices that incorporate soybean-optimized diets is a critical investment. This technology fulfills our mission of collaboration, demand growth and education of the main benefits that American soybeans offer. We hope that all producers looking to start or expand an aquaculture operation have access to recommendations, research, and technologies that support their efforts. And we hope that US soybeans will be a natural choice for their aquaculture diets.

MODULACIÓN EPIGENÉTICA DEL CAMARÓN BLANCO *Penaeus vannamei* EN RESPUESTA A COMPUESTOS BIOACTIVOS ALTAMENTE DILUIDOS (CBAD)

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En la camaronicultura disponer de reproductores con alto desempeño reproductivo que aseguren la producción de gametos y larvas de alta calidad es una prioridad. Recientes investigaciones han evaluado el efecto de Compuestos Bioactivos Altamente Diluidos en la maduración gonádica y acumulación de reservas energéticas asociadas al desempeño reproductivo de sub-adultos de *P. vannamei* cultivado en granja comercial, comprobando su eficacia innovadora y sustentable.

La capacidad reproductiva, tasa de crecimiento y resistencia a enfermedades han sido caracteres centrales en programas de mejoramiento genético, pero no han sido considerados los procesos epigenéticos, los cuales implican la transferencia transgeneracional de rasgos fenotípicos sin modificar la información genética. Por ello, evaluar la modulación epigenética debe ser complementario al mejoramiento genético, para la producción de fenotipos con un mayor potencial reproductivo capaces de transferir dichas características a la progenie.

El enfoque de este proyecto es determinar si los tratamientos formulados con CBAD, podrían generar un nuevo fenotipo con alto desempeño productivo y reproductivo, e inducir una reprogramación epigenética que permita la herencia transgeneracional del fenotipo adquirido, teniendo como especie objetivo a *P. vannamei*. La cuantificación de reservas energéticas; el análisis histológico; la evaluación de la calidad espermática; la expresión de genes asociados al potencial reproductivo y las posibles modificaciones epigenéticas se analizarán para lograr el enfoque del proyecto.

Algunos resultados preliminares indican que las hembras tratadas con CBAD (T1) tienen mayor área y diámetro total en ovocitos vitelogénicos secundarios en comparación con las del tratamiento control (T3) (Fig. 1).

En machos se obtuvo una mayor calidad de espermatozoides reflejada en un mayor porcentaje de espermatozoides vivos y normales en el tratamiento con CBAD (T1) en comparación al resto de tratamientos (Tabla 1).

Fig 1. Área total y diámetro total en ovocitos vitelogénicos secundarios evaluados en hembras mediante cortes histológicos.

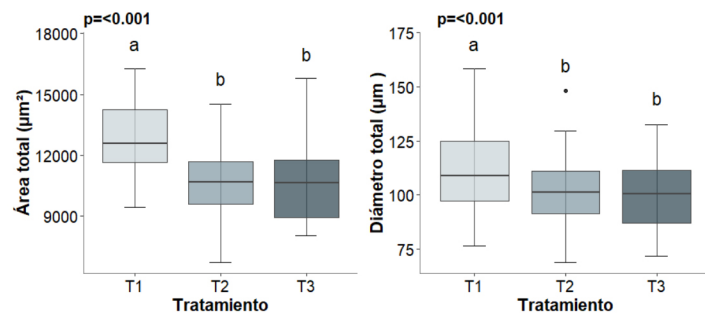


Tabla 1. Análisis de calidad espermática mediante recuento de espermatozoides.

Tratamiento	Vivos (%)	Muertos (%)	Normales (%)	Anormales (%)	Total
Muestreo Inicial	86.72	13.27	79.54	20.45	60.18
T1	94.39	5.60	79.12	20.87	38.53
T2	93.83	6.16	72.93	26.93	49.48
T3	91.12	8.87	74.00	25.99	31.22

PRODUCCIÓN DE *O. niloticus* EN ESTANQUES TRADICIONALES SEMBRADOS A ALTA Y BAJA DENSIDAD COMPARADOS A IPRS

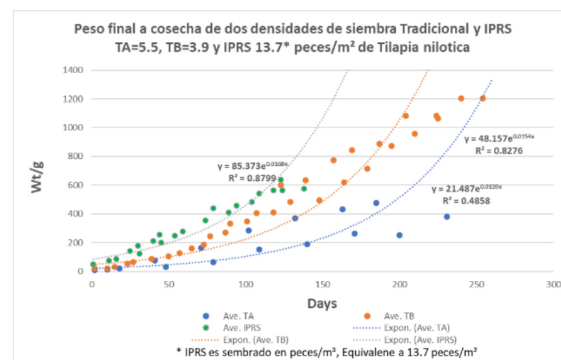
Esau Arana*, Mildred Avila, Oscar Botero, Diana Pasos, Jesse Chappell PhD

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Productores de tilapia nilótica en Latino América están adaptando la tecnología In-Pond Raceways System -IPRS- pero necesitan tener una comparación precisa de esta nueva tecnología en contra de la producción tradicional en estanques de tierra. En el presente estudio se evaluará la producción de dos estanques sembrados en forma Tradicional Alta (tratamiento TA) a una densidad de 5.5 peces/m², peso inicial de 11 g, cosechados para mercado nacional con peso promedio de 488.5 g; dos estanques sembrados en forma Tradicional Baja (tratamiento TB) a una densidad de 3.9 peces/m², peso inicial de 20 g, cosechados para mercado de exportación con peso promedio de 1143 g y un estanque con 4 celdas de IPRS, peso promedio inicial de 49.2 g, cosechado para mercado nacional con peso promedio de 589 g. Mediante análisis estadístico ANOVA se encontró variabilidad entre tratamientos en peso final de cosecha, Kg/Ha/Cosecha, días de cultivo y ganancia de peso (P-value <0.05) y FCA (P-value >0.05) (Tabla 3). La producción promedio fue de 14.657 Kg/Ha/Cosecha en 230.5 días, 26.576 Kg/Ha/Cosecha en 237 días y 36.971 Kg/Ha/Cosecha en solo 146.5 días (t = 0.045) para TA, TB e IPRS respectivamente; la ganancia de peso diario en gramos para los tratamientos TA=2.12, TB = 4.74 e IPRS = 3.69 (Gráfica 1); el Factor de Conversión Alimenticia (FCA) fue de 1.07, 1.31 y 1.29 para TA, TB e IPRS respectivamente, mostrando mejores resultados en TA, pero hay que tener en cuenta que para solventar bajos niveles de oxígeno hubo que restringir la dieta alimenticia en el tratamiento TA, debido a su alta densidad. El oxígeno disuelto para tratamientos TA y TB mantuvieron niveles aceptables por encima de 4.0 mg/L en los primeros 5 meses, descendiendo a valores entre 1 – 2 mg/L, mientras que para IPRS estos niveles permanecieron más estables. La prueba de IPRS originalmente estaba programada para evaluar la producción de peces vacunados y no vacunados, pero el exceso de manejo en el proceso de vacunación concluyó en altas mortalidades a la siembra, por lo que se sembraron peces no vacunados en reposición. La alimentación total por tratamiento fue TA = 70.98, TB = 147.9 y IPRS = 247 kg/Ha/D y la sobrevivencia correspondió a 73.5%, 76.6% y 61.8% para TA, TB e IPRS respectivamente. La alta productividad de la tecnología IPRS estriba en su capacidad de extracción de excretas del medio acuático, mantener buena calidad de agua y mantener alta concentración de oxígeno disuelto 24/7. Los resultados demuestran que densidades de cultivo superiores a 4 peces/m² en estanques en tierra, afectan negativamente los indicadores productivos, como velocidad de crecimiento y sobrevivencia, pero tecnologías como IPRS se convierten en una opción para utilizar el recurso hídrico de una forma más eficiente y obtener mejores rendimientos en el cultivo peces.

	TA	TB	IPRS*
Densidad de siembra (Peces/m ²)	5.5	3.9	13.7 *
Peso final Wt/g	488.5	1143.0	589.2
Kg/Ha/Cosecha	14,657 a	26,576 b	36,971 c
Días ciclo	230.5 a	237 a	146.5 b
Ganancia diaria Peso g/D	2.12 a	4.74 b	3.69 c
FCA	1.07 a	1.31 b	1.29 a, b
% Sobrevivencia	73.5	76.6	61.8

* IPRS siembra es basado en metros cúbicos. Equivalente a 13.7 peces/m² en estanque tradicional.
a = Tratamientos con la misma vocal indican no diferencia estadística.
ab = Tratamientos con diferentes vocales indican diferencias estadísticas.
TA= Tratamiento de siembra Tradicional Alta
TB= Tratamiento de siembra Tradicional Baja
IPRS= In-Pond Raceways System



IMPACT OF MICROALGAE CULTURE-ASSOCIATED BACTERIAL LOAD ON SEA URCHIN LARVAL (*Paracentrotus lividus*) MORTALITY

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Bacterial diseases of sea-urchins have been reported to cause mass mortality in most oceans, but also in aquaculture. These infections cause lesions on the sea urchin adults' body, resulting in spines, podia and pedicellaria loss. Typical lesions have a green to black central area where the calcareous skeleton is exposed to the external medium and a peripheral belt of necrotic epidermal tissues surrounding it, in many cases resulting in the death of the individuals (Becker et al., 2008; Jangoux, 1990). Pathogens that affect sea-urchin include marine bacteria, most notably Gammaproteobacteria and Vibrionaceae, as well as protists and viruses (Smith et al., 2022). With the sea urchins' aquaculture production, there is an increasing need to understand the mechanisms and agents responsible for their pathologies. However, this knowledge is still quite scarce, being practically non-existent for the larval rearing stage. In the present work the impact of different microalgae diets on the survival and development of *Paracentrotus lividus* larvae was tested, while the bacteriological load of the larval culture medium was analyzed. The diets used were: D1- *Rhodomonas* spp., D2- *Skeletonema costatum*, D3- Mix of the two microalgae. At days 2, 8, 12 and 15 days after hatching (DAH), biometric sampling of the larvae was performed, and mortality was estimated. On the last day of the trial (15DAH), water samples were taken from the larval culture medium for bacterial analysis. Microbiological quality of the water was analyzed using TSA (non-selective medium) and TCBS (Vibrio-selective medium). The inoculated medium was then incubated at 23°C for 48 hr. Isolated bacteria were subjected to taxonomical analysis according to Bergey and Holt (1994), and were identified by using API20 NE system. Larvae fed the D2 and D3 diets had higher rates of survival at 15 DAH (55.8% and 39.9% respectively) compared to D1 diet (5.5%). Larvae fed with *S. costatum* showed a lower development than other diets. According to the microbiological analysis, water samples were taken from D1 water and from the *Rhodomonas* spp. culture medium both contained a significant number of bacteria from the genus Vibrionaceae. The genus Vibrionaceae and total bacteria levels were low in the microalgae *S. costatum* culture but were relatively high in the replicated D2 analysis. It was later discovered that *Vibro alginolyticus* (96.51% identification score) and *Vibrio pectencida* (65.70% identification score) were the two species identified. Through this work the impact that bacterial contamination from feed (microalgae) can have on the survival of *P. lividus* larvae was verified, also confirming the pathogenicity of the genus Vibrionaceae in sea urchins. In larval rearing of *P. lividus* the importance of a close control of microbial quality during microalgae production and feeding should thus be considered. Such control should include efficient disinfection and periodic analysis of both the water used and the microalgae inoculum, to avoid pathogenic bacteria contamination.

ANÁLISIS DEL ESTADO DE CONSERVACION DE LAS ESPECIES ACUATICAS ORNAMENTALES SEGÚN SU IMPORTANCIA COMERCIAL PARA COSTA RICA

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En Costa Rica en el año 2008 se cumplieron 20 años del inicio del comercio de especies acuáticas ornamentales. Diferentes estudios han demostrado que la industria de estos organismos ha afectado a las comunidades naturales debido a la alta demanda que el mercado genera. Como principal objetivo se pretende determinar las especies acuáticas ornamentales de interés comercial en Costa Rica que presentan mayor vulnerabilidad según su estado de conservación.

El estudio fue realizado del mes de septiembre 2021 a abril del 2022. Se realizaron entrevistas en acuarios y revisiones en páginas web, que posteriormente se utilizaron para la creación de bases de datos. Se realizó un índice de comercialización con valores de 0 a 5, según la cantidad de publicaciones en las que se menciona la especie (5= ≥ 40 , 4= < 40 y ≥ 30 , 3= < 30 y ≥ 20 , 2= < 20 y ≥ 10 , 1= < 10 y 0= no se menciona). Como resultados se obtuvo que la mayoría de las especies comercializadas son exóticas, siendo los niveles de comercialización 2 y 3 los que presentan mayor cantidad de especies. Al analizar la importancia comercial con relación al estado de conservación, se determinó que el nivel 3 es el que presenta mayor cantidad de especies, con presencia de especies de preocupación menor (LC) y sin información (-). Por último, al hacer un enfoque en las especies que se encuentran más vulnerables, se logró determinar un total de 29 especies, las cuáles se encuentran en peligro crítico (CR) y en peligro (EN) (Figura 1). Se puede concluir que es de suma importancia conocer las especies más vulnerables para poder tomar medidas como reducir la extracción, fomentar estrategias de conservación y desarrollar campañas de educación ambiental.

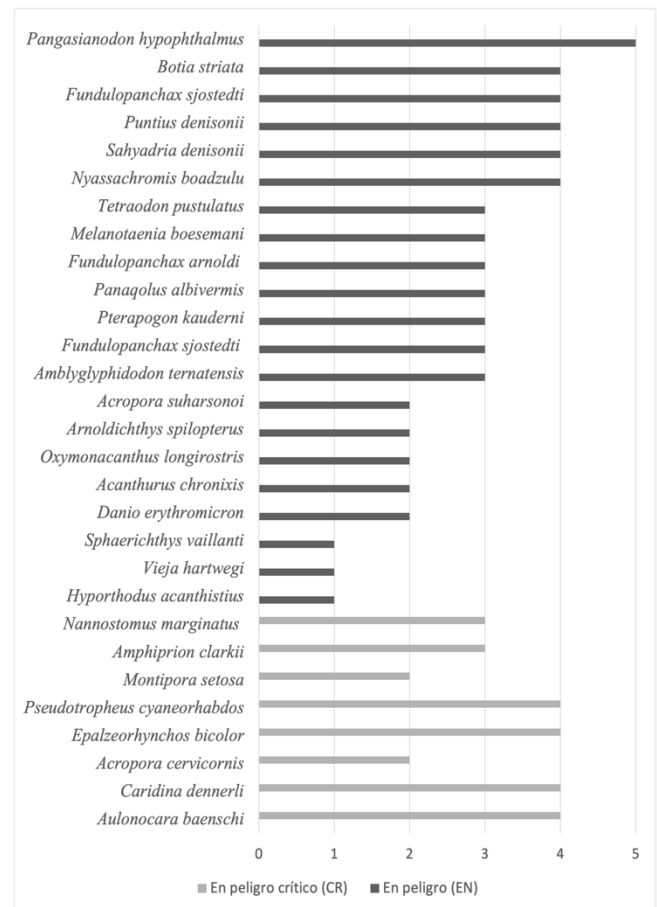


Figura 1. Especies más vulnerables según su importancia comercial.

EFFECT OF DIALLYL SULFIDE IMMERSION BATHS IN THE LIFE STAGES OF *Zeuxapta seriolae*, A PARASITE OF CALIFORNIA YELLOWTAIL (*Seriola dorsalis*)

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Monogeneans cause significant reductions in the productive performance and survival of farmed fish. Although there are pharmacological treatments against these parasites, they are not equally effective for all stages of their life cycle and could be harmful to fish and the environment, hence the interest in studying the therapeutic potential of plant-derived products. This study evaluated the anthelmintic effect of diallyl sulfide (DAS), a secondary metabolite of garlic, on immersion baths, through *in vitro* and *in vivo* trials, on the life stages of *Zeuxapta seriolae*. *In vitro*, we found that eggs exposed acutely or continuously at 0.01 mg DAS/mL exhibited reduced hatching success, the oncomiracidial lifespan was significantly reduced when exposed to 0.01 mg DAS/mL. *In vivo*, mean parasite intensity decreased significantly with 0.01 mg DAS/mL; higher concentrations of DAS had adverse effects on the fish, impeding treatment completion. These results add to the mounting evidence of the utility of garlic extract, or other isolated compounds from garlic like DAS to control *Z. seriolae* affecting California yellowtail and other commercially important species.

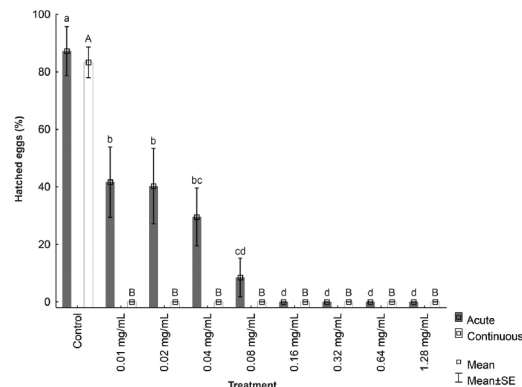


Fig. 1 Hatched eggs exposed *in vitro* to seawater (control) and diallyl sulfide (0.01 to 1.28 mg/mL). Acute exposure (1 h) and continuous exposure (throughout 7 days of incubation). Data points represent mean \pm standard error. Lowercase and capital letters mean significant differences among acute exposure and continuous exposure treatments, respectively ($p < 0.001$)

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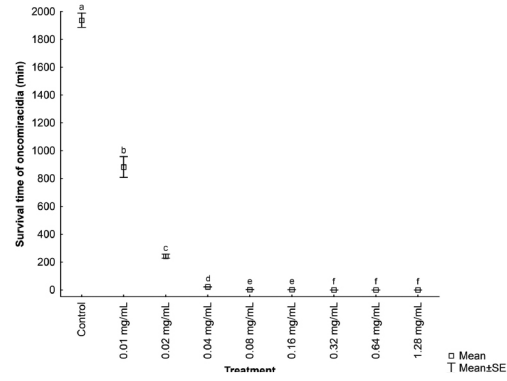


Fig. 2 Survival time of *Z. seriolae* oncomiracidia (h) exposed in vitro to seawater and diallyl sulfide (0.01 to 1.28 mg/mL). Data points represent mean \pm standard error. Different letters mean significant differences ($p < 0.001$)

Table 1. Mean intensity of *Z. seriolae* after 1 h of exposure to garlic extract and diallyl sulfide *in vivo*

	Treatment	Mean intensity (parasites/fish)	Fish that accomplished the 1-h exposure (%)
Diallyl sulfide (mg/mL) + 0.01% Tween 20	Control	501.6 \pm 54.9 ^a	100 ^a
	0.01	10.3 \pm 1.4 ^b	100 ^a
	0.02	9.7 \pm 1.3 ^{b*}	43.3 \pm 9.2 ^b
	0.03	53.89 \pm 7.04 ^{c*}	0 ^c
	0.04	21.27 \pm 4.33 ^{d*}	0 ^c

¿ES EL IPRS (IN-POND RACEWAY SYSTEMS) UN MODELO DE OPTIMIZACIÓN DE COSTOS DE PRODUCCIÓN?

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El Sistema IPRS introduce una nueva estructura de costos a la producción piscícola. Desde la implementación del sistema IPRS, la USSEC¹ ha hecho un esfuerzo importante para compartir los métodos técnicos de construcción y operación de esta nueva tecnología, no obstante, es claro que para la evaluación de los resultados financieros de este sistema se hace imprescindible la retroalimentación desde las organizaciones y empresas beneficiarias, permitiendo así que los nuevos productores interesados en la tecnología tomen decisiones basadas en la información de costos de producción. Este trabajo busca exponer los costos unitarios incurridos, durante el año 2022, para la producción de Tilapia de las especies Roja (*Oreochromis sp*) y Negra (*Oreochromis niloticus*) en dos regiones de Colombia, tomando información de un total de 182 ciclos de producción en cuatro (4) granjas de las empresas Acuacultivos el Guajaro S.A. (Cartagena) y Latinpez SAS (Huila), usando los sistemas de producción en lagos tradicionales, jaulas flotantes y el Sistema IPRS, detallando así la eficiencia en costos de producción de cada uno.

Estos resultados se recolectaron a partir de Modelos de Estimación de Costos de Producción (MECP), los cuales, discriminan a través de controladores los costes incurridos en cada granja con sujeción a las normas internacionales de información financiera NIIF del IASB². En el MECP se utilizaron sistemas en función de la producción orgánicos y por procesos y, modelos mixtos de tipo *direct costing* e *imputación racional* para los distintos controladores de costos. Finalmente se consolidaron los resultados por granja y sistema productivo para describir su comportamiento.

Los costos de producción en IPRS resultan mayores para el caso de estudio en la producción de Tilapia Negra, donde un kilo cuesta 1.453 USD versus los 1.678 USD del sistema IPRS, no obstante, esta diferencia se ve explicada a través del FCA del IPRS de la granja, donde se han presentado impases. Por su lado la Tilapia Roja es potencialmente más eficiente en Sistemas IPRS (1.590 USD) versus el sistema de jaulas flotantes (1.596 USD) que se explica en un mayor control del FCA en el sistema IPRS.

United States Soybean Export Council (USSEC)
 International Accounting Standards Board (IASB)

Tabla 1 Detalle de Inf. Técnica Cultivo y Costos de Producción por Kilo en USD - 2022

DETALLE	LAGOS TIERRA	JAULAS EMBAL.	IPRS ACUA.*	IPRS LTP**	IPRS PLAN***
ESPECIE	NEGRA	ROJA	NEGRA	ROJA	ROJA
KG BIOMASA	1.651.830	368.893	658.128	11.886	12.901
KG ALIMENTO	1.807.373	560.530	893.594	18.940	18.955
FACTOR CONVER. FCA	1,09	1,52	1,36	1,59	1,47
CANTIDAD CICLOS	83	23	75	1	1
PROMEDIO KG/CICLO	19.902	16.039	8.775	11.886	12.901
COSTO JUVENILES	0,306		0,271		
CONCENTRADO	0,683	1,149	0,866	1,190	1,097
ENERGIA Y COMB.	0,114	0,001	0,154	0,433	0,168
COSTOS VARIABLES	0,044		0,048		
MANO DE OBRA	0,200	0,056	0,224	0,101	0,050
COSTOS FIJOS	0,006		0,006		
MANTENIMIENTO	0,065	0,006	0,072	0,140	0,019
DEPRECIACIONES	0,036	0,013	0,037	0,006	0,005
COSTEOS		0,084		0,175	0,077
ALEVINOS		0,120		0,141	0,130
VACUNACION		0,087			
GASTO DE PESCA		0,080		0,047	0,044
TOTAL COSTO KILO	1,453	1,596	1,678	2,233	1,590
*Acuacultivos el Guajaro SA **Latinpez SAS ***Plan Producción Latinpez SAS					

FOSTERING OPPORTUNITIES TO ENHANCE AQUATIC VETERINARY EDUCATION

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Since 2006, WAVMA has been supporting the global development of a veterinary task force with expertise in a wide range of aquatic animals and specialties. The WAVMA is: to serve the discipline of aquatic veterinary medicine in enhancing aquatic animal health and welfare, public health, and seafood safety in support of the veterinary profession, aquatic animal owners and industries, and other stakeholders. In 2023 the Regional Director for Latin America and the Caribbean plans to inform faculties of Veterinary Medicine in the region about opportunities offered by WAVMA and in aquatic medicine. A trained workforce is needed to serve the aquaculture industry, both worldwide and in the Central/Southern American region, driven by the salmon industry in Chile, tilapia in Brazil, Colombia, and Mexico, and shrimp in Ecuador. WAVMA offers two certification programs, the Certified Aquatic Veterinarian (CertAqV) and the recently established Certified Aquatic Veterinary Nurse/Technician (CertAqVNT).

Since 2019, the WAVMA Education and Students Committee (ESC) actively worked to dispense complementary training to aquatic veterinarians and veterinary students around the world. ESC is composed of volunteers and is currently organized into three subcommittees, each chaired by a dedicated WAVMA member. ESC provides guidance for the establishment of Student Chapters at veterinary universities around the world, to provide additional learning opportunities to veterinary students, either through lectures or practical activities on aquatic animals, fostering networking with professionals in the field. Students can better appreciate the roles of an aquatic veterinarian in the various domains associated with the well-being of aquatic animals, within the framework of the UN Sustainable Development Goals and One Health. The WebCEPD subcommittee runs the Continuing Education and Professional Development (CEPD) program, offering webinars from experts in their fields. In 2021, the ESC achieved its goal of conducting one webinar per month, attracting a great audience. Live webinars are open to anyone interested at no cost, while recordings remain available for free to WAVMA members and upon a small fee payment for non-members. Upon the completion of a short knowledge and skills assessment (KSA), Continuous Education (CE) credits can be obtained. The Education Resources subcommittee aims to expose students to training opportunities. This is achieved through announcements on the WAVMA website and virtual events for young veterinarians, such as “A Sea of Opportunities” where examples of career paths and other formative experiences are shared. The Education Support subcommittee manages small funding schemes both for WAVMA Student Chapters (the Mini-Grant) and for individuals. The John L. Pitts Aquatic Veterinary Education Awards Program enables awardees to gain expertise in aquatic veterinary medicine. For regions of the world where the aquaculture industry has grown much faster than the capacity for aquatic animal health management and biosecurity control could have been established, such as Latin America and the Caribbean, WAVMA may provide great opportunities for rapidly bridging the gap in exposure, practical knowledge, and skills for veterinary students, and practicing aquatic veterinarians through its numerous programs and resources.

DESAFIOS SANITARIOS DEL CULTIVO DE TRUCHA ARCOIRIS *Oncorhynchus mykiss* EN COLOMBIA

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La truchicultura en Colombia representó para el 2021 el 16% de la producción piscícola nacional y el 8,6% de las exportaciones hacia Estados Unidos y la Unión Europea principalmente. Como todos los sistemas de producción animal, se enfrenta a desafíos sanitarios en la que la vigilancia epidemiológica, los monitoreos sanitarios y el diagnóstico de rutina aporta información relevante para conocer el estatus sanitario de la especie.

En Colombia la pancreatitis infecciosa necrótica (IPN) es la enfermedad de trucha arcoíris (*Oncorhynchus mykiss*) bajo vigilancia epidemiológica por la autoridad sanitaria ICA. Adicionalmente, los laboratorios de diagnóstico veterinario registrados ante el ICA como CORPAVET y MolecularVet, y la Autoridad Nacional de Acuicultura y Pesca (AUNAP) han apoyado las actividades de monitoreo sanitario en esta especie en el segundo semestre del 2022. Adicionalmente, el diagnóstico de rutina de los laboratorios registrados aporta información adicional para conocer el estatus sanitario de la especie.

Se presenta información del periodo 2017 a 2022 basado en los resultados de la vigilancia epidemiológica, monitoreos sanitarios y diagnóstico de rutina en los que CORPAVET y MolecularVet ha participado para mostrar el estado actual de identificación de patologías, así como su prevalencia específica de aquellas de origen viral (IPN), bacteriológico (*Flavobacterium psychrophilum*, *F. branchyophilum*, *Edwardsiella piscicida*, *Weissella tructae*, entre otros), parasitológico (microsporidiasis, myxosporidios, *Ichthyophthirius multifiliis*, digeneos, trichodinas y arácnidos), enfermedades de origen nutricional y por inadecuada calidad del agua (microbiológica, físico-química y toxicológica).

Se concluye con la aproximación a estrategias biotecnológicas en desarrollo para prevenir, controlar y mitigar el impacto de las enfermedades.

PHYTASE QUANTUM BLUE IMPROVES PHOSPHORUS RETENTION IN TILAPIA (*Oreochromis niloticus*) FED PLANT-BASED DIETS WITH REDUCED LEVELS OF PHOSPHORUS AND PROTEIN

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Phytases have been employed in animal feeds for several years, used primarily for reducing the environmental impact and phosphorus loads of farm effluents. A total of 750 male tilapia (*Oreochromis niloticus*) of approximately 20g were randomly allocated to 19 tanks (4 replicates per 4 treatment, except treatment NC2+2.500 which had 3 replicates) of 100 l each, using a recirculating aquaculture system. Duration of trial was 81 days. The five dietary treatments comprised a nutrient adequate positive control diet (PC), a negative control diet (NC1) formulated with a 0,20% avP, 0,16% Ca, and 0,56% protein matrix, the NC1 supplemented with 1.500 FTU/kg of phytase (NC1+1.500), a negative control diet (NC2) formulated with a 0,24% avP, 0,18% Ca, and 0,65% protein matrix, and the NC2 diet supplemented with phytase at 2.500 FTU/kg (NC2+2.500). The phytase used in this study was an advanced *E. coli* phytase (Quantum Blue, AB Vista UK). To determine nutrient retention, 30 fish were euthanized at the start of the feeding trial with 10 fish being pooled into one of 3 sample replicates. On termination of the growth period, 10 fish/tank were euthanized and samples pooled. Whole body homogenates and diet samples were analysed for dry matter, nitrogen (N), P, ash, lipid and gross energy. The nutrient retention in Tilapia over the 81-day feeding period is shown in Table 1. Retention of N was decreased with each nutrient downspec applied, even though the analysed protein downspec was similar in both NC1 and NC2 diets. This suggests that the greater P deficiency in NC2 diets was limiting protein utilization. Comparing the higher phytase levels of 2.500FTU/kg on top of the NC2 diet increased N retention to a level which was comparable to both the PC and NC1. Both phytases treatments gave significantly greater P retentions than all other treatments. Consequently, calculated P excretion was also lower in the phytase treatments compared to the controls.

In summary, by supplementing an appropriate level of phytase, the inclusion level of these nutrients can be reduced in diets, thereby creating diet cost savings, while preserving nutrient retention and having a positive impact on water pollution.

Table 1. Nutrient retention/excretion of Tilapia fed different levels of dietary P and protein, with or without phytase Quantum Blue (QB) supplementation 1.500 and 2.500 FTU/kg.

QB, FTU/kg	Nutrient Retention, %				Excretion, g/kg weight gain	
	N	Energy	Ash	P	N	P
PC	35,8 ^a	39,5 ^a	29,1	44,9 ^b	47,2 ^b	6,9 ^a
NC1	31,6 ^b	24,5 ^b	28,5	37,4 ^b	54,0 ^b	7,1 ^a
NC2	27,1 ^c	24,2 ^b	25,8	40,3 ^b	62,7 ^a	6,9 ^a
NC1+1.500	31,7 ^a	35,6 ^a	30,7	61,0 ^a	48,7 ^b	4,1 ^b
NC2+2.500	33,5 ^{ab}	37,0 ^a	30,1	69,7 ^a	47,4 ^b	2,9 ^b
SEM	1,17	2,65	1,76	5,08	2,75	0,71
P-value	0,002	0,002	0,336	0,002	0,005	0,003

PHYTASE QUANTUM BLUE MAINTAINS GROWTH PERFORMANCE IN TILAPIA (*Oreochromis niloticus*) FED PLANT-BASED DIETS WITH REDUCED LEVELS OF PHOSPHORUS AND PROTEIN

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Phytate is the main storage form of phosphorus (P) in many plants, but phytate-bound P is not available to fish. Phytase, an enzyme specific to hydrolyze indigestible phytate, has been increasingly used in fish feed during the past two decades, mainly in response to performance and heightened concerns over P pollution to the aquatic environment. A total of 750 male tilapia (*Oreochromis niloticus*) of approximately 20g were randomly allocated to 19 tanks (4 replicates per 4 treatment, except treatment NC2+2.500 which had 3 replicates) of 100 l each, using a recirculating aquaculture system. Duration of trial was 81 days. The five dietary treatments comprised a nutrient adequate positive control diet (PC), a negative control diet (NC1) formulated with a 0,20% avP, 0,16% Ca, and 0,56% protein matrix, the NC1 supplemented with 1.500 FTU/kg of phytase (NC1+1.500), a negative control diet (NC2) formulated with a 0,24% avP, 0,18% Ca, and 0,65% protein matrix, and the NC2 diet supplemented with phytase at 2.500 FTU/kg (NC2+2.500). The phytase used in this study was an advanced *E. coli* phytase (Quantum Blue, AB Vista UK). Diets were extruded to produce 3mm pellets, with phytase applied by post-pellet liquid application. At days 0 and 81 all fish per tank were weighed and feed intake recorded daily in order to calculate total feed intake (FI), body weight gain (BWG), specific growth rate (SGR) and feed conversion ratio (FCR). The efficiency of protein use was determined by the protein efficiency ratio (PER) which is calculated as weight gained/protein intake over the entire feeding period. Over the 81-day feeding trial, performance of tilapia worsened with each nutrient downspec, from PC>NC1>NC2 (Table 1). Addition of phytase to each respective NC diet increased weight gain and improved FCR to a statistically similar level as the PC. Feed intake was not significantly affected by treatment. PER showed a poorer conversion of ingested protein to weight gained in NC2 fed fish, however, PER was restored with the supplementation of 2.500 FTU/kg phytase.

In conclusion, degradation of dietary phytate with phytase supplementation in diets that are reduced in avP and protein resulted in better growth performance of tilapia.

Table 1. Performance of Tilapia fed different levels of dietary P and protein, with or without the Phytase Quantum Blue (QB) supplementation 1.500 and 2.500 FTU/kg for 81 days.

QB, FTU/kg	BWG, g/d	SGR, %/d	FI, g/d	FCR, g/g	PER, %
PC	1,46 ^a	2,36 ^a	1,91	1,30 ^b	2,18 ^a
NC1	1,20 ^{ab}	2,12 ^{bc}	1,73	1,46 ^{ab}	2,04 ^{ab}
NC2	1,01 ^b	1,96 ^c	1,58	1,59 ^a	1,88 ^b
NC1+1.500	1,35 ^a	2,25 ^{ab}	1,79	1,33 ^b	2,25 ^a
NC2+2.500	1,35 ^a	2,25 ^{ab}	1,78	1,32 ^b	2,25 ^a
<i>SEM</i>	0,094	0,080	0,082	0,058	0,079
<i>P-value</i>	0,030	0,026	0,122	0,015	0,022

USO DE INSECTOS COMO ALIMENTO PARA LA ACUICULTURA: EXPERIENCIAS EN COLOMBIA

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La acuicultura cada vez ocupa una posición más relevante en el sistema agroalimentario mundial. De hecho, la producción acuícola de subsistencia y a pequeña escala es parte del desarrollo local y regional en emergencia en países del sur global. Sin embargo, los costos de alimentación representan el rubro más relevante de los sistemas acuícolas, en cualquiera de sus escalas. Dentro de las principales causas están la dependencia de materias primas importadas, como la torta de soya, maíz, harina y aceite de pescado, entre otras. Estos recursos, son costosos y su producción podría ser insostenible con el tiempo.

En búsqueda de alternativas alimenticias, varias especies de insectos han sido ampliamente utilizadas, principalmente como fuente proteica. Dentro de las especies más ampliamente usadas se encuentran la mosca soldado negra (*Hermetia illucens*; BSF por sus siglas en inglés), la mosca doméstica (*Musca domestica*), el grillo doméstico (*Acheta domestica*), el grillo de campo (*Gryllus assimilis*) y los gusanos de la harina (*Tenebrio molitor* y *Zophobas morio*). Así, los dípteros son las especies con mayor ventaja porque se pueden producir a partir de residuos orgánicos agroindustriales, contribuyendo a la Economía Circular (EC) de los sistemas de producción y ofreciendo perspectivas interesantes para la innovación en el sector de la acuicultura. Está claro que la cría de insectos está creciendo rápidamente en todos los continentes y sus beneficios se pueden ver a gran, mediana y pequeña escala, contribuyendo a la sostenibilidad de los sistemas agroalimentarios desde las dimensiones social, económica y ambiental. En esta ocasión revisaremos las oportunidades de usar insectos como fuente de nutrientes para la alimentación de peces, presentaremos información comparada de su composición nutricional, documentando algunos ejemplos y presentando experiencias en laboratorio y campo realizadas en Colombia utilizando las especies *H. illucens*, *T. molitor* y *Z. morio* en la alimentación de tilapia (*Oreochromis niloticus*) y cachama (*Colossoma macropomum*). Desde la perspectiva social y la producción a pequeña y mediana escala, nos enfocaremos en la producción de *H. illucens* como componente de alimentos para tilapias por parte de pequeños piscicultores en diferentes escenarios económicos. Aunque los insectos como alimento alternativo en el sector acuícola no son la única opción, su interesante contribución a la sostenibilidad desde las dimensiones social, económica y ambiental podría ser estratégica en el sector acuícola, principalmente a nivel de peces tropicales.

RESPUESTAS FISIOLÓGICAS DEL ERIZO BLANCO *Tripneustes ventricosus* BAJO DIFERENTES DIETAS EN CONDICIONES DE LABORATORIO

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Entre los erizos más grandes del Caribe está el erizo blanco, *Tripneustes ventricosus* (Lamarck, 1816) (diámetro de testa de hasta 150 mm, entre 4 – 5 años de vida) (Figura 1). Es una especie que tiene una importancia ecológica como controladora del crecimiento algal y económica dado que sus gónadas son apetecidas en el mercado asiático, generando una importante pesquería en el Caribe oriental.

Con el fin de sentar las bases para el desarrollo de su cultivo con fines de producción, repoblación y/o biorremediación, se evaluaron las respuestas fisiológicas (tasas de ingestión (IR) y absorción (AR), eficiencia de absorción (AE), tasas de consumo de oxígeno (OCR) y excreción (UR), y crecimiento potencial (SFG)) y productivas (crecimiento y sobrevivencia) con relación a diferentes dietas bajo condiciones de laboratorio. El diseño consistió en tres tratamientos (por triplicado), en donde se probaron tres tipos de alimento: artificial, macroalga fresca *Sargassum* sp. y una mezcla de los dos anteriores. Para cada tratamiento, se dispusieron cinco ejemplares adultos (>40 mm) en tanques con 600 L de agua de mar ($1 \mu\text{m}$) y se mantuvieron durante 30 días con un flujo continuo ($20\% \text{ h}^{-1}$), temperatura de $27 \pm 1^\circ\text{C}$, salinidad de 37 ± 1 ppt, y saturación de oxígeno superior al 80%.

Las mayores tasas de alimentación (IR) se obtuvieron en los animales alimentados con la dieta de macroalga y los menores con la dieta artificial. Mientras que mayores valores de (AE y AR) se obtuvieron con la dieta artificial. No se encontraron diferencias significativas entre los tratamientos para las tasas asociadas al metabolismo (OCR y UR). Finalmente, los mayores valores de SFG se obtuvieron cuando los animales se alimentaron con la dieta artificial ($3,85 \text{ KJ d}^{-1} \text{ animal}^{-1}$) y los menores en los del tratamiento de macroalga ($0,62 \text{ KJ d}^{-1} \text{ animal}^{-1}$). En cuanto a las variables productivas, el tipo de dieta no afectó la sobrevivencia ni el crecimiento de los animales. Este trabajo sugiere que la respuesta fisiológica mejora con la adición de una dieta artificial, por lo que, a largo plazo, se podría conseguir un mayor desempeño en la salud y producción bajo condiciones de laboratorio, lo que lo convierte en un avance para el desarrollo del cultivo del erizo blanco *T. ventricosus* con fines de producción, repoblación y/o bioremediación.



Figura 1. Ejemplar de *T. ventricosus*.

ASENTAMIENTO LARVARIO DE LA ALMEJA ESTUARINA AMENAZADA *Polymesoda arctata* (Deshayes, 1854) CON FINES DE REPOBLACIÓN

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La almeja estuarina *Polymesoda arctata* es uno de los bivalvos más importantes en la pesquería del Caribe Colombiano, pero la sobreexplotación y pérdida de hábitat la ha llevado estar considerada en riesgo de conservación.

En esta investigación se evaluó su asentamiento larvario bajo condiciones de laboratorio, de tal forma que a futuro permita la producción de juveniles en laboratorio con fines de acuicultura o repoblación. Con larvas pediveliger obtenidas en laboratorio, se llevaron a cabo dos experimentos de asentamiento, en los que se probó por triplicado el efecto de diferentes estímulos suministrados al agua (epinefrina, serotonina, GABA y baja temperatura), sustratos de asentamiento (arena, sedimento, biofilm de microalgas y artificial) y tiempos post-estimulación (6, 24, 48 y 72 h) sobre el asentamiento y mortalidad larvaria (Figura 1). Mayores valores de asentamiento larvario fueron obtenidos sin suministrar estímulos al agua, sobre sustratos de biofilm artificial y a las 24 horas de estimulación.

Así mismo, la mortalidad larvaria fue mayor sobre este sustrato, especialmente cuando se aplicaron agentes químicos al agua y luego de 24 h de estimulación.

Los altos valores promedio de asentamiento (40 y 73%) y bajos valores de mortalidad (0 y 27%) durante el estudio le confieren a *P. arctata* un alto potencial para ser producida en laboratorio y ser usada en acuicultura o repoblación para contribuir a su uso sostenible y conservación.

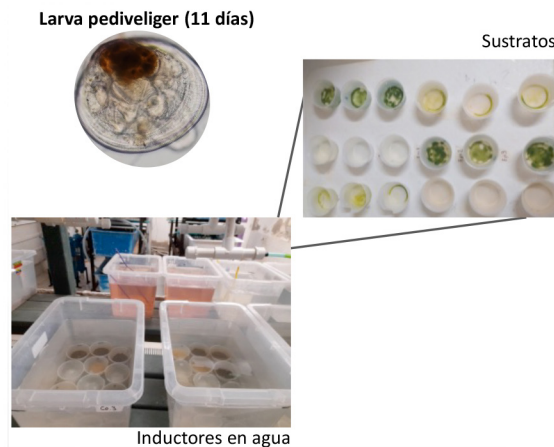


Figura 1. Diseño del asentamiento de las larvas pediveliger de *P. arctata*.

REARING PERFORMANCE OF JUVENILE YELLOWTAIL SNAPPER, *Ocyurus chrysurus*, IN A SEA WATER RECIRCULATION SYSTEM AT TWO DIFFERENT STOCKING DENSITIES

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The evaluation of the performance of new species in controlled aquaculture systems is important to reduce the pressure on the wild stock and potential negative environmental and social externalities, by offering sustainable ways to supply the demand in the markets of these species. The rearing performance of yellowtail snapper *Ocyurus chrysurus* reared in a controlled aquaculture system with partial discharge was studied and discussed, to have a first approach to technical and biological performance indicators. In this study, two densities were stocked, D_1 : 10 fish/m³ (mean 258.3 ± 57 g) and D_2 : 20 fish/m³ (mean 235.6 ± 55.9 g) in three tanks (1.7 m³) supplied with seawater (range 20.5 – 30°C). Fish were fed to satiety with an extruded diet containing 46% crude protein and 12% crude lipid. The survival rate was above 93%. After 238 days, the mean weight was 534.5 ± 19.4 g and 606.9 ± 34.5 g for D_1 and D_2 respectively. The final feed conversion (3.13 for D_1 and 3.03 for D_2) did not differ significantly between densities. The exponents (b) of the length-weight relationship calculated for D_1 (3.15) versus D_2 (3.10) demonstrated a higher condition factor than their wild counterparts. This study is one of the few reports on this specie performance in juvenile stage in RAS.

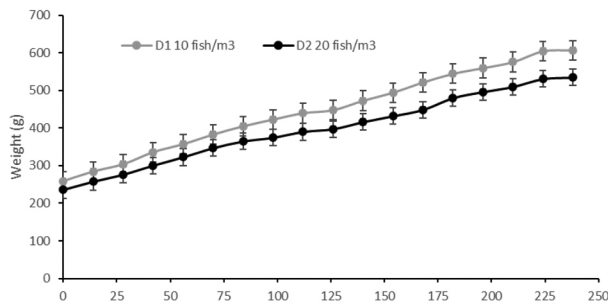


Figure 1: Mean weights (SE ±) of the yellowtail snapper, *Ocyurus chrysurus*, grown in RAS at two culture densities during 238 days of experiment.

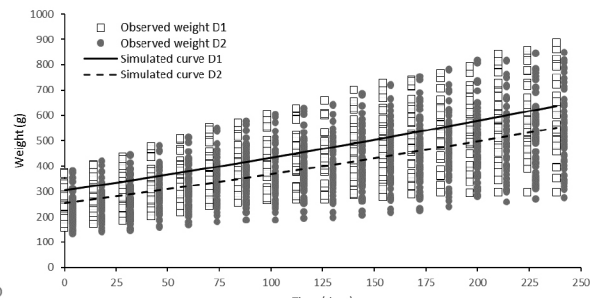


Figure 8: Modeling of the simulated data using the von Bertalanffy model, for two different densities of the *O. chrysurus* culture in $D_1= 10 \text{ org/m}^3$. $D_2= 20 \text{ org/m}^3$.

MARINE FISH AQUACULTURE IN THE AMERICAS: FROM TECHNOLOGICAL ADVANCES TO COMMERCIAL REALITY

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Full cycle aquaculture technology of several commercially important species of marine fish has become or is quickly becoming available. Hatcheries are now capable of spawning broodstock and producing juveniles of species such as cobia (*Rachycentron canadum*), Hamachi / kampachi (*Seriola rivoliana*, *S. lalandi* / *S. dorsalis*), pompanos (*Trachinotus carolinus*), snappers (*Lutjanus guttatus*, *L. peru* and *L. campechanus*), yellowtail snapper (*Ocyurus chrysurus*), totoaba (*Totoaba macdonaldi*), red drum (*Sciaenops ocellatus*), mahi (*Coryphaena hippurus*), tripletail (*Lobotes surinamensis*), olive flounder (*Paralichthys olivaceus*) – among others. Steady supply of high-quality juveniles of certain species is still limited, but it is unlikely that this will remain a bottleneck for industry expansion. Technology is ahead of the industry. For example, the limitations for expanding commercial growout operations for species such as the olive flounder, red snapper and yellowtail snapper are mainly due to a lack of interest in investing in new facilities for raising them.

Nursery and growout technologies are readily available. Open ocean / offshore aquaculture, recirculating aquaculture systems (RAS) and flow-through in-line raceways are, in our view, the most viable options. Large scale production required to achieve commercial viability will require advanced technologies demanding high levels of investment and long-term commitment. Hence, fish produced in these systems must be sold at high prices to compensate the high capital and operating costs required, limiting their demand in a highly competitive white fish market.

Commercial viability has been achieved in Europe and Asia long ago. Yet, with a few exceptions, it remains elusive in the Americas and the Caribbean – where the industry is still in its infancy. Infrastructure and logistics are in place, as well as market demand. Technology continues to expand rapidly. Granted, challenges such as optimizing genetics, nutrition, and diseases control must be tackled to secure commercial viability. Automation is progressing fast but still needs refinement. Machine learning and artificial intelligence tools are becoming available and being incorporated to perfect systems automation. The development of practical, specialized feeds for all developmental stages of species such as cobia, snappers and *Seriola* remains a challenge. FCRs are still very high, limiting performance and increasing production costs.

We present and discuss these challenges and how the industry is collectively working with researchers to address and resolve issues limiting the expansion of the industry. Nonetheless, commercial production has become or is becoming a reality.

PHYTOGENICS TO AVOID THE USE OF ANTIBIOTICS IN AQUACULTURE AND INCREASE PROFITABILITY

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Given the global issues of bacterial resistance, commercial rejection of products with traces of antibiotics, and emerging diseases that affect aquaculture, alternatives are needed for the prevention and treatment of pathologies that affect aquaculture production.

Phytonutrients are an excellent alternative to address the problems. Worldwide research has demonstrated their antibacterial, antiparasitic, antifungal effects, in addition to acting as immunomodulators and increasing the consumption of concentrated food.

Commercial products based on phytogetic resources have demonstrated, under laboratory conditions and multiple field tests, the effects of plant extracts such as Garlic (*Allium sativum*), Oregano (*Origanum vulgare*), Turmeric (*Curcuma longa*), Cinnamon (*Cinnamomum verum*), and Rosemary (*Rosmarinus officinalis*) among others, on bacterial agents such as *Edwardsiella sp.*, *Aeromonas hydrophila*, *Pseudomonas sp.*, *Flavobacterium sp.*, *Streptococcus agalactiae*, *Vibrio sp.*, and *Weisella ceti*.

Thesis documents and field implementations of these phytonutrients in Tilapia, Trout, and Cachama productions have shown favourable results, where an increase in profitability is confirmed through better survival, feed conversion, final weight, and daily weight gain, among other factors resulting from the use of these types of additives.

It is necessary to continue researching the combination of these active principles, validating the antiparasitic and antifungal effects that are widely documented in international literature under different conditions. Likewise, a greater number of field studies are needed to standardize processes, dosages, and reach the best cost-benefit ratios using plant extracts.

EVALUACIÓN DE UN SISTEMA ACUAPÓNICO MULTITROFICO DESACOPLADO, EN LA PRODUCCIÓN DE CAMARON BLANCO (*Litopenaeus vannamei*) Y TOMATE (*Solanum lycopersicum*)

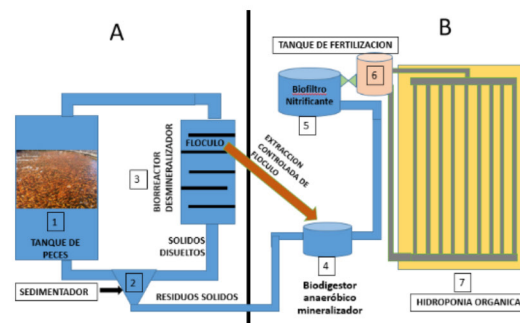
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A pesar de la viabilidad técnica y económica de la producción integrada de peces y hortalizas utilizando modelos acuapónicos acoplados, estos sistemas presentan problemas en el manejo de la carga de sólidos suspendidos, los cuales deben ser extraídos para evitar la obstrucción de la unidad hidropónica, un paso que representa una pérdida significativa de nutrientes totales. La implementación de sistemas acuícolas integrados desacoplados para la producción de hortalizas puede aumentar la eficiencia de los agroecosistemas en términos de reutilización de agua y nutrientes. El propósito de esta investigación es comparar la eficiencia en la recuperación de nutrientes y desempeño productivo del Camarón Blanco (*Litopenaeus vannamei*) y el tomate *Solanum lycopersicum* en dos sistemas acuapónicos con diseño acoplado y desacoplado.

Para ello se propone la implementación de un diseño básico de un sistema de acuaponía acoplado y otro desacoplado, este último dividido en dos secciones principales: una con el sistema de recirculación de agua para los peces y otra con recirculación de agua para la hidroponía de las plantas, incluyendo una unidad desmineralizadora que producirá biomasa bacteriana, así como un biodigestor anaeróbico. Adicionalmente, se realizará el montaje de una unidad de hidroponía convencional de tomate como tratamiento control para las plantas. Se determinará el desempeño zootécnico del Camarón Blanco cultivado en ambos tipos de sistema, así como las propiedades que determinan la calidad de los frutos de tomate. Se espera que en los resultados se evidencie una diferencia en las cantidades de nutrientes disponibles en las soluciones nutritivas para las plantas, siendo mayormente producidas en el sistema desacoplado por las unidades de mineralización aeróbicas y anaeróbicas, así como el aporte de organismos acumuladores naturales como el Flóculo y Azolla, generado nutrientes en el mineralizador. De esta manera, se busca realizar un avance en la comprensión de las posibilidades que ofrecen los sistemas acuapónicos desacoplados en la transformación de los nutrientes que pueden mejorar la calidad de ambas especies de interés.

Elemento	NO3	NH4	P	K	Ca	Mg	SO4
mmol·l ⁻¹	13,75	1,25	1,25	8,75	4,25	2	3,5
ppm	192	18	39	341	170	48	112



COBIA *Rachycentron canadum* NUTRITION: P/E RATIO REQUIREMENT, AND *IN-VIVO* DIGESTIBILITY

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Aquafeeds comprise one of the largest operational costs of the aquaculture sector. It is imperative to lower costs while formulating diets with high-quality ingredients which nutritional composition meet the requirements of the target species. If a target species is a novel one such as cobia (*Rachycentron canadum*), resources must be invested in investigating those nutritional requirements to optimize growth, health, and feed efficiency.

Protein and energy are two nutritional components that must be carefully considered when formulating diets as an imbalance of the two can have detrimental effects on the health of the fish and on overall production. Here we summarize the progress and results of a multi-factorial bio-energetic study on cobia of commercial sizes to estimate the requirements of protein/energy and amino acids. This information will be key to formulating more nutritionally precise diets tailored to the various commercial sizes.

Digestibility of nutrients and diets is another topic that must be evaluated when formulating diets. Most publications utilize fish that are significantly smaller than commercial size to carry out *in-vivo* digestibility. This can pose an issue due to the fact that as fish grow closer to their harvest size, their nutritional requirements will change and thus diet composition must also be altered. Here we summarize the progress and results of *in-vivo* digestibility studies on cobia of different sizes to understand how fish size might affect digestibility.

EVALUACIÓN PRODUCTIVA DE CINCO NIVELES DE INCLUSIÓN DE LA HARINA DE LA *Hermetia illusens* EN EL CULTIVO DE POSTLARVA DE CAMARÓN

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La mosca soldado (*Hermetia illusens*) es una alternativa ecológica como fuente proteínica en la alimentación pecuaria. El objetivo del estudio fue evaluar el efecto de cinco niveles de inclusión de la harina de *Hermetia illusens* en la dieta diaria de la postlarva de camarón durante 30 días de cultivo.

El estudio se realizó en el laboratorio húmedo del Centro Universitario Regional del Litoral Pacífico de la UNAH. Se manejaron camarones en el estadio de PL5 hasta PL35 que se alimentaron con el 2.5, 5.0, 7.5, 10.0 y 12.5% de inclusión de harina de *Hermetia illusens*. Se registraron las sobrevivencias, sobrevivencias a la prueba de estrés, pesos y tamaño.

En las supervivencias finales no se encontraron diferencias estadísticas entre tratamientos ($P > 0.6313$), pero sí se encontró en las supervivencias después de la prueba de estrés ($P < 0.0006$), observando la menor supervivencia en el tratamiento control. Se encontró diferencias estadísticas ($P < 0.0001$) en los pesos finales de las postlarvas, los camarones con el mejor peso se lograron con el 12.5% de inclusión de *Hermetia illusens* (Fig. 2).

Al comparar las longitudes finales de las postlarvas se obtuvo diferencias estadísticas ($P < 0.0001$), los camarones más grandes fueron los alimentados con el 12.5% de inclusión de la *Hermetia illusens*. La harina de *Hermetia illusens* podría ser una alternativa ecológica en la producción larvaria de camarón.

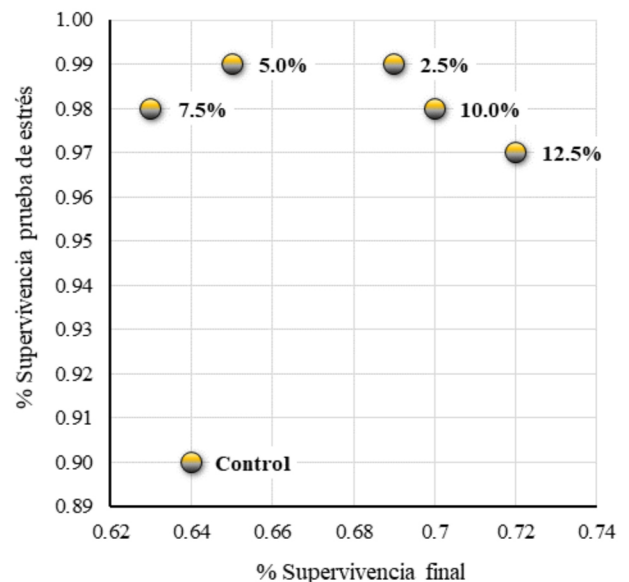


Fig. 1. Porcentajes de supervivencia después de la prueba de estrés y supervivencia final según los niveles de inclusión de harina de *Hermetia illusens* en la dieta diaria de postlarvas de camarón.

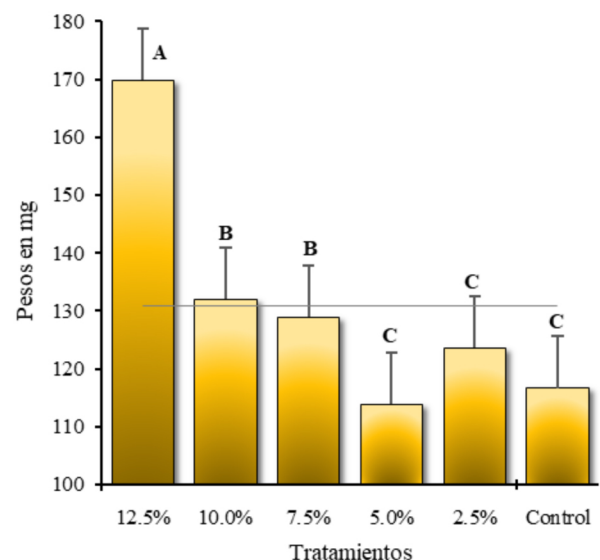


Fig. 2. Pesos en mg de postlarvas de camarón alimentados a diferentes niveles de inclusión de *Hermetia illusens* durante 30 días de cultivo.

EFECTO DE LA INCLUSIÓN DEL ACEITE DE KRILL Y LA YEMA DE HUEVO EN LA ALIMENTACIÓN DE LA POSTLARVA DE CAMARÓN

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En larvicultura los lípidos es uno de los nutrientes más importantes de la dieta diaria. El objetivo de la investigación consistió en observar el efecto de la inclusión del aceite de krill y la yema de huevo en el desarrollo de la postlarva de camarón.

El estudio se realizó en el laboratorio húmedo del Centro Universitario Regional del Litoral Pacífico de la UNAH. Se usaron postlarvas desde el estadio de PL5 hasta PL30, se manejó como tratamiento, el aceite de krill que se incluyó al 7, 10 y 15%, y, en otro grupo se usó una pasta de yema de huevo de gallina a la inclusión del 7, 10 y 15% en la ración diaria de los camarones. Se registró la longitud, peso, supervivencia, supervivencia a la prueba de estrés.

En la comparación de las longitudes finales se encontraron diferencias estadísticas ($P > 0.0001$), los camarones que recibieron aceite de krill presentaron los tamaños más favorables (Fig. 1). En la comparación de los pesos también se obtuvo diferencias estadísticas ($P > 0.0001$), las postlarvas que se alimentaron con el 7% de inclusión de aceite krill alcanzó el mejor peso (Fig. 2).

En las supervivencias se observaron diferencias estadísticas ($P > 0.0119$), las mejores supervivencias se obtuvieron en las postlarvas que fueron alimentadas con aceite de krill. En las supervivencias después de la prueba de estrés hubo diferencias estadísticas ($P > 0.0247$), la menor supervivencia se encontró en el tratamiento control. La inclusión de aceite de krill mejoró el desempeño de las postlarvas.

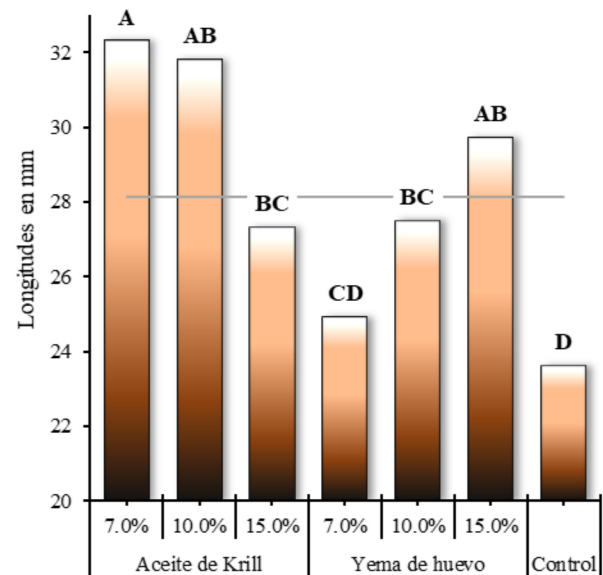


Fig. 1. Tamaños finales de postlarvas de camarón alimentados con diferentes niveles de inclusión de aceite de krill y yema de huevo, promedios con una letra en común no son significativamente diferentes ($P > 0.05$).

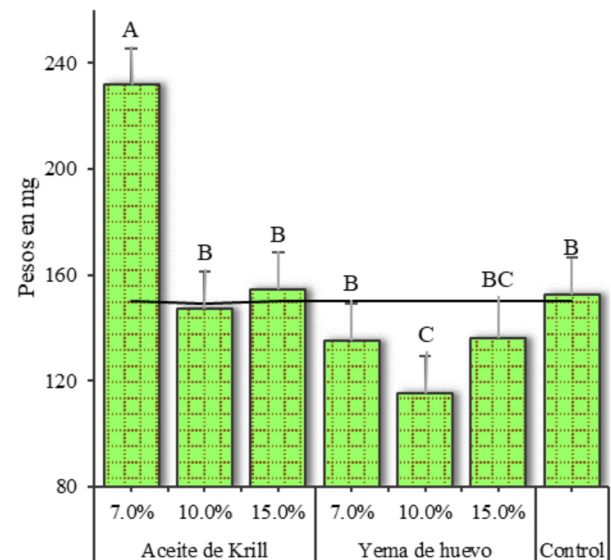


Fig. 2. Pesos de postlarvas de camarón alimentados con diferentes niveles de inclusión de aceite de krill y yema de huevo en su dieta diaria.

COMPARACIÓN PRODUCTIVA DE LA HARINA DE KRILL Y HARINA DE *Hermetia illusens* INCLUIDOS EN LA ALIMENTACIÓN DE POSTLARVA DE CAMARÓN

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En la alimentación de postlarvas de camarón, la fuente de proteína es un insumo de importancia económica, siendo necesario contar con alternativas para optimizar este factor. El objetivo de la investigación fue comparar el desempeño productivo de las postlarvas alimentadas con harina de krill y harina de *Hermetia illusens* al 5, 7.5 y 10% de inclusión.

El estudio fue realizado en el laboratorio húmedo del Centro Universitario Regional del Litoral Pacífico de la UNAH. Se manejaron postlarvas de camarón en el estadio de PL5 hasta PL30.

Un grupo de postlarvas se alimentó con el 5.0, 7.5 y el 10% de inclusión de harina de krill en su dieta diaria, y otro grupo se alimentó con el 5.0, 7.5, y 10% de inclusión de harina de *Hermetia illusens*. Se registró longitud, pesos finales, sobrevivencias a la prueba de estrés y supervivencia final.

Las postlarvas con los tamaños ($P < 0.0001$) y los pesos ($P < 0.0001$) más favorables (Fig. 1), fueron alimentadas con el 10% de inclusión de harina krill y el 7.5% de *Hermetia illusens*. En la supervivencia a la prueba de estrés, hubo diferencias estadísticas ($P < 0.0348$), siendo el tratamiento control la menor supervivencia.

En las supervivencias finales también se encontraron diferencias estadísticas ($P < 0.0394$), la mejor supervivencia se observó en los camarones con el 10% de inclusión de harina de krill en su dieta diaria (Fig. 2). La harina de krill y la harina *Hermetia illusens* influyeron positivamente en los crecimientos y las sobrevivencias de las postlarvas de los camarones.

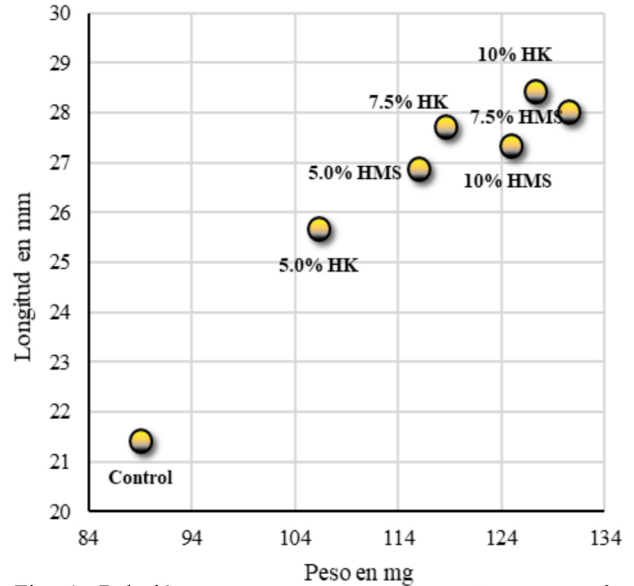


Fig. 1. Relación entre peso en mg y tamaño en mm de postlarva de camarón alimentados con el 5, 7.5 y 10% de inclusión de harina de krill (HK) y con el 5, 7.5 y 10% de harina de *Hermetia illudens* (HMS), durante 30 días de cultivo.

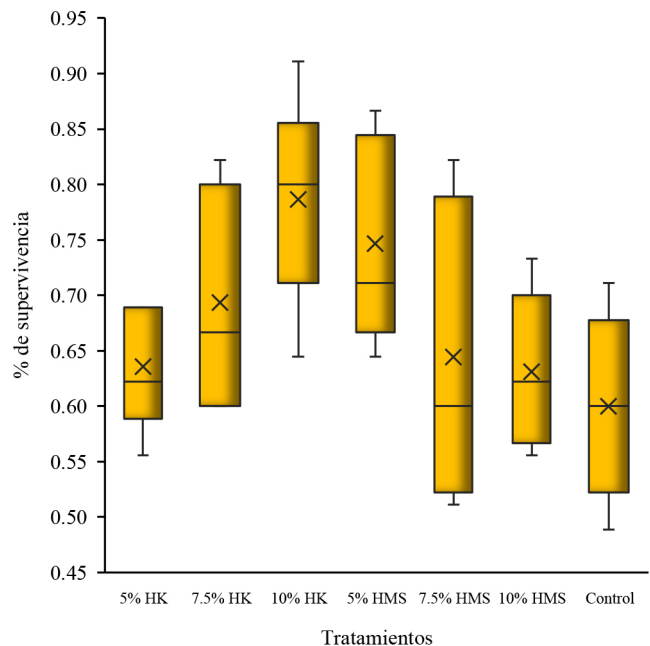


Fig. 2. Supervivencia final de postlarvas de camarón alimentados a diferentes niveles de inclusión de *Hermetia illusens* (HMS) y harina de krill (HK), en su dieta diaria.

DETECCIÓN DEL *Vibrio spp* EN DOS TECNOLOGÍAS DE DESCAPSULACIÓN DE LA *Artemia franciscana*

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El objetivo del estudio fue observar la presencia de *Vibrio spp* en nauplios de *Artemia franciscana* eclosionados por medio de dos tecnologías de desencapsulado.

El estudio se realizó en el laboratorio húmedo del Centro Universitario Regional del Litoral Pacífico de la UNAH. Se sembraron cistos de *Artemia francisca* de alta calidad a la densidad de 3.0 g por litro, que fueron manejados con la técnica de desencapsulación química y la otra con la tecnología de separación de cistos por magnetismo.

Se recolectaron muestras de nauplios recién eclosionados y a las 48 horas después de la eclosión, por cada tecnología de desencapsulado que fueron sembradas en placas bacteriológicas con agar TCBS para detectar colonias de *Vibrio spp*, y con agar TSA para evitar el crecimiento de *Pseudomonas spp*, manejando por triplicado diluciones de 1:1, 1:100, 1:1,000, 1:10,000 y 1:100,0000

Entre las dos tecnologías de desencapsulados no se encontraron diferencias estadísticas ($P < 0.2248$) en la detección de colonias verdes de UFC/g, pero sí ($P > 0.0125$) entre las dos tecnologías de desencapsulado y el tiempo después de la eclosión (Fig. 1). También, se encontraron diferencias ($P > 0.05$) en la presencia de colonias amarillas de UFC/g según las tecnologías de desencapsulado (Fig. 2). En la detección de colonias negras y RTB, no se encontraron diferencias ($P < 0.7347$). La tecnología de desencapsulado magnético presentó menor población de colonias verdes a las 48 horas después de la eclosión, y de colonias amarillas, el desencapsulado magnético es más amigable con el ambiente y de mejor operatividad.

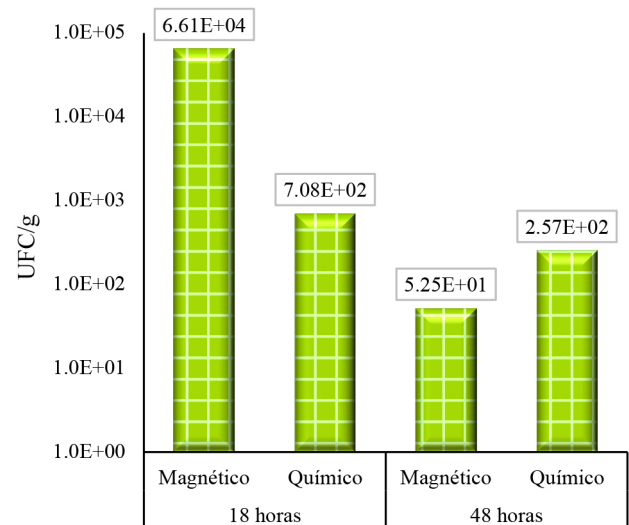


Fig. 1. UFC verdes por gramo de *Artemia franciscana* tratados con dos tecnologías de desencapsulado.

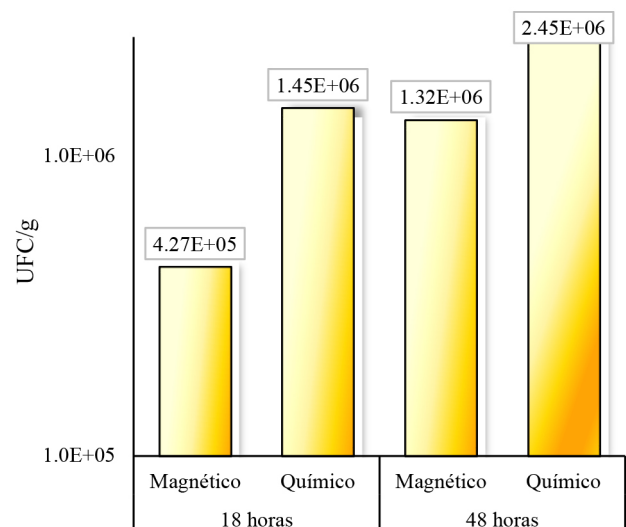


Fig. 2. UFC amarillas por gramo de *Artemia franciscana* tratados con dos tecnologías de desencapsulado.

CICLO REPRODUCTIVO Y PRIMERA MADUREZ SEXUAL DE CHITA *Anisotremus scapularis* (Tschudi, 1846)

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Anisotremus scapularis conocida localmente como chita o sargo, es una especie comercialmente importante en el Perú, por ello, es considerada como prioritaria para el desarrollo de su acuicultura. El objetivo del estudio fue establecer el ciclo reproductivo de hembras de *A. scapularis*, mediante un muestreo estacional entre los años 2019 y 2020 en las costas de Callao – Perú. Se colectó 81 ejemplares y se realizó el estudio macroscópico e histológico de las fases de desarrollo ovárico de acuerdo a la clasificación propuesta por Brown-Peterson *et al.* (2011). Se calculó los índices biométricos como el índice gonadosomático (IGS) y el *índice hepatosomático (IHS)*, determinándose también la talla de primera madurez sexual.

El estudio permitió identificar por histología todas las fases del ciclo reproductivo, a excepción de la fase de regresión. Los ovarios de *A. scapularis* presentaron una forma fusiforme con un espectro en su coloración asociado a el estado de desarrollo del ovario, donde las fases inmaduras presentan un color translúcido claro sin vascularización, variando a un naranja intenso y vascularizado en las fases maduras (Figura 1). Los mayores valores del IGS se observaron en la estación de verano, esto se correlacionó con la mayor proporción de individuos en la fase “capaz de desovar”, estos resultados permiten pensar que el verano es la principal estación reproductiva de *A. scapularis*. Los valores observados para IHS se asociaron a la modulación observada para IGS, siendo el invierno la estación con los menores valores. Respecto a la talla de primera madurez sexual fue calculado el L_{100} en 25,3 cm, con el 95 % de intervalo de confianza. El análisis histológico brindó información del ciclo reproductivo de *A. scapularis*, permitiendo definir a la especie como un desovador asincrónico con fecundidad indeterminada por la presencia de ovocitos en diferentes estadios de maduración, atribuyéndose por ello un periodo largo de desove.

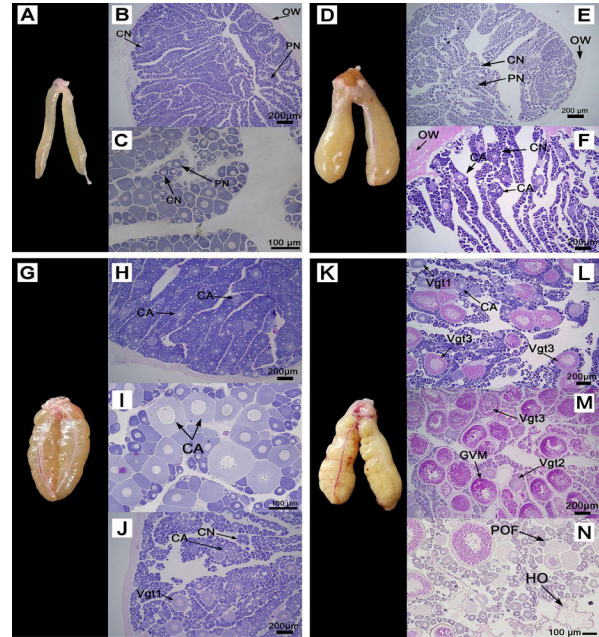


Figura 1. Microfotografías macroscópicas de los ovarios asociados a los cortes histológicos transversales, las diferentes fases del ciclo reproductivo de *A. scapularis*. A) ovario en fase inmadura, B-C) histología de ovario clasificada como fase inmadura. D) ovario en fase de regeneración, E-F) histología de ovario clasificadas como fase de regeneración. G) ovario en fase de desarrollo. H -I-J) histología de ovario clasificados como fase de desarrollo. K) ovario en fase de capacidad de desove, L-M-N) histología de ovario clasificadas como fase de capaz de desovar. Los cortes histológicos muestran: pared ovárica (OW), ovocitos cromatina nucléolo (CN), ovocitos perinucleares (PN), ovocitos cortico alveolares (CA), ovocitos vitelogénicos primarios (Vgt1), ovocitos vitelogénicos secundarios (Vgt2), ovocitos vitelogénicos terciarios (Vgt3), migración de la vesícula

BETA-GLUCAN INFLUENCES THE SURVIVAL RATE OF NILE TILAPIA AFTER *Francisella orientalis* BACTERIAL CHALLENGE

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The aim of this study was to evaluate the effect of dietary supplementation with β -glucan on the survival of Nile tilapia challenged with *Francisella orientalis* (*Fo*), a pathogen of great importance for Brazilian and world aquaculture. Considering the immunomodulatory properties of β -glucan, Nile tilapia juveniles were supplemented with β -glucan and subsequently submitted to bacterial challenge with *Fo*. Changes in behavior, clinical signs and daily mortality were evaluated for 15 days after infection.

Tilapia is the main species of fish produced in Brazil; in 2021, production was 534 thousand tons, equivalent to 63.5% of the total Brazilian aquaculture (PEIXE BR, 2022). *Francisella orientalis* (*Fo*) is a pathogen of tropical fish that causes francisellosis (SOTO *et al.*, 2009). No commercial vaccine is available against francisellosis in Brazil. Thus, one of the ways to prevent outbreaks of francisellosis in the country is using additives in the diet to increase the immune system of the fish (RAGHIANTE *et al.*, 2017).

240 Nile tilapia juveniles (91.41 ± 7.6 g) were distributed in twelve tanks (250 L, 20 fish per tank) with aeration and continuous water flow. During the experimental period, water temperature, pH, dissolved oxygen were monitored and kept within than recommended for the comfort and well-being of the tilapia. The IA2203 strain (*Francisella orientalis*) was obtained from the strain collection of the Laboratório de Sanidade Aquícola (PREVET, Jaboticabal/SP.), which was isolated from Nile tilapia produced in the region of Santa Fe do Sul, SP. For the bacterial growth, it was seeded on agar plates enriched with cysteine at 24°C for 72 h. After this period, typical colonies were transferred to BHI broth and incubated at the same temperature.

A randomized design was used, with two supplementation levels (1 g kg⁻¹ (T1, 0.1%) and 3 g kg⁻¹ (T2, 0.3%)) of β -glucan (Macrogard® Lot QT19120, > 60%, Biorigin, Brazil) and a control diet (no β -glucan added) and four replications. After 15 days of acclimatization, fish began to be fed with the experimental diets (1.5% of live weight) split twice a day, for a period of 30 days. Two tanks containing fish from the control group (C) and four tanks from groups T1 and T2 were inoculated intracelomically with 0.1 mL of *Fo* bacterial suspension at a pre-established dose of LD50% (1.95×10^9 CFU.mL⁻¹). The other two tanks of the control group were inoculated with 0.1 mL of PBS, denominated as C0. After bacterial inoculation, changes in behavior, clinical signs and mortality were recorded daily for 15 days to determine the survival rate and the cumulative mortality of each evaluated treatment. This study demonstrated that dietary supplementation with 3 g kg⁻¹ β -glucan provided greater survival in fish after challenge with *Francisella orientalis* under the experimental conditions tested.

EVALUACIÓN DE LA HIDROESTABILIDAD EN ALIMENTOS FORMULADOS PARA CAMARÓN BLANCO *Litopenaeus vannamei* UTILIZANDO DIFERENTES TIPOS DE AGLUTINANTES COMERCIALES

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En el sector acuícola, la camaricultura representa una de las actividades principales, por su gran aporte a la seguridad alimentaria (Faillace *et al.* 2016). Debido a esto, el aumento de granjas ha potenciado los problemas ambientales por los residuales descargados en zonas acuíferas. En la actualidad se buscan estrategias que ayuden a realizar éstas actividades de manera sostenibles (FAO, 2020). El uso de alimentos formulados con características físico-químicas adecuadas, puede representar una reducción de costos de producción, mayor rendimiento, calidad y sostenibilidad (Casto & Ceballos, 2021). El objetivo de este trabajo fue la evaluación de dietas para camarón blanco *L. vannamei* elaboradas con diferentes compactadores comerciales con el fin de conocer su porcentaje de hidroestabilidad y de lixiviación las cuales son características importantes en los alimentos destinados para esta especie.

Se elaboraron tres dietas según Gil-Núñez (2018), donde se incluyeron los compactadores A, B y C a 0.4% para cada una de las dietas (Tabla 1).

Las pruebas de hidroestabilidad se realizaron según la metodología descrita por Bortone & Jory (2017), con 4 repeticiones, utilizando la siguiente formula:

$$\% \text{ (p/p) LOD} = \% \text{ (p/p) de humedad} = 100 \times \frac{\text{pérdida de peso por secado (g)}}{\text{porción de prueba en peso (g)}}$$

$$\% \text{ Materia seca} = 100 - \% \text{ LOD}$$

Para el secado del alimento se utilizó el método 930.15 de la AOAC (AOAC INTERNATIONAL, 2005). Los análisis estadísticos fueron a una significancia de $P < 0.05$ mediante una ANOVA de una vía y una prueba Duncan usando Statgraphics 5.1. La dieta con el compactador "A", presentó un mayor porcentaje de hidroestabilidad, mayor al 90%, en comparación con las dietas que se obtuvieron con los compactadores B y C, los cuales mostraron una estabilidad hídrica menor al 90% ($P < 0.05$).

La hidroestabilidad mayor al 75% en los alimentos formulados con 35% de proteína promueve una buena detección y consumo del alimento, eficiencia en el uso del alimento, disminución de residuales, mejor conversión alimenticia y una mayor rentabilidad en la producción (Bartone & Jory 2017).

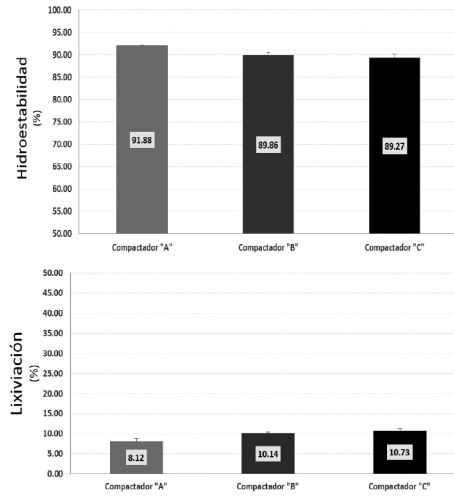
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Tabla 1. Formulación de alimento balanceado

Ingredientes (g/Kg alimento)	Dieta 1	Dieta 2	Dieta 3
	Compactador A	Compactador B	Compactador C
Harina de pescado	200.00	200.00	200.00
Harina de soya	270.00	270.00	270.00
Harina de trigo	433.00	433.00	433.00
Harina aviar	40.00	40.00	40.00
Aceite de pescado	15.00	15.00	15.00
Lecitina de soya	35.00	35.00	35.00
Dresbond AC	4.00	0.00	0.00
Compactador M30	0.00	4.00	0.00
Compactador M40	0.00	0.00	4.00
Vitaminas	1.00	1.00	1.00
Minerales	1.00	1.00	1.00
Conservador	1.00	1.00	1.00

Tabla 2. Resultados de pruebas en alimentos

Dieta	Hidroestabilidad	Lixiviación
	%	
Compactador A	91.9 ^b	8.12 ^b
Compactador B	89.9 ^a	10.14 ^a
Compactador C	89.3 ^a	10.73 ^a

**Figura 2. Porcentajes de hidroestabilidad y lixiviación con.**

ROADMAP FOR A FUNCTIONAL MICRODIET FOR WHITELEG SHRIMP POST-LARVAE

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High quality post-larvae (PL) are required for the farming industry of whiteleg shrimp (*Penaeus vannamei*), and hatcheries continuously improve rearing and feeding protocols. The early rearing is a critical period in shrimp development, with the weaning from live-feeds to inert microdiets being strongly influenced by diet quality. Microdiet quality has a large impact on shrimp performance in the long-term, affecting the downstream production of high-quality juveniles. Therefore, there is room for optimizing a weaning diet for shrimp larvae/post-larvae, in particular to improve robustness. In fact, industrial shrimp farming is characterized by inconsistent yields as it is quite susceptible to pathogenic outbreaks. Once shrimp cannot be vaccinated and the use of antibiotics is legally limited in many countries, functional dietary additives can be used as a prophylactic alternative to stimulate the shrimp immune condition. This work summarizes the development of a functional premium microdiet boosting shrimp post-larval performance and quality.

Four trials were conducted with white leg shrimp PL (initial wet weight 3-13 mg) reared under standard procedures in triplicate tanks. Shrimp were reared at RIASEARCH Lda facilities (Portugal), at 27-28°C, and fed on microdiets *ad libitum* for 18-21 days.

Firstly, the protein requirement at the post-larval stage was evaluated; 6 diets ranging from 34 to 63% crude protein were used. Results show a dose-response pattern for growth of shrimp PL (3-70mg wet weight), with a break-point at 47.1% dietary crude protein.

Protein sources were subsequently tested using 4 diets containing either fish meal, squid meal, krill meal or a balanced mix of these three (52% crude protein), as main ingredients. Results show no significant differences between treatments for final body weight, and survival was lower in the fish meal-based diet.

Functional additives were evaluated using 4 experimental microdiets: a commercial like diet as positive control (PC); a negative control diet (NC) based on PC but lower in vitamin C and E; the NC diet supplemented with taurine plus methionine (T+M); and the NC diet supplemented with β -glucans (BG). Results suggest dietary vitamin C and E to impact pathogen susceptibility, while β -glucans seem to decrease lipid peroxidation, and boost the antioxidant and immune status.

Finally, the cost-effectiveness of 3 microdiet prototypes was then assessed. Results showed no differences for PL survival (75 - 87%) or economic feed conversion ratio, but shrimp PL fed an ultra-premium diet achieved a significantly higher final body weight and relative growth rate (19.8 %/day) than those fed the standard (15.6 %/day) or premium (17.1 %/day) diets.

In short, this study shows that: 1) A dietary protein requirement of 47.1% was established for shrimp PL (3-70 mg wet weight); 2) Squid and krill meals proved to be good sources of protein for the early development of shrimp, as well a mixture of these two with a high quality fish meal; 3) The use of functional dietary additives, such as β -glucans, vitamins C and E, bring benefits to the antioxidant capacity and immune condition of the shrimp PL; 4) Higher quality diets can be advantageous in early phases of production, leading to a reduction of time to reach commercial size, and savings in operational costs.

Acknowledgements: This work was part of the project FA_05_2017_005 SHELLWIN, financed by the Blue Fund program of the Ministry of the Sea, Portuguese Republic.

IMMUNO-MODULATORY EFFECTS OF BIOACTIVE PEPTIDES PRESENT IN PROTEIN HYDROLYSATES FED TO SEABASS JUVENILES SUBMITTED TO ACUTE STRESS

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In intensive farming conditions fish encounter stress situations, which often increase susceptibility to disease. Consequently, feeds should not only fulfil the nutrient requirements for growth, but also strengthen the immune system and stress resistance. Several studies have evaluated peptides and protein hydrolysates (PH) activity as nutraceuticals. The dietary inclusion of PH has been shown to improve growth, antioxidant activity and fish immunity. Hydrolysis can give rise to bioactive peptides believed to be more effective than the whole protein in terms of disease resistance. Low molecular weight peptides (< 3kDa) are described as having antimicrobial, immune-stimulating, anti-inflammatory and antioxidant properties. The present work aims to assess the effects of different PH on stress resilience, immune response and oxidative stress of seabass (*Dicentrarchus labrax*) juveniles prior and after acute stress.

A practical commercial-like diet was used as control (CTR), whereas 3 other diets were formulated based on CTR to contain a 3% inclusion level of a short chain purified bioactive peptide in diet BPP, 3% shrimp PH in diet SPH and 3% feather meal PH in diet FMH. Diets were randomly assigned to triplicate groups of 120 fish (IBW approx. 2 g) that were hand fed to satiation 4 times a day for 21 days. After 3 weeks of feeding, fish were subjected to an acute stressful event (i.e., water volume in experimental tanks was reduced to 1.7% of the initial volume for 30 minutes). Intestine samples were taken for gene expression, immune parameters and oxidative stress analysis, immediately prior to stress and one day following acute stress. Caudal fin samples were also taken for cortisol levels measurement, one hour after stress.

Dietary treatments induced mild effects on the innate immune and antioxidant functions in the gut. However, transcriptomic data showed *cd4*, *cd8 β* , *il1 β* and *tnfa* genes down-regulation with significant differences arising one day after the stress stimulus. Integrating gene responses into a multivariate analysis (PCA-DA), it becomes clearer that acute stress induced a general down-regulation of immune genes in seabass gut that was independent from the dietary treatments. Moreover, after the stress stimulus a dietary effect is perceivable, fish fed BPP and FMH diets clustered together and were different from CTR. Differences at this stage pointed to higher *tnfa* and *cd8 β* expression than CTR. In conclusion, BPP and FMH dietary treatments seem to counteract more effectively the immunosuppression in seabass gut caused by acute stress. This, could be of advantage to improve immunocompetence during acute stressful events.

This work is part of project NOSTRESS_047122 supported by Portugal and the European Union through FEDER, LISBOA 2020, NORTE 2020 and CRESC Algarve 2020, in the framework of Portugal 2020.

OPTIMIZING FEEDING OF NILE TILAPIA UNDER SPECIFIC FARMING CONDITIONS

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Currently, there is a wide variety of commercial aquafeeds for tilapia. A precise evaluation of the suitability of aquafeeds for the particular conditions of a given farm is required to optimize fish feeding and economic feed conversion, while controlling waste emissions. This is highly relevant for optimal fish growth and performance, while ensuring minimal environmental impacts. Monitoring feeding efficiency indicators is very important not only for the economics of feed conversion but also for planning and managing production plans. In this context, it is paramount to develop decision supporting tools for monitoring and forecasting the fish performance as well as nutrient waste. Herein, we illustrate the application of a nutrient-based model (FEEDNETICS™) to compare two feeds with different protein contents, and at two temperature profiles.

The model was calibrated and validated with success for Nile tilapia (Soares et al. 2023). Data sets related to in vivo experimental trials covering a wide range of rearing and feeding conditions were used. Most of these data sets were collected from the scientific literature, and complemented with some trials run by SPAROS and UTAD (Vila Real, Portugal). Calibrating the model with these data sets means that prior knowledge is being integrated through mathematical functions and made easily available to support new advances in tilapia farming and nutrition.

Simulations were performed for Nile tilapia from 50 to 700 gr, with diets containing 32% crude protein (CP) / 9.4 % crude fat (CF), or 35% CP / 6% CF, both fulfilling all known nutritional requirements of tilapia, and with two annual temperature profiles: 23-31°C and 20-28°C. Feeding was according to available feeding tables for the species.

The simulations show a very similar growth performance of the two feeds at 23-31°C, reaching 700 g in around 164 days, but with the 35/6 diet having a 6 % lower feed conversion ratio (FCR), while the 32/9 show a 0.8% lower economic FCR and a 4% higher nitrogen waste. However, at the 20-28°C the differences are somewhat augmented: the 32/9 diet show a 1.5% lower economic FCR and a 5.3 % higher nitrogen waste.

In conclusion, we show here that a nutrient-based simulation model can be a useful tool to optimize feeding and control environmental impacts in Nile tilapia. Each farm may choose the most suitable feed to reach its production objectives, under its specific conditions, while evaluating its nutrient emissions.

This work results from activities of projects AquaIMPACT, funded by the European Union's Horizon 2020 research and innovation program under grant agreement no.818367; and FEEDNETICS 4.0, funded by EUROSTARS-2 program, and by Portugal and the European Union through FEDER/ERDF, CRESC Algarve 2020 and NORTE 2020, in the framework of Portugal 2020 under reference E!12516-FEEDNETICS 4.0_40813.

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TRATAMIENTO Y REUSO DE AGUAS NATURALES EN ACUICULTURA CONTINENTAL SOSTENIBLE

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El cambio climático, está provocando en el mundo serios estragos, sobre todo en zonas desérticas donde el agua es fundamental para promover el nexo agua-energía-alimentación. La producción acuícola mundial fue de 82,1 millones de toneladas en 2018, sin embargo, bajo la piscicultura en jaulas flotantes en aguas marinas o dulces o en sistemas de flujo continuo en tierra, ha generado preocupación sobre la sostenibilidad a largo plazo de estos sistemas debido al alto uso de agua. En este sentido, el uso de aguas residuales/naturales, son una alternativa que cada día está siendo más utilizada en diferentes sectores, como agricultura, acuicultura, industria, entre otros. Por ejemplo, el agua puede ser utilizada en sistemas acuícolas de recirculación (RAS) en el continente, ya que permiten una recirculación del 90–99 % del agua utilizada en los tanques de crianza promoviendo una sostenibilidad de los sistemas y un desarrollo productivo a largo plazo.

La calidad del agua es crucial para determinar si un agua puede ser utilizada o no, considerando que para riego o cultivo de peces en Chile se debe cumplir con la NCh1333of78mod1987. En la región de Arica y Parinacota, Chile, el agua es escasa y de mala calidad, por tanto, esta iniciativa tiene por objetivo *Tratar y reutilizar aguas naturales mediante la aplicación de tecnologías solares sostenibles para obtener una buena calidad de agua para la acuicultura continental.*

Se implementaron 3 alternativas para dar solución a esta problemática, para ello, se está comparando diferentes tecnologías para el tratamiento de agua, un *Reactor fotocatalítico (A)*, una planta de Ósmosis Inversa (B) y un sistema *Raceway (C)*, los cuales pueden tratar aguas naturales y residuales para producir un agua de calidad para el cultivo de peces y hortalizas.

La calidad del agua producto obtenida a partir de tecnologías de tratamiento de aguas, puede considerarse como una solución rentable, respetuosa con el medio ambiente y de bajo mantenimiento, sobre todo en las alternativas A y C. En el caso de B, esta puede ser amigable con el medioambiente siendo sustentada por energía solar fotovoltaica y realizando un reusó del agua de rechazo (salmueras).

Parámetros físicos-químicos	Agua río Camarones	NCh1333of 1978 Mod. 1987
Temperatura, °C	22,30	30
Cloruro, mg L ⁻¹	564,30	200
Sulfato mg L ⁻¹	178,50	250
Sodio, mg L ⁻¹	557,70	-
Potasio, mg L ⁻¹	34,20	-
Manganeso, mg L ⁻¹	0,10	0,20
Magnesio, mg L ⁻¹	15,60	-
Calcio, mg L ⁻¹	101,80	-
Arsénico, mg L ⁻¹	1,20	0,10

DESEMPEÑO REPRODUCTIVO Y CALIDAD DE HUEVOS DE LA PRIMERA GENERACIÓN (F1) DE CHITA *Anisotremus scapularis*: ANÁLISIS COMPARATIVO CON LOS DESOVES DE REPRODUCTORES SILVESTRES

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Anisotremus scapularis es un pez marino que en Perú se le conoce como Chita o Sargo, se distribuye a lo largo de la franja costera peruana. Es una especie de importancia comercial en el mercado nacional. En este sentido, el IMARPE inició las investigaciones para su acondicionamiento y reproducción en cautiverio; sin embargo, para la producción de semilla a nivel comercial, es necesario no depender de un lote de reproductores silvestres. Por ello, resulta importante evaluar las condiciones reproductivas de ejemplares nacidos en cautiverio (primera generación - F1) a fin de evitar la presión de captura en las poblaciones naturales y con ello, apoyar la demanda de semilla para el escalamiento productivo de la especie.

Al respecto, se observó que los dos lotes de reproductores (silvestres y F1) presentan una tendencia similar de producción de huevos, no obstante, la mayor producción fue de los ejemplares silvestres, desovando en promedio $90\,804 \pm 77\,273$ huevos/mes equivalente a $190\,450$ huevos/kg/hembra y la generación F1, $50\,688 \pm 30\,598$ huevos/mes equivalente a $136\,694$ huevos/kg/hembra. Sin embargo, la generación F1 presentó porcentajes de huevos viables (F1: $64,64 \pm 22,00\%$ y silvestres: $58,84 \pm 24,25\%$), y porcentajes de eclosión (F1: $90,90 \pm 11,23\%$ y silvestres: $86,24 \pm 14,49\%$) significativamente mayores al lote de chitas silvestres. Para determinar la similitud o disimilitud entre ambos lotes, en los diferentes parámetros reproductivos evaluados en la presente investigación, se realizó un análisis de componentes principales (PCA) (Figura N° 1), donde se observa la similitud de los parámetros reproductivos entre los dos lotes de reproductores.

Se presentan los primeros resultados de *A. scapularis* de desempeño reproductivo y calidad de huevos obtenidos de la generación (F1), los cuales permiten deducir que este lote puede proporcionar huevos de calidad, no obstante, en menor cantidad con relación a los ejemplares silvestres; sin embargo, es una alternativa confiable para la formación de un lote de reproductores en condiciones de cautiverio y con ello contribuir al desarrollo acuícola de la especie.



Figura 1. Análisis de componentes principales de los parámetros reproductivos de reproductores de "chita" *Anisotremus scapularis* de primera generación (F1) y medio natural.

BIOPROSPECCIÓN DEL ERIZO DE MAR *Arbacia dufresnii* EN BAHÍA NUEVA (GOLFO NUEVO, CHUBUT, Argentina) CON FINES EXPLORATORIOS PARA ESTABLECER UNA ACTIVIDAD ACUÍCOLA

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El erizo de mar *Arbacia dufresnii* posee una amplia distribución en Sudamérica, desde Mar del Plata en el Océano Atlántico hasta Puerto Montt en el Océano Pacífico. Esta especie presenta un gran potencial para el desarrollo de una actividad acuícola, existiendo en la Patagonia un emprendimiento con dicho fin. Sin embargo, hasta el momento no se han realizado bioprospecciones sistemáticas para determinar la viabilidad de la extracción de ejemplares para la actividad acuícola. En este trabajo se presentan los resultados de la prospección sistemática de tres sitios en el Golfo Nuevo (Chubut, Argentina) para generar una línea de base sobre la densidad poblacional. Los sitios fueron Punta Arco (PA, 42°42'36.97"S-65° 0'4.91"O), Bahía Norte (BN, 42°43'36.97"S-65° 1'25.88"O) y Punta Cuevas (PC, 42°46'33.73"S-65° 0'0.27"O).

En cada uno de los sitios se relevaron 3 profundidades diferentes (5m, 10m y 15m) con un cuadro de 1m². En cada profundidad se tomaron 3 muestras. Los ejemplares fueron medidos, pesados y sexados en el laboratorio.

Los resultados arrojaron que las mayores densidades se registraron a los 10m y a los 15m de profundidad en todos los sitios (Tabla 1).

Respecto a la biomasa se registraron los menores valores a 10m y 15m de profundidad en Punta Arco y Bahía Norte, en cambio, en Punta Cuevas los mayores valores se registraron entre los 5m y los 10m de profundidad (Tabla 1).

Los resultados obtenidos en esta prospección son de suma importancia para conocer los valores de densidad y biomasa de erizos de mar disponibles en aguas del Golfo Nuevo y así poder realizar un manejo adecuado de la extracción de individuos con fines productivos acuícolas.

Sitio	Prof.	N	Densidad (ind/m ²)	D.E.	biomasa (g/m ²)	D.E.	%H	%M	%I
PA	5	30	0,80	1,30	0,66	0,58	33	27	20
PA	10	179	4,93	3,17	0,62	0,08	6	4	3
PA	15	258	6,87	5,15	0,39	0,06	4	3	2
BN	5	0	0,00		0	0			
BN	10	16	0,43	0,32	1,92	0,53	63	50	38
BN	15	68	1,80	2,08	1,4	0,27	15	12	9
PC	5	60	1,50	0,36	0,83	0,69	17	13	10
PC	10	193	5,50	3,22	0,56	0,29	5	4	3
PC	15	88	2,13	1,91	0,23	0,2	11	9	7

IMPLEMENTING ETHICAL AND WELFARE PRACTICES TO ECHINODERM RESEARCH AND AQUACULTURE

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Even though only a few species are considered to be dangerous, pests or vectors, the majority of invertebrates produce a feeling of aversion in humans. This has contributed to the delay in the development of ethical considerations as regards this group in contrast with vertebrates, with the exception of cephalopods. In the present study, we provide an overview of the current situation on animal ethics and welfare in order to contribute to the development of a framework for ensuring invertebrate welfare. Today, animal welfare is a multidisciplinary in nature to a very high degree as it includes ethology, physiology, pathology, biochemistry, genetics, immunology, nutrition, cognitive-neural, veterinary medicine, and ethics. Animal welfare is a complex concept, difficult to achieve successfully from one perspective. As a consequence, we propose to include the five domains (Nutrition, Environment, Health, Behaviour and Mental State) along with the three conceptions (Basic Health and Functioning, Affective State and Natural Living), as well as the 5R Principle (Replace, Reduction, Refinement, Respect and Responsibility) in seeking to achieve a comprehensive welfare state. We consider that in both research and animal production, the individual and collective ethical concerns coexist and, in fact, the main moral concern to account for is the collective one and that, within that collective view, the individual moral concern should be applied with responsibility and respect for the individual. Finally, we propose a practical example of invertebrate welfare production in sea urchin aquaculture with the aim of including animal production of invertebrates in this important discussion.

OPTIMIZING LARGE SCALE VACCINATION OF TILAPIA BY AUTOMATION – EXPERIENCES FROM BRAZIL (ORAL PRESENTATION)

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The growth and industrialization seen in global aquaculture production the recent decades have resulted in increasing biomasses and numbers of fish that need to be handled and cared for. Despite rapid innovation in knowledge and technology, disease and environmental footprint remain bottlenecks for sustainable growth. Animal health and welfare, production efficiency and cost are all key performance indicators. Vaccination has a positive effect on all of these by improving health, survival, growth performance and product quality. Vaccines also lessen the environmental impact by reducing or replacing the need for therapeutic intervention and by increasing the overall production efficiency.

Today the most common method of vaccination is injection of oil-based vaccines into the abdominal cavity. Success depends not only on product efficacy but also on proper delivery to the fish. Injection can be done either manually using hand-held syringes or automatically by machine. The choice of method depends on fish numbers, farm infrastructure and economical aspects such as labor cost and ability to invest. In the salmon industry automation has gradually replaced manual vaccination, and close to 90% of the fish is currently injected by machines in Norway. For species such as European sea bass and tilapia manual vaccination is still by far most common, but the interest in automation is growing. Today there is a limited but increasing selection of machines available for the Tilapia market. These range from simple machines that inject one vaccine in a pre-set injection point, to machines capable of delivering multiple vaccines simultaneously with automatic adjustment of the injection point, and that sorts the fish by size after vaccination. One machine operated by 2-3 staff may inject up to 8-9 000 fish per hour, equivalent to the capacity of 8 experienced vaccinators. It will not get tired after a long day, and it delivers high and consistent quality of injection.

Vaccination machines were introduced for the first time to tilapia in Brazil in August 2021, one has been through a steep learning phase, and several large producers are now successfully using the technology. This presentation will, with a practical perspective, review experiences and highlight obstacles and key success factors for introduction of automatic vaccination in tilapia farming.

SHRIMP PRODUCTION AND NUTRIENT DENSITY OF THE DIET

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The concept of nutrient dense diets, in my opinion, was developed by the trout industry and was primarily driven by regulations that limited the quantity of feed that could be used by a given operation with the idea that this would limit pollution loading. As feed inputs were limited, there was a move to increase nutrient digestibility and evaluate the effects of increased nutrient density (e.g. protein and energy) on performance and economic returns. In general, this resulted in both improved economic returns but also reduced pollution loading. In cage and flow through systems there is good control over inventory, and they also do not typically have contributions of natural foods. Hence, the decision on nutrient density of a diet is straight forward favoring highly digestible and nutrient dense feeds. However, in systems where natural foods are present and utilized by the culture animal, and inventory control is less controlled, the decisions on nutrient density are less clear. From a nutritional perspective, using a highly digestible and nutrient dense diet clearly results in reduced FCR and lower levels of nutrients entering the culture system. However, production systems which rely on phototropic and autotrophic organisms (e.g. ponds and biofloc type systems) to process nutrients which are in turn used as a secondary food source may actually benefit from a lower level of nutrient density. Furthermore, in many of these systems inventory control (survival of the animals) is not well controlled or known, which can lead to over or under feeding. In the case of over feeding, using a nutrient dense diet contributes more to water quality issues and increased cost. Whereas, in the case of underfeeding the animals will perform better as more nutrients will be available for growth. Furthermore, there are numerous management decisions which contribute to the interpretation of what type of feed results in the best performance. This presentation will discuss the concepts of nutrient density regarding production and pollution loading. We will also provide examples of previous work and recent data on performance of shrimp offered diets containing different levels of nutrients in both semi-intensive pond production systems as well as intensive biofloc type systems.

APPLYING INNOVATIVE BIOPHOTONIC TECHNOLOGY TO ENHANCE AQUACULTURE PROCESSING AND ECONOMICS

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Aquaculture plays a pivotal role in addressing the increasing global demand for seafood. In this presentation, we delve into the implementation of Engeenuity's Biophotonic Technology within the aquaculture processing sector, emphasizing its transformative impact on processing methodologies and economics. Biophotonics is the science that studies and harnesses light and its energy to modify biological processes, offering a unique approach to enhance the overall efficiency and quality of aquaculture production.

The application of Engeenuity's Biophotonic Technology in aquaculture processing presents numerous advantages. Foremost, it substantially reduces the reliance on chlorine and other chemical additives by ~50%, promoting environmentally sustainable and eco-friendly practices. By incorporating biophotonic technology into water treatment, the surface tension decreases, enabling deep cellular hydration. This optimization results in diminished waste and improved yield during processing, facilitating a reduction in supplementary product packing to achieve the net weight requirements at the destination.

Certified as achieving a bacteriostatic mechanism of action, Engeenuity's Biophotonic Technology aids in preserving the quality of aquaculture products for extended periods. Consequently, shelf life experiences an increase of +30%, providing a considerable economic advantage for producers and suppliers, naturally.

Furthermore, the diminished use of chemicals in the production process amplifies nutrient availability and absorption capacity, yielding a healthier and more nutritious product for consumers. The integration of Engeenuity's Biophotonic Technology not only advocates for sustainable and environmentally friendly practices in aquaculture but also ensures superior quality products for the market.

In summary, Engeenuity's Biophotonic Technology holds the potential to revolutionize the aquaculture processing industry by offering economic benefits and fostering more sustainable practices. Our presentation at the Latin American & Caribbean Aquaculture 2023 conference aims to provide valuable insights into the advantages of adopting this trailblazing technology within the aquaculture sector.

	Fecal Coliforms (CFU/100ml)	Total Coliforms (CFU/100ml)	E. coli (CFU/100ml)	Mold & Yeast (CFU/ml)	Salmonella (CFU/100ml)	Heterotroph Count (CFU/100ml)	pH (unit)
Raw Water	200	6300	<1	9	<1.8	8.8E+3	7.10(19.5°C)
Raw Water + Biophotonics	106	504	<1	3	<1.8	3.6E+3	7.70(19.4°C)

Source: Hidrolab Colombia, 2022 Report N° 202202001869 & 202202001870

ORGANIC SELENIUM AND NUTRITIONAL EMULSIFIERS TO IMPROVE GROWTH PERFORMANCE AND FEED EFFICIENCY OF WHITE LEG SHRIMP WHEN FED DIETS LOW IN FISHMEAL

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In shrimp aquaculture, the use of fishmeal and fish oil is still common, but the inclusion levels have dropped over the last years, due to environmental, economic and availability challenges. At the same time shrimp production has been increasing, so alternative ingredients like plant materials are used progressively. This causes several challenges since the fats and proteins used as alternatives for fishmeal and fish oil are sub-optimal, with a consequent decrease in growth performance. Additionally, the selenium content in the feeds and shrimp body is decreasing, which causes a decreased growth performance and health status of shrimps. To counteract this, fish farmers and feed formulators can add selenium and/or nutritional emulsifiers to the diet. The goal of this experiment was to evaluate the efficacy of different selenium sources and the use of a nutritional emulsifier based on castor oil on growth performance and feed efficiency.

Shrimp were fed four different diets; 1. Control diet, low in fishmeal (10%) and fish oil (1%) without any added selenium; 2. Diet SS, control diet + 0.5 ppm selenium from sodium selenite, 3. Diet SM, control diet + 0.5 ppm selenium from L-selenomethionine; 4. Diet SMNE, Control diet + 0.5 ppm selenium from L-selenomethionine + 500 ppm nutritional emulsifier based on castor oil. During the 8-week feeding trial, the fish were analyzed for growth performance and feed efficiency every fortnight. The parameters analyzed were: total biomass, individual weight, weight gain (WG), average daily gain (ADG), specific growth rate (SGR), feed intake (FI), feed conversion ratio (FCR) and survival rate (S).

Overall, the inclusion of inorganic selenium, as sodium selenite, did not affect growth performance, only the specific growth rate was significantly improved by using diet SS in comparison with control diet. In sharp contrast, when shrimp were fed diet SM and diet SMNE, tank biomass, individual weight, weight gain, average daily gain and specific growth rate were all significantly improved compared to both the control diet and diet SS. On top off this, shrimp immunity and antioxidant status were significantly improved in all shrimp fed selenium-rich diets, again showing the significantly best results in diets SM and SMNE.

In conclusion, the addition of selenium can be beneficial for shrimp growth performance, feed efficiency and health. However, it is important to pick the right, organic source. In this experiment, L-selenomethionine is shown to be more efficient compared to sodium selenite. Additionally, it can be observed that adding a nutritional emulsifier can further improve shrimp growth performance and health.

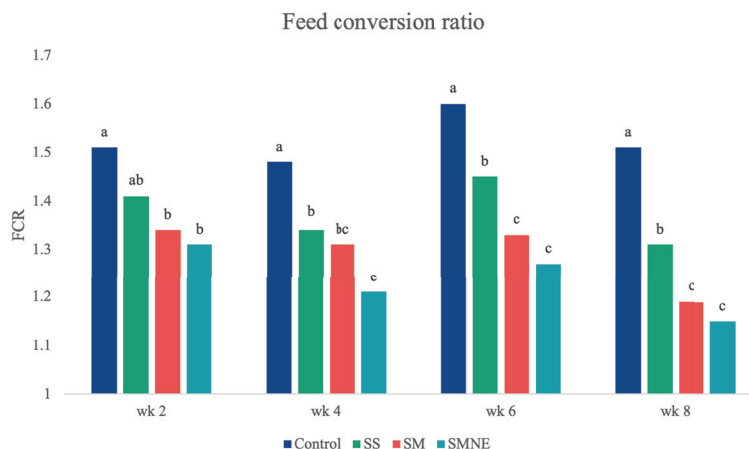


Figure 1: FCR of shrimp fed different sources of selenium with and without a nutritional emulsifier

CROSS-SPECIES COMPARISON OF THE EFFECTS OF STOCKING DENSITY ON THE RESPONSE OF THE SKELETON IN TWO MODEL FISH (MEDAKA, *Oryzias latipes* AND ZEBRAFISH, *Danio rerio*) AND A COMMERCIALY REARED MARINE FISH (GILTHEAD SEABREAM, *Sparus aurata*)

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Skeletal studies in teleosts have been dedicated to the investigation of osteopathologies in humans and to improve the quality of aquaculture fish production. Recent investigations have highlighted that rearing at low stocking densities in two model fish species, medaka, *Oryzias latipes* (Di Biagio et al., 2022) and zebrafish, *Danio rerio* (Martini et al., 2020), as well as the reared marine fish, gilthead seabream, *Sparus aurata* (Dellacqua et al., 2023) reduces the incidence of some skeletal anomaly types. Medaka seemed to exhibit a reduced magnitude of phenotypical response to augmentation of the density with respect to both zebrafish and gilthead seabream. Noteworthy differences were found between the anomaly types and their localization in the different body regions, highlighting species-specificities. In particular, vertebral centra anomalies (fusions among vertebral centra included) showed a higher response in the hemal, abdominal, and cephalic region in seabream and zebrafish reared at high densities, while medaka show an increased prevalence in the caudal region. Associated vertebral elements responded to density only in the hemal region of zebrafish and in all regions in gilthead seabream, while in medaka only in the modified associated elements of the caudal vertebrae. Gilthead seabream displayed a higher incidence of cephalic vertebral arch anomalies than the other species, while zebrafish showed augmented frequencies of arch anomalies of the abdominal and hemal vertebrae; medaka displayed much lower frequencies of anomalous vertebral arches and rib anomalies in all regions compared to the other species, except for the modified elements in the caudal region. Regarding anomalies of fin rays and pterygophores, density did not play any discernable effect. In general, the caudal fin was the most frequently affected fin, followed by the anal, then dorsal fin, in all three species. Zebrafish displayed the highest frequencies of affected individuals in the caudal fin among the species, while gilthead seabream displayed the highest frequency of individuals affected by anal fin anomalies among the species. Medaka, again, very rarely displayed any fin anomalies.

Detailed anatomical and histological observations carried out on vertebrae fusions revealed further differences among these three species (Fig. 1). All these differences have been analysed under an eco-evo-devo perspective.

This project has received funding from the European Union's Horizon 2020 Research and Innovation Programme under the Marie Skłodowska-Curie grant agreement No. 766347, BioMedAqu, ETN 766347.

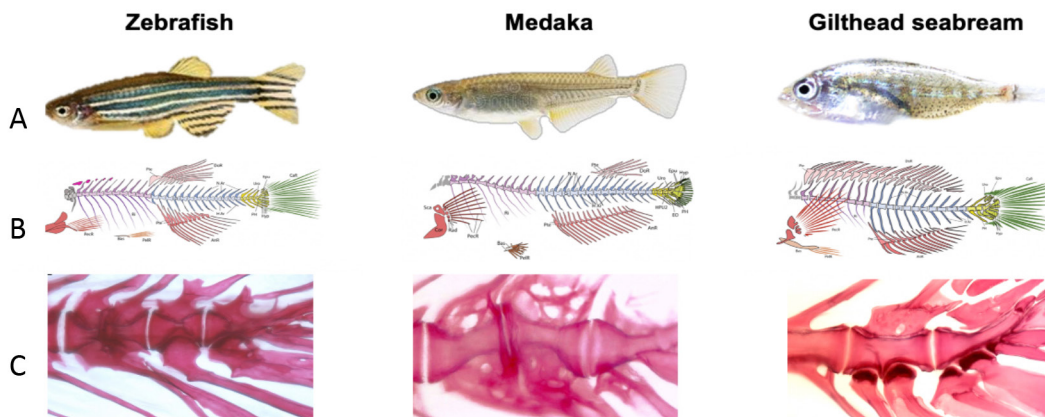


Figure 1. Comparative example of differences in centra fusions (C; whole-mount Alizarin Red staining) among preural vertebrae in zebrafish, medaka and gilthead seabream (A). The sketch of the skeleton is showed in B for each species.

NON-CODING RNA REGULATION OF THERMAL STRESS RESPONSE IN LIVER AND GILLS ON RED CUSK-EEL *Genypterus chilensis*

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The *Genypterus* genus contains native species for aquaculture diversification in Chile, including red cusk-eel (*Genypterus chilensis*), which is aquaculture produced. Previous studies have showed that thermal stress could generate oxidative damage and coding transcriptional modulation in red cusk-eel juveniles. However, the role of non-coding RNA regulation on thermal stress response is unknown. The objective of this work was to determine the effect of thermal stress on non-coding RNA regulation on liver and gills of red cusk-eel.

We use data from a previous assay in which fish were obtained from CIMARQ center and separated on control and stress groups, with a high-temperature protocol for five days in the stress group, determining stress response through increased cortisol levels. We use RNA-seq data to determine previously described long-non coding RNAs (lncRNAs) and novel lncRNAs, determine differential expression of lncRNAs with Deseq2, and determine the enriched process regulated by the differentially expressed lncRNAs in liver and gills due to thermal stress impact.

Thermal stress generates increased cortisol levels in gills (Figure 1A). The RNA-seq analysis of lncRNAs showed more than with 14,614 putative lncRNAs. We observe a total of 1599 differentially expressed lncRNAs in liver, with 842 down-regulated and 757 up-regulated (Figure 1B). These results showed that thermal stress generates a relevant lncRNAs regulation in these tissues, showing that stress response in fish is a complex response with the interaction of coding and non-coding response. The negative impact of thermal stress on this species should be considered for sustainable aquaculture production. Funding: CONICYT FONDECYT Postdoctorado 3180283, Programa de Inserción Académica PIA 82510015.

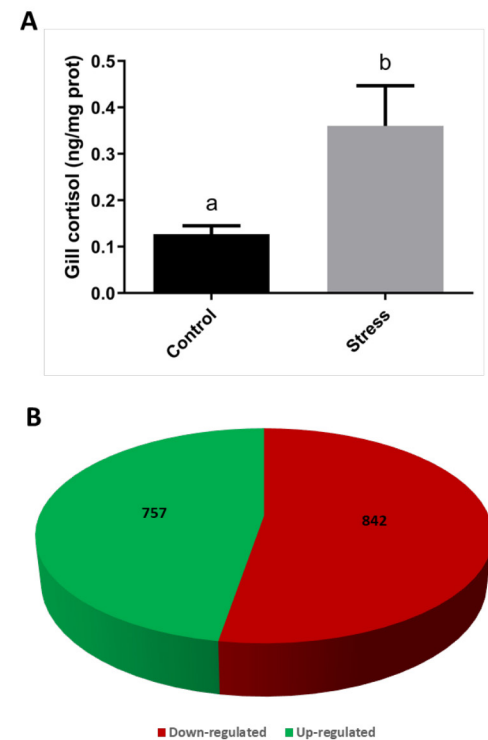


Figure 1. Comparison of gill cortisol levels and differentially expressed lncRNAs in liver of red cusk-eel under thermal stress. A= cortisol level in gills ($p < 0,05$), B= differentially expressed lncRNAs in liver in response to thermal stress.

DETERMINATION OF MICROPLASTIC POLLUTION IN BIVALVE MOLLUSK OF ECONOMIC RELEVANCE ON CHILEAN COAST

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The bivalve mollusk includes several economically important relevant for Chilean marine industry. Several of these species have aquaculture potential as Chilean clam (*Venus antiqua*) and Chorus mussel (*Choromytilus chorus*) or have been farmed, generating a relevant industry as Chilean mussel (*Mytilus chilensis*). However, these species remain in marine ecosystems, therefore, are exposed to different environmental stressors and pollutants. One of these pollutants are microplastics, which are abundant in marine environments. Due to its geographical location and biological characteristics, these species could be exposed to marine pollution, specially microplastics. This study aimed to evaluate the prevalence of microplastic in bivalve mollusks including Chilean clam (*Venus antiqua*), Chorus mussel (*Choromytilus chorus*) and Chilean mussel (*Mytilus chilensis*) from the coast of Chile.

These species of bivalve mollusks were sampled in central and south localities of the Chilean coast registering length, weight, and the tissue of the animals. The tissue was digested in KOH and then filtered using Whatman glass microfiber and analyzed using a high-resolution optical microscope. We found microplastic presence in the Chilean clam population of the central coast, with fiber as the most represented type of microplastic in this species. In the case of Chilean mussels, we also found the presence of microplastics in the sampled locations. Finally, in the Chorus mussel, the biggest species of the tree evaluated, we found important contamination with microplastic in the intestine (Fig 1A), while in gills, microplastic contamination was present but in a low level (Fig 1B), showing that exist a differential pattern of pollution according to tissue. Additionally, we observe that does not exist any direct correlation between the weight and length of the individual with microplastic contamination. This information is evidence that microplastic pollution level is a relevant issue for Chilean bivalve mollusks, and that could be influenced by species and location, requiring more studies to determine its effect at the physiological level on these species. Funding: Programa de Inserción Académica PIA 82510015.

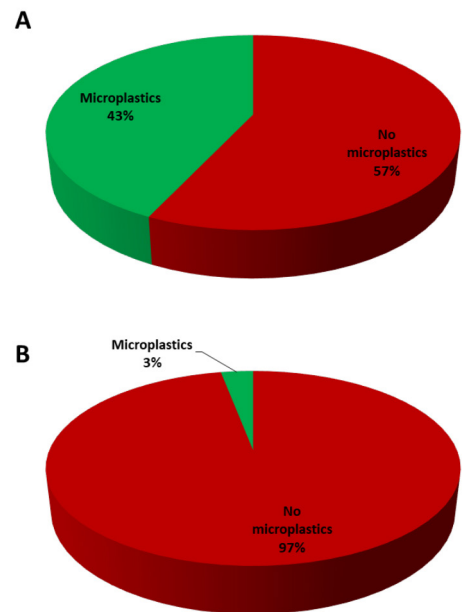


Figure 1. Microplastic pollution in Chorus mussel gills and intestine. Percentage of microplastic pollution on intestine (A) and gills (B) in the central Chilean coast.

EL ACEITE ESENCIAL DE ORÉGANO AFECTA LA VIRULENCIA DE *Vibrio parahaemolyticus* CAUSANTE DE LA ENFERMEDAD DE NECROSIS HEPATOPANCREÁTICA AGUDA EN EL CULTIVO DE CAMARÓN

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En esta última década los aceites esenciales (EO, siglas en inglés), se han mostrado como una alternativa promisoriosa al uso de antibióticos para el control de las bacterias patógenas emergentes, incluyendo las de acuicultura. A nivel global, varias especies de *Vibrio* han sido asociado con la enfermedad de necrosis hepatopancreática aguda (AHPND, siglas en inglés), por producir las toxinas PirA/PirB altamente letales para los camarones peneidos, provocando cuantiosas pérdidas económicas a la industria del cultivo de camarón. En este contexto, evaluamos el efecto del aceite esencial de orégano (EOO) sobre la virulencia de un aislado local de *Vibrio parahaemolyticus* causante de AHPND. Siete concentraciones sub-letales de EOO se evaluaron sobre tres fenotipos de virulencia incluyendo, producción de exopolisacáridos, formación de biopelículas y motilidad de enjambre. El efecto *in vivo* del EOO fue corroborando mediante una prueba de desafío, infectando camarones *Penaeus vannamei* con inóculos bacterianos cultivados con EOO y como control cultivos sin exposición al EOO. Adicionalmente, para dilucidar el efecto del EOO a nivel molecular se realizó la secuenciación transcriptómica del ARNm de *V. parahaemolyticus* sobre la motilidad de enjambre cultivada con y sin EOO, a fin de identificar genes expresados diferencialmente (DEG). Los resultados mostraron que el EOO redujo significativamente $P < 0.05$ los tres fenotipos de virulencia (Fig. 1A-1B), y el efecto fue dependiente de la concentración de EOO. La virulencia de *V. parahaemolyticus* también se afectó, debido a que se incrementó significativamente la supervivencia en los camarones tratados con EOO, respecto al grupo control. El análisis transcriptómico reveló un total de 181 DEG (Fig. 1C), 93 genes estaban regulados al alza y asociados con la restauración de la membrana, proteínas de estrés, osmoadaptación, transporte de eflujo de múltiples fármacos, transportadores ABC, transporte de zinc y nitrógeno. Los DEG regulados a la baja se asociaron con el ensamblaje flagelar, la quimiotaxis, los sistemas de secreción, la resistencia a los antibióticos, la formación de monocapas, el metabolismo, las proteínas estructurales de los ribosomas, el transporte transmembrana y los reguladores de detección de quórum. Estos resultados muestran que EOO tiene diferentes dianas terapéuticas para inhibir la virulencia de *V. parahaemolyticus* e ilustran las ventajas de usar EOOv en sistemas de cultivo de camarones, como una alternativa amigable con un bajo riesgo de inducir resistencia bacteriana.

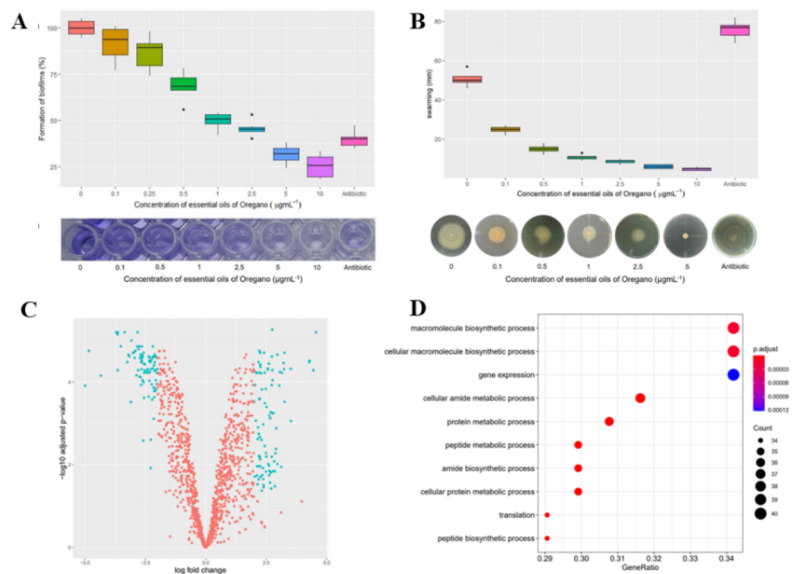


Fig. 1. Efecto del aceite esencial de orégano a dosis subletal sobre la virulencia de *V. parahaemolyticus*. A) Efecto sobre la formación de biopelículas. B) Efecto sobre la motilidad de enjambre. C) Genes expresados diferencialmente por efecto del EOO respecto al control. El celeste indica expresión regulada a la baja y al alza con tasa de cambio (FC: > -2 y < 2). El rojo indica genes con tasa de cambio (FC: < -2 y > 2). D) Genes expresados diferencialmente enriquecimiento en la categorización de ontología génica.

A NUTRIENT ABSORPTION ENHANCER TO ENABLE OPTIMIZING FEED FORMULATION IN AQUACULTURE

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Lysophospholipids act as biological emulsifiers, dramatically improving the formation of micelles and hence facilitating digestion and absorption of fat. Therefore, lysophospholipids are more powerful nutrient absorption enhancer than dietary lecithin for aquaculture. A dietary emulsifier from Kemin AquaScience™ containing optimized combination of lysophospholipids, monoglycerides, and synthetic emulsifier was proven to be an efficient nutrient absorption enhancer. It has been found to increase digestibility and absorption of fat, protein and pigments, enhance growth performance, and improve intestinal health of aquatic animals in multiple trials. Studies conducted in shrimp and tilapia are covered in this paper, where feed formulation optimization and on-top supplementation were evaluated respectively.

A study was conducted to evaluate effects of the dietary emulsifier on partial fish oil replacement by soya oil in white shrimp (*Litopenaeus vannamei*) diets. Three treatments were included; diet with 2% fish oil as positive control, 1% fish oil and 1% soya oil as negative control, and diet with 1% fish oil and 1% soya oil supplemented with 0.1% dietary emulsifier as test diet. Results showed that partial replacement of fish oil by soy oil significantly ($p < 0.05$) reduced the digestibility coefficient, production and weight gain of shrimp. However, supplementing the negative control diet with the dietary emulsifier helped reinstate the growth performance and keep comparable nutrient digestibility coefficients of shrimp to the level of the positive control diet. Also, there were no significant ($p > 0.05$) differences on histology of shrimp hepatopancreas and immune parameters evaluated between test diet and positive control groups. An investigation of the effects of the dietary emulsifier (0.1% added on top of control diet) on nutrients digestibility and growth performance of Nile tilapia (*Oreochromis niloticus*) was performed. Significantly ($p < 0.05$) higher digestibility of gross energy (3% higher), protein (2% higher), lipids (2% higher), and phosphorus (10% higher) were observed when supplementing the dietary emulsifier than by control diet alone. Growth performance of juvenile tilapia, including weight gain and feed conversion rate, were significantly ($p < 0.05$) increased in the treatment using dietary emulsifier compared to the control.

Lipid and protein components of feed are becoming increasingly costly and face issues on availability and hence solutions to enhance digestibility and absorption of these nutrients are beneficial to both economics and productivity of aquaculture. Based on both studies, it is concluded that incorporation of the dietary emulsifier containing optimized combination of lysophospholipids, monoglycerides, and synthetic emulsifier in aquafeed can be applied both as a replacement strategy to optimize feed formulation for better economics, and as an on-top supplementation to enhance the growth and feed utilization.

REPLACEMENT OF FISHMEAL BY CANOLA PROTEIN CONCENTRATE IN PACIFIC WHITE SHRIMP (*Litopenaeus vannamei*) DIET ON GROWTH PERFORMANCE AND DIGESTIBILITY

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Canola protein concentrate (CPC) (78.9% CP) was added to isocaloric, isonitrogenous White Leg shrimp (*Litopenaeus vannamei*) diets as a replacement for 65% CP fishmeal at 0, 5, 10 or 20% inclusion in the final formulation. Juvenile shrimp (~2 gm) were stocked at 80 shrimp/m³ (25 shrimp/tank) and fed 3 times daily at 3-4% bodyweight for 8 weeks. The study was carried out in 24 aquarium (4 treatments*6 replicates), each with 240 L capacity and containing 150 L of 10-15 ppt saline water, pH 7.7-8.2, DO>5 ppm, temperature 27-30°C, total ammonia <1.0 ppm. Aquarium water was batch-exchanged 15-20% every 2 days. Feed was provided thrice daily at 3-4% bodyweight. At 8 weeks, the growth of shrimp fed 5-20% CPC was higher (p<0.05) than the growth of control shrimp fed 0% CPC. At 6 and 8 weeks, weight gain was higher (p<0.05) at 10% and 20% CPC than at 0% CPC, while shrimp fed 5% CPC did not differ from the control group. At 6 and 8 weeks, specific growth rate was also higher (p<0.05) at 10% and 20% CPC than the control shrimp, while shrimp fed 5% CPC did not differ from the control group. Feed intake did not differ (p>0.05) between treatments, but the feed conversion ratios (FCRs) at 2, 4 and 6 weeks were lower (p<0.05) than the control FCR at 5-20% CPC. At 8 weeks, the FCRs were equivalent (p>0.05), as were survival rates (p>0.05). CPC was highly digestible: dry matter=74.10±3.55%, protein=86.00±2.70%, lipid=95.58±0.24%, calcium=40.55±15.05%, phosphorus=95.82±1.88%, energy=78.97±2.29%. The haemocyte count and hemolymph protein did not differ between treatments (p>0.05), whereas phenoloxidase activity was higher in shrimp fed 5-20% CPC (p<0.05) relative to the control. The moisture, dry matter, ash, calcium, phosphorus, lipid, and fiber contents of shrimp for all treatments were similar (p>0.05), while the protein content of shrimp fed 10% and 20% CPC was higher (p<0.05) than the protein content of the control shrimp. After 8 weeks, 10 shrimp from 3 replicates/treatment were moved to 100 L challenge test aquaria. Shrimp were subcutaneously injected with *Vibrio parahaemolyticus* (EMS) at 0.1 ml/shrimp. Shrimp survival during 7 days of infection did not differ among the 4 treatments from days 0 to 6 (p>0.05), but at day 7, the shrimp fed 20% CPC had a higher survival rate (p<0.05) than did shrimp fed 0% and 5% CPC. Hemocyte counts, hemolymph protein, and phenoloxidase activity were the same (p<0.05) as were the *Vibrio* counts in the hemolymph (p<0.05). However, *Vibrio* counts in the hepatopancreas and intestine were lower in shrimp fed 5-20% CPC (p<0.05) compared to control shrimp. CPC promoted a reduction in hepatopancreatic and intestinal *Vibrio* counts under conditions of vibriosis due to improved health and immunity. CPC can replace fishmeal in the diet of Pacific White Leg shrimp (*Litopenaeus vannamei*) at inclusion rates from 5-20%. CPC has high protein and lipid digestibility, and it was shown to promote growth performance, immunity and disease resistance against *Vibrio parahaemolyticus* EMS at an inclusion rate as high as 20%.

IS METHYLATION BALANCE A VIABLE BIOMARKER FOR A NUTRITIONAL INSULT IN FISH?

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Introduction

The continuous growth of the aquaculture sector requires an understanding on how to improve fish robustness throughout the production cycle. Nutrition and concomitantly gut health are core components to promote performance and juvenile quality. Methods and biomarkers for assessing dietary effects on fish growth and health will contribute to increase biological efficiency.

An inflammatory process will automatically affect cellular metabolism, and consequently the methylation balance that is pivotal to animal homeostasis. Nowadays, changes in the concentrations of specific metabolites involved in the methylation cycle are utilized as biomarkers for Humans diseases. In some cases, the methylation potential, measured as plasma levels of S-adenosyl methionine (SAM) and S-adenosyl homocysteine (SAH), may highlight homeostatic disruptions in the gut. In addition, SAM is a known precursor of glutathione and its modulation associated to apoptosis and polyamine synthesis in intestinal inflammatory conditions.

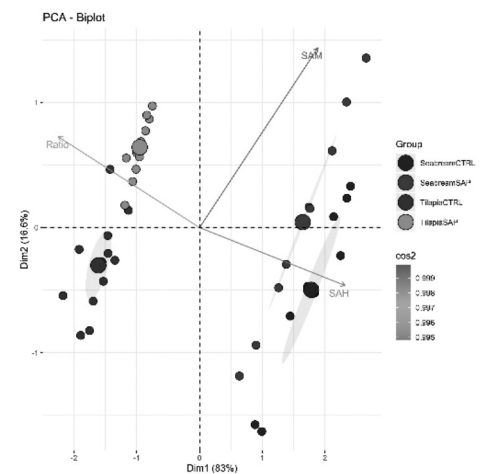
Soy saponin (SAP) have been shown to provoke mild to severe intestinal inflammatory processes in fish. In this study Nile tilapia (*Oreochromis niloticus*) and gilthead seabream (*Sparus aurata*) juveniles were fed with a commercial-like diet supplemented with SAP with the purpose of assessing if the metabolites of methylation cycle could shed some light on possible biomarkers for gut disruption in fish.

Tilapia were fed one of the two diets for three days. Seabream juveniles were fed diet pellets by the “assisted-feeding” technique. Fish were fed one of the two diets according to the experimental treatment: CTRL – fish fed diet without SAP; SAP– fish fed diet containing SAP (98% chemical purity). All fish were fed at 3% of body weight. Two groups of 15 per species and treatment were transferred to 100 L cylindric-conical tanks and kept at optimal conditions.

At 3 days of feeding for tilapia, 24h after assisted-feeding for seabream, intestine was sampled in 12 tilapia and 9 seabream juveniles per treatment ($n=2$) for SAM and SAH analyses. Data analysis was performed using t-test. Also, data was subjected to principal component analysis (PCA) using the ggbiplot and factoextra packages for the open-source software R version 4.2.1 (R Core team).

Preliminary results suggest that methylation capacity could be species-specific since the ratio SAM:SAH was 3-fold higher in tilapia than in gilthead seabream. A lower capacity could be expected since tilapia were fed a higher amount of SAP during the feeding period. These results are a novel approach in fish to assess the intestine response to a nutritional insult.

This work was funded through Project FICA, co-financed by COMPETE 2020, CRESC Algarve 2020, Portugal 2020 and the European Union through ERDF under reference ALG-01-0247-FEDER-047175. This study received Portuguese national funds from FCT – Foundation for Science and Technology through projects UIDB/04326/2020, UIDP/04326/2020 and LA/P/0101/2020 to CCMAR.



***In vivo* PATHOGENICITY OF TWO *Vibrio parahaemolyticus* (AHPND) ISOLATES FROM NORTHERN SINALOA**

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Shrimp aquaculture is a major animal production activity worldwide, producing 5,717 million tons in 2020 (FAO 2020). In Mexico, Sinaloa produced 96,606 tons (45% of the national farmed shrimp volume) in 2020 (CONAPESCA 2022). Nonetheless, disease is a major constraint for shrimp farming worldwide. Acute hepatopancreas necrosis disease (AHPND) causes severe mortalities and production losses. The pathogenicity of isolates is related to the severity of the disease. Hence, the aim of this study was to evaluate the pathogenicity of two AHPND isolates from Guasave Sinaloa.

Bacterial isolates from shrimp farms with AHPND disease outbreaks were obtained, characterized by growth on TCBS and Chromagar Vibrio. PCR analyses were done to detect PirA (AP3) and PirB (VpIT) genes. Cell counts (CFU ml⁻¹) were done at a 10⁻⁶ concentration of cultures with OD₆₀₀=1. Afterwards, two bioassays were done using different CFU ml⁻¹ concentrations (Table 1) in groups of 10 juvenile shrimp (n= 120; MBW = 0.48 ± 0.28 g). Bacteria on TCBS displayed green or yellow colonies on TCBS, but on Chromagar Vibrio, green, white or mauve colonies indicated that not all isolates were *V. parahaemolyticus*. Two isolates (HP1 and HP5) were *V. parahaemolyticus* and AHPND. Cell counts of these isolates were 10^{7.97} and 10^{8.04} CFU ml⁻¹, respectively. Inoculation of shrimp with 350,000 CFU ml⁻¹ of each of these isolates showed slight differences in pathogenicity (Table 1; Figure 1). It is concluded that differences in pathogenicity may exist in AHPND isolates in Northern Sinaloa, and this feature should be further studied.

Table 1. Bacterial concentration and shrimp mortality with two AHPND isolates.

Expt	isolate	CFU ml ⁻¹	Time (hpi)	Mortality (%)
1	HP5	100,000	144	30
	HP5	250,000	144	90
	HP5	350,000	120	100
	HP1r	100,000	144	20
	HP1r	250,000	128	100
	HP1r	350,000	128	100
2	HP5	350,000	72	100
	HP5	350,000	96	100
	HP5	350,000	96	100
	HP1r	350,000	96	100
	HP1r	350,000	104	100
	HP1r	350,000	144	70

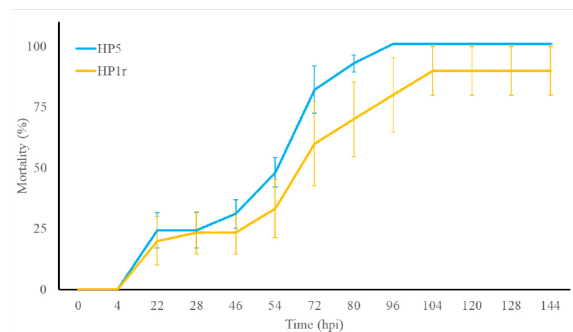


Figure 1. Cumulative mortality of shrimp inoculated with two AHPND isolates.

ANÁLISIS DE LA RELACIÓN DE LAS BACTERIAS *Vibrio cholera*, *Vibrio vulnificus* Y *Vibrio parahaemolyticus* CON LAS CONDICIONES CLIMÁTICAS PRESENTES EN MIRAMAR, CARIBE PANAMEÑO

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La acuicultura ha sido una actividad que, desde años ha generado sustentabilidad a nivel mundial, además de brindar empleos a comunidades y localidades que, gracias a esta actividad, dependen de la misma para subsistir. A esta actividad se le han sumado las empresas con una gran actitud positiva para incrementar la productividad de la acuicultura, utilizando especies de peces con alta tolerancia a las variables ambientales, sin embargo, las bacterias se han reflejado junto con la aparición de esta actividad, provocando pérdidas económicas. La empresa Open Blue Sea Farms S.A., ha experimentado la aparición de la bacteria *Vibrio* en el pez Cobia, una bacteria que se mueve junto con las aguas cálidas y otras variaciones ambientales. Gracias a la data registrada y obtenida de parte de la empresa se han podido realizar análisis estadísticos para responder interrogantes sobre la aparición de esta bacteria.

Se realizó una correlación biológica con la variable de temperatura y la frecuencia de presencia de la bacteria *Vibrio spp.* Las temperaturas mostraron un comportamiento estacional, mostrando un incremento durante los meses de marzo del 2019, 2020, 2021 y 2022, y reportándose la temperatura más alta con 29°C en el mes de junio del año 2020. Cabe destacar que la mayor frecuencia de presencia de la bacteria se observó en los meses donde las temperaturas se encontraban entre los 27°C a 27.5°C; tomando en cuenta que el rango de temperaturas para el crecimiento de *Vibrio* en aguas cálidas, las temperaturas exceden solamente los 17°C (Thompson y Polz, 2006). (Ver Figura No.1).

En el análisis de regresión en Excel se observó la correlación de las variaciones ambientales y la frecuencia de presencia de las bacterias. Siendo la temperatura la primera variable en el análisis de regresión. Dando como resultado un coeficiente de correlación de 0.28 (con una correlación débil) lo que indica que no existe una correlación con el aumento de la frecuencia de presencia de las bacterias *Vibrio spp.* y el aumento de las temperaturas. En cuanto al coeficiente de determinación (F estadística/ modelo estadístico) se observó un valor de 0.080 lo que indica que no hay asociación de la frecuencia y la temperatura. Para el P valor (valor crítico de F) se observó un valor de 0.1 lo que indica que no es significativa la regresión (Ver Cuadro No. 1), mostrando una correlación negativa en cuanto a las temperaturas elevadas de 28°C a 29°C y el aumento de la frecuencia de presencia de la bacteria *Vibrio spp.*

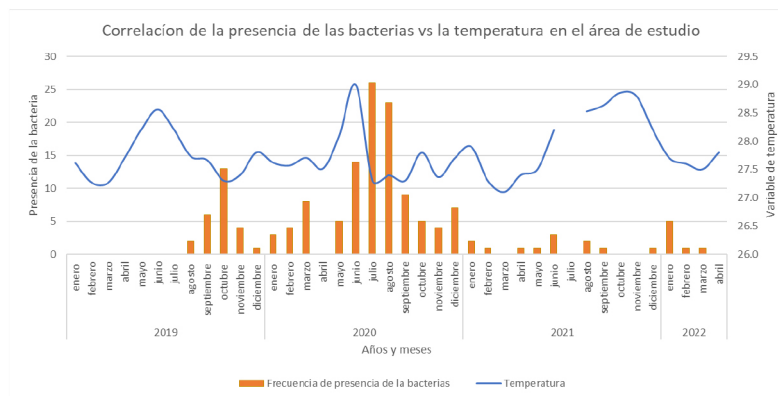


Figura No. 1. Correlación biológica de la variable de temperatura con la frecuencia de presencia de las bacterias durante los cuatro años de cosecha de la cobia en Miramar, Colón.

UNDERSTANDING THE USE AND IMPACT OF ANTIBIOTICS IN AQUACULTURE

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Aquaculture production plays a crucial role in providing food to the growing human population, and it is projected to increase rapidly through 2030. But aquaculture producers face a significant challenge derived from the intensification of aquaculture activity in the context of climate change. The main challenges include sustainable sources of raw materials, decreased impacts on seabed and watercourses, and disease management of bacterial diseases. Prevention and control of bacteria include using antimicrobials, which have the potential to cause environmental and human health impacts. Antibiotics are one of the most convenient and cost-effective tools, with few alternatives available to control bacterial diseases.

The Monterey Bay Aquarium Seafood Watch® (SFW) program and the World Bank aimed to address the state of antimicrobial use in aquaculture, establishing the basis to identify ecological impact indicators, characterizing the social drivers of the use and misuse of antimicrobials, and developing the bases for a standardized methodology to measure the ecological impact under the One Health approach. To accomplish this, a series of workshops were conducted, supported by recognized researchers of diverse areas, covering the following areas: 1) antimicrobial (AM) ecological impacts in aquaculture, 2) the socio-economic perspective, 3) antimicrobial resistance (AMR) role in aquaculture and 4) identifying monitoring tools that can be adapted and implemented across sectors and countries. The meetings focused on identifying the knowledge gaps, and strengthening the AM impacts assessment methodology by establishing the basis to distinguish ecological impact indicators and thresholds. The experts shared experiences regarding effective antimicrobial use governance, socio-economic considerations, and monitoring approaches. The overall process produced a series of recommendations related to AMR and aquaculture, on the need to further explore the environmental impact of AMU in aquaculture, socioeconomic drivers, and methodological aspects.

The Antimicrobial assessment on Global Aquaculture Production (AGAP) series' results allowed us to establish an initial risk assessment framework that aquaculture stakeholders can utilize to better estimate the potential environmental impacts associated with antibiotic use at the farm and regional levels. Also, it will provide assessments to be conducted on the type and degree of impact(s) expected from using AM in a specific socio-ecological, regional and farm-based context. In addition, the risk framework and accompanying standardized sampling protocols may be used on the ground in projects that could be useful for NGOs, benefactors, governments, the aquaculture industry, and other institutions that aim for sustainability targets related to the chemical uses to establish baselines of current impacts, decrease AM use, and increase the wellbeing and health of animals, humans, and ecosystems.

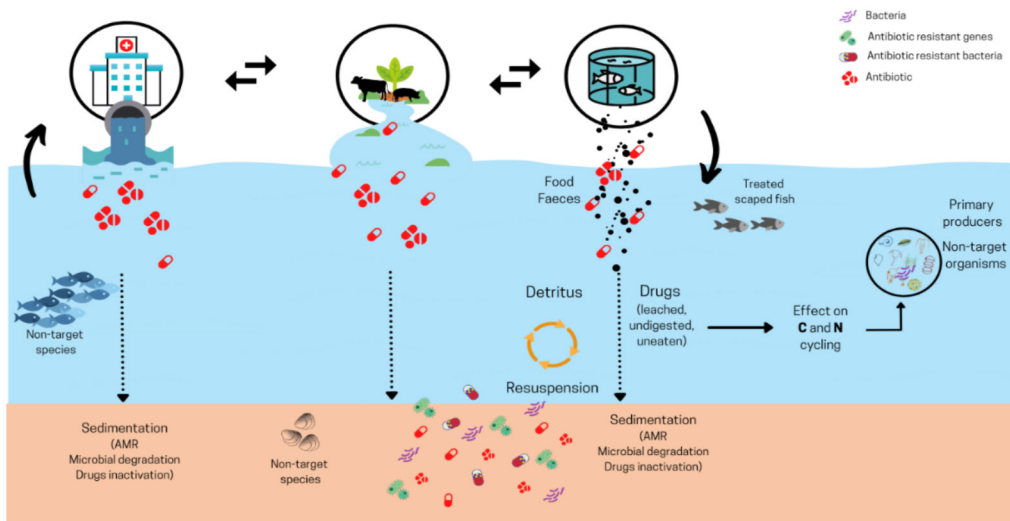


Figure 1. The theoretical framework of potential antimicrobial spread in the aquatic ecosystems. Adapted from Danner et al 2019 and Rigos & Troisi 2005.

DIVERSIFYING SEA CUCUMBER AQUACULTURE IN LATIN AMERICA: THE PROMISING EXAMPLE OF *Holothuria floridana*

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Holothuria floridana is the second most commercialized tropical western Atlantic Ocean holothuroid after *Isostichopus badiionotus*. Its market value is, on average, one quarter to one third that of *I. badiionotus*. For this reason, its aquaculture potential has been largely overlooked, although the species suffers from similar fisheries and ecological issues as other holothuroids. This work provides a general overview of the recent advances in its aquaculture through a historical and regional lens, focusing on the first large-scale hatchery in the Caribbean, Panama-based PanaSea, comparing it with other efforts in Mexico and Belize and discussing its economic, societal, ecological, and general sustainability potential. While identifying its main problems and providing options to solve them, suggesting future goals, objectives, and guidance.

Biological potential

H. floridana widespread distribution throughout the Caribbean and the Gulf of Mexico and its relatively generalistic feeding and environment habits makes it easier to procure than other related species. Its simple life cycle, with direct development, hatching as a small juvenile after 3 to 8 days post fertilization, and reaching 0.2 g in under a month while exhibiting high survival rates, also increases its aquaculture potential, providing an easy framework for research and development.

Societal aspects

H. floridana presents strong populations in many coastal areas where fishing efforts focused in *I. badiionotus* because of its prize, this reduces competition, poaching and potential crimes towards aquaculture facilities. Its simple life cycle and aquaculture processes makes it an ideal species for impoverished locations with poor infrastructure and unskilled labor, providing an economically sound alternative for development in the region.

Aquaculture technologies

For the past 5 years the research has focused in developing aquaculture processes that leverage the biological and societal characteristics of the species, providing simple, inexpensive, scalable, and resilient technologies. These processes reduce the costs of other more traditional aquaculture systems by around 70% and are simple enough to be transferred to communities. Using locally sourced feeds, reducing the need for complex filtration and pumping systems and electricity, and directly using the sea for scaling up production through hapa pens and sea ranching.

Future

Recent advances with the aquaculture of *H. floridana* indicate that it can become the cornerstone for large-scale sea cucumber aquaculture in the wider Caribbean. The unique technologies and protocols designed thus far for its production have had rapid success. This should spark increased interest in stakeholders from private and public sectors that will eventually generate and enact the policy changes necessary to explore its full potential in the region.

GROWTH OF SEA CUCUMBER JUVENILES (*Holothuria floridana*) IN LAND FACILITIES COMPARISON OF DIETS, DENSITIES, AND FEEDING RATIOS

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Introduction

Holothuria floridana has become one of the most promising sea cucumber species for aquaculture in Latin America for its easy rearing in captivity, high resistance to variations in the water-physicochemical conditions, and widespread broodstock availability when compared with *Isostichopus badionotus*, the most expensive species in the area. However, further research is needed, especially regarding developing diets and optimizing rearing conditions to massify its cultivation under diverse conditions (inland and coastal marine environments). This study aims to develop new diets and protocols for cultivating *H. floridana* in inland facilities.

Methods:

Four experiments were conducted. The first one (A) compared three different diets containing a mix of ingredients, of which the only ingredients that varied were: diet E, containing 1g of spirulina per dose; diet M, with 0.5 g of spirulina and 0.5 g of yeast, and diet Y, with 1 g of yeast. The second experiment (B) dealt with densities (15, 30, and 46 org/m²) using 6-month-old juveniles produced *in situ* that were fed 40 ml of a seaweed meal/fish feed/enricher blend and 50 ml of pretreated mud from a mangrove lagoon close to the experimental facilities. For the third experiment (C), the densities were changed accordingly with the growth of the organisms, evaluating 15, 26, and 38 org/m², and the feed ration was proportional to the number of animals per tank (40, 70, and 100 ml, respectively). In the last experiment (D), we selected the average between the best-performing densities (23 org/m²), in this case, evaluating four feeding rates equivalent to 25, 50, 75, and 100% of the total biomass/week. For every experiment, sea cucumbers were weighed weekly; water temperature was kept at 26 ±1 °C; animals were fed three times a week, using 76 L tanks with a base area of 0.26 m² with four replicates for every experiment.

Results

The mixed spirulina/yeast diet resulted in higher growth and survival, followed by the one containing only yeast. High levels of spirulina seem to have detrimental effects on survival and growth. For the second set of experiments, densities of 15 and 30 org/m² tend to present better growth, up to 200 %, after a month (15 org/m²), possibly due to insufficient feed availability for all the organisms at the 46 org/m² density. In the second experiment, all treatments behaved similarly until the end, where the lower density performed better. In the third experiment, with equal density (23 org/m²) higher feeding rates outperformed the lower feeding rates initially; however, 50% to 75% of the weekly weight performed better overall in the end, possibly due to the accumulation of uneaten organic matter in the tank, which led to the appearance of fungi and bacteria in some replicates in both experiments C and D.

Conclusion.

These results prove that *H. floridana* is an excellent candidate for inland cultivation, where external feeds are necessary, and cultivation area can be a limiting factor. These experiments demonstrated that it is possible to design easily sourced and cheap diets and that the species can resist relatively high densities without significantly reducing growth. We recommend including yeast on the feeds, potentially enriching with low spirulina doses, and using an initial density between 15 to 30 org/m² and a feeding rate of 50 to 75 % of the stoking biomass per week to produce the best growth performance.

IMPORTANCIA DE LA BIOTECNOLOGÍA PARA LA ACUICULTURA EN EL SENTIDO ECONÓMICO Y SOCIAL

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La acuicultura es una de las prácticas más importantes actualmente en la producción de alimento de calidad, al alcance de todos. Sin embargo, la pandemia ocasionada por el virus COVID19, marcó una época de crisis económica a nivel mundial, afectando a la mayoría de las industrias, sin dejar fuera a la acuicultura. La condición emocional, social y productiva dejó marca en los acuicultores, así como en otras actividades económicas. Ante esta situación, se evidenció la importancia del desarrollo tecnológico y la implementación de estrategias novedosas para hacer frente a los retos en cuestión de salud y, en general, para la recuperación de la producción. En este trabajo se repasan algunas estrategias de la biotecnología acuícola, y su impacto en el incremento productivo, así como algunos aspectos sociales del efecto de la pandemia en los acuicultores.

Los principales parámetros estudiados son: la eliminación o control de patógenos bacterianos y virales y el mejoramiento productivo (peso y supervivencia). Para abordar dichas problemáticas se evaluó el uso de plantas medicinales como albahaca *Ocimum basilicum* L, orégano *Origanum vulgare*, romero *Rosmarinus officinalis* y chicalote *Argemone Mexicana* para el control de patógenos, obteniendo una vía eco-friendly de control, eliminando el uso de antibióticos.

El uso de probióticos es altamente benéfico, dado que propociona varios beneficios: control de patógenos por competencia o por producción de metabolito antimicrobiano, incremento de digestibilidad del alimento por producción de enzimas, inmunomodulación, incremento productivo, etc.

Estas estrategias son altamente eficientes para el mejoramiento de los sistemas acuícolas, sin embargo, no están generalizadas como estrategias en el quehacer cotidiano de los acuicultores. La pandemia afectó al sector productivo y su entorno social. En este estudio se realizó un acercamiento a una granja en el estado de Nayarit y otra en el estado de Jalisco, México, reflejando diferentes grados de impacto de la pandemia en el país respecto a la actividad acuícola y la aceptabilidad y frecuencia en el uso de estrategias con base científica para el mejoramiento de la actividad acuícola, en el mejoramiento de la calidad y rendimiento del producto y en el manejo y tratamiento del agua.

Tabla I.- Inhibición del crecimiento bacteriano (R= de rana, Os=de ostión y L= de camarón) con los extractos de A=Albahaca, Aq=Albahaca acuapónica y O=Orégano. Ø dato no disponible, - sin halo, + halo <6.2mm, ++ 6.2-10mm. +++ >10mm

	A			Aq			O		
	R	Os	L	R	Os	L	R	Os	L
Infusión	Ø	Ø	Ø	-	++	-	-	++	-
Decocción	-	+	-	Ø	Ø	Ø	-	++	-
Alcohol 70									
24 h	Ø	Ø	Ø	+++	+++	++	Ø	Ø	Ø
15 d	-	+	-	+	+	+	Ø	Ø	Ø
Alcohol 96									
24 h	+	+	-	+	+	-	+	+	-
15 d	+	+	-	+	+	-	+	+	+
Arrastre	++	++	-	++	++	-	+++	+++	+++
Resina	+++	+++	+++	Ø	Ø	Ø	+++	+++	+++
Resina 50%	++	++	+++	Ø	Ø	Ø	++	++	+++

SOIL-BASED AQUAPONICS: THE EFFECTS OF SOIL ADDITION AS INVESTIGATED IN NINE DIFFERENT EXPERIMENTS

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Introduction

Under the new Commission Regulation (EU) 2018/848, which has entered into law in January 2022, aquaponic produce cannot be certified as organic in the European Union. Given the multiple components of an aquaponic system, which involve growing plants in hydroponic conditions, recycling of fish waste, and raising fish in artificial conditions, the achievement of organic certification for aquaponic produce is a complex matter dictated by many parameters. In the EU, aquaponics is considered a type of hydroponics, and mainly because of the lack of soil in its systems it is excluded from organic certification. This exclusion is considered to hinder the development of aquaponics, as it makes it difficult for producers to increase their earnings and effectively market their products. The research undertaken explores ways through which different soil substrates and potting mixes can be included in coupled and de-coupled aquaponics, and aims at helping aquaponics with its marketability, commercialisation, public acceptance, and popularity by bringing the technology one step close to organic certification. The research was done through nine different experiments, which took place between April 2021 and August 2022. The experiments aimed at investigating the effects that soil has on the health, growth, and quality of the plants and the fish, whilst examining how the soil microbiome is affected by the use of aquaponic water and processed sludge. This presentation will include the results and conclusions from all the experiments. The experiments are listed below, with a short overview for each.

Experiment 1: Coupled aquaponics of Basil and Nile tilapia #1

This experiment investigated the effects of aquaponic water on the growth and quality of basil (*Ocimum basilicum*), as well as potential effects of soil addition to fish health. The plants were grown in soil-filled pots placed in trays on top of fish tanks, creating full-recirculation, coupled aquaponic systems. The growth of the plants in soil-based aquaponic systems was compared to that of conventional, soil-less aquaponics. Two types of soil potting mixes were used, one with compost, and one without. The design of the systems was inspired by conventional coupled aquaponics, however the plant units were designed to allow the plant roots in soil-filled pots continuous access to fish water.

Experiment 2: Coupled aquaponics of Basil and Nile tilapia #2

This experiment was a continuation of the previous one, with a few modifications: compost amount was reduced, and the soil-less treatment was substituted by another soil-based treatment.

Experiment 3: De-coupled aquaponics of Basil in pots

This experiment investigated the effects of aquaponic water and processed sludge on plant growth and quality and soil microbiome in basil (*Ocimum basilicum*) cultivated in pots. The effects of the use of the different substrates and water type on plant health, quality, growth, as well as soil microbiome composition were investigated.

(Continued on next page)

Experiment 4: De-coupled aquaponics of Onions in raised beds

This experiment investigated the effect of watering onions (*Allium cepa*) cultivated in raised beds and watered with water from different sources; the aims of the study were to compare the effects of manure, currently allowed in organic production, and fish effluents used as fertilisers on the growth and quality of the plants, and to investigate the effects of the different fertilisation regimes on the soil microbiome composition. Four outside raised beds were divided into four sub-units, and each subunit was devoted to the cultivation of onion sets. The four treatments were the following: onions watered with tap water, onions supplied with horse manure and watered with tap water, onions watered with aquaponic water, and onions watered with aquaponic water with sludge.

Experiment 5: De-coupled aquaponics of Bok Choy in certified topsoil

This experiment investigated the effect of watering bok choy (*Brassica rapa* subsp. *chinensis*) cultivated in detached containers in UK-certified topsoil and watered with water from different sources. The aim of the study was to compare the effects of manure, currently allowed in organic production, and fish effluents used as fertilisers on the growth and quality of the plants. The four treatments, each replicated four times, were the following: plants watered with tap water, plants supplied with horse manure and watered with tap water, plants watered with aquaponic water, and plants watered with aquaponic water and sludge.

Experiment 6: De-coupled aquaponics of Turnip in certified topsoil

This experiment investigated the effect of watering turnip (*Brassica rapa* subsp. *rapa*) cultivated in detached containers in UK-certified topsoil and watered with water from different sources. The methodology followed was identical to the methodology of experiment 5.

Experiment 7: Use of Barley for nutrient uptake of soil treated with fish effluents

This experiment investigated the use of barley (*Hordeum vulgare*) grown in the same raised beds where the onions from experiment 4 grew, in order to measure the uptake and retention of nutrients that would otherwise be washed off by rain by a cover crop.

Experiment 8: Coupled aquaponics of Chilli peppers and Nile tilapia

This experiment investigated the effects of aquaponic water on the growth and quality of chilli peppers (*Capsicum annuum*) grown in soil-filled pots, placed in trays on top of fish tanks, creating full-recirculation, coupled aquaponic systems. Two types of soil potting mixes were used, one with compost, and one without.

Experiment 9: De-coupled aquaponics of Chilli peppers in pots

This experiment investigated the effects of aquaponic water and processed sludge on plant growth in chilli peppers (*Capsicum annuum*) cultivated in pots. The effects of the use of the different substrates and water type on plant health and growth, and fruit quality were investigated.

EVALUATION OF THE GROWTH OF JUVENILES OF *Centropomus undecimalis* USING DIETS WITH REPLACEMENT OF FISHMEAL BY SOYBEAN MEAL

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The common robalo (*Centropomus undecimalis*) is a species with great importance in national and international markets, due to its high demand and economic value. It is a sequential protandric hermaphrodite species, however, osmotic pressure can affect growth at low salinities affecting the metabolic expenditure of ionic and osmotic regulation and the energy available for growth.

The objective of this study was to evaluate the growth parameters of Common Snook juvenile sea bream caught in the Ciénaga Grande de Santa Marta (Colombian Caribbean) with an average weight of 13.5 cm 2.5, cultivated in a sweetish culture. For the experiment the animals were randomly distributed in tanks of 2000L to a density of 16 fish per tank, where three diets formulated at 45% PB were evaluated (Table 1) as follows: T1: 0% without replacement of fishmeal by soya meal, T2: 35% replacement and T3: 55% replacement), each with three replicates. Each diet was performed a proximal analysis, fed to 5% of biomass and every 20 days biometrics were performed to adjust the food ration, Daily physical-chemical parameters (oxygen, temperature, and pH) were recorded. The experiment determined the increase in weight and the Specific Growth Rate (SGR). The production variables did not meet assumptions of normality and homogeneity of variance, so the non-parametric test of Kruskal Wallis was applied.

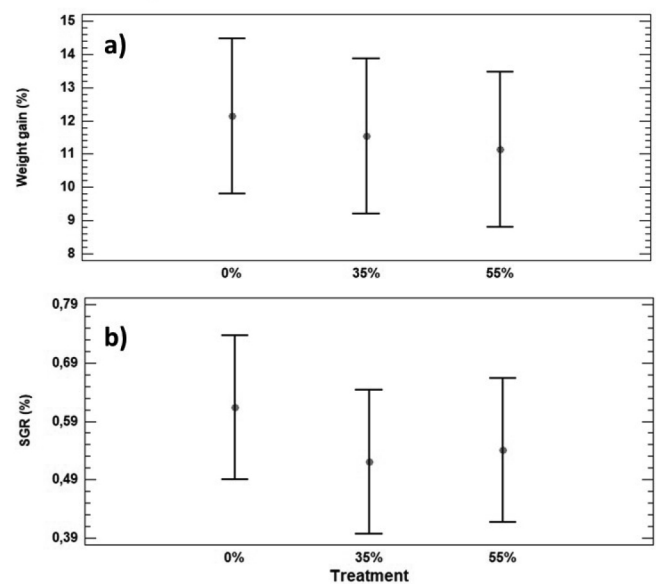
The main results indicated that there was no significant statistical difference of the analyzed variables between the treatments evaluated (Figure 1). The increase in weight varied between 9 and 14.5% being greater in T 0%. The SGR was 0.61 for T 0%, 0.52 for T 35% and 0.54 for T 55%. Survival during the 120 days was close to 100%, mortality of only one individual occurred in the W treatment.

In conclusion, the use of high percentages of soy flour (55%) as a replacement for fishmeal for *C. undecimalis* juvenile diets is feasible, as it does not affect the main growth indicators.

TABLE 1. Percentage composition of diets supplied to *Centropomus undecimalis*, with different replacements of fishmeal for soybean meal.

Ingredients	0%	35%	55%
Fishmeal	44,87	31,29	22,60
Soybean meal	20,39	38,73	50,46
Shrimp meal	16,31	17,50	18,26
Cornmeal	15,33	10,38	7,21
Fish oil	1,53	1,038	0,72
Free space	1,57	1,06	0,75

FIGURE 1. Comparison of means of the variables a) weight gain and b) Specific Growth Rate (SGR), obtained for the different replacement treatments.



EFECTO DEL COLOR DE LA LUZ SOBRE EL CRECIMIENTO, SUPERVIVENCIA Y PROPORCIÓN SEXUAL EN UNA POBLACIÓN EXPERIMENTAL DE PECES TETRA EMPERADOR *Nematobrycon palmeri*

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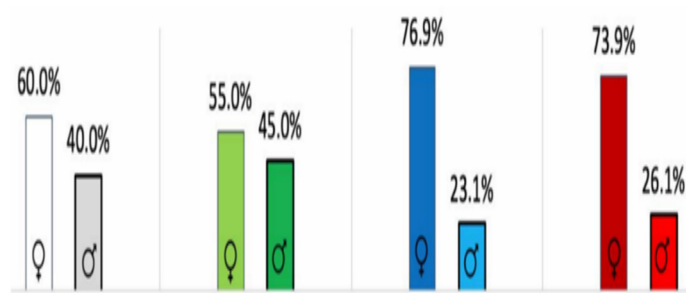
Este estudio evaluó los efectos de luces LED: blanca, verde, azul y rojo en la supervivencia, crecimiento y proporción sexual del pez ornamental tetra emperador *Nematobrycon palmeri*. Se realizó durante 12 semanas (octubre 2019- enero 2020) en el laboratorio de acuicultura de la universidad del Pacífico. Colombia. Los datos obtenidos se analizaron mediante un ANOVA unidireccional y una prueba de chi cuadrado. Los peces utilizados tenían aproximadamente dos meses de edad al inicio del ensayo, se aclimataron por tres semanas (acuarios, alimento, luz) se seleccionaron al azar y se asignaron a acuarios y grupos de tratamiento por tres réplicas. Figura 1. Durante el experimento los peces se observaban sanos y se alimentaban normalmente. Se presentó mortalidad atribuida a lesiones comunes que ocurren con la captura y manipulación iniciales; la supervivencia global fue del 79%. La diferenciación sexual externa ocurrió durante el período experimental de 12 semanas. Todos los machos se volvieron más coloridos que las hembras y desarrollaron el característico rayo extendido en el medio de la aleta caudal, dándole la apariencia de un tridente. Los machos también fueron significativamente ($p < 0.05$) más pesados (468 ± 125 mg) y más largos (3.4 ± 0.2 en longitud total LT) que las hembras (305 ± 5 mg; 2.8 ± 0.4 LT).

Los peces de todos los grupos de tratamientos ganaron una longitud y peso corporal significativo ($p < 0.05$), 1.8 ± 0.1 a 2.4 ± 0.1 cm de longitud estándar y 169 ± 24 mg a 359 ± 53 mg. Sin embargo, los diferentes colores de luz no tuvieron un efecto significativo ($p > 0.05$) en la supervivencia o crecimiento del tetra emperador. Más importante fue la observación de que los diferentes colores de la luz LED artificial afectaron la proporción de sexos de la población experimental, con un sesgo significativo ($p < 0.05$) con una relación aproximadamente de 3 hembras por 1 macho cuando la población se cultivó bajo luces azules y rojas. Bajo luces blancas y verdes, la proporción de sexos no se desvió significativamente ($p > 0.05$) de la paridad, 1:1. Después de una extensa revisión de literatura, no se encontró otra información con respecto a la alteración de la proporción de sexos en peces cultivados bajo luz de colores de diferente longitud de onda. Este hallazgo puede ser aplicable a otras especies de peces ornamentales y convertirse en una herramienta muy práctica en su producción comercial.

Figura 1. Infraestructura



Figura 2. Proporción de sexos (♀ hembra y ♂ macho) del Tetra emperador *Nematobrycon palmeri* cultivados bajo diferentes colores de luz (blanco, verde, azul y rojo) durante 12 semanas



EFFECT OF L-ASCORBYL-2-POLYPHOSPHATE (Vitamin C) ON IMMUNE AND ANTIOXIDANT RESPONSE OF *Litopenaeus vannamei* (Boone, 1931) BROODSTOCK MALES

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This study evaluates the effect of L-ascorbyl-2-polyphosphate (Vitamin C) on *Litopenaeus vannamei* immune and antioxidant responses, as well as sperm quality of broodstock males. Four diets were formulated: Basal (control group (16 mg/kg of total Vitamin C), and the other three prepared with different vitamin C levels: **A** (322 mg/kg); **B** (628 mg/kg); and **C** (934 mg/kg). Circulant cholesterol, triglyceride (TG), glucose, and total protein were measured. Activities and differential expressions of superoxide dismutase (SOD), catalase (CAT), glutathione peroxidase (GPx) and the immune gene system in the reproductive tract were measured. Sperm quantity and quality were determined. The lowest activity of the antioxidant enzymes was obtained in **B** (628 mg/kg) and the highest one in **C** (934 mg/kg) ($p \leq 0.05$) diets. The immune system genes only showed differences in hemocyanin where the highest expression was obtained in **B** ($p \leq 0.05$) diet. The highest sperm quantity was determined in individuals fed **B** ($p \leq 0.05$) diet, which supplemented with 628 mg/kg Vitamin C benefit *L. vannamei* broodstock males because it guarantees less antioxidant system activity, suggesting a good physiological state.

INTEGRACIÓN DE UN CULTIVO DE BAJA SALINIDAD DE CAMARÓN BLANCO (*Penaeus vannamei*) Y TOMATE CUAUHTÉMOC (*Solanum lycopersicum*) UTILIZANDO DOS SISTEMA HIDROPONICOS

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En la producción acuícola, los altos efluentes residuales ocasionan problemas ambientales (Guerra *et al.* 2013). Se han implementado nuevas tecnologías para mitigar el impacto de las aguas residuales mediante la integración de sistemas (Rijn *et al.* 2006). Los sistemas agro-acuícolas ayudan a que los nutrientes residuales de la acuicultura sean reutilizados en la nutrición vegetal (Martínez-Córdova & Peña-Messina, 2005). La integración de cultivos es una alternativa para disminuir el impacto ambiental y a su vez eficientar el uso el agua, haciendo a estas actividades sostenibles. El objetivo de este trabajo fue integrar los efluentes de un cultivo de *P. vannamei* de baja salinidad y *S. lycopersicum* mediante la utilización de un sistema hidropónico de flujo laminar NFT y uno de sustrato con el fin de aprovechar los nutrientes residuales como nutrientes vegetales. Se probaron 3 tratamientos hídricos en 2 sistemas de producción vegetal, NFT y sustrato, **T1** (100% Steiner), **T2** (50% Steiner + 50% agua residual) y **T3** (100% agua residual). La preparación de la solución nutritiva Steiner fue según Santos *et al.* (2016). Para la producción de plántula se germinó las semillas en charolas en invernadero con riegos diarios, se trasplanto a cada sistema cuando alcanzó una altura de 20 cm. Al inicio del ensayo se llevó a cabo el tutorado de la planta y la eliminación de brotes axilares, además de la medición de conductividad eléctrica y pH. Para el sistema en sustrato se pusieron las plantas en vasos de unicel y se realizaron riegos diarios. Se realizaron biometrías semanales (10 semanas) donde se midió: altura (cm), número de hojas, peso de raíz y peso de fruto. A cada serie de datos se le realizó un ANOVA de una vía y una prueba de Duncan para comparaciones múltiples ($P < 0.05$). Se utilizó el programa STATGRAPHICS centurión.

Los resultados mostraron que T3 en sistema NFT fue superior a los demás tratamientos y sistema en altura ganada (Figura1), peso de fruto y peso de raíz (figura 3) de manera significativa ($P < 0.05$). En los que respecta a ganancia de hojas los mejores fueron T2 y T3 en NFT (Figura 2).

El uso de efluentes de cultivo de camarón a baja salinidad en sistema NFT puede tener un buen aprovechamiento de residuales acuícolas, principalmente de nitrógeno que se sabe que el 80% de este no se aprovecha en sistemas acuícolas. Sin embargo, se debe tener en consideración que las sales acumuladas en el sistema puede causar deficiencias en el crecimiento de raíz. En NFT se puede aprovechar los residuales nitrogenados mediante la eliminación de las sales periódicamente.

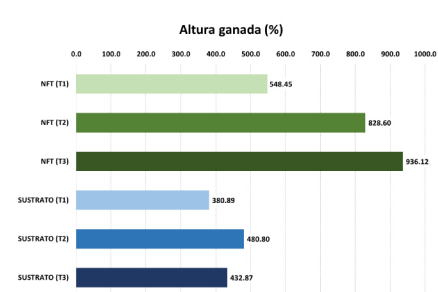


Figura 1. Altura obtenida en dos sistemas de cultivos hidropónicos.

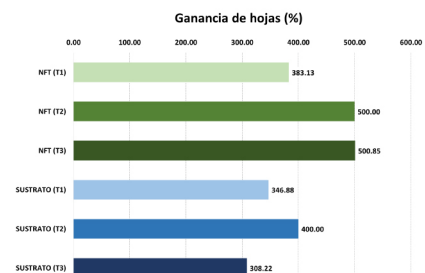


Figura 2. Numero de hojas obtenida en dos sistemas de cultivos hidropónicos.

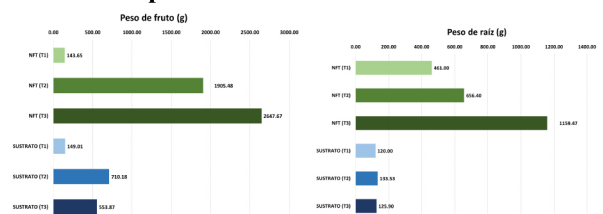


Figura 3. (A) Peso de fruto y (B) Peso de raíz final, obtenidos al final del experimento.

ANÁLISIS DE LAS ESPECIES ORNAMENTALES CONTINENTALES Y MARINAS SEGÚN SU IMPORTANCIA COMERCIAL EN COSTA RICA

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El estudio del mercado de la acuariofilia en Costa Rica es de suma importancia para comprender el funcionamiento económico social y ambiental del mercado en relación con los diferentes grupos de especies marinas y continentales que se comercializan en el país. Por estas razones este estudio busca caracterizar las especies acuáticas ornamentales de Costa Rica según su interés comercial y como estas se desenvuelven en los mercados físicos y virtuales en relación con el valor económico, la importancia comercial y la proporción de especies e individuos. Se realizó un índice de importancia comercial a partir de una rigurosa búsqueda en las redes sociales tomando en cuenta el número de publicaciones de cada especie (Tabla 1). Este índice evidenció una mayor proporción de especies en los niveles 2 y 3.

Se realizó un análisis para determinar el valor promedio de las especies en los niveles de importancia comercial. Este evidenció especies con precios altos en los niveles 2 y 3 y precios bajos en los niveles 4 y 5. Los análisis radiales indican que los peces continentales tienen mayor número de especies en los niveles 4 y 3. En el caso de los peces marinos la mayoría de especies se encuentran en el nivel 3. Los invertebrados marinos se encuentran casi en toda su totalidad en el nivel 2; mientras que los continentales poseen muy pocas especies (22), las cuales se encuentran en mayor medida en el nivel 4 (Figura 1).

Muchas de las especies comercializadas en Costa Rica son especies que se encuentran en el nivel 5. Este nivel está abarcado casi en su totalidad por peces continentales. Aunque el nivel 5 sea el más publicado, es el que menos especies posee, lo cual indica que el mercado se encuentra abarcado por peces continentales con precios bajos.

Tabla 1. Índice de importancia comercial.

Nivel de importancia	Menciones
5	≥ 40
4	< 40 y ≥ 30
3	< 30 y ≥ 20
2	< 20 y ≥ 10
1	< 10



Figura 1. Número de especies según su importancia comercial. Grupos: (Peces continentales); (Peces marinos); (Invertebrados marinos); (Invertebrados continentales).

IDENTIFICATION OF THE OPTIMAL STOCKING DENSITY AND SITE SELECTION FOR A REPOPULATION STRATEGY OF *Isostichopus badionotus*, SEA CUCUMBER, IN THE WEST OF THE YUCATAN COAST

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The global production of sea cucumber is not enough to meet market demand in a sustained manner (WIOMSA, 2014). The causes of the problem presented in the case of sea cucumber populations can be grouped into two categories: indirect and direct anthropogenic impact (González, 2018). The indirect problem caused by the effects on their natural habitat due to climate change that entails, for example, the acidification of the oceans (EEA, 2015). Which affects the biological parameters of sea cucumber populations and thereby hinders the healthy growth and development of the specimens. While the direct anthropogenic pressure is related to overexploitation due to the high demand for bench-de-sea in the Asian market, which leads to a reduction in the density and abundance of sea cucumber populations (Sánchez-Tapia *et al.*, 2018). If the problem continues, it is unlikely that sea cucumber populations will recover to sustainable levels in the short term.

In this research, the objective was to determine, under a bioeconomic and decision theory approach, the quasi-utility (QII) and optimal stocking density to develop an aquaculture repopulation strategy of the *Isostichopus badionotus* species on the Yucatan coast, and propose a methodological design for the selection of the optimal site applying a multicriteria method, based on social, economic, biological and bioeconomic factors.

The methodology applied consisted of a documentary research which served to identify four sites on the Yucatan west coast. With that information we apply a bioeconomic model. The next step of the methodology was to applicate the decision theory. The decision making on the decision theory was based on an averse to the risk point of view. Finally, the last step on the methodology was the multiple-criteria technique which helped to analyze variables that differ between them.

State of Nature	Decision Theory			Maximin			Multi Criteria Adequability
	$\theta_1 = \mu:0.41$	$\theta_2 = \mu:0.62$	$\theta_3 = \mu:0.51$	$\theta_1 = \mu:0.41$	$\theta_2 = \mu:0.62$	$\theta_3 = \mu:0.51$	
Z1 Celestun							
D1	0	0	0	1,337,792	562,943	894,819	0.99
D2	771,119	383,695	550,047	566,673	179,249*	344,771	0.66
D3	385,560	191,847	274,816	952,233	371,096	620,002	0.83
Z2 Celestun							
D1	0	0	0	2,565,901	1,666,228	2,074,852	0.92
D2	1,350,708	900,872	1,105,948	1,215,193	765,357*	968,904	0.59
D3	675,354	450,436	552,592	1,890,547	1,215,793	1,522,260	0.75
Z3 Sisal							
D1	0	0	0	502,272	-88,689	145,637	0.56
D2	407,947	112,467	229,844	94,325	-201,155*	-84,207	0.23
D3	203,974	56,233	114,815	298,299	-144,922	30,822	0.40
Z4 Progreso							
D1	0	0	0	419,856	-146,290	78,197	0.33
D2	386,114	103,041	215,490	33,742	-249,331*	-137,294	0.00
D3	193,057	51,520	107,642	226,799	-197,810	-29,445	0.17

(Continued on next page)

The results showed that D1 01 is the one that presents the best values due to the fact that it has a greater number of individuals per square meter as well as a greater survival of organisms. Therefore, it is the strategy that represents a higher value of biomass (VB). On the opposite case, the D2 02 strategy which presents a lower number of organisms per square meter and a lower survival; therefore, it will be the option with the lowest performance. It is logical that D3 03 is the one that presents intermediate values because it is the strategy built with the averages of what is reported. Regarding the adequacy of the multi-criteria analysis, it can be explained that the best results are presented by Celestun because it has a higher degree of social backwardness than the ports of Sisal and Progreso and for this reason it was given greater importance in standardization.

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RESISTENCIA ANTIMICROBIANA EN AISLADOS DE *Vibrio parahaemolyticus* ASOCIADOS A MORTALIDADES DE CAMARÓN BLANCO (*Litopenaeus vannamei*)

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El cultivo de camarón blanco *Litopenaeus vannamei* representa el 51.7% del total de crustáceos cultivados a nivel mundial, con un volumen de 5.8 millones de toneladas en 2020 (FAO, 2022). La bacteria *Vibrio parahaemolyticus* promotor de AHPND, afecta la producción de camarón blanco (Escobedo-Bonilla, 2016). El tratamiento se hace con antibióticos, no obstante, su uso indiscriminado promueve la generación de bacterias resistentes. Por ello, es necesario conocer la resistencia antimicrobiana de aislados de *V. parahaemolyticus* con el fin de usar responsablemente aquellos que sean eficaces contra las bacterias, e investigar nuevos antimicrobianos de origen natural para reducir el riesgo de resistencia antimicrobiana. El objetivo de este trabajo fue evaluar la resistencia de aislados de *V. parahaemolyticus* contra 4 antibióticos de uso común en acuicultura.

Se hicieron 3 muestreos de agua en 3 estanques de cultivo de camarón con mortalidad asociada a AHPND. Las muestras fueron sembradas en Agar TCBS. Bacterias con características de *V. parahaemolyticus* fueron usadas en antibiogramas con 4 antibióticos: Fosfomicina (50 µg); Florfenicol (30 µg); Enrofloxacin (5 µg), y Oxitetraciclina (30 µg) usando la técnica de Kirby-Bauer.

En los 3 muestreos se obtuvieron un total de 1003 colonias en agar TCBS. El 48.75% mostró colonias verdes (posible *V. parahaemolyticus*) y el 51.24% colonias amarillas. Los aislados evaluados (n=17) mostraron mayor resistencia a fosfomicina (n =8), enrofloxacin y oxitetraciclina (n = 5) (Tabla 1). Se encontraron 5 aislados con resistencia a dos o más antibióticos, por lo que se propone tener mayor control en el uso de antibióticos contra estas bacterias, y hacer investigación sobre nuevas moléculas antimicrobianas de origen natural.

FAO. (2022). El Estado Mundial de la Pesca y la Acuicultura 2022. Hacia la Transformación Azul.

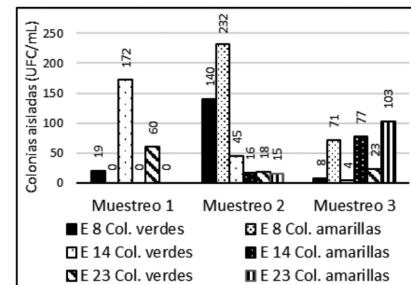


Figura 1. Proporción de colonias verdes amarillas en TCBS por muestreo.

Tabla 1. Resistencia antimicrobiana: R=Resistente, I=Intermedio, S=Sensible y “---” = no se pudo medir la sensibilidad.

Aislado	Enrofloxacin (5µg)	Florfenicol (30µg)	Fosfomicina (50µg)	Oxitetraciclina (30µg)	Nº antibióticos a los que muestra resistencia	Índice de resistencia múltiple
1 I	S	S	S	S	0	0
2 I	S	R	S	S	1	0.25
3 I	S	S	S	S	0	---
4 I	S	S	S	S	0	---
5 II	I	---	R	S	1	0.66
6 II	S	---	R	S	1	0.33
7 II	S	---	R	S	1	0.33
8 II	S	---	---	S	---	---
9 II	I	---	I	S	0	0
10 II	S	---	R	S	1	0.33
11 II	S	---	S	S	0	0
12 II	S	---	S	S	0	0
13 III	R	---	R	R	3	1
14 III	R	---	R	R	3	1
15 III	R	---	R	R	3	1
16 III	R	---	R	R	3	1
17 III	R	---	I	R	2	1

Escobedo-Bonilla, C.M. (2016) Emerging Infectious Diseases Affecting Farmed Shrimp in Mexico. Austin J Biotechnol Bioeng, 3, 1062-1064.

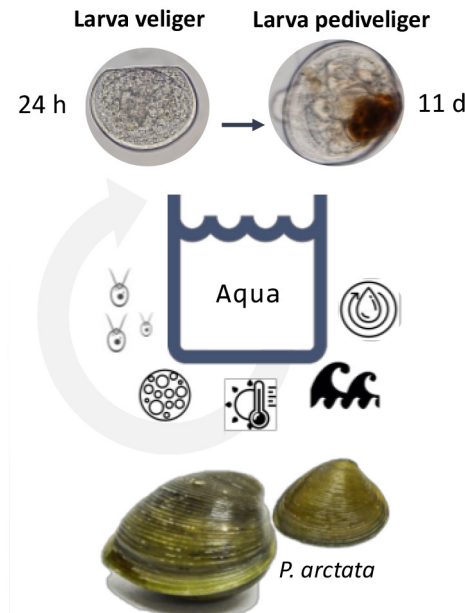
CULTIVO EXPERIMENTAL DE LARVAS DE LA ALMEJA ESTUARINA AMENAZADA *Polymesoda arctata* EN CONDICIONES DE LABORATORIO (Deshayes, 1854)

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Polymesoda arctata es una almeja estuarina perteneciente al grupo de los moluscos bivalvos con mayor importancia en la pesquería artesanal del Caribe, encontrándose actualmente amenazada con un estado vulnerable debido a su sobreexplotación y pérdida del hábitat. Con el fin de proporcionar las bases biológicas y tecnológicas que permita la producción de juveniles por acuicultura como herramienta de conservación para repoblación y aprovechamiento sostenible, se evaluó el crecimiento y supervivencia larvaria bajo diferentes condiciones de cultivo en laboratorio. Realizándose cinco experimentos de cultivo de manera consecutiva en los que se probaron diferentes concentraciones de alimento (20 y 40 cel de *I. galbana* $\mu\text{L}^{-1} \text{d}^{-1}$), densidades de cultivo (1 y 5 larvas mL^{-1}), temperaturas (25, 27 y 29°C), salinidades (5, 15 y 20‰) y sistemas de recambio de agua (total: bajando el nivel del agua de los tanques y parcial: adicionando agua al sistema sin bajar el nivel del agua). La concentración de alimento, la densidad y el recambio del agua no afectaron la supervivencia, pero si el crecimiento de las larvas, encontrándose los mayores valores en aquellas que fueron alimentadas con una baja concentración de alimento (20 cel de *I. galbana* $\mu\text{L}^{-1} \text{d}^{-1}$), mantenidas a una densidad baja de cultivo (1 larvas mL^{-1}) y realizándoles un recambio total del agua. De otro lado, la salinidades y temperaturas probadas afectaron la supervivencia presentándose mayores valores en los tratamientos de 5 y 15‰ y 27 y 29°C respectivamente. Mientras que, cuando se cultivaron en rangos de salinidad de 15 y 20‰ y temperatura entre 27 y 29°C hubo un efecto significativo sobre el crecimiento en longitud total de la concha de las larvas.

Los valores altos de supervivencia (50%) obtenidos en este estudio permiten afirmar que esta almeja tiene un alto potencial para ser producida en condiciones de laboratorio, especialmente aplicando bajos niveles de concentración de alimento, densidad, temperatura y salinidad, así como un recambio de agua de agua total. Este trabajo representa el primer paso para el desarrollo de un protocolo con el fin de obtener juveniles de esta especie, ampliando su conocimiento sobre su biología reproductiva y del desarrollo.



CAMBIOS EN LOS PATRONES DE EXPRESIÓN GÉNICA ASOCIADOS CON LA MADURACIÓN GONADAL Y SISTEMA INMUNE DE *Crassostrea virginica* EN RESPUESTA A LA APLICACIÓN DE COMPUESTOS BIOACTIVOS ALTAMENTE DILUIDOS (CBAD)

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El aumentar la capacidad reproductiva e inmunoestimulante en organismos utilizados como stock reproductivo en acuicultura es de gran importancia. La utilización de este tipo de compuestos en *C. virginica* es novedoso. La gran importancia comercial que tiene esta especie ha impulsado el uso de estos compuestos como una manera de mejorar su capacidad reproductiva e inmune.

Se evaluó el efecto de compuestos bioactivos altamente diluidos (CBAD), en reproductores de ostión americano *Crassostrea virginica*. Se sometieron a 5 tratamientos; [T1 (*Streptomyces sp.* RL8), T2 (ViP 7C+VIA 7C), T3 (PhA 7C+SIT 7C), T4 (ViP 7C+VIA 7C+RL8), T5 (PhA 7C+SIT 7C+RL8)] y dos controles [T6 (Etanol) y T7 (Agua Destilada) en condiciones de laboratorio comercial productor de semillas. Se estimó la expresión génica de genes asociados a reproducción y sistema inmune de *C. virginica*, se caracterizaron los cambios fisiológicos mediante histología cuantitativa y cualitativa.

El gen de la lectina tipo C se sobre expresa en el tratamiento T1. Esta sobre expresión de la lectina esta relacionando a la función de regular y controlar agentes infecciosos. La caracterización de los estadios de madurez mostro la estimulación del desarrollo gonádico en el T1. El almacenamiento de lípidos, la cobertura de los túbulos digestivos mostró diferencias estadísticas positivas en el T1. Estos efectos positivos están relacionados a la capacidad de los CBAD, de mejorar la absorción de micronutrientes y transporte de energía, aumentado su disponibilidad. Los CBAD, tienen la capacidad de promover la maduración gonádica, así como mejorar el sistema inmune en *C. virginica*.

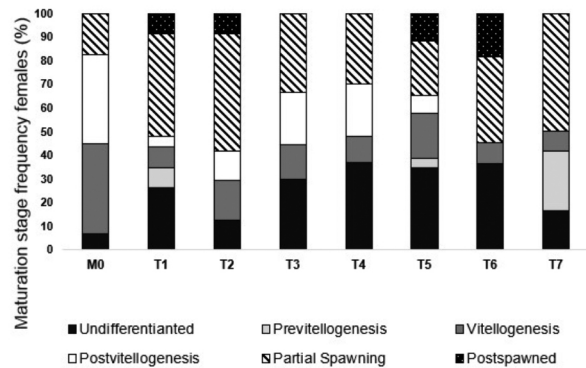


Figura 1.- Frecuencia de estadios de desarrollo gonádico de hembras.

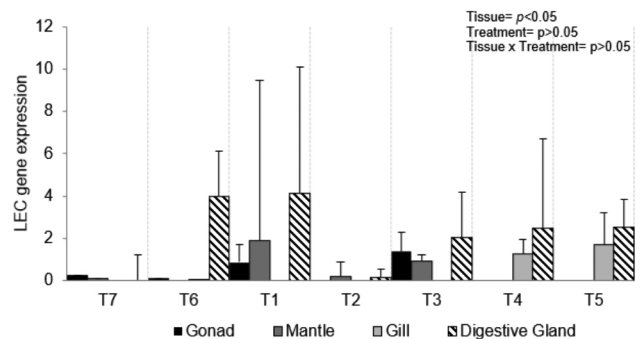


Figura 2.- Expresión del gen de la lectina tipo C.

EFECTO DE LA SUPLEMENTACIÓN CON SELENIO ORGÁNICO EN DIETAS DE PACO *Piaractus brachypomus*: RESPUESTA PRODUCTIVA

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Introducción:

En sistemas de producción intensivos de Paco *Piaractus brachypomus* cuyas densidades oscilan de 2 a 4 Fish/m³, el crecimiento y supervivencia se ve afectado tanto por la competencia del oxígeno disuelto y el espacio del estanque. Como una alternativa surge la inclusión de algunos aditivos para que mejore la performance de los peces en la fase de crecimiento, reduzca la efectiva invasión de patógenos, mejore la respuesta inmunológica así como la eficiencia alimentaria. (Romero *et al.*, 2021). Por otro lado, algunos aditivos por su naturaleza química dependerán de su efectiva absorción, así como la dosis óptima en la preparación y el precio que oscila en los piensos. (Wangkahart *et al.*, 2022). De tal manera que en la investigación al adicionar minerales de diferente fuentes dietética como el selenio (Se) podría verse afectado de forma positiva o negativa la respuesta productiva en los peces.

METODOLOGIA:

El experimento tuvo una duración de 6 meses, la cantidad de alevinos iniciales fueron 3000 peces con 10.58 ± 0.110 (cm) de talla y peso 19 ± 0.584 (g), distribuidos en estanques con un área de 1000 m², cada tratamiento contó con 3 repeticiones, T1, T2, T3, T4 (0 mg; 0,3 mg; 0,6 mg de Se- levadura/kg de dieta y Alimento Comercial); el objetivo de la investigación fue evaluar dietas suplementadas con selenio orgánico en Paco *Piaractus brachypomus*, evaluando los parámetros productivos

Se logró obtener el menor FCA en los peces alimentados con 0 mg/kg de Se-Levadura de (1.12 ± 0.071). Estos datos fueron casi similares a los encontrados por Takahashi *et al.* (2017) que suplementaron 0.94 y 0.72 mg/kg de selenio orgánico en una dieta para pacú logrando una conversión alimenticia de (1.20 y 1.40).

Los peces alimentados con 0 mg/kg de Se-levadura demostraron un ligero incremento en peso final (358.21 ± 21.458 g), y biomasa (89.55 ± 5.807 kg) en comparación con los otros tres tratamientos. Estudios realizados en diferentes especies indican que no se encontró diferencia significativa en el desempeño productivo en concentraciones tales como selenio (0.00 – 1.00 mg/kg); (0.00 – 4 00 mg/kg) + Vit. E (0, 100 y 200). Se concluye que la inclusión de selenio como suplemento de dieta para paco, no presentó mortalidad ni signos de deficiencia y toxicidad.

Tabla N° 1 Contenido Nutricional Dietas

	Inicio			Crecimiento		
	T1	T2	T3	T1	T2	T3
Proteína Cruda	28	28	28	25	25	25
Grasa (%)	7.7	7.7	7.7	6.75	6.75	6.75
Ceniza (%)	5.21	5.21	5.21	5.45	5.45	5.45
Fibra (%)	1.87	1.87	1.87	2.45	2.45	2.45
CHOS (%)	42.2	42.2	42.2	45.2	45.2	45.2

Tabla N° 2 Resultados de Parámetros Productivos

Parámetros	Tratamientos			
	T1 (control)	T2 (0.3 mg de Se)	T3 (0.6 mg de Se)	T4 (comercial)
N° peces	750	750	750	750
Inicial				
PI (g)	19.65 ± 0.58 a	18.95 ± 0.58 a	18.99 ± 0.58 a	19.40 ± 0.58 a
Biomasa (kg)	4.91 ± 0.14 a	4.74 ± 0.14 a	4.75 ± 0.14 a	4.85 ± 0.14 a
Final				
PF (g)	358.21 ± 21.4 a	328.09 ± 21.4 a	324.14 ± 21.4 a	345.77 ± 21.4 a
Biomasa (kg)	89.55 ± 5.807 a	82.02 ± 5.807 a	84.14 ± 5.807 a	86.44 ± 5.807 a
GP (g)	338.56 ± 21.4 a	309.14 ± 21.4 a	305.15 ± 21.4 a	326.367 ± 21.4 a
S (%)	100	100	100	100

Peso inicial (PI), Longitud inicial (LI), Peso final (PF), Ganancia de peso (GP), Longitud final (LF), Incremento de Longitud (IL) y Supervivencia (S).

ACUICULTURA DE PRECISIÓN: ANÁLISIS DE DATOS EN FAVOR DE LA SOSTENIBILIDAD Y LA EFICIENCIA ENERGÉTICA

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La acuicultura de precisión surge como una alternativa de solución a problemas que requieren de la aplicación de principios de ingeniería e innovación a tareas tales como el monitoreo y el control de la biomasa/especímenes, así como de los elementos que componen el proceso de producción dentro de las granjas acuícolas. En tal sentido, esta importante actividad económica de producción de alimentos, como toda industria, afronta retos relacionados con el futuro de la humanidad.

En otras palabras, la digitalización de procesos manuales, no implica solamente incorporar elementos tecnológicos novedosos para el procesamiento de datos, sino el logro de una transformación digital vinculada con el cuidado del medioambiente y la sostenibilidad.

Por ello, uno de los objetivos principales de este estudio, consiste en el aprovechamiento de los recursos implicados en el proceso de producción de tilapias, maximizando las ganancias y reduciendo el consumo energético. Por otro lado, la combinación de tecnologías IoT para la recolección de datos, junto con la ciencia que permite su exploración y análisis, reduce el nivel de incertidumbre y permite una toma de decisiones mucho más confiable.

Asimismo, este trabajo, presenta los resultados preliminares obtenidos a partir del monitoreo del nivel de oxígeno disuelto en el agua contenida en estanques utilizados para la crianza de tilapias. Para ello, es utilizado un sensor analógico de este elemento, marca DfRobots, calibrado con un LabQuest Vernier y conectado a una placa de microprocesador Arduino.

La investigación se lleva a cabo a partir del diseño de experimentos que analizan el comportamiento de diversas variables, controladas y no controladas, entre las que destacan, la temperatura del agua, el tiempo, la cantidad de biomasa, el tamaño del estanque, el tipo de aireador y si éste se encuentra prendido o apagado.

Finalmente, la gran cantidad de datos almacenada, se analiza estadísticamente y se preprocesa, con el fin de a futuro, aplicar algoritmos que permitan encontrar patrones que sirvan de base para optimizar el uso de los tres diferentes tipos de aireadores utilizados en la granja de estudio.

STORYTELLING EN FAVOR DEL ANÁLISIS DE DATOS ACUÍCOLAS Y LA SOSTENIBILIDAD ENERGÉTICA

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La acuicultura de precisión surge como una alternativa de solución a problemas que requieren de la aplicación de principios de ingeniería e innovación a tareas tales como el monitoreo y el control de los elementos que componen el proceso de producción dentro de las granjas acuícolas. En tal sentido, esta importante actividad económica de producción de alimentos, como toda industria, afronta retos relacionados con el futuro de la humanidad.

La digitalización de dichos procesos no implica solamente incorporar elementos tecnológicos novedosos para el procesamiento de datos, sino el logro de una transformación digital vinculada con el cuidado del medioambiente y la sostenibilidad.

Por ello, uno de los objetivos principales de este estudio, consiste en el monitoreo de 2 variables implicadas en el proceso de producción de tilapias, procurando con esto, la reducción del consumo energético, apoyado en el uso de un sensor analógico de oxígeno disuelto marca DfRobots y un sensor de temperatura DS18B20, calibrados con un LabQuest Vernier y conectados a una placa de microprocesador Arduino, aunado a la exploración y análisis de los datos mediante python para reducir el nivel de incertidumbre y llevar a cabo una toma de decisiones mucho más confiable.

Entre los primeros avances obtenidos, se encuentra la clasificación de las características del ecosistema acuícola a partir del nivel de oxígeno disuelto (OD) y temperatura (T) (Fig. 1), así como el registro del comportamiento de dichas variables. (Fig. 2).

Finalmente, la gran cantidad de datos almacenada, se analiza estadísticamente y se pre-procesa, con el fin de determinar los algoritmos que permitan encontrar patrones que sirvan de base para optimizar el uso de tres diferentes tipos de aireadores utilizados en la granja de estudio y así minimizar el consumo energético sin afectar a las especies.

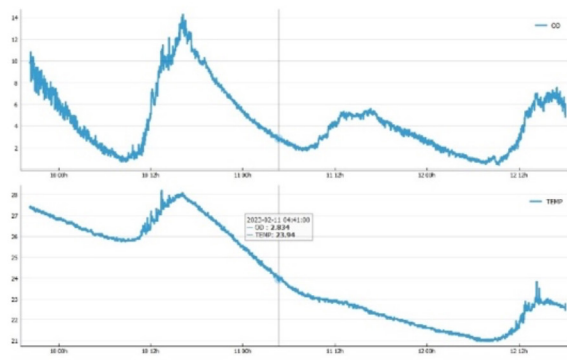


Fig. 1. Comportamiento de OD y T

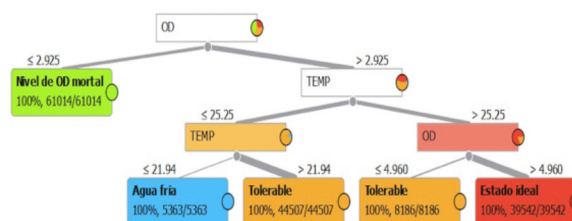


Fig. 2 Clasificación de variables del sistema acuícola

CARACTERIZACIÓN Y CONSISTENCIA EN LOS ESTILOS DE AFRONTAMIENTO AL ESTRÉS EN JUVENILES DE LISA *Mugil cephalus*

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La lisa *Mugil cephalus*, es una especie cosmopolita y constituye un recurso pesquero importante, por ello se considera una especie con potencial acuícola. Los estilos de afrontamiento al estrés (EAE) se definen como conjuntos de patrones conductuales consistentes y divergentes que muestran los individuos de una misma población al estrés (Koolhaas et al., 1999). De manera general, se han evaluado diferentes pruebas individuales y grupales para caracterizar con éxito los EAE en larvas, juveniles y reproductores de peces de interés comercial y así identificar individuos proactivos y reactivos. Los organismos proactivos son relativamente exploratorios, poseen mayor éxito reproductivo y son agresivos en relación a los reactivos. Considerando ello, el objetivo del presente trabajo fue caracterizar el perfil de comportamiento y la consistencia del mismo en juveniles de lisa.

El experimento se realizó en las instalaciones del Laboratorio de Biotecnología Acuícola (CENITT), en 3 tanques de 120 L donde se colocaron 22 individuos/tanque (~ 3 Kg/m³), con un peso y talla promedio inicial de 10.37 ± 0.95 g y de 12.10 ± 0.23 cm. Los peces fueron sometidos a 1 prueba grupal (toma de riesgo) y a 3 pruebas individuales (confinamiento, depredador y restricción) para su caracterización y todas las pruebas fueron repetidas en 2 ocasiones con 4 meses de intervalo. Cada prueba evaluó distintos parámetros (descritos en Tabla 1). Asimismo, se evaluó crecimiento, cortisol y glucosa. Los resultados demostraron que la lisa exhibió respuestas proactivas y reactivas. Asimismo, se observó variaciones significativas en términos de comportamiento, crecimiento y variables sanguíneas. Finalmente, se determinó un alto grado de consistencia en los resultados. Se concluye que los EAE podrían tener impacto en la acuicultura de la especie.

Los autores agradecen a CONACyT y al Proyecto CONACYT-SEP-CB-2016-284167 por el financiamiento para la realización de la presente investigación coordinado por ZIZ.

Tabla 1. Resumen de variables de EAE entre individuos proactivos y reactivos en el periodo de experimento (4 meses).

Coping style test	Variable	Proactive (crossed)	Reactive (did not cross)
A. Net	NetEsc (s)	51.19 ± 4.46^a	15.83 ± 1.33^b
	NetAct (s)	50.87 ± 3.17^a	24.84 ± 1.59^b
B. Predator	PreEsc (s)	9.03 ± 0.83^a	2.80 ± 0.57^b
	PreAct (s)	42.98 ± 4.02^a	10.20 ± 1.04^b
C. Confinement	ConOBR	105.34 ± 0.52	108.70 ± 0.58
	ConEsc (s)	10.43 ± 1.36^a	4.50 ± 0.58^b
	ConAct (s)	26.16 ± 2.30^a	11.40 ± 0.97^b
D. Growth parameters	Weight (g)	14.07 ± 0.37^a	12.22 ± 0.25^b
	Length (cm)	16.47 ± 0.15^a	14.57 ± 0.11^b
E. Blood parameters	Cortisol	83.04 ± 11.72^a	187.45 ± 36.54^a
	Glucose	41.54 ± 2.03^a	51.60 ± 3.92^b

ANÁLISIS TRANSCRIPTÓMICO DE CEREBRO DE JUVENILES DE LISA *Mugil cephalus* CON DISTINTOS ESTILOS DE AFRONTAMIENTO AL ESTRÉS

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En peces, se han caracterizado estilos de afrontamiento al estrés (EAE) del tipo proactivo y reactivo para resolver la variación en los datos de expresión molecular. Por lo tanto, comprender la base molecular de las respuestas contrastantes de los peces a situaciones de estrés resulta clave para seleccionar individuos que se adapten bien al cautiverio durante la intensificación de la acuicultura. El empleo de las herramientas genómicas ofrece nuevas oportunidades para descifrar los mecanismos moleculares afectados por la domesticación.

El experimento se realizó en el Laboratorio de Biotecnología Acuicola (CENITT), en 2 tanques de 120 L donde se colocaron 25 individuos/tanque, con un peso promedio inicial de 7.25 ± 4.07 g. Los peces fueron sometidos a 1 prueba grupal (toma de riesgo) y 3 pruebas individuales (confinamiento, nuevo ambiente y red) para su caracterización. Al término de las pruebas (Tabla 1), se seleccionaron 8 ejemplares proactivos (P) y 8 reactivos (R) para extraer RNA a partir de muestras de cerebro del hemisferio izquierdo (I) y derecho (D). La secuenciación de RNA generó un total de 445,166,299 lecturas pareadas, las cuales fueron filtradas por calidad ($Q > 30$) y posteriormente ensambladas *de novo* en 580,756 transcritos, de los cuales 187,248 (32.2 %) fueron anotados con la base de datos de Gene Ontology (GO), y 16,559 (2.9 %) se asociaron a una vía KEGG (Kyoto Encyclopedia of Genes and Genomes). El análisis de expresión diferencial entre EAE y hemisferios cerebrales (PD vs PI, RD vs RI, PD vs RD, PI vs RI) mostraron 193, 223, 592, y 17754 genes expresados diferencialmente (GEDs) respectivamente. Para visualizar los GEDs, se generaron gráficas de volcán para cada comparación (Figura 1). Los GEDs fueron anotados según el criterio GO. En función molecular se observan procesos involucrados en procesos de unión y actividad catalítica. En componente celular, se observan proceso metabólico célula y membrana. Finalmente, respecto a componente biológica, se observan procesos celulares y metabólicos. Este estudio abre camino a nuevas investigaciones en los campos de la etología y de la acuicultura.

Tabla 1. Resumen de variables de EAE entre individuos proactivos y reactivos

Prueba	Variable	Proactivo	Reactivo
Red	Escape	53.71 ± 454^a	26.85 ± 6.03^b
	Actividad(s)	46.38 ± 2.77^a	30.59 ± 2.32^b
Nuevo Ambiente	Escape	10.23 ± 0.63^a	3.43 ± 0.46^b
	Actividad (s)	27.06 ± 0.79^a	12.77 ± 0.02^b
Confinamiento	Movi. Opercular	110.86 ± 2.52	117.00 ± 1.88
	Escape	11.81 ± 2.26^a	5.03 ± 1.20^b
	Actividad	32.10 ± 1.32^a	18.56 ± 0.46^b
Crecimiento	Peso (g)	8.42 ± 0.25^a	7.66 ± 0.12^b
	Talla (cm)	9.41 ± 0.03^a	8.95 ± 0.03^b

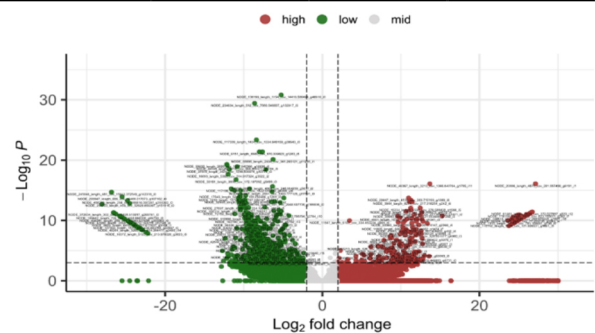


Figura 1. Volcano plot de GEDs al comparar PD vs RD. Puntos verdes y rojos indican genes reprimidos e inducidos, respectivamente.

Los autores agradecen a CONACyT y al Proyecto CONACYT-SEP-CB-2016-284167 coordinado por ZIZ.

LAS CAMARONERAS Y SU PAPEL DENTRO DEL PLAN DE CONSERVACIÓN PARA LOS HUMEDALES DE LA BAHÍA DE PARITA

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La bahía de Parita es reconocida como un Área Importante para Aves (AIA) y es el segundo sitio más importante para las aves playeras migratorias en Panamá, debido a sus extensos fangales que brindan alimento y refugio. Los humedales de la bahía de Parita ubicados entre las provincias de Coclé, Herrera y Los Santos incluyen ríos, ciénagas, lagos, bosques de manglar y planicies intermareales; además, sistemas productivos tales como las camaroneras y las salinas. Estos humedales son importantes ya que brindan alimento y refugio a las etapas juveniles de peces y camarones de valor comercial que contribuyen a la economía panameña. La Sociedad Audubon de Panamá a través de la metodología de los Estándares Abiertos para la Práctica de la Conservación, y mediante un proceso altamente participativo, elaboró el Plan de Conservación para los Humedales de la Bahía de Parita. Durante la elaboración del plan se realizaron 18 talleres en los cuales se seleccionaron seis objetos de conservación: albinas, salinas y camaroneras amigables con las aves playeras, almejas y concha negra, chorlo de Wilson, camarón blanco, corvina y los manglares. Las amenazas o retos de conservación que se reconocieron incluyeron cambio climático, contaminación, disturbios e intrusión humana, modificación del régimen hidrológico, pérdida de hábitat y la sobreexplotación del recurso pesquero. Para hacerle frente a las amenazas se consensuaron siete estrategias con las cuales se espera contribuir a disminuir o eliminarlas: 1.Promover las investigaciones científicas; 2.Promover e implementar las buenas prácticas acuícolas, agrícolas, ganaderas y pesqueras, así como la restauración ecológica; 3.Crear alianzas multisectoriales; 4.Promover el ecoturismo, aviturismo y agroturismo rural; 5.Implementar el Plan (CECoP); 6.Promover e incidir en la elaboración e implementación de planes de ordenamiento territorial y 7.Fortalecer las capacidades técnicas, financieras y operativas de las instituciones y autoridades regionales y locales. La elección de las camaroneras como objeto de conservación se basó en los servicios y beneficios que les ofrecen a las aves playeras tales como: alimentación de pequeños invertebrados que sobreviven en los estanques en deshuso, áreas de descanso, áreas de reproducción en los muros y orillas de los estanques, refugio y seguridad ya sea en diferentes momentos del día o en la temporada migratoria. La composición y abundancia de especies de aves playeras en camaroneras, depende de los hábitats naturales que rodean a las camaroneras tales como los manglares, ciénagas, lagos y fangales. Se han documentado polluelos del Chorlo de Wilson (*Charadrius wilsonia beldingi*) así como polluelos y juveniles de la Cigüeñuela Cuellinegra (*Himantopus mexicanus*) en la camaronera de El Retén, provincia de Herrera. A nivel regional se ha documentado el uso de camaroneras por aves playeras en México, Guatemala y Nicaragua. Uno de los objetivos del Plan de Conservación para los Humedales de la Bahía de Parita es incidir en Panamá, de la mano con los acuicultores, en una acuicultura amigable con las aves playeras.

ESTUDIO DEL CULTIVO A PARTIR DE ESPORAS, ANÁLISIS FILOGENÉTICO Y NUTRICIONAL DE MACROALGAS DE INTERÉS ECONÓMICO EN EL CARIBE (PANAMÁ) Y LA BAHÍA DE CÁDIZ (ESPAÑA)

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Las especies seleccionadas para este estudio fueron *Chondracanthus teedei* y *Gracilaria gracilis*, ambos tienen un ciclo de vida de tres fases; las algas en general poseen biomoléculas de interés económico (agar, alginatos y carragenanos), bioactivas o de interés nutricional (proteínas, fibras, vitaminas, minerales, ácidos grasos y aminoácidos); utilizados en diferentes industrias a nivel mundial. Se llevaron a cabo cultivos de campo y laboratorio de estas especies confirmados tras análisis de ADN, además se realizó un análisis nutricional de los cultivos en campo y por último un estudio filogenético de especies de algas rojas en la bahía de Cádiz, España y la costa de Colon, Panamá.

Los cultivos vegetativos, se realizaron en una salina tradicional en la bahía de Cádiz, alcanzaron tasas máximas de crecimiento en abril (3,64% día⁻¹) para *G. gracilis* y en noviembre (4,68% día⁻¹) para *C. teedei*.

Cultivos de esporas en laboratorio, se utilizó como medio de cultivo Provasoli enriquecido con agua de mar (medio ES), Miquel A+B y f/2 a una temperatura de 18 °C y una irradiación de 30 $\mu\text{mol m}^{-2} \text{s}^{-1}$ en fotoperíodo 12:12 h. Ambas especies desarrollaron un disco basal después de 12-15 días en medio ES y Miquel A+B, y se observaron nuevas plántulas microscópicas a los 20-25 días en medio ES. Con medio f/2, no se observó crecimiento después de la esporulación. El ciclo de vida de *G. gracilis* se completó en medio ES durante un período de 11 meses con una tasa de crecimiento promedio de 3,28 % día⁻¹.

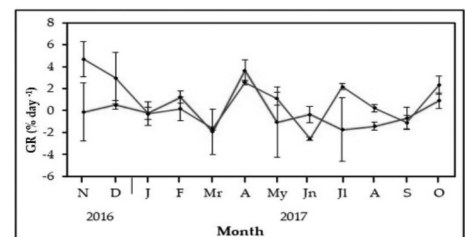


Fig. 1: Tasa de crecimiento mensual de *Gracilaria gracilis* (línea roja) y *Chondracanthus teedei* (línea azul). Las barras de error en SE.

Capacidad nutricional, se analizaron grasas, cenizas, proteínas, minerales, metales, carbohidratos y aminoácidos. Los resultados obtenidos en las estaciones mostraron diferencias significativas en *C. teedei* en el contenido en grasas ($p < 0.023$) y proteínas ($p < 0.0039$); para *G. gracilis* es significativo solo en grasas ($p < 0.04$). En el contenido mineral y de metales la diferencia significativa estuvo dado de acuerdo con el elemento analizado. En el análisis de carbohidratos mostró diferencia significativa para *G. gracilis* (sacarosa $p < 0.04$ y almidón $p < 0.00005$). Para los aminoácidos solo la LYS no presentó diferencia significativa en *C. teedei* y en *G. gracilis* la ALA, PRO, TRP y TYR.

Filogenia, Colectamos un total de 16 muestras para la Bahía de Cádiz y un total de 22 muestras para Panamá; se identificaron mediante el gen *rbcL*; la mayoría de los individuos presentó un porcentaje de similitud arriba del 98%. Se lograron identificar 5 especies para cada país.

Conclusiones: Ambas especies son técnicamente factibles para el cultivo a partir de carposporas en laboratorio. Este resultado aunado al obtenido en cultivos in situ y los valores del análisis nutricional que sugieren que son aptas para el consumo humano son de gran importancia para el establecimiento de cultivos a escala piloto en las antiguas salinas.

Para una identificación rápida el gen *rbcL* es funcional, sin embargo, al hacer el árbol filogenético presentamos inconsistencia, la solución es realizar los análisis filogenéticos con otros grupos de genes y complementar.

A STRATEGIC PARTNERSHIP PROJECT IMPROVING PRODUCTIVITY AND SUSTAINABILITY IN THE TILAPIA VALUE CHAIN IN COLOMBIA: NORAD

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Tilapia production in Colombia has doubled in volume over the last decade and it is now one of the main exporter countries of tilapia to the US. This Strategic Partnership project, funded by NORAD (Norwegian Agency for Development Cooperation) and PHARMAQ part of Zoetis recognizes the importance of adoption of best aquaculture and fish health management practices are important for continued sustainable growth, together with the wider societal and economic benefits of a profitable and productive aquaculture sector. The project was led by Caritas Norway and involved key partners from the private sector, PHARMAQ AS, Zoetis Colombia, the Colombian-Norwegian Chamber of Commerce, and Piscícola Botero, one of the largest Colombian producers and exporters of tilapia.

The overall aim of the project was to increase productivity, profitability, and sustainability in the tilapia value chain in the regions of Huila and Caquetá, by using a combination training in fish health management and fish vaccination; disease surveillance, promotion of environmental sustainability and the formalization of businesses; and the stimulation of business alliances between producers and buyers at local, national and international level.

The project provided a framework for partners to cooperate and deliver agreed project outcomes, which included delivery of theoretical and practical training in fish health management, the first use of vaccines on 7 tilapia farms in Huila, and the execution of a disease surveillance program. These outcomes and some of the wider benefits of the project will be discussed.

The Strategic Partnership model proved to be effective at encouraging collaboration between private enterprises and public/non-commercial organizations, enabling participants to share knowledge, experiences, know-how, and expertise. The project outcomes provided measurable contributions to several of the UN's Sustainable Development Goals SDGs. The project demonstrated that the Colombian tilapia farming industry is very open to improving in fish health management, including adoption of vaccination to prevent and control diseases. There was an obvious appetite for more technology and implementation of better routines in fish farms to further improve the productivity and sustainability of the tilapia production in Colombia.

MANEJO DEL SISTEMA DE ACUAPONÍA PARA EL CULTIVO DE *Lemna minor*

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Actualmente, la sostenibilidad junto con la seguridad alimentaria, son de los principales objetivos a alcanzar en la producción primaria. La acuaponía es una técnica que permite combinar el cultivo de animales acuáticos, como los peces, con la producción hidropónica de plantas, las cuales, funcionan como filtros biológicos. El buen funcionamiento del sistema se basa en el equilibrio dinámico de los elementos que lo conforman, tanto bióticos como abióticos. Existen diversos estudios que le confieren a las macrófitas acuáticas como *Lemna minor*, grandes atributos, destacando su utilización para la alimentación de diferentes especies, desafortunadamente, existe muy poca información sobre el manejo del sistema acuapónico para el cultivo de esta especie. Con el objetivo de determinar los parámetros de manejo adecuados para el cultivo de *L. minor* integrada a la producción de *Oreochromis niloticus*, en acuaponía, se realizaron 3 experimentos para evaluar el efecto del tiempo de retención hidráulico (TRH) y la densidad de siembra, así como, el balance de nutrientes en el sistema.

Las variables evaluadas fueron producción de biomasa, tasa absoluta de crecimiento, diseminación de la planta en la cama hidropónica (CH) y su relación con los días de cultivo, también se determinaron el balance de masas y de N y P. Se utilizaron dos modelos distintos de sistema de acuaponía, y los cultivos se llevaron a cabo en invernaderos.

Los resultados muestran que la mayor producción de biomasa y crecimiento vegetal se logran con una tasa de flujo de agua altas y TRH cortos. También se observó que la densidad de siembra en las CH tiene un efecto directo sobre el comportamiento productivo de la planta. La mayor producción de biomasa vegetal, crecimiento y diseminación de la planta (%) de *L. minor* acuapónica se presentan con un manejo de 30 min de TRH y 300 g m² de densidad de siembra. En los peces, no se observaron signos aparentes de enfermedad o mortalidad. En cuanto al balance, entre el 7 al 8% de los nutrientes (entrada en base seca, N y P) son retenidos por *L. minor*, manteniendo la calidad de agua dentro de límites adecuados para la producción. Una vez estable el sistema acuapónico, los parámetros de calidad de agua se mantienen para el adecuado crecimiento de *L. minor* y *O. niloticus*, donde se recomiendan valores de conductividad eléctrica mínima de 1.4 mS/cm³, con temperaturas alrededor de 25°C, 7.5 de pH y 5 mg L⁻¹ de oxígeno disuelto. Con una entrada diaria al sistema (por medio del alimento) de 18 a 19 y 3 a 3.5 g de materia seca de N y P, respectivamente, es factible cultivar entre 5 y 6 m² de área de siembra de *L. minor*, se recomienda tomar en cuenta, la especie animal a producir, el grado de digestibilidad del alimento y la tasa de alimentación a utilizar, para calcular la biomasa animal del estanque para la siembra. Los resultados aquí presentados nos permiten concluir que es más conveniente utilizar la relación entrada de nutrientes : biomasa vegetal a producir, que la relación convencional de biomasa animal : vegetal, y sobre la disponibilidad de nutrientes calcular la biomasa animal a cultivar.

BIENESTAR EN EL CULTIVO DE TILAPIA: EVALUACIÓN DE INDICADORES OPERACIONALES CON ENFOQUE EPIDEMIOLÓGICO

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El bienestar animal es el conjunto de actividades que el acuicultor debe realizar para proporcionar tranquilidad, comodidad, protección y seguridad a los animales durante su crianza, mantenimiento, producción, transporte y matanza. La epidemiología veterinaria es el estudio de las enfermedades que se presentan en las poblaciones y los factores que determinan su ocurrencia; siendo la palabra clave la población, incluye la investigación y evaluación de otros eventos relacionados a la salud, en particular aquellos que impactan en la producción, por lo tanto, las herramientas epidemiológicas resultan útiles al estudiar el estatus de bienestar de un grupo determinado, estableciendo criterios diagnósticos para realizar evaluaciones que permitan la prevención, detección, corrección y control de problemas. Los análisis epidemiológicos determinan la exposición de una población a un factor de riesgo, es decir, la probabilidad de presentación de un evento específico en un tiempo definido. La producción acuícola se evalúa tomando en cuenta la población, no es individual, por lo cual, las ventajas de analizar indicadores de bienestar (IB) con herramientas estadísticas epidemiológicas, permite visualizar el estatus de un conjunto determinado de peces (estanque), avanzando en el conocimiento del bienestar animal y la aplicación de los IB en laboratorios o granjas. El objetivo del presente estudio fue evaluar con un enfoque epidemiológico el efecto de diferentes tasas de alimentación sobre indicadores de bienestar operacionales en el cultivo de *Oreochromis niloticus*.

Se utilizó un estudio de cohorte (prospectivo), basado en la evaluación de la ocurrencia de un evento (presencia / ausencia) como resultado del seguimiento en el tiempo de un grupo, como consecuencia de haber estado expuesto o no (grupos de comparación) a una determinada exposición (factor de riesgo / tratamientos). Por medio de determinar daños / lesiones corporales en los peces. Se utilizaron 4 tasas de alimentación como tratamientos y se obtuvieron datos de 6,480 peces. Se determinaron la incidencia y el riesgo relativo, en 5 etapas de crecimiento de tilapias, cultivadas en sistemas de recirculación acuícola. El proyecto fue evaluado y aprobado por el Comité Institucional de Bioética en la Investigación de la Universidad de Guanajuato (clave: CIBIUG-A59-2020).

La incidencia de mortalidad, disminución del peso y condición corporal, y el daño en aletas caudal y anal, pueden utilizarse como Indicadores Operacionales de Bienestar en el cultivo de *O. niloticus* aplicando un enfoque epidemiológico, ya que estas se presentaron de forma contundente en las fases de cultivo evaluadas. Como resultado de este estudio, se puede concluir que el análisis epidemiológico es una herramienta valiosa para la producción, además, el método de abordaje desarrollado es fácil de implementar, económico y propone un semáforo de riesgo (con límites definidos) que podría tener un gran potencial, permitiendo una evaluación y toma de decisiones progresivas para corregir las situaciones de riesgo que se puedan presentar en las diversas fases del ciclo productivo.

IMPLEMENTACIÓN EXITOSA DE LA TECNOLOGÍA IPRS EN LA PRODUCCIÓN DE TILAPIA EN COLOMBIA

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Debido a la necesidad de incrementar la producción de tilapia se recurrió a desarrollar una explotación picola bajo el sistema IPRS con el animo de tener una producción sostenible ambientalmente y que mejorase los parámetros productivos que llevasen a una mayor rentabilidad.

Por este motivo en el año 2019 se inició la construcción de un estanque con capacidad de 160,000,000 mt³ en el cual se construyeron 16 canales para la producción de tilapia roja y a su vez se implemento una zona de pre-levante de 24 piscinas de 64 mt³ con el fin de complementar la fase de engorde en los canales, para así lograr producir un promedio entre 35 y 40 toneladas mensuales de tilapia roja entera.

En el desarrollo del proyecto el objetivo principal fue tener bioseguridad por lo cual se construyo el mismo con sistemas que pudiesen mitigar cualquier inconveniente de tipo eléctrico , hidráulico y sanitario.

Al ser un sistema de producción en el cual realizar reparaciones o mantenimientos pueden afectar el ciclo productivo, este mismo se construyó con materiales que perduren en el tiempo o que por lo menos se mantengan hasta que el cuerpo de agua requiera un cambio total por daño de las condiciones físico químicas del agua o por reproducción de diferentes especies en el estanque.

Como resultado de tres años de producción, podemos concluir que el sistema a sido exitoso porque se a logrado mejorar los parámetros zootécnicos como conversión alimenticia, velocidad de crecimiento, sobrevivencia y densidad poblacional. lo que a generado en una mayor rentabilidad debido a disminución de los costos de producción.

También podemos concluir que hay que mejorar el sistema de extracción de la heces, la oxigenación, la seguridad de las mallas y los tiempos de cosecha para obtener mejores resultados y así disipar los costos.



**PARAMETROS CELULARES Y BIOQUIMICOS DE SEMEN FRESCO Y
CRIOCONSERVADO A DIFERENTES TIEMPOS DE ALMACENAMIENTO DE YAMÚ
*Brycon amazonicus***

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La crioconservación seminal permite una producción constante de peces nativos de interés comercial como el yamú. No obstante, esta causa daños a los espermatozoides debido al estrés tóxico y osmótico de los diluyentes y por las bajas temperaturas. El objetivo de este trabajo fue comparar parámetros de calidad espermática como: duración de la motilidad, porcentaje de motilidad, viabilidad y morfología espermática, capacidad antioxidante total (TAC) y concentraciones de ATP, tanto en semen fresco (SF) como en crioconservado (SC) 24 horas, 1 mes y 3 meses de *B. amazonicus*. La investigación se llevó a cabo en el Laboratorio de Reproducción y Crioconservación de Peces del Instituto de Acuicultura y Pesca de Los Llanos. Ocho machos sexualmente maduros (1,2±0,1 Kg), se indujeron con Extracto de Hipófisis de Carpa (4 mg/Kg), a las 18 horas posteriores, el semen con una movilidad >90%, fue diluido en una proporción 1:4 en una solución de glucosa (5,5%), yema de huevo (12%) y DMSO (10%), empacado en macrotubos de 5 ml y congelados en vapores de nitrógeno líquido (-70°C) durante 30 minutos, posteriormente fueron sumergidos en tanques a -196°C y evaluado a las 24 horas, 1 mes y 3 meses de crioconservación. El porcentaje de movilidad fue superior (p<0,05) en el SF (95,5 ± 2,9%). La duración de la movilidad del SF fue significativamente mayor (113,6 ± 22,6s) a la del SC 3 meses (71 ± 12,2s). La viabilidad espermática del SF fue mayor (97,1 ± 1%) a los tratamientos del SC. Las anomalías espermáticas en el SF fueron menores (12,4 ± 3,2 %) que el resto de los tratamientos. Las concentraciones de ATP del SF (1,74 ± 4,5 nM.10⁸ sptz) solo fueron superiores (p<0,05) al SC 1 mes (1,16 ± 1,2 nM.10⁸ sptz). La TAC fue mayor (p<0,05) en el SF (26,46 ± 1,2 mM de Trolox) en comparación a los tratamientos de SC, sin embargo, no se encontraron diferencias significativas (p>0,05) de este parámetro entre los tiempos de crioalmacenamiento.

CULTIVO EXPERIMENTAL DE JUVENILES EN LA ALMEJA ESTUARINA AMENAZADA *Polymesoda arctata* (Deshayes, 1854), EN LA REGIÓN DE SANTA MARTA, CARIBE COLOMBIANO

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La almeja estuarina *Polymesoda arctata* es un bivalvo del Caribe de importancia comercial, el cual actualmente se considera amenazado debido a su sobrepesca y pérdida de hábitat. Como parte de un esfuerzo para garantizar su conservación y uso sostenible mediante acuicultura, se evaluó la viabilidad biológica y tecnológica del cultivo de juveniles producidos en laboratorio en diferentes lugares de la región de Santa Marta, Caribe Colombiano. Para ello, se llevaron a cabo varios experimentos en los que se probaron diferentes sitios (laboratorio, estanques en tierra, así como en Tasajera, Bodega, Isla Majagualito, Palmira y Nueva Venecia, estos últimos ubicados en el complejo lagunar de la Ciénaga Grande de Santa Marta), densidades (30, 50 y 74% de cobertura del fondo de la red) y métodos de cultivo (fondo y suspensión). Mensualmente, a lo largo de un periodo de hasta 4 meses, se evaluó el crecimiento en peso vivo y en longitud de concha, la supervivencia de los animales de cada tratamiento, así como algunos parámetros fisicoquímicos (concentración de oxígeno, temperatura, salinidad, pH, amoníaco, seston total y orgánico).

Mayores valores de crecimiento y supervivencia fueron hallados en los juveniles cultivados en laboratorio, mientras que los menores ocurrieron en Isla Majagualito y Nueva Venecia, encontrándose una mortalidad total en el último sitio, asociada a la alta concentración de seston y a la baja saturación de oxígeno. En la Bodega se encontraron altos valores de crecimiento, pero se registró pérdida de animales por robo. Mientras, en los cultivos en estanques en tierra y en Tasajera se observaron valores bajos o intermedios de crecimiento y supervivencia correlacionados con cambios abruptos de salinidad. Respecto a la densidad de cultivo, no se encontró efecto de esta sobre la supervivencia de los juveniles, pero mayores valores de crecimiento se verificaron en las almejas mantenidas a densidad baja. Finalmente, el crecimiento de las almejas fue mayor cuando se cultivaron en suspensión que en el fondo, pero la supervivencia fue superior en el cultivo de fondo. Estos resultados sugieren que el cultivo de almejas juveniles producidas en laboratorio con longitudes de concha menores a 2cm, es biológica y tecnológicamente viable, obteniéndose los mayores desempeños biológicos cuando son mantenidos en laboratorio o en el medio natural en zonas con baja fluctuación de salinidad, niveles altos de oxígeno y concentraciones de seston moderadas, y en condiciones de baja densidad, ya sea en el fondo o suspensión. Resulta importante continuar experimentando el cultivo de esta especie en otras zonas estuarinas de la región y usando otros sistemas de cultivo que permitan optimizar los resultados obtenidos.

CONTROLES DURANTE EL MANEJO Y ALMACENAMIENTO DE ALIMENTOS CONCENTRADOS PARA COBIA (*Rachycentron canadum*) EN PANAMÁ

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Los controles de monitoreo y verificación, durante el proceso de elaboración del producto Cobia (*Rachycentron canadum*) en Open Blue Sea Farms, son fundamentales para cumplir con un sistema eficiente de calidad e inocuidad alimentaria. Una parte muy importante del aseguramiento de la calidad e inocuidad de nuestro producto, son los controles del alimento concentrado con el que se alimenta la Cobia en la Granja. Estos controles inician desde la recepción del alimento y se mantienen durante su almacenamiento y utilización en los barcos de alimentación, permitiendo así garantizar un suministro constante de los nutrientes y energía requerida por la Cobia, para luego convertirse en el producto de la más alta calidad que entregamos a nuestros clientes.

Se logró determinar los controles requeridos en el manejo y almacenamiento del alimento concentrado. Se inicia desde su recepción en la bodega de almacenamiento, en donde se verifica que el mismo no presente hongos, parásitos, objetos extraños u otros contaminantes. Se toman muestras aleatorias y se procede a los controles físicos, químicos y microbiológicos para conocer el estado del alimento recibido y su cumplimiento con la especificación. El alimento se almacena a una humedad y temperatura que oscila entre 60 % - 90 % y 25 °C – 35 °C respectivamente y cumple con la rotación establecida para cada tipo de alimento. Al solicitar un alimento para consumo en granja, se aplican los controles de despacho para aprobar que el alimento esté conforme para su uso.

Los controles establecidos, toman en cuenta las condiciones físicas y climáticas del país, pues esto influye en la degradación de los nutrientes contenidos en el alimento concentrado. Esto es validado por medio de estudios y análisis de laboratorio, de manera que se pueda establecer por ejemplo el tiempo máximo de almacenamiento y las tolerancias permitidas en las variaciones de los parámetros controlados.

Todos los alimentos concentrados recibidos en Open Blue Sea Farms deben pasar por 12 controles para su uso, tal y como se indica en la tabla #1.

Los resultados muestran que, al aplicar controles de calidad rigurosos durante las inspecciones desde la recepción hasta el despacho, el alimento que se recibe en la Granja cumple con los estándares establecidos para garantizar la adecuada nutrición de la Cobia y que el producto terminado sea de la más alta calidad, garantizando la inocuidad y el contenido nutricional ofrecido a nuestros consumidores.

Tabla #1. Controles de calidad por etapa aplicados en al alimento concentrado en Open Blue Sea Farms.

Controles Aplicados en la Recepción de Alimento Concentrado
Registro de Recepción de Alimento
Registro de Inspección de Sacas
Registro de Análisis Físico de Alimento
Controles Aplicados durante el almacenamiento de Alimento Concentrado
Registro de Humedad y Temperatura
Registro de Control de Plagas
Registro de Rotación de Alimento
Registro de Alimento No Conforme
Bitácora de Inspección Mensual de Alimento
Controles Aplicados en el despacho de Alimento Concentrado
Registro de Salida de Alimento
Base de Datos de Alimento Concentrado
Resultado de análisis físicos
Resultado de análisis químicos
Resultados de análisis microbiológicos

EFFECT OF STRESS ON DIFFERENT AGE GROUPS OF CULTURED *Labeo victorianus* CAUSED BY PHYSICO-CHEMICAL WATER QUALITY PARAMETERS

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Given the growth of the aquaculture industry and concerns over negative effects of stress on fish, it is important to research how cultured fish respond to stress. The duration and intensity of stress can lead to fish mortality, disease outbreaks, poor growth performance, and reproductive failure.

This study aims to investigate the impact of physico-chemical water quality parameters on the stress response of different age groups of *Labeo victorianus*, a cultured fish species. Four treatments will be conducted, each consisting of 100 fish of different age groups (5g, 20g, 50g, and 100g) housed in four tanks and replicated three times. The fish will be fed high-quality feeds with a crude protein content of 30% throughout the experimental period.

Blood samples will be collected from each age group every two days, and the cortisol, glucose, sodium, and chloride ion concentrations will be analyzed. This process will continue for 10 days, with subsequent blood samples taken every two days to monitor the effects of stress. Physico-chemical parameters of each experimental set-up will also be measured by taking three water samples from each setup before extracting blood samples from the experimental fish.

The analyzed blood and water samples from each treatment will be compared to evaluate the response of different age groups of *Labeo victorianus* to different water quality parameters. This study will contribute to a better understanding of how fish respond to stress and may inform strategies to mitigate negative impacts on cultured fish.

INFLUENCE OF WATER TEMPERATURE ON GROWTH AND PROXIMATE BODY COMPOSITION OF FINGERLING LARGEMOUTH BASS *Micropterus nigricans*

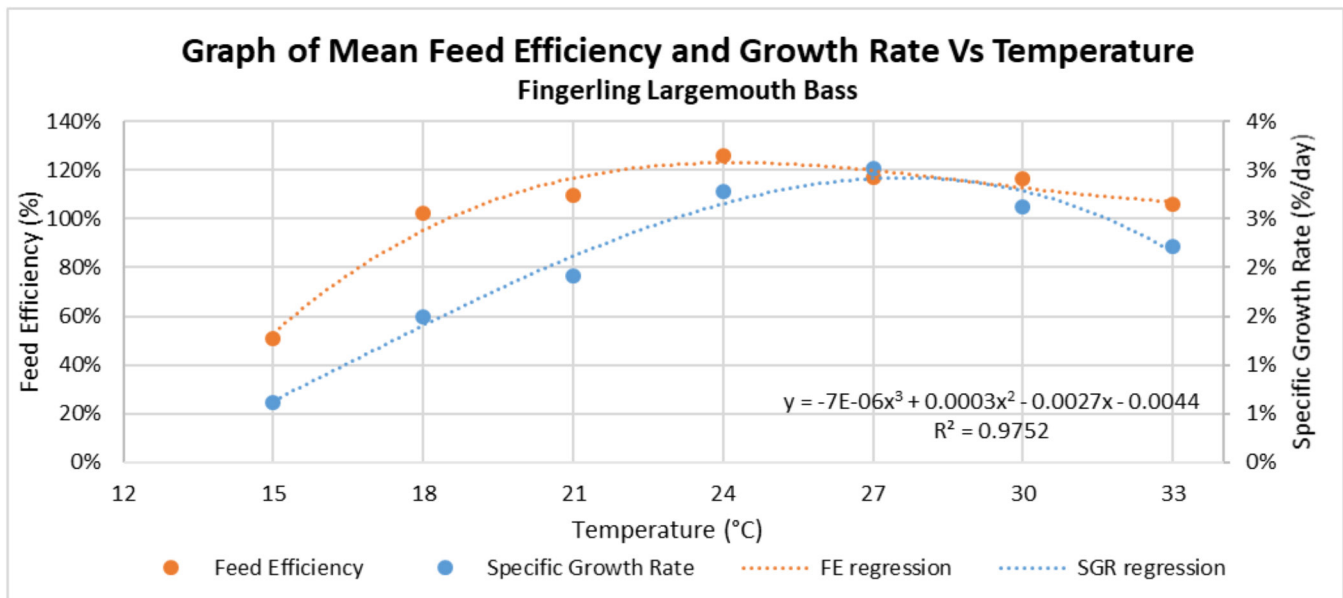
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This 6-week study examined the influence of water temperature on growth, condition factor, feed consumption, feed efficiency, and proximate body composition for young of the year feed trained largemouth bass (LMB) fingerlings.

Seven individual recirculating systems with four replicate aquarium tanks per system were randomly assigned a temperature treatment (15, 18, 21, 24, 27, 30, and 33°C). Each tank was stocked with 25 feed-trained fingerling LMB ($6.5g \pm 0.40$ / fish) and fed twice daily by hand to apparent satiation with slow-sinking commercial trout feed (45% protein, 20% fat). Water quality was monitored to maintain conditions suitable for growth. Weight and length for each fish was recorded at the end of the study. Fish in each aquarium were frozen and subsequently processed for proximate body composition. Significant differences were determined with One-Way ANOVA, and relationships described with regression analysis.

Feed consumption and growth among treatments increased to a maximum and then decreased with increasing temperature. Specific growth rate (SGR), final length and weight, feed consumption, and body weight gain (%) were significantly higher at 27°C ($P < 0.05$). Regression equation maximum for SGR was 28.45°C with an R^2 of 0.97. Feed efficiency was significantly higher at 24°C ($P < 0.05$). Regression equation maximum for feed efficiency was 24.91°C with an R^2 of 0.85. There was no significant difference in survival among treatments. Proximate body composition results will be reported in the presentation.



EFFECTS OF TEMPERATURE AND SALINITY ON REPRODUCTION AND SURVIVAL OF THE CYCLOPOID COPEPOD *Apocyclops panamensis*

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Apocyclops panamensis is a cyclopoid copepod that has emerged as an excellent live food organism for culture of larval marine fish. To determine the optimal temperature and salinity for culturing *A. panamensis*, a series of four experiments were conducted to measure the effects of temperature and salinity on survival, development time, reproductive capacity, and population growth. Temperatures of 18, 20, 22, 24, 26, 28 and 30°C and salinities of 0, 5, 10, 15, 20, 20, 25, 30, 35, 40 and 45 g/L were evaluated in multiple separate studies. Three experiments were the same for temperature and salinity. For the first experiment nauplii were stocked into 1 L beakers and cultured until maturation of the entire population, and survival, sex ratio, maturation time, and fecundity were determined. For the second experiment, nauplii production of one breeding pair was measured for 10 days. For the third experiment, the effects on growth and population composition were determined by stocking 10 breeding pairs in a 1 L beaker for 10 days. For temperature, the fourth experiment measured the effects on nauplii production in a group of 25 breeding pairs that were stocked into a 1 L beaker and nauplii production was determined. For salinity, the fourth experiment subjected nauplii and adults to an abrupt salinity change and survival was determined after 24 hours.

Temperature and salinity had numerous significant effects on *Apocyclops panamensis* culture and production. Results of sex ratio, the percentage of ovigerous females, and the proportion of eggs in each egg sac were not affected by temperature or salinity. First maturation and full population maturation were reached earlier at higher temperatures and lower salinities. Temperature and salinity significantly affected nauplii production per breeding pair and group nauplii production. Resulting population compositions were significantly different among temperatures and salinities. The culture temperature and salinity with the highest survival and highest nauplii production were 26°C and a salinity range from 20 g/L and 35 g/L.

EFFECTS OF DIETARY LONG CHAIN POLYUNSATURATED FATTY ACIDS (LC-PUFA) ON PACIFIC BLUE TANG (*Paracanthurus hepatus*) EGG AND LARVAL QUALITY

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The Pacific blue tang (PBT; *Paracanthurus hepatus*) is one of the most popular fish species sold to the marine ornamental aquarium trade. Although aquaculture has successfully produced this species, the only nutritional requirement known is the larvae require copepod nauplii in their diet. Long-chain polyunsaturated fatty acids (LC-PUFA), docosahexaenoic acid (DHA, 22:6n-3), eicosapentaenoic acid (20:5n-3; EPA), and n-6 LC-PUFA arachidonic acid (ARA, 20:4n-6) have effects on the egg and larval quality in aquaculture species. However, the effects of increasing LC-PUFA levels in PBT broodstock diets on egg and larval quality are unknown. A study was conducted to evaluate the effects of PBT broodstock nutrition on the quality of the eggs and larvae. Three experimental diets with different LC-PUFA concentrations: 3.5 % LC-PUFA (D3.5), 5% LC-PUFA (D5), and 6% LC-PUFA (D6) were fed to PBT broodstock for 7 months, the effects broodstock diets had on quantity and quality of PBT eggs and larvae was evaluated.

PBT egg production ($P = 0.083$) and fertilization percentage ($P = 0.088$) were not significantly different among diets. Egg hatching success ($P = 0.022$) and 3 dph larval survival ($P = 0.031$) were both significantly higher when broodstock were fed dietary LC-PUFA of 5% and 6%. Broodstock fed D5 and D6 produced significantly ($P = 0.033$) larger egg diameters, significantly ($P = 0.028$) larger oil globule diameters and significantly ($P < 0.001$) larger 3 dph larvae. 0 dph and 3 dph larvae from broodstock fed D6 had significantly ($P = 0.001$) larger oil droplet diameters. The different LC-PUFA concentrations affected the fatty acid composition of spawned eggs. High DHA and ARA concentrations in eggs improved egg and larval performance. A DHA:EPA ratio of nearly 2 in eggs was associated with improved larval quality. Results indicated that modifying the dietary PUFA content of PBT broodstock resulted in significant changes in egg and larval performance. Data suggested that increasing the LC-PUFA dietary content in PBT broodstock diets to 5% enhanced egg and larval quality.

RECOMMENDATIONS FOR SUCCESSFUL CULTURE OF PELAGIC SPAWNING MARINE ORNAMENTAL FISH SPECIES AND FIRST CULTURE SUCCESSES AT THE UNIVERSITY OF FLORIDA INDIAN RIVER RESEARCH AND EDUCATION CENTER

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Over the past ten years, University of Florida's Indian River Research and Education Center (UF-IRREC) and the Tropical Aquaculture Laboratory (UF-TAL) have been conducting aquaculture research on marine ornamental fishes to define species specific protocols for captive volitional spawning, feeding of larvae with copepods and other live food organisms, and juvenile growout to market size. Our goal is to support conservation by increasing the supply and number of species of marine ornamental fishes available from commercial aquaculture to the \$4.5 billion USD annual global reef aquarium industry.

This presentation will detail the current recommended best practices for captive volitional spawning and larval culture methods for pelagic spawning marine ornamental fishes. This presentation will cover broodstock systems and feeding, egg collector design options, larval culture system recommendations, and larval and juvenile feeding protocols.

The following pelagic spawning marine ornamental reef fishes were first cultured in captivity at UF-IRREC. Cuban hogfish (*Bodianus pulchellus*), reef butterflyfish (*Chaetodon sedentarius*), banded butterflyfish (*Chaetodon striatus*), copperband butterflyfish (*Chelmon rostratus*). Pacific blue tang (*Paracanthurus hepatus*) was first cultured by UF-TAL and later at UF-IRREC. For each species, the volitional spawning patterns in captivity will be presented. The successful larval feeding and culture protocols used, and photos detailing development from egg to the juvenile stages will be presented. Additionally, opportunities and challenges to commercial aquaculture of these species will be discussed.

EFECTO NUTRITIVO DE LA MICROALGA *Tetraselmis chuii* CULTIVADA CON ENSILADO DE DESECHOS DE PESCADO EN LA PRODUCCIÓN Y CONTENIDO PROTEICO DEL ROTÍFERO *Brachionus plicatilis*

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Brachionus plicatilis es una de las especies más utilizadas como alimento vivo para fases larvales -principalmente de peces- en acuicultura. Para su cultivo, se utilizan principalmente microalgas. Considerando la importancia de la calidad nutritiva de los rotíferos, en este estudio se evaluó el efecto de las microalgas del dinoflagelado *Tetraselmis chuii* cultivadas con ensilado de desechos de pescado sobre la producción y contenido de proteína soluble del rotífero *B. plicatilis*. Los desechos de pescado de “Chac chi” (*Haemulon plumierii*) fueron obtenidos de pescadores del puerto de Sisal, Yucatán, México. Los desechos fueron homogeneizados y se utilizó ácido fórmico a una relación de 20 ml kg⁻¹ (v/p) y el pH inicial y durante el ensilaje en 30 días fue registrado de acuerdo a Gallardo et al (2012). El experimento contó con dos tratamientos: A) rotíferos alimentados con las microalgas cultivadas con F/2 Guillard y B) rotíferos alimentados con microalgas cultivadas con una mezcla de F/2 Guillard y ensilado de 30d. El efecto de las microalgas sobre el crecimiento poblacional de los rotíferos (número de individuos y producción de huevos) y su contenido de proteína soluble después de 4 días de cultivo fue evaluado.

Una mayor producción de rotíferos fue observada cuando las microalgas utilizadas

fueron cultivadas con el ensilado hacia el final del bioensayo (Fig. 1). No se observaron diferencias en el porcentaje de producción de huevos entre ambos tratamientos durante el bioensayo ($p > 0.05$)

En cuanto al contenido de proteína soluble de los rotíferos, una mayor concentración fue observada en aquellos alimentados con las microalgas cultivadas con el ensilado (Fig. 2).

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Agradecimientos

Este trabajo fue realizado con el apoyo del proyecto PAPIIT IT201621 de la DGAPA-UNAM bajo la responsabilidad del Dr. Pedro Gallardo

Tabla 1.- Diseño experimental del cultivo de rotíferos *B. plicatilis* alimentados con las microalgas *T. chuii* cultivadas con dos medios de fertilización.

Tratamiento	Descripción de la fertilización	N
A	F/2 Guillard (Sol. A + Sol B)	4
B	F/2 Guillard (sol A) + ensilado	4

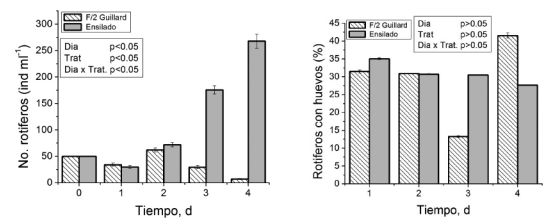


Fig. 1.- Número de individuos y porcentaje (%) de producción de huevos del rotífero *B. plicatilis* alimentados con *T. chuii* cultivadas con diferentes medios de fertilización. Promedio \pm E.S., n=4.

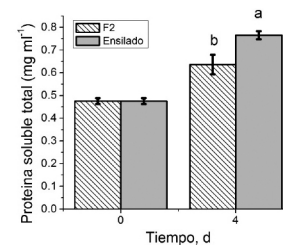


Fig. 2.- Contenidos de proteínas solubles totales (PS) evaluadas en los rotíferos *B. plicatilis* alimentados con microalgas *T. chuii* cultivadas con diferentes medios de fertilización. Promedio \pm E.S., n=4.

EVALUACIÓN DE LA MUDA DEL CANGREJO AZUL *Cardisoma crassum* EN CONDICIONES DE LABORATORIO

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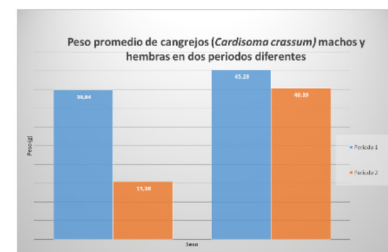
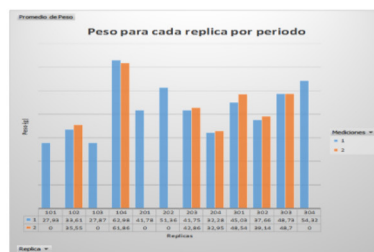
INTRODUCCIÓN. El cangrejo azul, *Cardisoma crassum* es uno de los recursos hidrobiológicos más apetecidos en el pacífico colombiano, por la calidad de su carne y condiciones organolépticas, este cangrejo es uno de los habitantes de las zonas de manglar con mayor importancia ecológica, participa en la reabsorción de desechos vegetales y animales Es un generador de recursos económicos a las familias que habitan en estas las zonas.

PLANTEAMIENTO DEL PROBLEMA Y JUSTIFICACIÓN Se desconocen los protocolos para el mantenimiento en cautiverio del cangrejo *Cardisoma crassum* la muda es uno de los factores que limita su desarrollo En tal sentido, se busca establecer los protocolos y mecanismos que posibiliten esta y con ello el crecimiento, así como la sobrevivencia en cautiverio.

REFERENTE TEÓRICO. *Cardisoma crassum* es un habitante normal de las zonas de manglar, se lo encuentra desde el sur de México hasta el norte del Perú, participa activamente en las dinámicas en la remoción del suelo en las playas y zonas de manglar El cangrejo azul se encuentra en terrenos salobres donde construye una serie de túneles en el suelo (Fischer et al 1995 Es de importancia económica para las familias que habitan en las zonas de manglar y alledaños. (Tabares Berón, 2017. **OBJETIVOS:** General: Evaluar la muda del Cangrejo Azul (*Cardisoma Crassum*) en un sistema cerrado de recirculación. Específicos: - Adaptar el *Cardisoma crassum* a condiciones de cautiverio. – Desarrollar procesos zootécnicos para la muda del *Cardisoma crassum* en condiciones controladas. **METODOLOGÍA.** La investigación se realizó en la Universidad del Pacífico ubicada en 3°50'52" .33 N - 76°59'58.81 O, a 18 metros sobre el nivel del mar, en la ciudad de Buenaventura, Valle del Cauca, Colombia. Se estableció un sistema de recirculación con doce (12) acuarios donde se han colocado un cangrejo en cada uno de ellos, con una capacidad de 2.7 litros por acuario un filtro con base en tela poliéster (guata), arena de sílice, piedra grava, y carbón activado. Se alimentan con camarónina con un contenido de 33% de proteína, que es un alimento balanceado para camarones marinos. Los animales se miden y pesan cada 15 días, diariamente se observan para establecer si se han presentado mudas. Se toman los parámetros físicos y químicos del agua que se encuentra a 16 Unidades Prácticas de Salinidad (UPS), semanalmente se realiza un recambio de agua del 10%. Los datos se analizan por individuo y por sexo. con SPSS se evalúa ANOVA.

RESULTADOS

Muda de cangrejos			
Replica	H	M	Total
102	1		1
104		1	1
203		3	3
204	1		1
301		1	1
303		2	2
Total	2	7	9



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EFECTO DE LA ADICIÓN DE *Azospirillum* SP. EN LA PRODUCTIVIDAD DE LECHUGA (*Lactuca sativa* VAR. KRISTINE) DENTRO DE UN SISTEMA ACUAPÓNICO CON TILAPIA GRIS (*Oreochromis niloticus*)

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La creciente demanda alimenticia y de productos pesqueros han propiciado la búsqueda de alternativas de producción sostenible. La acuaponía atiende a diversos desafíos socioambientales dado que permite combinar la producción de acuícola con la hortícola en un sistema integrado de recirculación. Permite una doble producción diseñada para el reciclado de nutrientes de las aguas residuales acuícolas. No obstante, en los sistemas acuapónicos puede ocurrir deficiencia de ciertos nutrientes, para estos las rizobacterias como *Azospirillum* sp., pueden aumentar la biodisponibilidad de los nutrientes y fijar nitrógeno. Los objetivos del presente estudio fueron evaluar el rendimiento de tilapia (*Oreochromis niloticus*), analizar el efecto del *Azospirillum* sp. en el rendimiento de lechuga y monitorear la calidad de agua recirculada en el sistema acuapónico. Se trasladaron al sistema 56 tilapias de 238 g promedio y lechugas variedad Kristine de 27 días, colocando 28 por unidad experimental. Para el experimento se utilizó un diseño experimental completamente al azar compuesto por un control y dos tratamientos con tres repeticiones cada uno. Dentro de los parámetros acuícolas se obtuvo un ICA de 2.62 con una sobrevivencia de 62.5% y ganancia de peso diaria de 1.15 gramos. El rendimiento de lechuga para los tratamientos inoculados con *Azospirillum* sp. mostraron mayor rendimiento en peso fresco foliar, peso fresco de raíz y largo de raíz en comparación con el control (Cuadro 1). La asimilación de nitrógeno en los tratamientos con *Azospirillum* sp., presentaron una mejor absorción y aprovechamiento de nutrientes lo cual resultó en mejores indicadores de calidad de agua.

Cuadro 1. Parámetros productivos de lechuga Kristine dentro de un sistema acuapónico.

Tratamientos	Largo de raíz (cm)	Peso fresco			Clorofila (SPAD)
		Raíz (g)	Foliar (g)	Total (g)	
Control	26.89 ±5.47 ^B	12.93 ±5.03 ^C	43.94 ±21.03 ^B	56.87 ±25.52 ^B	12.86 ±1.86 ^A
<i>Azospirillum</i> sp. – 1	32.52 ±5.13 ^A	21.93 ±8.22 ^A	60.65 ±14.48 ^A	82.60 ±21.84 ^A	12.73 ±1.77 ^A
<i>Azospirillum</i> sp. – 2	20.60 ±9.07 ^C	17.95 ±6.12 ^B	67.56 ±24.16 ^A	85.51 ±28.50 ^A	12.04 ±1.85 ^A
P	<0.0001	<0.0001	0.0001	<0.0001	0.1789

Nota. Medias con la misma letra no son significativamente diferente (P ≤0.05)

CAPTURA, TRANSPORTE, ACONDICIONAMIENTO Y PRIMER DESOVE DE *Sarda chiliensis chiliensis* PARA EL DESARROLLO DE HUEVOS Y LARVAS: UNA ESPECIE ALTERNATIVA PARA LA ACUICULTURA CHILENA

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La población silvestre de bonito del Pacífico Sur *Sarda chiliensis chiliensis*, tiene una amplia distribución en el norte de Chile, y se considera como una especie potencial para la acuicultura chilena. La viabilidad biológica del cultivo de cualquier especie marina comienza con el establecimiento de una población reproductora inicial para obtener huevos, larvas y juveniles.

En este trabajo se realizaron 22 campañas de pesca de bonito del Pacífico Sur en Pisagua, Chile, entre la primavera y el verano. Se obtuvieron al menos 74 ejemplares de los cuales 24 sobrevivieron a los procesos de captura y transporte. Los peces fueron reemplazados en un sistema de acuicultura terrestre de recirculación y a los 14 meses de cautiverio, los peces comenzaron a desovar.

Se recogieron huevos, para describir algunas fases de desarrollo, y se colocaron en incubadoras a 20 °C, al tercer día eclosionaron los huevos.

Las larvas alcanzaron una longitud total entre 1,44 y 1,70 mm, las cuales se caracterizaron los cambios morfológicos durante sus primeros estadios.

Este es el primer trabajo que describe la captura, transporte y aclimatación en cautiverio de una población de reproductores del bonito del Pacífico Sur en el norte Chile.

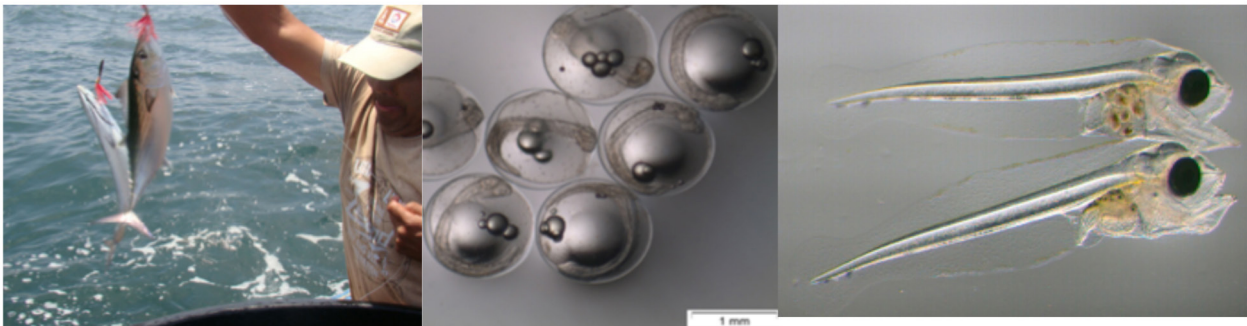


Figura1.- Captura, desarrollo embrionario y larvario de *Sarda chiliensis chiliensis*

RELACIÓN TALLA-PESO Y FACTOR DE CONDICIÓN DE TILAPIA ROJA *Oreochromis Sp.* PRODUCIDA EN SISTEMA SEMI-INTENSIVO Y VALORIZACIÓN TECNOLÓGICA DE SU PIEL POST-FILETEADO

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El objetivo de este trabajo fue evaluar la relación talla-peso (LWR) y el factor de condición relativo (Kr) de tilapia roja (*Oreochromis Sp.*) producida en un sistema semi-intensivo en estanques de geomembrana en la piscícola Playapez, y dar un aprovechamiento a la piel obtenida post-procesamiento a través de la extracción de colágeno. Se sembraron 4000 peces, se midió manualmente la longitud (L) y el peso (W) durante 6 meses y se analizaron los datos estadísticamente para estimar los parámetros “a” y “b” de LWR y calcular Kr. Al alcanzar la etapa adulta, las tilapias se filetearon y su piel se utilizó para la extracción de colágeno.

La tilapia (*Oreochromis Sp.*) se considera una de las fuentes de proteína animal más importantes del mundo (Arias et al., 2022). En Colombia, la producción de tilapia en 2021 fue de 111.660 toneladas representando un 58% de la producción nacional (Fedecua, 2022). Sin embargo, no existe información sobre estudios de relación talla-longitud (LWR) para tilapia roja o sobre la extracción de colágeno a partir de su subproducto, a pesar de su gran valor económico a nivel mundial.

La relación entre talla y peso de las tilapias (LWR) y el Kr se calcularon mediante las ecuaciones $W=aL^b$ y $Kr = W/(aL^b)$ (Le Cren, 1951), respectivamente, donde W y L son el peso (g) y la talla (cm) de la tilapia, mientras que “a” y “b” son los parámetros biométricos de LWR (Tran et al., 2021). El colágeno se obtuvo empleando un método de extracción que implicó hidrólisis básica con NaOH (0,1 N) e hidrólisis ácida con CH₃-COOH (0,5 M) para la obtención del colágeno.

La talla y el peso estuvieron altamente correlacionados ($p<0.05$), los valores de b exhibieron un crecimiento alométrico negativo ($b<3$) y Kr presentó valores cercanos a 1,0 durante las diferentes etapas de producción, indicando un buen estado de salud en las condiciones del estudio. Por otro lado, el rendimiento de extracción del colágeno de piel fue mayor al 15%, indicando que este subproducto de la tilapia roja podría considerarse una buena fuente de esta importante proteína.

Tabla 1. Parámetros de relación talla-peso y factor de condición relativo de tilapia roja

Parámetro	Etapa productiva		
	Alevino	Juvenil	Adulta
N	4000	3643	2626
L _{min-max} (cm)	2.4 - 6.5	7.3 - 20.0	15.0 - 22.5
W _{min-max} (g)	1.1 - 7.7	16.0 - 315	103 - 423
b	2.78	2.95	2.69
K _r	1.12±0.19	1.04±0.20	1.02±0.14

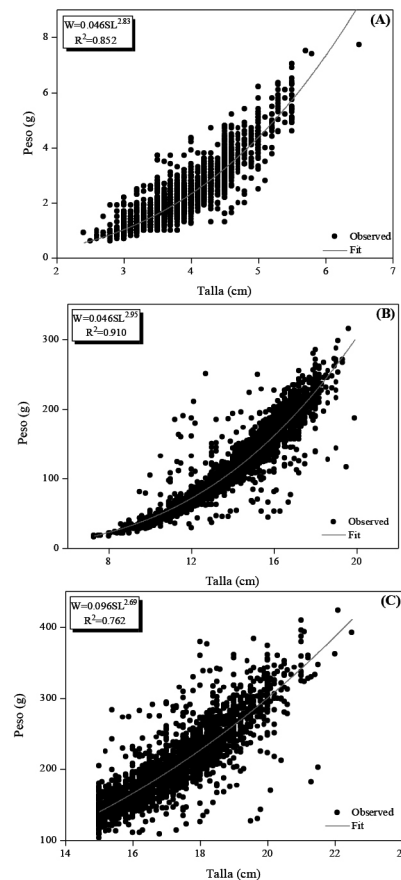


Figura 1. Estudio de relación talla-peso para *Oreochromis sp.* en la estación Playapez en etapa A) alevino, B) juvenil y C) adulto.

TILAPIA EN TIEMPOS DE GUERRA, EXPERIENCIA DE UNA EMPRESA EN HAITI

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Taino Aqua Ferme S.A. es una empresa fundada en Haiti en el año 2015 que a la fecha ha cosechado 1200 toneladas de tilapia cultivadas en jaulas en el lago Azuei, un lago con 10 ppt de salinidad ubicado en la frontera con Republica Dominicana. Desde el homicidio del presidente Jovnel Moise en Julio del 2021, el país ha entrado en una fase de violencia y desgobierno que ha dificultado enormemente el operar una empresa, especialmente una acuícola que depende de la importación de alimento desde el extranjero y vende su pescado entero fresco en el mercado nacional adonde no hay seguridad vial pues las pandillas se han tomado las vías principales.

El énfasis de esta charla es demostrar con resultados de jaulas cosechadas como la tilapia ha sido la especie ideal para cultivar en esta difícil situación de orden público, adonde hemos llegado a periodos de hasta 33 días sin alimentar las jaulas y cuando si hemos logrado importar alimento las tasas de alimentación han estado por debajo de 40% saciedad.

Como es esperado, los indicadores de duración del ciclo de engorda se han incrementado en promedio unos 62 días (incremento de 29%) y el peso promedio a la cosecha se ha disminuido en 122 gramos en promedio (disminución de 20%). Lo gratamente sorprendente y el merito de la tilapia es que, con periodos tan extendidos sin alimentación y subalimentación, los índices de eficiencia en produccion no se han deteriorado. El índice de conversión alimenticia mejoro de 1.79 a 1.69 y la sobrevivencia a partir de vacunación y conteo laser mejoro de 83% a 86%.

No tiene sentido subalimentar, o no alimentar, para obtener mejores índices de eficiencia en el cultivo, pues la productividad del sistema disminuye sustancialmente. Pero en momentos de dificultad en la operación de una empresa en nuestros países adonde es común haya problemas de orden público, dificultades logísticas o desastres naturales, la biología de la tilapia y su habilidad de filtrar alimentos naturales y aprovechar el fouling en superficies del cultivo la hace una especie ideal para cultivo en países en vía de desarrollo.

ACUACULTURA SUSTENTABLE: PRODUCCIÓN DE PANGASIUS CON ALIMENTO ORGÁNICO PARA LA SEGURIDAD ALIMENTARIA

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La producción orgánica en la acuicultura surge como una necesidad de la demanda social de alimentos cada vez más nutritivos e inocuos sobre todo en la era Post-COVID. Una producción sustentable que use cada vez menos insumos químicos con menor huella ecológica y que a la vez resulte en proteína alternativa a menor costo es la tendencia actual.

Además, la producción de peces con alimentos producidos *in situ* por el mismo acuicultor con insumos locales usando sus recursos naturales y fuerza de trabajo familiar promete ser altamente rentable para el pequeño productor y apuntalar la seguridad alimentaria.

El pez Pangasius (*Pangasius Hypothalmus*) también denominado Basa, originario de Vietnam y Camboya, es un organismo omnívoro, no muy exigente en proteína y puede comer alimento no flotante. Con las nuevas tecnologías de alimentos fermentados y pre-digeridos producidos en la granja se puede sustituir más del 50% del alimento comercial en la producción de Pangasius.

Esta investigación consistió en evaluar la tasa de crecimiento del Pez Basa alimentado con alimento orgánico producido en la granja por el acuicultor usando insumos locales como Maíz, Yuca y Malanga fermentados y pre-digeridos; y compararlo con la alimentación comercial de productos balanceado al 32.5% de Proteína.

El ensayo consistió en el desarrollo un tratamiento con dos repeticiones y un testigo. El tratamiento consistió en alimentación orgánica producida *in situ* en la granja a base de maíz, yuca y malanga fermentada y pre-digerida, el testigo fue alimentado con alimento balanceado comercial al 32.5% de proteína. Esto fue en una unidad de producción comercial, en estanques circulares de cemento de 25 m. de diámetro con fondo cónico y un metro de profundidad en la pared vertical y 2.5 m. de profundidad en el centro. Se sembraron 1,500 organismos de 250 a 300 gr. de peso. Se llevó seguimiento por 3 meses con biometrías cada 20 días.

Los resultados demostraron que no hay diferencias significativas en crecimiento del pez entre el tratamiento con sus repeticiones y el testigo.

Se concluye que es factible de sustituir gran parte del alimento comercial por alimento orgánico producido en la granja por el mismo acuicultor usando ingredientes cultivados por él. Esta sustitución puede ser del 50% o más, para engorda y finalización del pez basa, con un ahorro en el costo de producción de hasta el 30%. Es una estrategia para incrementar la seguridad alimentaria en la población de escasos recursos en las comunidades rurales con potencial acuícola.

GENOME EDITING FOR GENETIC IMPROVEMENT IN FINFISH AQUACULTURE

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Increasing ability to harness the power of genomics is forcing a rethinking of aquaculture genetic improvement strategies. Successful breeding programs will always be built on the careful selection of the next generation of broodstock, detailed record keeping, and accurate collection of phenotypic data. Genomics allows this base of phenotypic selection to be enhanced, and ultimately accelerated to increase genetic gain per generation. This is currently done in finfish at the most sophisticated level through the use of Genomic Selection. However, another exciting technology is on the horizon that will fundamentally change how we deliver genetic improvement. This technology is Genome Editing.

Genome Editing is a technology that can be thought of as “precision breeding”. It will be an important tool in the future toolbox for genetic improvement in aquaculture. The current state of the art in Genome Editing in aquaculture is impressive and on the cusp of significant commercial application. The basic concept is that enzymatic tools (such as CRISPR technologies) can be used to create variants in specific DNA sequences that create a desired phenotype (such as sterility, monosex, rapid growth, or disease resistance). The technique does not involve adding new DNA, so is not transgenic and does not create a GMO. It simply involves understanding the genomics and underlying genetic variant that is needed for a trait to be expressed, and harnessing natural processes to create that variant rather than sorting through many thousands of broodstock and many generations to achieve the same effect.

The power of genomic research is that we are beginning to understand the exact genes involved in performance traits, and how variation in those genes leads to improved performance. Harnessing the power of Genome Editing allows us to transfer this knowledge to application in commercial breeding programs for heritable, quantum advances in genetic improvement. Importantly, sterility will be a requirement in most applications of GE in aquaculture as a method of biocontainment to prevent escape to the environment, or the inadvertent application of genetically improved animals.

This presentation will provide background on how genome editing works, an update on regulation, and how this tool may be used to improve aquaculture genetics in the very near future.

EFFECT OF TILAPIA *Oreochromis niloticus* ON SUSPENDED SOLIDS CONSUMPTION WHEN INTEGRATED WITH *Litopenaeus vannamei* IN BIOFLOC SYSTEM

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Introduction

Total suspended solids (TSS) increase during the shrimp production in BFT system, which can affect water quality and animal performance. To control the excess of TSS during the shrimp production in the BFT system can be used mechanical filters (settling tanks) or the alternative integration with species that act in different trophic levels – Integrated Multitrophic Aquaculture (IMTA). The present study aimed to evaluate two stocking densities of tilapia in integrated culture with the shrimp *Litopenaeus vannamei* in biofloc system on a pilot scale.

Material and Methods

Two stocking densities of tilapia were tested, 35 and 65 fish m⁻³ in a recirculating system with 18 m³ tanks for shrimp culture and 4 m³ for tilapia culture with recirculation of 965.66 ± 92.83 L h⁻¹ during 78 days. The initial weight of the shrimp was 0.9±0.1 g and of the tilapia was 7.1±3.2 g. The shrimp received the amount of feed according to the feeding table and the fish were underfed to stimulate them to consume the bioflocs.

Results

Tilapia densities did not affect shrimp growth (11.5±1.9 g for treatment with 35 fish m⁻³ and 10.1±0.7 g for treatment with 65 fish m⁻³). The tilapia presented a FCR less than 1, proving the consumption of the bioflocs by the fish. The clarification time was shorter when compared to other studies with shrimp monoculture and among the treatments, where there was lower fish stocking density, there was a reduction of 10 hours in the system clarification when compared to the treatment with higher fish stocking density. The results demonstrate the feasibility of integrated shrimp and tilapia culture on a pilot scale, without compromising shrimp productivity.

EPPO: A PORTUGUESE RESEARCH FACILITY FOR THE DEVELOPMENT OF AQUACULTURE

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The Portuguese Institute for the Ocean and Atmosphere (IPMA, I.P.) is a public research institute and act as a counselor to the national authorities on the sea and atmosphere. IPMA, I.P., possesses a strong cluster of competences for the ocean and marine resources related to research, carried out by different groups, particularly dedicated to aquaculture and fisheries.

The Aquaculture Research Station of Olhão (EPPO, figure 1) stands out for the unique experimental conditions on aquaculture at the national and international levels. This marine core facility is equipped to carry out production studies at every scale from bench-top laboratory work to a much larger semi-industrial level. EPPO has an area of about 7ha with more than 250 tanks, including an hatchery fully equipped for research and experimental production with different rearing circuits (for broodstock, larvae, juvenile production, research with live animals and recirculation systems), a support building (with rooms for trophic chain production, daily routines and biological sampling), several analytical laboratories (biochemical, histological, molecular, microbiological and fish pathology), an unit for seafood packing, an area for pre-fattening (for earthen ponds and sea cages production) and 17 earthen ponds. It holds breeders of several marine fish species (e.g. meagre, gilthead seabream, seabass, Senegalese sole and sardine among others), microalgae and invertebrates as well as the know-how on the production of these species.

Production of new species, nutrition, welfare, environmentally friendly production systems and assessment of onshore and offshore and production systems for fish grow-out are some of research lines developed at EPPO (figure 2).

Acknowledgments: The research lines are partially funded by AQUARAS (Mar-02.05.01-FEAMP-0223), NOSTRESS_047122 and ALLARVAE_069971 (ALG-01-0247) projects.



Figure 1 - Aerial view of the EPPO

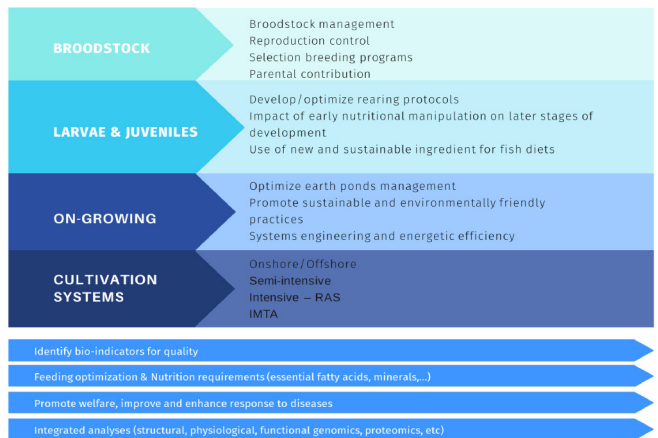


Figure 2 - On going research lines at EPPO

NEW MICROALGAE AND PROBIOTIC FORMULATIONS IN THE HEALTH OF MARINE FISH LARVAE

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Introduction

Despite the fast growth of aquaculture, there are still some bottlenecks to overcome towards a more sustainable and competitive industry. The high mortality rates of marine fish larvae, directly impact the number and quality of juvenile produced. During the larval stage most marine fish require live feed, for a correct development. Rotifers are great candidates for the early stages, as they have adequate size, slow movement, fast reproduction, and are easily cultivated. However, they are not nutritionally suitable for all marine species, and their enrichment is necessary. The green water technique consists on the introduction of microalgae in the larval tanks, as it creates a light diffusion pattern that facilitates the capture of prey and also enriches the live preys, providing essential nutrients to promote growth, survival, health, stress tolerance and reproduction. This work aims at the development of new formulations from microalgae towards the optimization of larval production, both to improve live feed and to increase larvae biological performance and stress response.

Methods

For the green water technique, a control (CTRL) with live *Nannochloropsis* sp. was compared to a group with *Nannochloropsis* sp. and *Chlorella* sp. supplemented with probiotics (NCp). Larvae of *Argyrosomus regius* were maintained for 18 days after hatching and growth and survival were analyzed. At this point, larvae were transported for 5 hours to induce stress. Larvae, from each treatment, were collected before and after stress to measure the impact of the treatments on oxidative stress by analyzing 1) enzymatic activity of oxidative stress enzymes and 2) gene expression of growth and stress markers. Larvae were also collected for microbiological analysis.

Results and Discussion

The use of the new microalgae formulation containing probiotics promoted a better survival compared to control (61.20 ± 15.79 % and 64.18 ± 9.31 , respectively). Throughout the trial, there were no significant differences in the number of total marine bacteria and Vibrionaceae in the digestive tract of the larvae. Through analysis of antioxidant enzymes, growth, and stress genes it was observed that the use of probiotics significantly increased the tolerance of larvae to stress.

In conclusion, no deleterious effects were provoked by the supplementation and the enzyme activity and genetic analysis suggested a positive effect of the probiotics on the tolerance to an external factor, contributing to improve larvae biological performance.

Acknowledgments

This work was financed by the project ALLARVAE (ALG-01-0247-FEDER- 069971) and AQUARAS (MAR-02.05.01-FEAMP-0223).

INDIRECT MEASURES FOR THE GENETIC SELECTION OF FEED EFFICIENT INDIVIDUALS IN COBIA *Rachycentron canadum*

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The high burden of natural resources for agriculture activities requires the development of the technologies and strategies that allow for more sustainable production. One of the main resources used in the aquaculture production is the feed, representing the highest cost in the production chain, ranging between 40% to 80% depending on the production system. The development of technologies that allow for the increase of Feed Efficiency (FE) will have direct impact on the sustainability of aquaculture industries and producers. Feed conversion rate (FCR) is a major indicator of the efficiency of a culture. It is defined as the mathematical proportion of feed given divided by an animal's weight gain. The commercial production of cobia (*Rachycentron canadum*) has a FCR above 2.5, note that this should not be compared to other more efficient aquaculture species with FCR values close to 1. Nevertheless, improvement and optimization of FE is possible through genetic selection processes, as has been demonstrated in other species, such as trout, salmon, and tilapia.

Genetic selection of feed efficient individuals would be a very effective strategy to reduce FCR. However, the processes to evaluate and obtain individual measures of feed intake for larger sized aquaculture species is complex. Poultry and trout investigations had developed indirect strategies to enable this evaluation, correlating phenotypic and metabolic indicators such as weight lost, yield, lipid contain, among others, with the FCR. The level of these relationships allows for the identification of patterns of individual EF, and for the definition of quantitative variables to be use into a breeding program.

The aim of this study was to determine if there is a significant correlation between the different metabolic and phenotypic markers, and FCR values after recovering from fasting for cobia fish (2.0 ± 0.5 kg). If any significant correlation was found, this FCR assessment method could be integrated into the breeding program at Open Blue to improve FE. The traits used to predict FCR would depend on the magnitude of the correlations identified. This study showed that individuals with major lost weight after starvation period achieved a more efficient FCR after recovery phase. Females had a significant higher weight gain than males (+5.5%), however, significant correlation were not found between lipids contain, and FCR.

GENETIC GAINS TAILORED TO YOUR NEEDS

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Selective Breeding is the process of improving one or more desirable traits of a cultured species through the selection of superior parents for the next generation. A breeding program is the implementation of a selective breeding strategy and the set of tools needed to deliver the desired outcomes. The approach selected should be designed to maximize the economic return by balancing input costs and with the expected genetic and economic gains for a commercial aquaculture producer.

In this talk we will discuss the general concepts and common strategies for shrimp breeding program management, from the simplest requiring the least amount of investment to the more complex with more investment required but greater genetic gains delivered. The aim of the talk is to provide aquaculture producers with the key elements to enable the informed assessment of the options for new or improved breeding program designs, and how they can tailor their program and genetic gains to their needs. The three general options for enhanced selective breeding management in shrimp are: 1) Mass Selection managing diversity and inbreeding, 2) Family based selection and 3) Genomic Selection. These management strategies should be used to build upon a good genetic foundation. It is recommended to assess the genetic base at the beginning, or before changing the strategy, of any breeding program. Key to assessing genetic diversity and to more sophisticated breeding strategies are genomic tools. The recent development of industry-wide, single nucleotide polymorphism (SNP) genotyping panels from 200 to 50,000 SNPs provides access to such tools at a very reasonable cost. When jumping from the basic to the complex, investment can be expected to increase with the need for genotyping, tagging equipment and supplies, more complex data collection, organization, and analyses, in addition to the training of personnel. While it is possible to change from a mass selection program directly to a genomic selection program, or to transition to a family-based plan on the journey to increased genetic progress. In all cases, training of personnel, and staged build-up of infrastructure and capabilities will be part of the process.

In summary, there are multiple options for enhanced selective breeding program management, each requiring different inputs and investment with varying potential returns and gains. Key to the selection of a genetic improvement design is the consideration of individual program's breeding goals, capacity, and available budget as well as the selection of the appropriate tools to support such a design.

LA SANIDAD EN PECES: HACIA UN CONCEPTO MAS HOLÍSTICO Y COMPLEJO

Edgar Andrés Pulido B. M.V. MSc

La presión por producir alimentos para una sociedad en constante crecimiento nos ha llevado a intensificar cada vez más los sistemas de producción, reevaluar las fronteras sanitarias para asegurar un mayor acceso a los productos e incorporar nuevas estrategias para optimizar los recursos hídricos y las fuentes de alimentación. Todo lo anterior, trae consigo nuevos retos en todas las áreas relacionadas con la producción donde la sanidad no es ajena a ello; por el contrario, cada vez es más común la detección de nuevas patologías, la adaptación e interacción de los patógenos ya presentes para provocar nuevos cuadros clínicos y una eficacia cada vez menor de los métodos de control usualmente empleados, entre otros. El éxito en el control de las enfermedades usando estrategias específicas y particulares es por ende, más limitado. Debemos propender por mejorar nuestro entendimiento de todos los factores y condiciones que rodean cada ecosistema y avanzar hacia una concepción más integral de la sanidad, donde se privilegien las estrategias de prevención y control más integrales, multicausales y multifuncionales.

En esta presentación haremos un resumen de las principales patologías, especialmente de los peces cultivados en aguas cálidas, y se expondrán algunos ejemplos que evidencian lo afirmado anteriormente.

FISH SLAUGHTER PRACTICES IN AQUACULTURE AND THEIR CONSEQUENCES FOR ANIMAL WELFARE

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The Food and Agriculture Organisation (FAO) in 2018 showed that the annual increase in fish consumption outpaced the growth in the consumption of meat from terrestrial animals. Unfortunately, welfare practices for aquatic animals remain incipient when compared to farmed terrestrial vertebrates. Within the aquaculture production chain, pre-slaughter and slaughter procedures are considered an important fish welfare issue, but often lack efficient humane slaughter methods. In summary, a slaughter is considered humane when performed in the absence of pain and fear, from the reception of animals in the slaughterhouse until their death. A humane slaughter process consists of a stunning step followed by the bleeding of an unconscious animal until its death.

The OIE Aquatic Animal Health Code, first adopted in 2012, and most recently updated in 2013, summarises the recommended fish slaughter methods (OIE 2021). For methods to be considered humane they need to result in the immediate loss of consciousness. Mechanical and electrical stunning, when applied correctly, are humane slaughter methods - both cause the immediate loss of consciousness. But these methods are rarely used. In practice, the most commonly used slaughter methods are not humane: chilling with ice in holding water, carbon dioxide (CO₂) in holding water, chilling with ice and CO₂ in holding water, salt or ammonia baths, asphyxiation by removal from water and direct exsanguination without stunning, are used in many countries, for many species, mostly tilapia and carp. All these methods have been shown to result in poor fish welfare and should be avoided. Mechanical or electrical stunning should be the preferred options.

In Brazil, for example, Coelho et. al, 2022, studied 62 facilities and observed that live chilling was the most commonly used method (82.0%), followed by electronarcosis (18.0%). In the case of tilapia, exsanguination (38.5%) and decapitation (2.5%) were prevalent. However, most Brazilian facilities (59%) fail to report the killing methods used.

We control what we measure

To be able to recognize the lack of humane slaughter we first we need to assess the stunning efficiency. While absence of consciousness may be difficult to recognise, signs of correct stunning include i) loss of body and respiratory movement (loss in opercular activity); ii) loss of visual evoked response (VER); iii) loss of vestibulo-ocular reflex (VOR, eye rolling) (OIE, 2015).

The practical Welfare Assessment Protocol, published by Pedrazzani et. al in 2020, successfully proposed the integration of individual welfare indicators into a single tilapia welfare assessment protocol, which proved easy to use and adapted to different farming practices. Regarding effective stunning, the indicators for the evaluation of tilapia consciousness included the clinical signs of opercular rate - estimated respiratory rate by counting the opercular movements (OR), vestibulo-ocular reflex, eye rolling (VOR), equilibrium in water, which is assessed by the position of the fish and its ability to swim when placed in the water. (EQ) and the tail-grab-reflex, the technique of grabbing the animal's tail to check if the fish tries to escape, (TGR). The indicators were classified in a 3-point scoring system as shown in Table 1. During this study, six properties refused to assess their slaughter practices. This suggests that some farms are insecure about the adequacy of their current practices.

	Level	Relevant indicators
Stunning efficiency	1	Instantaneous loss of EQ, TGR, OR and VER
	2	Instantaneous loss of EQ and TGR, progressive loss of OR and VER in ≤ 30s
	3	Progressive loss of EQ, TGR, VER, OR and VER in ≥ 31s

Table 1. Levels of stunning effectiveness according to relevant indicators for the slaughter of tilapia (adapted from Pedrazzani et al, 2020).

(Continued on next page)

Continuity and Actual Change

As part of the FAI Tilapia Welfare Project, funded by The Open Philanthropy, assessments have been performed on several tilapia farms and slaughterhouses in Brazil. The constant application of the protocol during the full production cycle, including slaughtering, has been a powerful tool to support the decision-making process that led to adapted handling procedures and investments in equipment to support effective stunning. To make the implementation of humane slaughter accessible to the industry, an offline tilapia Welfare Assessment App is freely available and in use to facilitate the information collection as well as to provide feedback to the users. As an interesting case study, one of the companies involved in the project has purchased electrical stunning equipment, to improve welfare practices and provide better working condition for their staff. With the right knowledge and methodology, it is possible to promote positive animal welfare changes within the industry. It is relevant to stress the importance of appropriate regulation, but successful private initiatives demonstrate both the feasibility and the need for improvements in fish slaughter practices.

Conclusion

The current scenario highlights the urgent need for development and enforcement of humane fish slaughter techniques, with routine supervision and normative requirements. We understand that with appropriate tools for welfare assessment and effective knowledge-transfer, it is possible to drive constant improvement on tilapia welfare with the agreement and support of fish farmers and the industry.

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Pedrazzani AS, Quintiliano MH, Bolfe F, Sans ECO and Molento CFM 2020 Tilapia on-farm welfare assessment protocol for semi-intensive production systems. *Frontiers in Veterinary Science* 7: 1-16. <https://doi.org/10.3389/fvets.2020.606388>

World Organisation for Animal Health (OIE) 2021 *Aquatic Animal Health Code*. <http://www.oie.int/standard-setting/aquatic-code>

ACUICULTURA DE PRECISIÓN Y SU IMPACTO EN LA EFICIENCIA DE PRODUCCIÓN DE CAMARONES *Litopenaeus vannamei* EN LATINOAMÉRICA

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El precio internacional de comercialización del camarón ha exigido la rápida implementación de técnicas y automatización que permiten alcanzar mejor rendimiento productivo y económico.

La acuicultura de precisión, con la automatización e implementación de equipos tecnológicos de alimentación automática, alimentación sónica y mediciones digitales complementarias de otras variables como las fisicoquímicas, así como protocolos de manejo ha permitido mejorar los indicadores productivos en el cultivo de camarón: mayor crecimiento y biomasa, menor Factor de Conversión Alimenticia (FCA), mejor índice de eficiencia productiva (IEP).

$$\text{IEP} = ((\text{Crecimiento semanal (g)} \times \text{Supervivencia (\%)}) / \text{FCA}) / 100$$

El seguimiento, evaluación y análisis integral del cultivo depende de un adecuado manejo de alimentación (según estacionalidad y momento en cada etapa del cultivo), la correcta forma de monitoreo, así como la interrelación con los análisis sanitarios como la patología en fresco, análisis de lípidos y de sanidad acuícola, microbiología, PCR u otros, que afiancen la correcta dosificación, control de la supervivencia, y permitan alcanzar el máximo crecimiento con el menor Factor de Conversión alimenticia (FCA).

En el manejo de precías se puede conseguir pesos entre 0,5 -0,7 g en tres semanas de cultivo, y sostener crecimientos lineales mayores de 2,2 g/semana con raleos (cosechas parciales) y pesos finales mayores de 38 g.

El desarrollo de esta industria ha requerido la implementación de estrategias y protocolos de biorremediación, adaptación a condiciones de cultivo de agua dulce (baja salinidad) y de la adaptación de otras tecnologías usadas en otras actividades como la pesca, para el conocimiento de la profundidad y condiciones del suelo de una piscina que permite realizar las mediciones de forma rápida y confiable.

El fortalecimiento de este cluster productivo es muy necesario, dado que se requiere agilidad en los proveedores de estos nuevos productos y servicios, así como en la academia, reforzando la preparación de futuros profesionales universitarios y técnicos.

Se presenta un comparativo de producción, estatus productivo, estrategias y técnicas empleadas entre Ecuador y los principales países de Latinoamérica. Ecuador es el primer productor del mundo con más de 1,3 Mío TM.

EFECTO DE LA CRIOPRESERVACIÓN SOBRE EL CRECIMIENTO DE LA MICROALGA *Chlorella* sp, COMO ESTRATEGIA EN LA CREACIÓN DE UN BANCO DE GERMOPLASMA

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Las microalgas son organismos fotosintéticos que producen altas cantidades de proteínas, vitaminas, pigmentos y otras moléculas, siendo aprovechadas en diversas áreas industriales como farmacéuticos, nutricionales, ambientales, entre otras. La criopreservación es una herramienta que ayuda a establecer bancos de germoplasma que mantienen la biodiversidad y aseguran la conservación genética de una especie brindando un escenario que permite mantener las condiciones y viabilidad celular durante su almacenamiento por periodos largos a temperaturas bajas (-196°C), además de garantizar la sanidad y calidad fisiológica de los ceparios de microalga. Una de las especies de mayor relevancia en el mercado y en la actividad acuícola es la microalga del género *Chlorella* sp, debido a su alto valor nutritivo, energético y por su facilidad en su cultivo con amplios rangos de tolerancia a niveles de pH, temperatura, salinidad, entre otros. Como parámetro de crecimiento sobre *Chlorella* sp, se evaluó el medio de cultivo complejo Remital® en tres concentraciones diferentes (0,6; 1,2 y 1,8 gr/L). De acuerdo, a los resultados obtenidos la concentración de 1,8 gr Remital®, presentó los mejores resultados en crecimiento. Para el proceso de criopreservación se evaluaron los crioprotectores Metanol y Glicerol en dos proporciones cada uno (10% y 15%), en dilución 1:4 (microalga:crioprotector), almacenado en pajillas de 0,5 ml y puestos en termo de vapores de nitrógeno líquido durante 20 min, posteriormente trasladadas a un termo de almacenamiento de nitrógeno Líquido (-196°C). La descongelación se realizó a 35 °C durante 90 seg, determinando parámetros de crecimiento y viabilidad celular, este ultimo usando el método TTC (2, 3, 5 - Cloruro de Trifeniltetrazolio).

Resultados

Los resultados muestran que el medio de cultivo Remital®, permitió un crecimiento exponencial a corto tiempo (2 días de cultivo), siendo efectivo como alternativa en la producción de *Chlorella* sp. El crioprotector Metanol 15%, presentó el mayor porcentaje de Viabilidad celular posdescongelación, proceso alternativo para la creación de banco de germoplasma para conservación células vegetales.

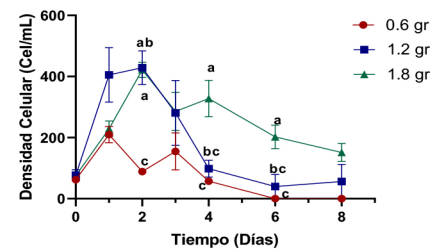


Figura 1. Densidad celular de *Chlorella* sp evaluada en Remital®. Datos expresados como media \pm desviación estándar. abcddefg Letras diferentes indican diferencias estadísticas significativas ($p < 0.05$) entre los días del medio de cultivo.

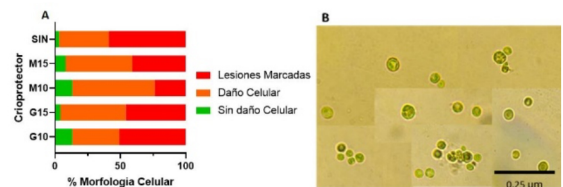


Figura 2. Morfología celular posdescongelación de *Chlorella* sp. A. Estado de la morfología. B. Estado morfológico pre congelación.

Tabla 1. Viabilidad celular posdescongelación de *Chlorella* sp. Datos como media \pm desviación estándar, (n=5).

Crioprotector	Viabilidad Celular (%)
Metanol 10%	20,51 \pm 2,4
Metanol 15%	30,16 \pm 13,08
Glicerol 10%	26,94 \pm 2,28
Glicerol 15%	18,9 \pm 2,53

FIRST EPIDEMIOLOGICAL STUDY TO DETECT *Megalocytivirus* AND *Ranavirus* IN ORNAMENTAL FISH FROM THE PERUVIAN AMAZON

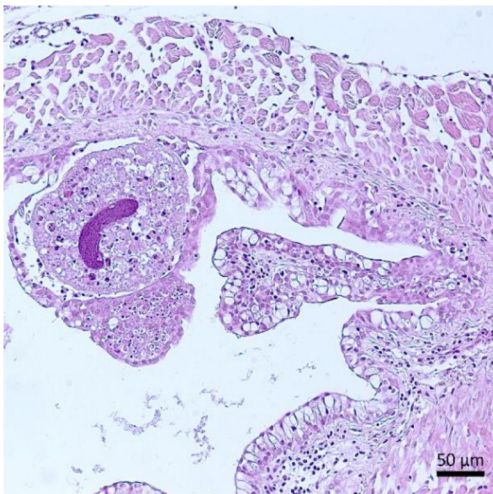
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The family Iridoviridae has three genera that affect fish (*Megalocytivirus*, *Ranavirus*, and *Lymphocystivirus*). Megalocytiviruses and ranaviruses are pathogens related to severe disease in fish farming worldwide. *Megalocytivirus* is responsible for high mortalities in ornamental fish industry. The aim of this study was to detect the presence or absence of *Megalocytivirus* and *Ranavirus* in ornamental fish species from the Peruvian Amazon. For that, a total of 600 different ornamental fish were collected between June and September 2022 from aquarium facilities of the city of Iquitos, Peru. The samples included five species *Hyphessobrycon erythrostigma*, *Blochis splendens*, *Carnegiella strigata*, *Pterophylum scalare* and *Ancistrus temminckii* and were analyzed by polymerase chain reaction (PCR) and histopathology. The PCR results were negative for both *Megalocytivirus* and *Ranavirus* (Table 01). Furthermore, the histopathology showed non-infectious lesions in the kidney and liver of all fish species and the presence of monogeneans and *Piscinoodinium* sp. in gills and metacercarial cysts in liver. In addition, the histopathological examination revealed an unusual finding of *Ichthyophthirius multifiliis* in the esophagus of *Ancistrus temminckii* (Figure 01). The results suggest that *Megalocytivirus* and *Ranavirus* are not circulating in five ornamental fish species from Peruvian Amazon and there are no histopathological lesions related to megalocytivirus-infected fish.

Table 01. Results of *Megalocytivirus* and *Ranavirus* detection from different ornamental fish species in 2022

Figure 01. *Ichthyophthirius multifiliis* in esophagus of *Ancistrus temminckii*



Species	Sample size	<i>Megalocytivirus</i>	<i>Ranavirus</i>
Rainy season			
<i>Blochis splendens</i>	60	Negative	Negative
<i>Hyphessobrycon erythrostigma</i>	60	Negative	Negative
<i>Pterophylum scalare</i>	60	Negative	Negative
<i>Carnegiella strigata</i>	60	Negative	Negative
<i>Ancistrus temminckii</i>	60	Negative	Negative
Dry season			
<i>Hyphessobrycon erythrostigma</i>	60	Negative	Negative
<i>Blochis splendens</i>	60	Negative	Negative
<i>Carnegiella strigata</i>	60	Negative	Negative
<i>Pterophylum scalare</i>	60	Negative	Negative
<i>Ancistrus temminckii</i>	60	Negative	Negative

THE HORIZONTAL INTEGRATION OF A SHELLFISH FARM IN A BROADER BUSINESS MODEL

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The demand for Eastern oysters over the last two decades has increased year after year. This steady continuous growth has created opportunity not only for oyster farmers and other businesses immediately supporting the shellfish aquaculture industry, such as gear and transportation, but it has also created opportunities just outside the shellfish aquaculture market. Opportunities to reach retail markets, such as restaurants and open-air markets, with their product and integrating into establishing those market on their own.

In order to meet those markets directly Matunuck Oyster Farm has horizontally integrated in each stage of the cycle of the eastern oyster (*Crassostrea virginica*). Matunuck Oyster Farm was established in 2002 as a 1-acre oyster farm with one employee. Now, 20 years later, that business has expanded to five additional businesses with over 200 employees, each business having the farmed Eastern oyster being a central, integral part of the business. Each of the new businesses support the farm, and the farm supports each business, creating more financial stability for the oyster farm.

The growth of Matunuck Oyster Farm into the six other sectors has been organic and determined by company needs. In addition to selling oysters to wholesalers, we expanded by offering different products such as Bay Scallops. We then started selling oyster seed to other farmers, selling at open air markets, and established Matunuck Oyster Bar, a popular restaurant overlooking the shellfish farm. This led to the establishment of Matunuck Organic Vegetable Farm, Matunuck Marina, Matunuck Shellfish Hatchery Research and Innovation Center and most recently a retail market in our adjacent downtown area of Wakefield, Rhode Island.

Perry Raso, Founder and Owner of these businesses, will discuss synergies between each of the businesses and how each business has strengthened and added value to each other.

**MITIGATING CHALLENGES FACING A GROWING INDUSTRY:
A REVIEW OF CURRENT TECHNIQUES AND TRIALS TO IMPROVE GROWTH,
SURVIVAL AND PUBLIC ACCEPTANCE OF THE SHELLFISH AQUACULTURE INDUSTRY
IN NEW ENGLAND, USA**

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Increasing demand for sustainable seafood with a plateauing supply available from wild stocks has created a widening gap between supply and demand. Shellfish aquaculture has tremendous potential to help fill that gap by producing nutritious seafood while providing ecosystem services such as increasing dissolved oxygen, increasing biodiversity, reducing erosion and stock enhancement.

The shellfish aquaculture industry faces challenges in the hatchery/nursery phase due to ocean acidification, bacteria and algae production for shellfish larvae food, all of which contribute to a shortage in shellfish seed. While shellfish aquaculture is widely recognized to be sustainable agriculture it does face challenges societal issues in the grow out phase increasing user group conflicts due to industry expansion, as well as human health concerns due to harmful algal blooms which are often times difficult to detect. These challenges must be addressed both on a societal and biological standpoint to allow the shellfish aquaculture industry to continue to grow.

This presentation will describe a combination of cutting-edge hatchery techniques being used to increase stocking densities, control bacteria and counteract lower Ph in hatchery water in order to increase larvae survival, and ways to more efficiently produce and deliver algae to larva and post larvae shellfish. Methods being used and developed to detect harmful algae blooms and mitigate user group conflicts in the Northeast USA will also be reviewed.

GESTIÓN DE LA ACUARIOFILIA EN COSTA RICA, RETOS Y OPORTUNIDADES

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La acuariofilia, es una actividad económica productiva que se basa en la tenencia de especies acuáticas en cautiverio como mascotas. A nivel mundial se considera una actividad de relevancia económica, con un crecimiento del 14% anual. En Costa Rica, desde el 1998 la actividad ha venido creciendo, siendo la importación la principal fuente de abastecimiento. Esta actividad genera un rol ecológico importante, por lo que la gestión adecuada es fundamental para resguardar los ecosistemas acuáticos. En Costa Rica, este proceso se ve regido por una coyuntura legal compleja, que involucra al Instituto Costarricense de Pesca y Acuicultura (INCOPECA), el Ministerio de Ambiente y Energía (MINAE) y el Servicio Nacional de Salud Animal (SENASA). El objetivo de este trabajo, es analizar la gestión de la acuariofilia en Costa Rica para identificar los retos y oportunidades que se presentan en el sector. El estudio se desarrolla desde Enero 2020 a Diciembre 2022 utiliza una metodología de Gestión Acción Participativa, con diversos mecanismos cualitativos y cuantitativos de obtención de la información. Se estima que en el país hay alrededor de 11500 acuaristas distribuidos a lo largo de todo el país. Sin embargo, existe una elevada tasa de informalidad en el negocio. Esto, aunado a la multiplicidad de entidades competentes dificulta la gestión de la actividad. Se presentan conflictos en los trámites de importaciones. Se han realizado esfuerzos intersectoriales por realizar una gestión integrada. Sin embargo, estos se encuentran en una etapa incipiente. Para realizar una gestión integrada del recurso se deben fortalecer los esfuerzos de gestión intersectorial, y el recabo de información sobre las dinámicas de comercialización.

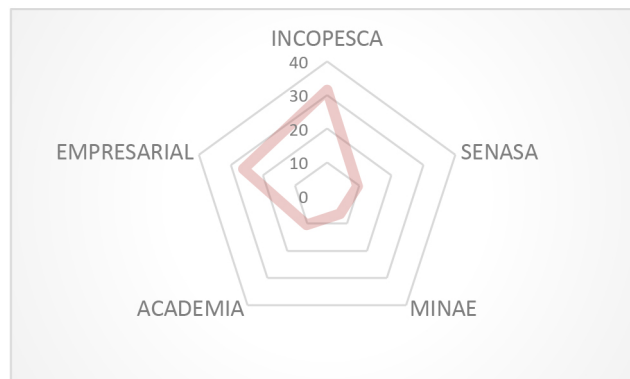


Figura: Participación intersectorial según el número de reuniones en proceso de construcción colectiva para la gestión interinstitucional 2020-2021.

PROCESO DE CONSTRUCCIÓN COLECTIVA PARA LA GESTIÓN INTERINSTITUCIONAL DEL ORDENAMIENTO DE LA ACTIVIDAD DE LA ACUARIOFILIA EN COSTA RICA

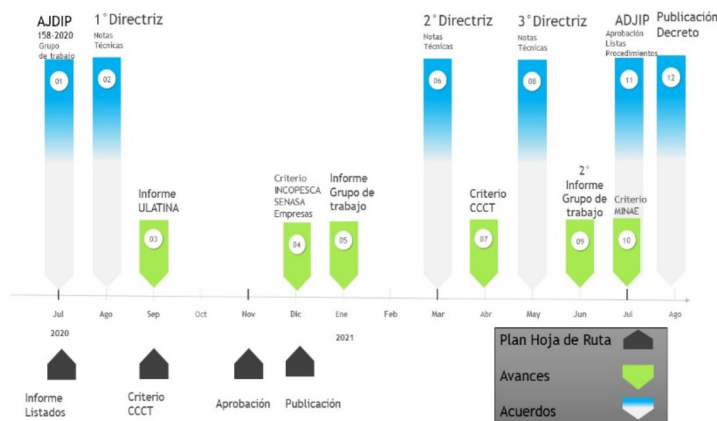
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La acuarofilia es una actividad de interés económica que consiste en mantener especies de acuáticas en ambientes controlados (acuarios) y cuidarlas como mascotas. Su gestión involucra múltiples instituciones gubernamentales. En el 2019 las importaciones especies acuáticas ornamentales en Costa Rica se paralizaron producto de la negativa de permisos hasta tanto de publique una lista oficial de especies de interés para acuarofilia. En respuesta la Junta Directiva del Instituto Costarricense de Pesque y Acuicultura nombra un grupo de trabajo interinstitucional para un proceso de construcción colectiva de gestión y ordenamiento de la actividad. Este trabajo sintetiza el proceso realizado.

El grupo de trabajo se conformó por el sector público, académico y empresarial. El proceso tuvo una duración de dos años y medio, logrando alcanzar las metas propuestas.

Se generaron siete productos tangibles que se utilizarán en la gestión y el ordenamiento de la actividad. Al final del proceso se tuvieron 7 puntos de consenso y 3 puntos de disenso. Las limitaciones que se presentaron fueron de índole administrativas, logísticas, materiales y legales para el cumplimiento de acuerdos. Pese a esto, al final se logró cumplir el 100% de las metas trazadas al inicio del proceso. El trabajo realizado permite responder a las algunas necesidades y problemáticas de ordenamiento y de gestión reportadas en Costa Rica y otros países para la actividad.



ONTOGENETIC DEVELOPMENT OF THE DIGESTIVE TRACT OF BARRED SAND BASS *Paralabrax nebulifer* (TELEOSTEI: SERRANIDAE) FROM CAPTIVITY

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The barred sand bass *Paralabrax nebulifer*, is a commercially important species in Baja California Sur, to date its digestive ontogeny in its initial phases of life has not been described. The objective of the present study is to describe the morphology of the digestive system of the verdillo at the beginning of the exogenous feeding until the transformation to the juvenile.

From verdillo reproducers, kept under controlled conditions of photoperiod and temperature, a static culture system was established in tanks of 250 l at a density of 33 embryos / l. The experiment lasted 32 days after hatching (DAH) with an average temperature = 23 ° C, and a mixed feeding scheme of live food (rotifers - *Brachionus plicatilis* and artemia - *Artemia* sp.) and three different aquaculture feed with varying particle size. From 5-20 organisms were selected daily and fixed in Davidson. Longitudinal and transverse sections 3 µm thick were made, which were stained with the histological techniques of hematoxylin and eosin (H&E) and periodic acid shift and alcian blue (PAS/AB).

The histological review made possible the identification of 4 phases of development. In the free embryo phase (0 - 3 DAH) we see an undifferentiated tube and hepatic tissue, being the oil globule the main source of nutrition in this early stage.

In the finfold larvae phase (3 – 16 DAH), the esophagus and intestine show a developed differentiation with the increase of surface area and epithelial folds, in contrast with the stomach which is less developed.

In the finformed larvae phase (16 – 25 DAH) the stomach presents a matured morphology, although there is no evidence of its functionality. The juvenile phase (25 DAH) consists of total maturity and functionality of the digestive tract as evidenced by the pyloric caeca.

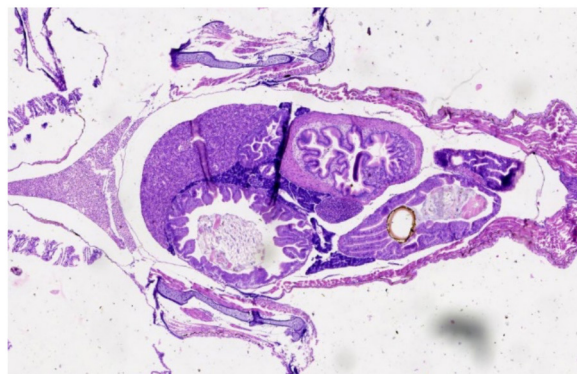


Figure 1.- Longitudinal view of *Paralabrax nebulifer* juvenile at 30 DAH.

PROMOTING OPPORTUNITIES AND SOLUTIONS IN THE CARIBBEAN THROUGH BUILDING THE CAPACITY OF WOMEN SCIENTISTS IN AQUACULTURE

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This paper will focus on the opportunities for aquaculture development for the CARICOM region and will identify key indicators for its success. The target is the CARICOM Group of Countries which span an area of over 2.6 million km² and comprises mostly small developing states of the former British, French, Spanish, and Dutch colonial empires and current dependencies of the West Indies, including; Barbados, Belize, Dominica, Grenada, Guyana, Jamaica, St. Lucia, St. Kitts and Nevis, Suriname, and Trinidad and Tobago and others. While each country has its priorities, many issues are similar and there is scope for sharing experiences and expertise across the region.

Aquaculture is globally the fastest-growing food sector, with an annual growth rate of 8.8 percent. However, production in the Caribbean region has declined by 40 percent over the last two decades. Aquaculture is commonly associated with the intensive culture of salmon in developed countries and the culture of tilapia and shrimp in developing countries. The suit of species to be cultured in the region goes beyond these given the diverse ecosystems and may include species such as conch, marine finfish, sea urchins, sea cucumbers, aquarium species, oysters, mussels, seaweeds and other aquatic plants, to name a few. Many blue foods are rich in bioavailable micronutrients and can be produced more sustainably. For Caribbean countries, aquaculture has the potential to positively address the problems of nutrition and food insecurity, the unsustainable exploitation of marine resources, and socio-economic inequalities, especially as it relates to the involvement of women. Conventional approaches to promoting aquaculture have largely failed. Most components necessary for aquaculture development in the region remain underdeveloped, including human and technical resources and the general knowledge required to take advantage of its opportunities. For instance, the vast coastal areas have hardly been explored for Mariculture / Blue foods development which can become the cornerstone of coastal communities. Additionally, given the critical state of important marine ecosystems such as coral reefs and mangroves due to overexploitation, the potential for aquaculture as an alternate source of fish protein and alternative livelihood activities has yet to be taken seriously.

Despite these weaknesses, the basic institutional framework to facilitate aquaculture development exists under the regional CARICOM body and in most countries. This Caribbean Aquaculture Network (CAN) seeks to leverage and strengthen this framework through women-led scientific research, with the introduction of aquaculture curriculum in secondary and tertiary institutions, and partnership initiatives to realize regional targets such as the CARICOM commitment to a 25 percent reduction in food imports by 2025 and the global 2030 agenda. In this way, we intend to identify and monitor key performance indicators at all levels of human and technical capacity in aquaculture production including the participation of women and youth.

CO-INFECTION BY LF-89-LIKE AND EM-90-LIKE GENOGROUPS OF *Piscirickettsia salmonis* IN FARMED ATLANTIC SALMON IN CHILE: IMPLICATIONS FOR SURVEILLANCE AND CONTROL OF PISCIRICKETTSIOSIS

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Piscirickettsiosis (SRS), caused by *Piscirickettsia salmonis*, is the main infectious disease of farmed Atlantic salmon in Chile. The current official surveillance and control plan for SRS has been based only on the detection of *P. salmonis*, but not on its genogroups (LF-89-like and EM-90-like). Surveillance at the genogroup level is essential not only for defining and evaluating the vaccination strategy against SRS, but is also of utmost importance for early diagnosis, clinical prognosis in the field, treatment and control of the disease. The objectives of this study were to characterize the spatiotemporal distribution of *P. salmonis* genogroups using genogroup-specific qPCR to discriminate LF-89-like and EM-90-like within and between seawater farms, individual fish, and tissues/organs during early infection in Atlantic salmon under field conditions. The spatiotemporal distribution of LF-89-like and EM-90-like was highly variable within and between seawater farms. *P. salmonis* infection is multigenogroup at the farm, fish and tissue levels. Our study demonstrated for the first time a complex co-infection of *P. salmonis* LF-89-like and EM-90-like in Atlantic salmon. Liver nodules could be associated with EM-90-like infection, but not with LF-89-like or co-infection of both genogroups. The positivity rate of *P. salmonis* LF-89-like increased significantly between 2017 and 2021 and was the main circulating genogroup in Chilean salmon aquaculture during this period (Figure 1). Finally, a strategy to identify *P. salmonis* genogroups based on novel genogroup-specific qPCR for LF-89-like and EM-90-like genogroups was reported. Consequently, our results help to better understand the biological interaction of *P. salmonis* and the host and generate knowledge to improve the surveillance and control strategy for SRS in Chile.

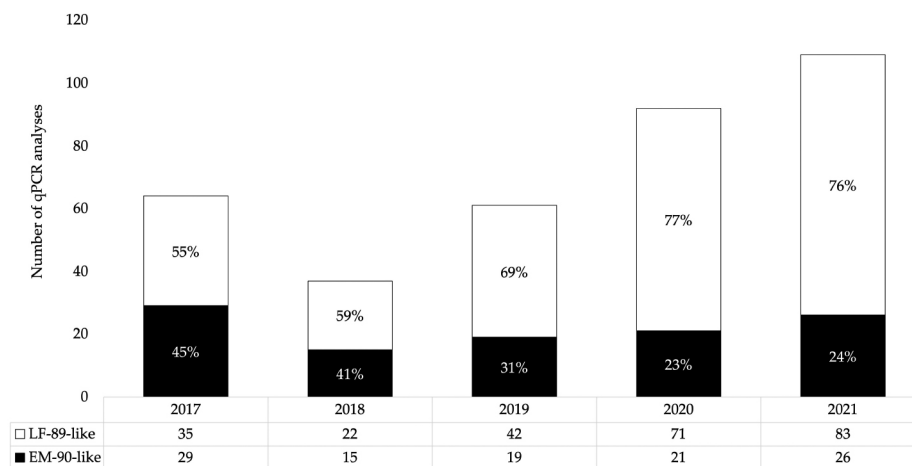


Figure 1. Comparative positivity rate for LF-89-like and EM-90-like genogroups of *P. salmonis* between 2017 and 2021 using geogroup-specific qPCR (n:363 fish)

WHY DOES *Piscirickettsia salmonis* BREAK THE IMMUNOLOGICAL PARADIGM IN FARMED SALMON? BIOLOGICAL CONTEXT TO UNDERSTAND THE RELATIVE CONTROL OF PISCIRICKETTSIOSIS

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Piscirickettsiosis (SRS) has been the most important infectious disease in Chilean salmon farming since the 1980s. It was one of the first to be described, and to date, it continues to be the main infectious cause of mortality. How can we better understand the epidemiological situation of SRS? The catch-all answer is that the Chilean salmon farming industry must fight year after year against a multifactorial disease, and apparently only the environment in Chile seems to favor the presence and persistence of *Piscirickettsia salmonis*. This is a fastidious, facultative intracellular bacterium that replicates in the host's own immune cells and antigen-presenting cells and evades the adaptive cell-mediated immune response (Figure 1), which is why the existing vaccines are not effective in controlling it. Therefore, the Chilean salmon farming industry uses a lot of antibiotics—to control SRS—because otherwise, fish health and welfare would be significantly impaired, and a significantly higher volume of biomass would be lost per year. How can the ever-present risk of negative consequences of antibiotic use in salmon farming be balanced with the productive and economic viability of an animal production industry, as well as with the care of the aquatic environment and public health and with the sustainability of the industry? The answer that is easy, but no less true, is that we must know the enemy and how it interacts with its host. Much knowledge has been generated using this line of inquiry, however it remains insufficient. Considering the state-of-the-art summarized in this review, it can be stated that, from the point of view of fish immunology and vaccinology, we are quite far from reaching an effective and long-term solution for the control of SRS. For this reason, the aim of this critical review is to comprehensively discuss the current knowledge on the interaction between the bacteria and the host to promote the generation of more and better measures for the prevention and control of SRS. We are also going to analyze the situation of vaccines against streptococcus in tilapia.

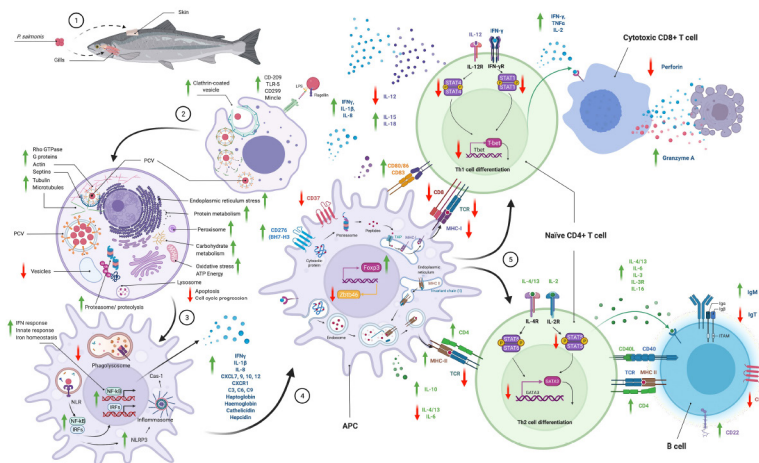


Figure 1. Schematic summary of the pathways used by *P. salmonis* to enter the cell and the immune responses modulated.

ATLANTIC SALMON PRE-SMOLT SURVIVORS OF *Renibacterium salmoninarum* INFECTION SHOW INHIBITED CELL-MEDIATED ADAPTIVE IMMUNE RESPONSE AND A HIGHER RISK OF DEATH DURING THE LATE STAGE OF INFECTION AT LOWER WATER TEMPERATURES

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Bacterial kidney disease (BKD) is widespread in many areas of the world and can cause substantial economic losses for the salmon aquaculture industry. The objective of this study was to investigate the pathophysiological response and gene expression profiles related to the immune response at different water temperatures and to identify the best immunopathological biomarkers to define a phenotype of resistance to BKD. The abundance of *msa* transcripts of *R. salmoninarum* in the head kidney was significantly higher in infected fish at 11°C. *R. salmoninarum* induced significantly more severe kidney lesions, anemia and impaired renal function at 11°C. In addition, the expression pattern of the genes related to humoral and cell-mediated immune responses in infected fish at 11 and 15°C was very similar, although *R. salmoninarum* induced a significantly greater downregulation of the adaptive immune response genes at the lower water temperature (Figure 1). These results could be due to a suppressed host response directly related to the lowest water temperature and/or associated with a delayed host response related to the lowest water temperature. Although no significant differences in survival rate were observed, fish infected at the lowest temperature showed a higher probability of death and delayed the mortality curve during the late stage of infection (35 days after infection). Thirty-three immunopathological biomarkers were identified for potential use in the search for a resistance phenotype for BKD, and eight were genes related specifically to the adaptive cell-mediated immune response.

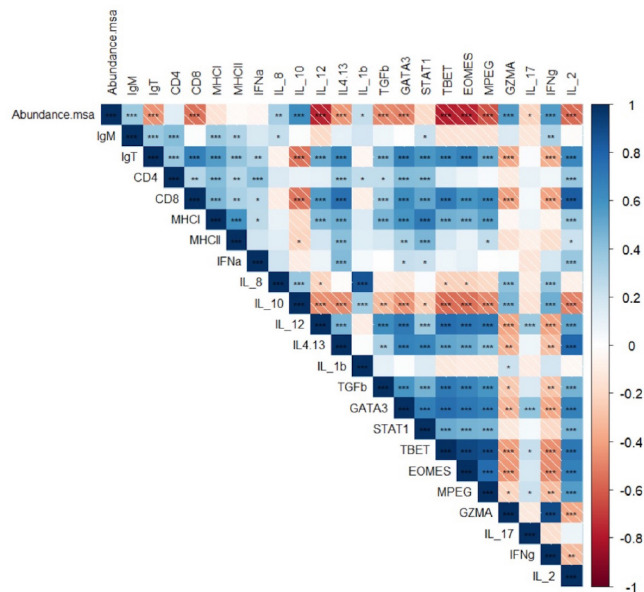


Figure 1. Pearson correlation coefficient (r) and p -value (p) between between the abundance of *msa* transcripts and the expression of target immune genes and association between the expression of each gene related to the innate and adaptive immune responses in the head kidney of Atlantic salmon pre-smolts infected with *R. salmoninarum* (* p < 0.05, ** p < 0.01, *** p < 0.001).

MOLECULAR BIOMARKERS APPLIED TO THE EVALUATION OF PATHOPHYSIOLOGICAL AND IMMUNOLOGICAL RESPONSES IN NILE TILAPIA

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Tilapia aquaculture has shown significant development in the last 5 years in Brazil, becoming the 5th largest producer of this species in the world. Intensive fish farming implies several management challenges in the health, reproduction and nutrition fields. To allow timely and properly decision-making biological indicators are required. In the health framework, there are several infectious diseases that increase the use of antibiotics and generate quality losses in fillets due to muscle injuries. A prophylactic measure is the administration of effective vaccines along with having diets that help strengthen the immune system and improve production yields. At the same time, to increase the efficacy of hormonal treatment for sexual reversion, more accurate, sensitive, validated, simple and rapid methods are required.

The aim of the present study was to show the application of predictive and quantitative transcriptomic biomarkers for the evaluation of vaccines, hormonal treatment for sex reversal, and diets in Nile Tilapia (*Oreochromis niloticus*). In the first case a trial under controlled conditions was carried out injecting fish intraperitoneally with a commercial vaccine against *Streptococcus agalactiae*. Gene expression was performed by RT-qPCR in head-kidney for il1b, il8, infg, cd3e, cd4 and cd8. Our results showed a strong activation of the innate immune response during the first 24 hours after injection followed by an activation of the cell-mediated immune response 5 days after injection. Additionally, a food restriction challenge was carried out under controlled conditions and its impact on growth indicators and expression of oxidative stress related genes in the liver was evaluated. Significant overexpression of genes related to oxidative stress (gpx and sod1) was observed from day 7 onwards in fish subjected to a dietary restriction higher than 40%. Besides, a lower expression of growth-related genes (igf1) was observed. Finally, we identified 3 genes with significant differential expression between male and female Nile tilapia, which were validated to assess sex reversion in fish as small as 2 g.

We can conclude that the application of transcriptomic tools is useful to provide a comprehensive diagnosis of the immunological and physiological status in cultured tilapia promoting timely and strategic decision making.

FIRST REPORT OF *Aeromonas veronii* AS AN EMERGING BACTERIAL PATHOGEN OF FARMED NILE TILAPIA (*Oreochromis niloticus*) IN BRAZIL

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At the end of December 2022, a mortality outbreak was reported in net-cages farmed Nile tilapia in the state of São Paulo, Brazil, characterized by gross pathology consistent with bacterial hemorrhagic septicemia. This article presents the results of the study that aimed to: (a) isolate and identify the putative causative bacterial agent of the mortality outbreak by conventional isolation methods, DNA sequencing of specific 16S rDNA targets and housekeeping genes (*gyrB* and *rpoB*) and phylogenetic analysis; (b) evaluate the antimicrobial sensitivity and minimum inhibitory concentration of the causal agent to different antibacterial drugs to recommend optimal treatment of the disease under field conditions; (c) confirm Koch's postulates and evaluate the pathogenicity of the causal agent by *in vivo* experimental infection challenge. In the current study, we have described the isolation, characterization, and virulence of the pathogenic agent, *A. veronii*, which caused hemorrhagic septicemia and mass mortality outbreak in tilapia farmed in Brazil. Overall, our results highlight the importance of effective epidemiological surveillance of diseases under field conditions to correctly identify the pathogens responsible for disease outbreaks and to promote appropriate and timely decision-making strategies to optimize the health and production management of the farmed tilapia industry and the prudent use of antimicrobials.

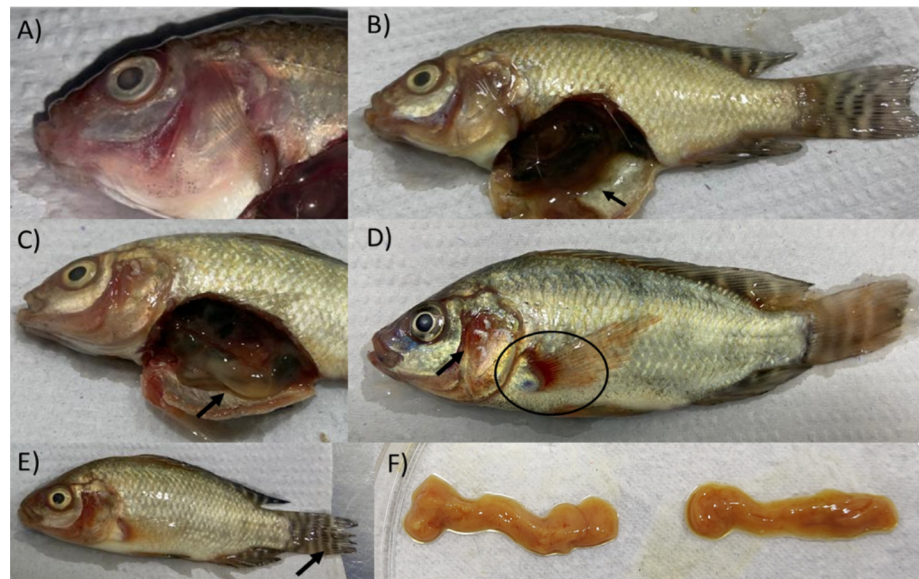


Figure 1. Gross pathology observed in juvenile Nile tilapia experimentally infected with a pathogenic strain of *A. veronii*. A) eye opacity; B) ascitic fluid; C) presence of fluid in the intestine and swelling; D) operculum lesion (arrow) and hemorrhage in the fin; E) fin corrosion; F) pale liver.

LA ACUICULTURA COMO FUENTE DE METABOLITOS PARA LA SALUD HUMANA: CASO LONG COVID

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El erizo de mar *Arbacia dufresnii* es foco de una innovadora actividad acuícola que se desarrolla en Argentina. Estos erizos de mar son cultivados con el objetivo de extraer metabolitos secundarios de sus huevos. Uno de los metabolitos más relevantes que posee es la Echinocroma A (EchA), un pigmento polifenol que está presente en diferentes especies de equinodermos. Esta molécula tiene una gran capacidad antioxidante y se conoce de sus múltiples beneficios para salud basada en esta capacidad. Su beneficio más evidente es su capacidad de bajar inflamación celular y potenciar el metabolismo del glutatión, mejorando el estado oxidativo celular e incrementando la masa mitocondrial. En Argentina, productos que contienen este pigmento están siendo utilizados en pruebas médicas para tratar pacientes con LongCOVID. Este trabajo tiene como objetivo presentar los desafíos sobre cómo se desarrolló una prueba médica en pacientes con Long COVID en hospitales de Argentina. La Spin off (ERISEA S.A.) utiliza tecnología acuícola desarrollada en CONICET, y a partir de los huevos desarrolló un suplemento dietario como vehículo para la ingesta del principio activo Echinocroma A. Este suplemento fue donado a hospitales públicos para realizar las intervenciones necesarias en los pacientes y poder de esta forma evaluar las mejorías de los síntomas. Esta prueba médica fue el fruto de un esfuerzo articulado entre el sector privado, salud pública y el sector académico para abordar una problemática social de gran relevancia.

TRANSFERENCIA CIENTÍFICA DE ACUICULTURA DE ERIZOS DE MAR AL SECTOR PRODUCTIVO

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La acuicultura de erizos de mar a nivel productivo es una asignatura pendiente en la industria. Si bien ha habido muchos intentos a lo largo de los años, solamente en los últimos 3 años se comenzó a realizar de forma piloto. Existen dos emprendimientos en el mundo actualmente enfocados en acuicultura de erizos de mar con focos diferentes: Urchinomics por un lado, enfocado en la pesca de erizos de mar en zonas donde los erizos forman “barrens” para alimentarlos en sistemas acuícolas y luego venderlos para gastronomía. Por otro lado esta Promarine Antioxidants (Erisea SA) que se enfoca en el cultivo de erizos de mar de ciclo completo para obtener metabolitos secundarios de sus huevos utilizando biotecnología. Para esto un desarrollo tecnológico integral fue desarrollado en el CONICET en Argentina y transferido a la Start Up. La Start Up exitosamente ha llevado productos al mercado en formato suplementos dietarios y ha logrado implementar la transferencia tecnológica enfocada en: generación de alimento balanceado para erizos de mar, cria y cultivo de erizos de mar y protocolo de bienestar animal; con un foco de economía circular y triple impacto. Esta Start Up ha inaugurado una industria en la región patagónica y en el mundo, generando productos biotecnológicos de origen marino con beneficios comprados para la salud humana, entorno a un contexto de sustentabilidad.

PAVLOVA LUTHERI: MICROALGA MARINA COMO POTENCIAL FUENTE DE OMEGA-3 NATURAL

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Los ácidos grasos altamente insaturados de cadena larga (LC-HUFA) como el ácido docosahexaenoico (DHA, 22: 6(n-3)) y el ácido eicosaepentanoico (EPA, 20:5(n-3)) son componentes importantes de la nutrición infantil y adulta. Ambos LC-PUFAs tienen un rol vital en la formación y función del sistema nervioso, cognoscitivo y visual, estando presentes en fosfolípidos de las membranas de neuronas en la corteza cerebral y en los fotorreceptores de la retina. Se pueden clasificar en las familias $\omega 6$ y $\omega 3$, derivados principalmente de la dieta consumida o del metabolismo del ácido linoleico dietético (LA, 18:2(n-6)) y del ácido α -linolénico (ALA, 18:3(n-3)). Los cambios en la dieta de las personas en las últimas décadas han resultado en el consumo de ácidos grasos en proporciones muy altas de $\omega 6$ a $\omega 3$, que tienen impactos tanto en la salud como en el desarrollo. Los PUFAs se obtienen actualmente de una serie de fuentes, incluidas las plantas superiores y el pescado azul, pero se ha hecho evidente que la producción de PUFAs a partir de fuentes actuales es inadecuada para abastecer este mercado en expansión. La microalga de origen marino *Pavlova lutheri* ha demostrado recientemente ser una buena candidata para el análisis bioquímico y molecular con el fin de comprender y manipular los procesos que son responsables de la producción y la incorporación de estos LCPUFA en los aceites de almacenamiento. Durante el presente estudio se cultivó *Pavlova lutheri* bajo diferentes fuentes de Carbono con y sin fuente de luz externa (Mixotropía y Heterotropía), con el objetivo de potenciar y maximizar la síntesis de VLCPUFA. Durante el experimento, se determinó la biomasa (g/L), productividad (g/L/día) y densidad celular (cel/ml) cada 48hs, así como también los parámetros fisicoquímicos (Temperatura, salinidad, pH, Presión, Oxígeno disuelto, entre otros). Al llegar a la fase estacionaria de cultivo, se cosecharon las muestras mediante centrifuga y la biomasa recuperada se secó a estufa hasta obtener peso constante. Los resultados preliminares demuestran que el cultivo de *Pavlova lutheri* bajo condiciones de carbono Dextrosa en 50um/L han resultado significativamente en un incremento de la productividad, como en un potenciamiento en la síntesis de DHA y EPA en valores de 231,18ug/g dw que corresponde a una abundancia del 4,38% de productividad. Esta información, llevada a un proceso de escalamiento superior podría considerarse como una plataforma de producción de Omega-3 de origen natural, proveyendo una alternativa productiva, inexplorada en la región latinoamericana y con un sistema de producción sustentable y ambientalmente amigable debido al modelo productivo de origen vegetal. PALABRAS CLAVES: DHA, EPA, NUTRICIÓN MICROALGAL, BIOTECNOLOGÍA

EFFECTS OF LOW SALINITY EXPOSURE ON MORTALITY AND AMMONIA EXCRETION OF THE SEA CUCUMBER *Holothuria (Halodeima) grisea* SELENKA, 1867

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The sea cucumber *Holothuria (Halodeima) grisea* Selenka, 1867 is a tropical, epibenthic, non-estuarine echinoderm inhabiting intertidal and subtidal rocky shores from the Caribbean region up to southern Brazil (Santa Catarina State). The commercial interest, the recent threats of unregulated capture, and the potential use of sea cucumber in integrated multitrophic aquaculture, highlighted this species as a candidate for aquaculture in Brazil. The knowledge of the limits of tolerance to low salinity is one of the important factors for adequate aquaculture site selection. However, little information is available about the effects of low salinities exposure on the mortality and physiological stress of *H. grisea*.

Adults were collected at Porto Belo (SC) (Lat. 27° 09' 18"; Long. 48° 33' 48" W) in April/ May 2022 (License Brasil/MMA/SISBIO no. 68215). Two laboratory assays were carried out to determine mortality and ammonia excretion at reduced salinities. The salinities tested in the first assay were 34, 30, 25, 20 and 15 PSU. A second assay tested the salinities 20, 15, 10, 5 and 0 PSU. The ambient temperature was controlled in both assays (20,5°C ± 1,5), pH and ammonia were monitored daily. Experiments were carried out in 10-L aquaria with four replicates per treatment. Observations were made at 6, 12 and 24 h of exposure, and subsequently every 24 hour up to 144 hours. Individuals were considered dead, when podia were not attached to the container walls and no contractile responses of the tentacles were displayed after touching with a glass rod. Death was confirmed after returning them to 34 PSU and no activity was recovered.

In the first assay, no mortality was recorded after 144 hours of exposure at the tested salinities, however at 20 and 15 PSU individuals were weakened at the end of the experiment. Whereas in the second assay, 100% mortality was attained after 6h at 0 PSU; 24 h at 5 PSU and 48 h at 10 PSU. Ammonia excretion (figure 1) results from protein metabolism, and its increase can be considered an indicator of stress resulting from amino acid catabolism for intracellular osmotic regulation. *H. grisea* can tolerate exposure to salinity as low as 15 PSU for up to 6 days, which indicates that this species is relatively resistant to low salinities, however, the high rate of ammonia excretion below 25 PSU indicates physiological stress. This information will be valuable for future development of sea cucumber aquaculture in Brazil.

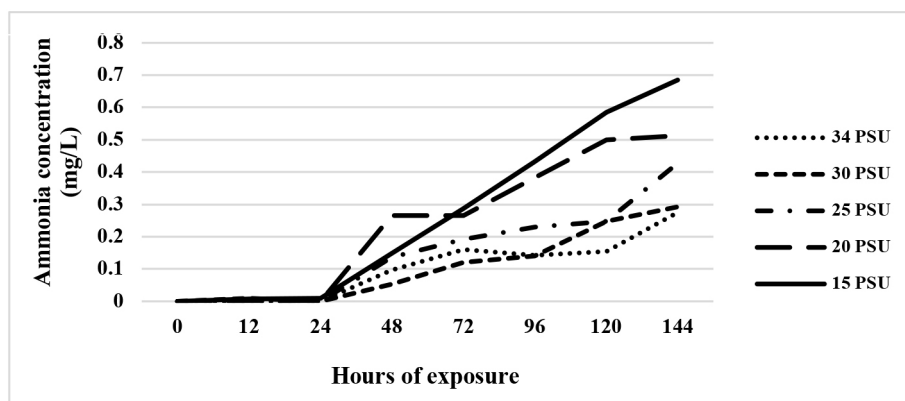


Figure 1. Ammonia concentrations in experimental chambers with *Holothuria grisea* exposed to different salinities over 144 hours.

USE OF MEDICINAL PLANTS AND PROBIOTICS FOR SUSTAINABLE AQUACULTURE

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The need to produce food under strict quality standards and reduce the impact on the environment, leads to development of food industry, particularly aquaculture practices. Minimizing the impact of this industry, implies the use of non-chemical antimicrobials and better practices for a sustainable management. The use of natural antimicrobials is essential to minimize the harmful effects of chemicals and minimize losses due to bacterial and viral pathogens. Medicinal plants offer a natural and sustainable alternative with high antimicrobial capacities, particularly if native species are used. Its use and administration in aquaculture systems must be evaluated for effective use.

Basil, *Ocimum basilicum* L. and oregano, *Origanum vulgare*, are plants with a wide distribution in Mexico and their antimicrobial potential, particularly of steam-entrained extracts of oregano, against *Vibrio parahaemolyticus*, an important pathogen in aquaculture practice, was demonstrated. In addition to the above, it was sought to take advantage of the potential of a native plant, so the antimicrobial potential of the chicalote *Argemone mexicana* L. was also verified to inhibit the growth of *V. parahaemolyticus*.

Plant tissue extracts were obtained by freeze-drying, alcoholic extraction and steam dragging of the dry leaves of each species. *V. parahaemolyticus* was obtained from a collection of the Center for Biological Research of the Northwest CIBNOR at La Paz, México.

The use of medicinal plants as antimicrobials in aquaculture systems requires the evaluation of the dose and method of application, since direct application can result in a certain degree of toxicity to organisms, as was verified by adding basil and oregano in experimental shrimp farming. Therefore, the feasibility of administering medicinal plant extracts in the form of microencapsulates supplied with pelletized food was verified.

The use of plant extracts in brine shrimp was evaluated to identify the lethal dose, L50, obtaining that a high dose of the plants is necessary to achieve lethality in the organisms, so its use is convenient to reduce the pathogenic bacterial load. Of crops.

The use of a bacterial mixture was evaluated for the increase in production in terms of weight and survival in white shrimp, obtaining better results than when using the bacterial isolates evaluated separately.

This research can be replicated with other medicinal plants native to the different regions producing marine farming organisms. This research provides a practical solution to viral and bacterial pathogens, avoiding the use of antibiotics, providing an efficient but more environmentally friendly solution. A strategy is proposed to improve the administration method of natural antimicrobials to minimize losses due to pathogens in aquaculture

ANALYSIS OF METABOLIC VARIABLES OF WHITE SNOOK *Centropomus viridis*, CULTURE IN FLOATING CAGES, AND WILD ORGANISMS IN NORTHWESTERN MEXICO

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Snook is considered one of the most important fisheries in Mexico due to its cultural and economic importance; nevertheless, the production potential remains to be untapped, as current commercial production is based on wild-catch temporality, distribution and abundance. For these reasons, the objective of this study was to evaluate the biochemical analysis of the Pacific White Snook *Centropomus viridis* culture in 10m diameter and 3m deep cages (235m³) and wild organisms. The experiment began in September 2019 when 15,000 organisms of *C. viridis* with an initial weight of 0.8±0.2g were stocked in one floating cage where they would remain for four months during the nursery stage. During the experiment physicochemical parameters such as dissolved oxygen, temperature, pH and salinity as well as nutrients such as ammonia, nitrites and nitrates were closely monitored, and recorded. Biochemical variables such as glucose (mg·dL⁻¹), protein (g·dL⁻¹), total lipids (g·dL⁻¹) and cholesterol (mg·dL⁻¹) were evaluated. The results of our performance variables were, Correlation between physical chemical parameters and growth was found between temperature and growth. The biochemical-blood results show us that the nutritional condition of the organisms in culture in comparison with the wild organisms. Using biochemical-blood techniques gives us the advantage of sampling broodstock in captivity without the need to sacrifice them to know their condition nutrition and state of health in which they find themselves.

Tabla 1. – Biochemical parameters of the wild and 120-day pre-grow-out stage of *C. viridis* culture in floating cages.

Biochemicals analysis	wild	grow-out	P<0.05
Glucose mg·dL ⁻¹	65.25±4.75b	45.76±2.19a	0,000002
Protein g·dL ⁻¹	4.40±0.88	3.40±0.59	NS
Total Lipids g·dL ⁻¹	0.64.8±0.06	0.67.5±0.84	NS
Cholesterol mg·dL ⁻¹	77.57±9.38b	32.74±6.24a	0,00363

PERFORMANCE ANALYSIS AND METABOLIC VARIABLES OF WHITE SNOOK *Centropomus viridis*, CULTURE IN FLOATING CAGES IN NORTHWESTERN MEXICO

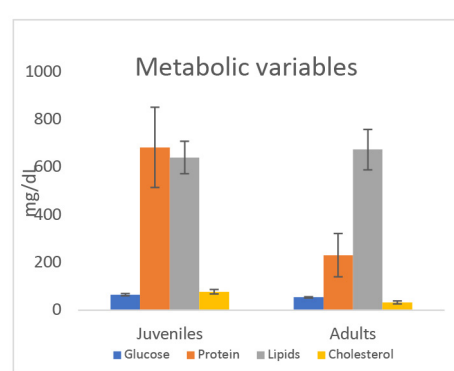
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Snook is considered to be one of the most important fisheries in Mexico due to its cultural and economic importance; nevertheless, the production potential remains to be untapped, as current commercial production is based on wild-catch temporality, distribution and abundance. For these reasons the objective of this study was to evaluate the performance and metabolic variables of the white snook *Centropomus viridis* culture in 10m diameter and 3m deep cages (235m³). 15,000 organisms of *C. viridis* with an initial weight of 0.8±0.2g were stocked in one floating cage where they would remain for four months during the nursery stage. Once the nursery stage came to an end, the fish were graded and separated into three different cages at three different weights (30g, 40g, y 60g) where they would remain for their grow out stage until September 2020. During the experiment physicalchemical parameters such as dissolved oxygen, temperature, pH and salinity as well as ammonia, nitrites, nitrates and metabolic variables such as glucose, protein, lipids and cholesterol were closely monitored and recorded. Performance variables such as specific growth rate, daily growth rate, feed conversion ratio, survival and total biomass were evaluated. The results of our performance variables were a specific growth rate of 119%, 110% and 95.87% a daily growth rate of 2.17 ± .06, 2.35 ± .05 and 2.49 ± .06 g, a feed conversion ratio of 1.12, 1.22 and 1.67, a total survival of 27% for the nursery stage and 60% for the grow out stage and a total biomass produced of 973kg; the metabolic variables the protein and cholesterol had significant differences. Correlation between physicalchemical parameters and growth was determined through a correlation analysis and a direct correlation was found between temperature and growth.



MANEJO MICROBIOLÓGICO CON USO DE PROBIÓTICOS CONCENTRADOS APLICADOS A LA BIORREMEDIACIÓN EN CAMARONERAS

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Los probióticos para suelos y agua son una biotecnología ampliamente establecida en los protocolos de biorremediación de los ambientes de cultivo para la mejoría de la salud de los camarones producidos. Muchos trabajos han demostrado la importancia de una buena calidad del ambiente de cultivo para alcanzar mayores desempeños de crecimiento, supervivencia y conversión alimenticia.

El éxito de una biorremediación está relacionado no solamente en el uso de especies y cepas de microorganismos seleccionados criteriosamente para ambientes acuáticos, la concentración (UFC/g) en el producto comercial y su dosificación empleada, pero también es dependiente de las condiciones químicas de calidad de suelo y agua de fondo para la maximización de la actividad microbiológica en la degradación de la materia orgánica producida durante el ciclo productivo. Mantener niveles adecuados de oxígeno en las piscinas, promover oxidación de sus suelos durante secado, entre ciclos de producción y ajustar su pH afectan directamente la cinética de las bacterias biorremediadoras, y por lo tanto son igualmente puntos esenciales en el manejo de la biorremediación en suelos de camaronerías.

Así el control de calidad de agua y suelos, junto con gestión de probióticos, son fundamentales y deben ser empleados en conjunto para garantizar la bioseguridad de los sistemas de cultivo y ayudar a reducir la formación de gases tóxicos, controlar el fitoplancton y la proliferación de patógenos.

Los puntos arriba comentados serán discutidos durante la presentación con el objetivo de aportar conocimiento a los productores sobre la optimización de la biotecnología de los probióticos en camaronerías.

CONSISTENCIA DE PROBIÓTICOS COMERCIALES Y BENEFICIOS PARA TILAPIA

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El interés por el uso de los probióticos en los protocolos de producción de tilapia ha crecido en los últimos años, por efecto de mejorar la calidad ambiental y de reducir las pérdidas causadas por las infecciones bacterianas en la producción de alevines y juveniles y engorde. Uno de los principales grupos de bacterias probióticas utilizados para tilapias han sido cepas de diferentes especies de *Bacillus*.

El potencial de exclusión de patógenos específico puede cambiar entre cepas de misma especie y entre especies. Esto establece la importancia de utilizar probióticos concentrados y constituidos por multicepas seleccionadas específicamente para competir frente a patógenos de especies acuáticas en cuestión.

Los mecanismos de exclusión competitiva, por sustrato/nutrientes y espacio, apoyados por mecanismos de antagonismo directo, por producción de moléculas inhibitorias son esenciales para que una bacteria probiótica pueda controlar las bacterias oportunistas y patógenas. Además, la síntesis de una amplia gama de exoenzimas promovida por los *Bacillus* es esencial para apoyar la digestión y mayor eficiencia alimenticia. Para que estos procesos de control del microbioma y de optimización de la digestión ocurran es fundamental su resistencia a las condiciones químicas existentes en el proceso digestivo de la tilapia.

El gran número de opciones de productos probióticos comerciales existentes en el mercado actual trae también una preocupación con relación a su seguridad, consistencia y calidad ofertada a la producción.

En la presentación veremos como los probióticos han colaborado en el control de patógenos y el desempeño animal y discutiremos finalmente sobre que el mercado ha ofrecido en estos años para la industria acuícola.

INSECTS AS A SUBSTITUTE FOR FISHMEAL: Influence on the product properties and the extrusion process

Julian M. Foerster, Ulrike Ito, Jessica Wiertz



Introduction

Due to the increasing costs and environmental impacts of fish meal production, insects could prove to be a better raw material for fish feed manufacturing in the future.¹ Their high protein content and low resource requirements are key factors in producing sustainable feed.² With Brabender Instruments it is possible, to extrude fish feed on a small laboratory scale and to optimize the composition of the raw materials as well as the way of manufacturing by analyzing the rheological properties of the finished product.

Material and Methods

Fish Feed manufacturing:

Three batches of fish feed were produced by use of a Brabender twin screw extruder KETSE 20/40 (Table 1 + Figure 1). The fish meal fraction in the raw material blend was 15 %. This fraction was replaced by defatted black soldier fly (*Hermetia illucens*) larvae meal by 0, 50 and 100 %.

Parameter	Value
Screw speed	400 rpm
Temperature profile	Hz 1: 40; Hz 2: 65; Hz 3: 90; Hz 4: 115; Hz 5: 135
Feed moisture	24 %
Throughput	7,5 kg/h
Nozzle diameter	2,5 mm

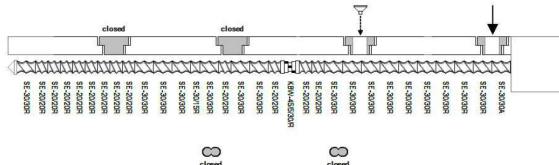


Figure 1: Screw Configuration KETSE 20/40

Procedure for the fish feeds digestibility related to its gelatinization properties:

1. Grinding of the extrudate with Brabender Break Mill SM4
2. Moisture determination of the pellets by Brabender MT-CA
3. Analysis of the gelatinization properties by use of the Brabender MVAG (Figure 3)

Results

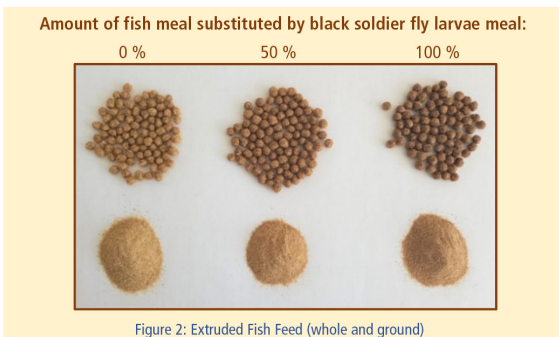


Figure 2: Extruded Fish Feed (whole and ground)

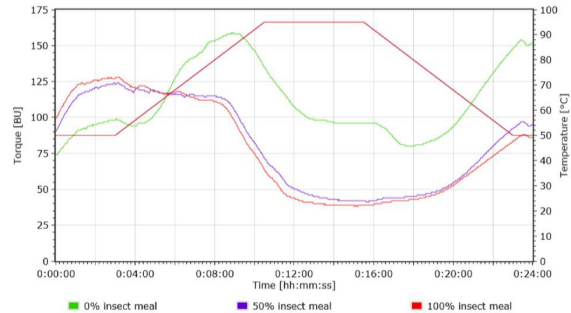


Figure 3: MVAG Measurements

The results of the MVAG measurements (Figure 3) show, that a higher concentration of insect meal increases the degree of cook of the starch, which is directly related to the fish's digestibility.³

	Amount of fish meal substituted by black soldier fly larvae meal [%]						ANOVA P-Value
	0		50		100		
	MV	SD	MV	SD	MV	SD	
ER [%]	123.5 ± 14.0	135.7 ^a ± 13.8	138.8 ^a ± 14.9	0.001			
BD [g/l]	281.0 ± 6.8	240.9 ^a ± 4.0	238.0 ^a ± 5.4	0.001			
FA [%]	100 ^a ± 0	100 ^a ± 0	100 ^a ± 0	1.000			
BF [N]	40.1 ± 8.8	35.1 ^a ± 7.8	32.2 ^a ± 7.6	0.001			
PDI [%]	98.5 ^a ± 0.7	98.1 ^a ± 0.6	98.4 ^a ± 0.4	0.296			
WS [%]	97.0 ± 0.5	96.6 ^a ± 0.4	96.5 ^a ± 0.4	0.001			
DP [bar]	125.7 ± 10.0	106.9 ^a ± 8.4	108.3 ^a ± 7.0	0.001			
SME [Wh/kg]	87.9 ^a ± 7.8	84.7 ^a ± 9.1	93.3 ± 7.0	0.001			
PT [°C]	130.6 ± 0.8	131.6 ^a ± 0.5	131.4 ^a ± 1.1	0.001			

MV = Mean Value; SD = Standard Deviation; ER = Expansion Ratio; BD = Bulk Density; FA = Floatability; BF = Breaking Force; PDI = Pellet Durability Index; DP = Die Pressure; SME = Specific Mechanical Energy; PT = Product Temperature

No significant difference ($p < 0.05$) between mean values marked with an "a"

Conclusion

Trials showed that insect meal can be used as fish meal substitution for fish feed manufacturing. It should be noted, that there are significant influences concerning the extrusion process and that the change of the product properties.

With regard to further investigations, changing of process conditions e.g. varying the extruder screw speed, feed moisture or temperature profile might optimize the product properties as desired. Feeding trials are needed to evaluate the feed acceptance and the nutritional value of the product. Studies indicate, that the nutritional value of black soldier fly larvae meal is lower than fish meal.⁴ Therefore, higher quantities may be required for a proper diet. Further research is needed in order to improve the omega-three fatty acid spectrum of the fish free product. The addition of micro algae with high omega-three contents might be a solution.

However the extrusion process has to be adapted when fish meal is substituted by insect meal. Should black soldier fly larvae meal gets cheaper than fish meal, it could prove to be a viable option to reduce the environmental impact of aqua culture in the future.

¹C. I. R. Payne, D. Dobermann, A. Forkes, J. House, J. Josephs, A. McBride, A. Müller, R. S. Quilliam, S. Soares: Insects as food and feed: European perspectives on recent research and future priorities. *Journal of Insects as Food and Feed* (2016): 1-8; ²M. Premalatha, Tasneem Abbasi, Tabassum Abbasi, S. A. Abbasi: Energy-efficient food production to reduce global warming and ecodegradation: The use of edible insects. *Renewable and Sustainable Energy Reviews* 15 (2011): 4357-4360; ³J. Holm, I. Lundquist, I. Björck, A. C. Eliasson, N. G. Asp: Degree of starch gelatinization, digestion rate of starch in vitro, and metabolic response in rats. *The American Journal of Clinical Nutrition* (1988): 1010-1016; ⁴Irungu, F.G., Mutungi, C.M., Faraj, A.K., Affognon, H., Kibet, N., Tanga, C., Ekesi, S., Nakimbugwe, D., Fiaboe, K.K.M., 2018. Physico-chemical properties of extruded aquafeed pellets containing black soldier fly (*Hermetia illucens*) larvae and adult cricket (*Archeta domestica*) meals. *Journal of*

DIETARY NUCLEOTIDES SUPPLEMENTATION IN *Litopenaeus Vannamei* ENHANCES SURVIVAL UPON CHALLENGE WITH *Vibrio parahaemolyticus*

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Introduction:

Vegetable protein sources are commonly used as replacement for fish meal (FM) in diets for Pacific white shrimp (PWS) *Litopenaeus vannamei* in some countries, including Vietnam and Indonesia. This has a negative impact on the health of PWS due to their high content in anti-nutritional factors. Nucleotides (N) modulate the immune response and could counteract this effect. The objective of this feeding trial was to evaluate the effects of dietary N supplementation on survival upon challenge with *Vibrio parahaemolyticus* in PWS receiving diets in which FM has been partially replaced by vegetable protein sources.

Methods:

A total of 600 PWS (0.72 ± 0.15 g) were used in this trial performed in Vietnam. After acclimation for 2 days, PWS were classified into 6 groups (4 replicates/group; 25 PWS/90L-tank) and received different diets for 28 days: 1 group with no challenge (260FMNoCh – Negative Control; 26% FM); and 5 groups challenged with EMS/AHPND-causing *V. parahemolyticus* strain: 260FM (Positive Control group; 26% FM; 0% N), 260FMN (26% FM; 0.1% N), 234FMN (23.4% FM; 0.1% N), 221FMN (22.1% FM; 0.1% N) and 208FMN (20.8% FM; 0.1% N). FM was replaced by vegetable protein sources. PWS were followed-up for 10 days post-challenge. The N used in the study were Nucleoforce® (Bioiberica SAU, Spain).

Results:

All groups in which diets incorporated N showed higher survival rates than the Positive Control group during the post-challenge period, with a significant improvement ($p < 0.05$) 15 hours post-challenge in groups 260FMN, 221FMN and 208FMN vs the Positive Control group (Figure 1).

Conclusions:

Nucleotides could be used as sustainable and effective functional ingredient in aquaculture given that, as observed in this study done in Vietnam, supplementation with 0.1% N in PWS receiving diets in which FM has been partially replaced by vegetable protein sources allows a higher survival rate upon challenge with EMS/AHPND-causing *V. parahemolyticus* strain.

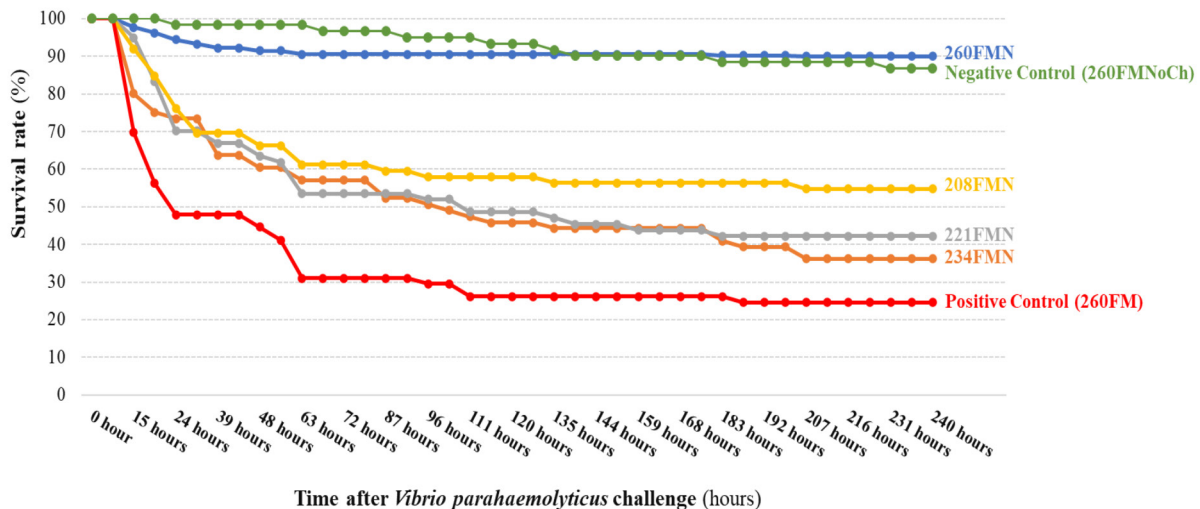


Figure 1. Survival rate of shrimp in each study group after challenge.

LA NUEVA ALTERNATIVA PARA EVITAR LA RESIDUALIDAD ANTIBIÓTICA

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El aumento de la resistencia a antibióticos y los residuos en la cadena final han generado objeciones al uso y obligado a la búsqueda de alternativas a los mismos. Los productos vegetales hoy conocidos como Fitogénicos, es una alternativa válida que viene aumentando las opciones de uso para la seguridad alimentaria. Estos productos derivados de las plantas medicinales pueden actuar como antibacteriales, aumentar la respuesta inmunitaria y generar mejor rendimiento zootécnico derivado de un blindaje sanitario, disminuyendo los riesgos de contaminación en el producto final.

La investigación en la extracción de los principios activos de las plantas medicinales ha crecido en los últimos años como una herramienta en investigación y desarrollo para la industria acuícola, donde tienen cabido no solo los extractos de aceites esenciales de plantas sino también ácidos orgánicos, que haciendo una correcta combinación es una alternativa muy exitosa en la sanidad animal.

Se les conoce efectos: antioxidantes, antimicrobianos, antiparasitarios, promotores de crecimiento, estimulantes de las secreciones digestivas, y muchos más mecanismos de acción que aún se desconocen.

Los efectos sinérgicos de estos compuestos mejoran las funciones del organismo animal con respuestas en la mejora del apetito, conversión alimenticia, estimulación de las enzimas digestivas y la digestión lipídica. La gran mayoría aumentan la actividad enzimática y la disminución de radicales libres en el organismo.

La fácil utilización de estos productos está generando verdaderos cambios en el manejo sanitario de las explotaciones acuícolas para verdaderamente encontrar la manera de prevenir la enfermedad sin necesidad de llegar al uso indiscriminado del antibiótico.

Las sustancias activas de estos compuestos pueden encontrarse en todas las partes de las plantas o en una localización específica de la misma, con los métodos modernos de extracción, se pueden lograr diferentes grados de concentración del principio activo, así como la identificación de una planta o especie indicada. Las plantas producen principios activos para protegerse de agentes nocivos externos como predadores, o ciertos microorganismos nocivos que pueden concentrarse en las hojas, semillas, tallos, flor, corteza. También la zona donde se encuentre la especie abre un camino infinito de investigación en fitogenia donde ejemplos de plantas amazónicas o de zonas boscosas aún no se han investigado y están generando toda clase de posibilidades de usos antibacterianos de tipo limpio. Ejemplos de plantas como el caso de el Orégano (*Origanum vulgare*) tienen principios activos primarios y secundarios, caso carvacrol y timol donde el primero es el primario y principal, pero combinados actúan en sinergismo efectivo. El mecanismo de acción antibacteriana se debe a su acción sobre la composición de la pared celular bacteriana, desnaturalizando y destruyendo las proteínas de la misma. Se ha demostrado que alteran la permeabilidad de las membranas citoplásmicas a los iones de hidrógeno y potasio.

THE USE OF PROTEASE IN FISH DIETS, A FEASIBLE TOOL FOR NEW PROTEIN SOURCES TOWARDS SUSTAINABLE AQUAFEEDS

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Sustainable nutritional solutions are the focus of modern aquafeed sector. Innovative compounds that support fish growth performance and to reduce the use on fish meal as well environmental concerns.

Being nutrition one of the fundamental pillars of animal health, adequate fish nutrition elevates animal and increases overall fish health without being detrimental to the environment or leaving residue in fish meat or water pond.

Advances in the knowledge of fish nutrition and health led to the development of high-performance, natural bioactive compounds to be used as fish feed additives thru precise nutrition than can help farmers and feed companies to use novel protein sources in fish feeds.

A series of trials work with the use of protease in warm water fish sown good evidence when reformulating aquafeeds under current situation of cost increase in LATAM and USA.

MODELO BIOECONÓMICO DE PRODUCCIÓN ACUAPÓNICA EN LA CIUDAD: PRODUCCIÓN DE LAMBARÍ Y MICROGREENS

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La acuaponía es considerada una tecnología sustentable y una opción productiva para las ciudades. Uno de los tres ejes de la sustentabilidad es el económico, por lo que la sustentabilidad económica de estos sistemas importante. La modelación bioeconómica permite evaluar la viabilidad económica de los sistemas productivos, ayudando en la toma de decisiones (Badue & Amorim, 2012). Los modelos bioeconómicos utilizan modelos matemáticos que relacionan el desempeño biológico de un sistema de producción con sus limitaciones económicas y técnicas (Llorente & Luna, 2016). El objetivo de este trabajo es evaluar mediante el uso de modelos bioeconómicos la viabilidad económica de producir microgreens de mostaza y lambarí en sistemas salinizados y no salinizados en entornos familiares. Los datos se obtuvieron de un experimento de producción de lambarí y microgreens con tres tratamientos a 0,1 y 2 g/L de salinidad (escenarios LR-0, LR-1 y LR-2). Para cada uno de ellos se parametrizaron y validaron modelos matemáticos (biológicos) de crecimiento. El modelo bioeconómico de cada escenario se creó relacionando el modelo biológico con el modelo de gestión (a partir de las condiciones experimentales) y el modelo económico. Con los resultados de los modelos bioeconómicos para cada escenario se simuló y evaluó un proyecto de producción familiar de lambarí y microgreens con un horizonte de tiempo de 10 años considerando 6 ciclos anuales de lambarí y 5 ciclos de producción de microgreens por cada ciclo de lambarí. Los indicadores utilizados para evaluar el proyecto simulado fueron el valor presente neto (VPN), la tasa interna de retorno (TIR) y la relación beneficio/costo (B/C). Los modelos de crecimiento seleccionados, validados y simulados fueron el monomolecular (MO) para LR-0, Gompertz (GP) para LR-1 y el logístico (LG) para LR-2 (figura 1). Los ingresos netos y beneficio operativo estuvieron fuertemente influenciados por la cosecha de microgreens (figura 2).

Todos los escenarios fueron económicamente viables. El escenario que mostró mayor viabilidad económica fue el LR-0, siendo los microverdes la mayor fuente de ingresos del sistema.

Financiamiento: FAPESP 2018/23658-5, 2017/50431-9; CNPQ 311108/2017-2

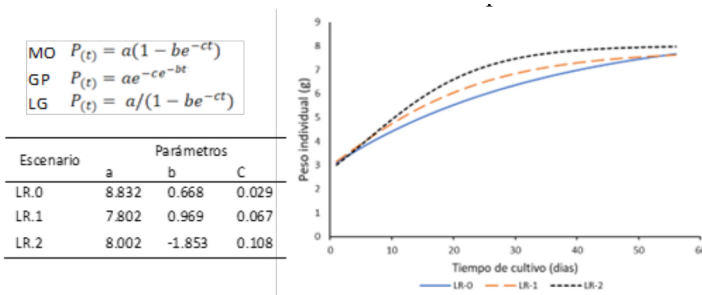


Figura 1. Modelos de crecimiento y parámetros para LR.0, LR.1 y LR.2

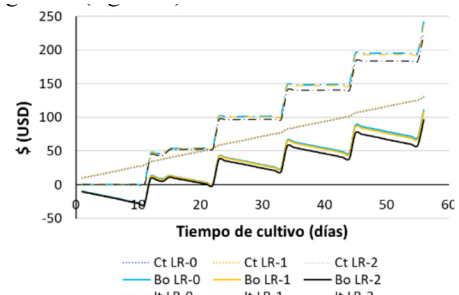


Figura 2. Costos totales (Ct), Beneficios operativos (Bo) e Ingresos totales (It) durante un ciclo de cultivo de lambarí en los sistemas de acuaponía propuestos

DISTRIBUCIÓN Y EPIDEMIOLOGÍA DEL VIRUS DE LA NECROSIS PANCREÁTICA INFECCIOSA - IPNV EN LA TRUCHA ARCOÍRIS *Oncorhynchus mykiss* EN PERÚ

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La acuicultura mundial se ha incrementado significativamente en las últimas décadas (FAO, 2020). En el Perú, la producción acuícola está liderada por la trucha arcoíris (*Oncorhynchus mykiss*) y se concentra en las regiones altoandinas, de acuerdo a la producción del año 2019 con un total de 47,924.00 TN (RNIA, 2020), donde destacan los departamentos de Puno (67%), Pasco (10%), Huancavelica (7.8%) y Junín (6.7%). El IPN es una enfermedad altamente contagiosa y mortal entre las truchas arcoíris con una distribución mundial (Munro y Midtlyng, 2006, Ariel y Olesen, 2002), siendo el agente etiológico el virus de la necrosis pancreática infecciosa (IPNV). Recientemente se confirmó su presencia en el Perú, en los departamentos de Cusco y Puno (SANIPES, 2019).

Ante ello, el presente estudio exploró las características epidemiológicas de la enfermedad, sobre la presencia y distribución en el sector acuícola de la trucha arcoíris en el país.

Material y métodos

El estudio comprendió los departamentos donde se realiza cultivo de truchas arcoíris en el Perú, como Ancash, Cusco, Huancavelica, Junín, Lima, Pasco y Puno. Se realizaron muestreos en los centros productores de trucha entre los meses de noviembre del año de 2019 hasta finales de octubre del 2020. Los centros monitoreados fueron de dos tipos: productor de semillas y de engorde.

Para el tamaño muestral, se utilizó una prevalencia esperada del 5% (OIE, 2020), para lo cual se calculó un total de 60 animales por centro de producción acuícola, a través de la conformación de 12 pools de 5 animales cada uno (Sergeant, 2018). Asimismo, el trabajo en campo comprendió la realización de necropsias de los peces, donde se registraron los signos clínicos y alteraciones anatomopatológicas, también referentes a la temperatura del recurso hídrico y las capturas fotográficas.

Se realizaron pruebas de RT-PCR en tiempo real empleando secuencias específicas de iniciadores y sondas para la amplificación de IPN y de un control positivo interno ELF1, de acuerdo con lo descrito por Tapia et al., (2015). Se consideró positivo un umbral de ciclo (Ct) menor a 40. Asimismo, todos los resultados positivos fueron verificados en geles de agarosa mediante electroforesis convencional.

Resultados

Se evaluaron un total de 1581 recolectadas en 7 departamentos del Perú. La prevalencia de la enfermedad obtenida en los departamentos positivos destaca en Cusco (4.05%), Puno (3.81%) y Huancavelica (0.23%), mientras que, en los departamentos de Ancash, Lima, Junín y Pasco no se encontró la presencia del patógeno.

La mayor proporción de casos positivos fue en primer lugar en los centros dedicados al engorde de truchas arcoíris, seguido por los centros de producción de semilla (hatchery) y finalmente aquellos que realizan el ciclo completo. Se demuestra algún grado de asociación entre la presentación de IPN y el tipo de centro de producción.

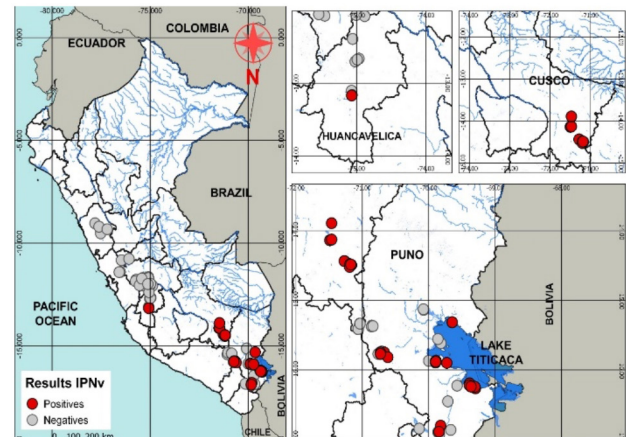


Figura 1. Distribución del IPNV en truchas arcoíris, Perú 2019 – 2020.

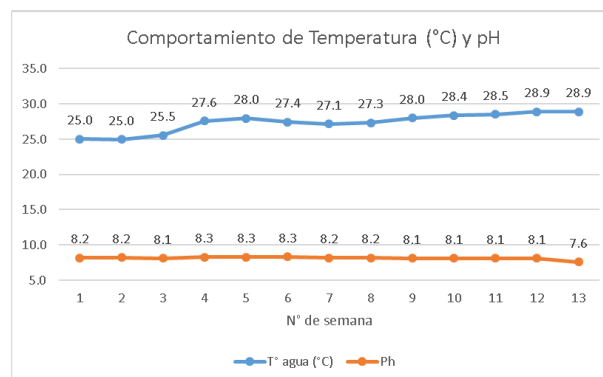
EVALUACIÓN DEL DESEMPEÑO PRODUCTIVO DE PAICHE *Arapaima gigas* CULTIVADOS EN CLIMA SUBTROPICAL

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El cultivo de paiche *Arapaima gigas* en Perú es de gran interés económico por su alto valor comercial en mercados nacionales y extranjeros como Europa y Norteamérica. La crianza de esta especie se ha desarrollado desde los años 90 en zonas de la Amazonía peruana en sistemas de baja densidad con baja tecnificación. Estas producciones tienen como característica que se realiza en estanques de tierra a temperatura entre 26 a 31°C en climas tropicales. Sin embargo, el crecimiento de la acuicultura y el aumento de la innovación por parte del estado peruano ha permitido aplicar nuestras tecnologías a la crianza de la especie, por lo cual, se ha logrado mejorar sus índices productivos, llegando a obtener pesos superiores a los 10 kg en 18 meses de crianza. Asimismo, el uso de sistemas de recirculación acuícola ha permitido que el paiche pueda ser manejado en diferentes latitudes diferentes a la selva peruana.

Esta investigación tuvo como objetivo evaluar el desempeño productivo de paiche en condiciones medioambientales de la zona costera de Huacho, cultivados en un invernadero y teniendo en consideración los parámetros físicos, como la temperatura ambiente, temperatura del agua y pH.



ARTISANAL FISHING OF RIVER PRAWN *Macrobrachium americanum* IN THE RURAL COMMUNITIES OF LA PAZ, BCS, AND GUERRERO

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The *Macrobrachium americanum* river prawn is a species that can reach a large size in the wild, which is why it is of great economic and ecological importance. For over a decade, artisanal fishermen have exploited river prawns to provide a product to local markets or for self-consumption (New, 2009). The constant deterioration of the habitat in which the river prawn develops, coupled with the increase in product demand by local markets, has put the wild populations of these crustaceans at risk (García-Guerrero et al., 2013).

Therefore, a conservation study of the species was carried out in the rural communities of La Paz, BCS, and Guerrero. It was carried out using the quantitative method to collect primary data (surveys) for six months (May to October). The information obtained through the surveys indicated that the capture of prawn rivers is generally carried out during the rainy season; when the reproduction of the species occurs. The regulation for its capture is limited, which has caused a considerable decrease in its populations in both locations (Fig. 1). Since the fact that the fishing volumes during each season are insufficient for the maintenance of the families of the fishermen, they have to carry out other activities, are they are not exclusively dedicated to fishing. There needs to be more information on the degree of fishing exploitation of the species, so the actual state of the wild populations is unknown. It is recommended that a permanent evaluation of the resource is necessary to implement measures that guarantee its conservation and sustainable management.

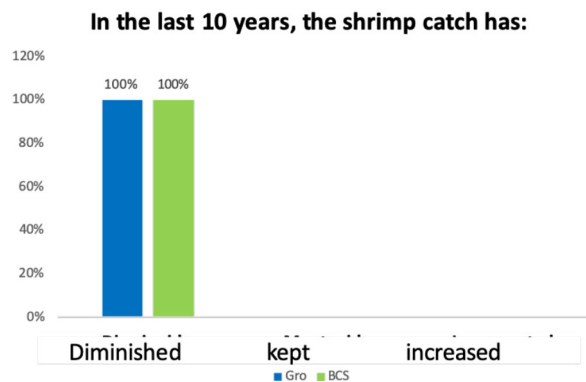


Fig. 1 the shrimp catch

OZONE CAN IMPROVE THE WATER QUALITY IN A RECIRCULATION SYSTEM TO ZEBRAFISH (*Danio rerio*)

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The aim of this study was to evaluate the use of ozone in a zebrafish (*Danio rerio*) water recirculation system and the effects on animal health and limnological parameters. 120 adults of zebrafish (*Danio rerio*) were used, eight to ten months old, and the water of each aquarium was ozonated with a commercial device (Ozone & Life, 1.5 RM, Brazil) for 10 minutes during 10 days, according to the following protocols: Group 1 (O52OD): 52 µg/ml once a day; Group 2 (O52TD): 52 µg/ml twice a day; Group 3 (O72OD): 72 µg/ml once a day; Group 4 (O72TD): 72 µg/ml twice a day; Control group (CG): water without ozone. The dissolved oxygen concentration (mg/L) was obtained by a multiparameter meter (AKSO – AK88). The more probable number (MPN) of coliform bacteria was determined by Hunt & Rice (2005) protocols and analysis was performed to nitrate (Yang et al., 1998 cited by Matos, 2012), nitrite (APHA, 1998 - Standard Methods 4500-NO₂-) and ammonia (Bordon et al., 2022).

The use of ozone significantly increased ($p < 0.05$) the concentration of oxygen and decreased ($p < 0.05$) the growth of coliform bacteria in all treated groups compared with the control group. Ozone decreased ($p < 0.05$) the levels of nitrate. Thus, the control and maintenance of oxygen are easier if an imbalance in oxygen can occur. Furthermore, ozone is mentioned as an important agent to remove pathogens in aquaculture systems (Powell and Scolding, 2018). The ozone in contact with bacteria causes an oxidation of phospholipase and lipoproteins present in the bacterial envelope, causing an elimination of the microorganism (Smith, 2017). High levels of nitrite cause great disorders to fish in water recirculation system, related to cardiovascular functions, decreased oxygen transport and other physiological functions (Kroupova et al., 2005). Therefore, the maintenance of the nitrogen compound levels at an ideal rate is very important to animal health. The use of ozone could be attributed to the influence on nitrifying activity by aerobic bacteria due to an increase in dissolved oxygen concentration (Malone, 2013; Hammer, 2020).

We realized in this study that ozone in the water recirculation system of zebrafish (*Danio rerio*) can be considered to improve water quality, enabling improvements in zebrafish culture.

This work was supported by the Coordination of Improvement of Higher Level Personnel (CAPES) and the Brazilian National Council for Scientific and Technological Development (CNPq).

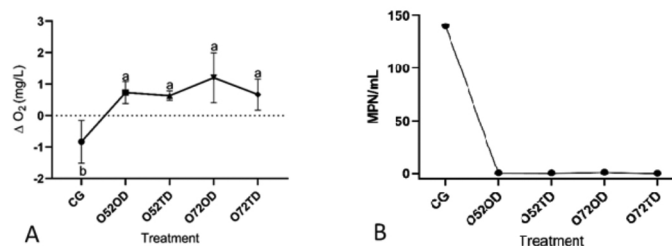


Figure 1. Dissolved oxygen concentration (ΔO_2) and More probable number (MPN) of coliform bacteria growth in an ozonated water recirculation system for zebrafish (*Danio rerio*)

Note: A – Delta (ΔO_2) between the final and initial dissolved oxygen concentrations. B – More probable number (MPN/MI). CG – control group; O52OD – ozone at 52 µg/mL once a day; O52TD – ozone at 52 µg/mL twice a day; O72OD – ozone at 52 µg/mL once a day; O72TD – ozone at 72 µg/mL twice a day.

PARASITE INDEX IN THE EARLY STAGE OF DEVELOPMENT OF THE HOLOTHUROID *Isostichopus fuscus* (ASPIDOCHIROTIDA: STICHOPODIDAE): AQUACULTURE IMPLICATIONS

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Aquaculture of the edible holothuroid *Isostichopus fuscus* in Ecuador has been partially limited due to occurrence of a highly virulent disease of their planktotrophic larva into the auricularia stage caused by a bacteria-protozoan consortium. The protozoan occurrence (abundance, infection rate and intensity of infection) was evaluated on five length groups of auricularia larva in a trial in April 2016: (1) early auricularia – EA: 250-300 μm ; (2) middle auricularia 1 – MA1; 300-600 μm ; (3) middle auricularia 2 – MA2: 600-900 μm ; (4) auricularia – A: 1.1-1.3 mm and (5) late auricularia – LA: \approx 500 μm . Trial lasted 25 days. A total of 14801 parasites were counted in six hundred larva. Of them, 42.5% were parasitized. Infection rate and intensity of infection significantly varied in relation to the host's body length. Stage A had the highest prevalence and intensity, respectively ($62.5 \pm 5.7\%$, 130.5 ± 13.0) than EA ($21.7 \pm 5.2\%$, 2.6 ± 0.7 , $p < 0.05$). Stage A without parasites were significantly larger (1494.1 ± 52.2 μm) than those larvae with parasites (1237.7 ± 24.4 μm , $p < 0.05$). Data demonstrates for the first-time dynamic changes of parasite infestation in the developmental stages of auricularia where larvae without parasites grew and developed faster (18-d) than infected ones (25-d).

Nowadays, aquaculturing of the sea cucumber *Isostichopus fuscus* represent more than their edible part for prized gastronomic seafood industry. Nonetheless, is evident the poor understanding of the diseases that affect the various its life stages during their farming. Our goal is to provide a quantitative data of the occurrence of parasitism disease in the earliest stage of larvae (auricularia as host specificity) of *I. fuscus* to determine its effects on the growth and survival on its different five length categories at an experimental rearing. This information provides that would help us gain insight into diseases of *I. fuscus*.

Broodstocks were collected in April 2016 in Santa Elena, Ecuador. Auricularia larvae were reared (stock density: 0.2 larva ml^{-1}) in eight 500-l conical tanks with filtered/UV seawater. Thirty larvae were sampled per replicate ($n = 4$) at 4 days intervals to monitor larval development, parasite counting and register larval size in length. Larvae fed daily a mix of microalgae. Five length-groups by each larval stage were: early auricularia – EA (250-300 μm); middle auricularia 1 – MA1 (300-600 μm); middle auricularia 2 – MA2 (600-1000 μm); auricularia A (1000-1300 μm) and late auricularia – LA (\approx 500 μm). Parameters were: temperature: $28.0 \pm 1.0^\circ\text{C}$; salinity: 34‰, pH: 8.2, DO: 5-6 $\text{mg O}_2 \cdot \text{l}^{-1}$ and illumination at 0.5 $\mu\text{E m}^{-2} \cdot \text{s}^{-1}$). The culture trial lasted for 25 days. Abundance, prevalence and infection intensity were determined following Bush et al. (1997). ANOVA tests were performed.

Three clinical signs occurred in the same disease: stomach ulceration, atrophy and rotting-edge. 24540 parasites were counted in 600 auricularia larvae. 53.3% showed between 2 to 279 parasites. Parasite infection risks varied significantly in relation to the five host size categories. The lowest and the highest parasite infection risk values were found in the EA and A, respectively. For abundance (EA: 0.5 ± 0.2 , A: 86.7 ± 5.6 , $p < 0.05$), infection rate (EA: 21.7 ± 5.2 , A: 70.8 ± 3.7 , $p < 0.05$) and intensity of infection (EA: 2.6 ± 0.7 , A: 130.5 ± 12.9 , $p < 0.05$). The largest auricularia were without parasites (A: 1494.0 ± 52.2 μm in length) and completed their development in 18 days with a high survivorship, but those larva with parasites in 25 days (A: 1238.0 ± 24.4 μm , $p < 0.05$). Our results are comparable to the findings of other authors focused on reviewing the culture density of larvae, water temperature, and quantity and quality of food available against this bacteria-protozoan consortium.

AQUACULTURE OF THE SEA URCHIN *Arbacia stellata* WITH INTEREST FOR NUTRACEUTICALS IN ECUADOR

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Echinoderm aquaculture in Latin America is incipient yet, but it represents a new frontier for the highly nutritious marine food production, with native species of high commercial value offering a vast potential when is compared to their weakened artisanal benthic fisheries by over fisheries. *Arbacia stellata* (Blainville, 1823) is a fast-growing pan-regional sea urchin that can inhabit environments with high salinity fluctuations within estuaries. It presents attractive biological characteristics, and attributes for aquaculture diversification and potential for extraction of macroenergetic biomolecules usable for the nutraceutical industry in Ecuador. Here is reported advances of studies on salinity tolerance on hatchery, diets for larval rearing and produce gonads in adults, and quantification of the pigment *EchA* in the celomic fluid. Aquaculture of this species would diversify our aquaculture and reducing the pressure on the depleted sea cucumber fisheries in the region.

The critical salinity in the initial stages of life was evaluated (percentage of fertilization, embryonic development and survival) in four salinities: 5, 10, 20 and 32 (control). Control showed 100% fertilization and survival, whose embryonic development was in 20 hours until the prism larva stage. However, salinities below 10 are critical for embryonic development and delayed the gastrula phase by more than 24 h without the formation of prism larvae.

A 25-days feeding trial was performed to evaluate the effect of three diets on the development (from pluteus to competence stage), growth and survival of the larval rearing (1 larvae ml⁻¹), as follows, Diet 1 - RHO: *Rhodomonas* sp, Diet 2 - CHAE: *Chaetoceros gracilis* and Diet 3 - T-ISO: *T-Isochrysis lutea*, and control (starved condition). Five larvae were analyzed per replicate (n = 3) at intervals of 4-5 days. Five variables were measured (postoral arm, midline body, stomach, rudiment length, and pigment concentration). Diet 2 showed the best performance for growth and development, respectively (595.8±2.3 µm in PO length, 216.9±2.0 µm in rudiment) in 14-d after fertilization. Most pigments were in diets 1 (90%) and 2 (63%). Our results suggest that *C. gracilis* with *Rhodomonas* sp for obtaining best results in larviculture of *A. stellata*.

A 98-day feeding trial was performed (n= 88; 29.3±0.2 mm and 14.5±0.3 g mean initial test diameter and weight, respectively) to evaluate the efficacy of three isoproteic low-cost dry formulated diets were prepared for promoting their growth (in test diameter and weight), gonadal yield and survival. Diet 1 (shrimp, *Penaeus vannamei*), Diet 2 (Sacha Inchi, *Plukenetia volubilis*) and Diet 3 (mixed). Sea urchins were fed every 48 hours under *ad libitum* condition. Diets 2 and 3 showed a significantly better performance for growth in test diameter (31.6±0.2 mm and 31.2±0.4 mm), weight (19.1±0.5 g and 19.1±0.5 g), feed conversion ratio and gonadal index. This study indicates that plant-based diets and the combination of various protein sources in the diets produced remarkable biological responses to *A. stellata* growth.

The content of the red pigment equinochrome naphthoquinone A (*EchA*) in the coelomic fluid of *A. stellata* was evaluated from small individuals (16.3±0.3 mm TD; 2.8±0.3 g) and large individuals (45.7±0.4 mm TD; 56.4±1.1 g). The absorbance values (expressed in optical density) were reported in two wavelengths: 387 and 487 nm. There was interaction between large individuals who recorded the highest absorbance peaks for *EchA* at both wavelengths (387 nm: 0.10±0.01 and 487 nm: 0.05±0.01; P <0.05). The results of this study are consistent with the findings in other echinoids, where the highest production of *EchA* in coelomic fluid occurs in larger individuals detected at an absorbance of 387 nm.

DIFFERENT RESPONSES OF IMMUNE GENES EXPRESSION IN TISSUES OF RAINBOW TROUT VACCINATED AGAINST *Yersinia ruckeri*

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The enteric redmouth disease causes significant failures in rainbow trout farms. This highly contagious disease is caused by *Yersinia ruckeri*, a common bacterial infection in Peru. Although vaccination is the best strategy in terms of fish survival, no commercial vaccine is currently available or authorized in Peru, perhaps due to incomplete clearness about native *Y. ruckeri* populations. Recently, vaccination (immersion and intraperitoneal) experiments against *Y. ruckeri* were conducted by IMARPE in rainbow trout, and its effect was evaluated by measuring the expression of five immune response genes, in different tissues (kidney and spleen).

Alevines from Peruvian farms (Juli, Puno) were selected and vaccinated by immersion (treatment T1) considering 10^9 CFU/ml, and after 30 days organisms were vaccinated intraperitoneally for a second time (T2). PBS for the control (no-vaccinated) groups of each treatment was considered (T1-co and T2-co). Also, organisms before the first vaccination (T0) were collected and considered as a normalization group. cDNAs (n=8 per treatment per tissue) were synthesized from high quality RNA samples, from the five groups. Primers and probes for Efact-1a, bAct, Cath-2, IgM, IgT, IL-1B, and SAA genes were selected from literature, while primers for bAct amplification were designed in our laboratory. Gene expression analysis was conducted using qRT-PCR, and $\Delta\Delta C_t$ method was used to obtain the relative fold change. The average of two reference genes (Efact-1a and bAct) was used as the internal calibrator. Non-parametric test was performed for media comparisons.

The expression of adaptive immune effector molecules genes were up-regulated in both tissues for IgM, and in kidney for IgT. Both vaccinated (T1 and T2) fish groups showed significant up-regulation ($p < 0.05$ and log fold change > 2 -fold) of IgM gene in both tissues, while IgT only registered significance in T2. Probably, both Ig were stimulated by antigens in vaccine formulation. On the other hand, the pro-inflammatory interleukin IL-1B, and effector molecules Cath-2 and SAA showed significant down-regulation in T1, in both tissues. In particular, IL-1B gene expression was also significant in vaccinated fish against their respective non-vaccinated groups. These observations were expected, since these molecules are active when an infection is ongoing. Although these immune responses patterns are influenced by several factors (such as temperature, type of vaccine, days post vaccination, and infection status after vaccination), it seems that the majority of target genes tested in our experiment serve as proper molecular markers for vaccine evaluation. A further immune response post challenge could improve our understanding of immune related genes in this study. However, testing more immune-related genes in different important tissues is crucial to propose an accurate gene panel for experimental *Y. ruckeri* vaccines in the *O. mykiss* cultivation.

Acknowledgment: This work was funded by PpR-2022, Meta 03 Desarrollo Tecnológico, IMARPE, Ministerio de la Producción, and the National Council of Science and Technology - CONCYTEC, Contract 128-2020-FONDECYT.

Aeromonas* spp ISOLATED FROM AMAZONIAN FISH HARBORING SEVERAL VIRULENCE GENES CAN CAUSE MORTALITY IN PACO *Piaractus brachipomus

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Aeromonas is a rod-shaped Gram-negative bacterial genus that has been frequently reported to cause diseases in farmed fish, resulting in mortality. This has been related to their ability to produce virulence factors driven by genes encoded within their genome that confer them advantages in the pathogenic process. Being necessary to explore the potential of *Aeromonas* spp to cause mortality in native species of importance in aquaculture in Peru, such as the fish paco *Piaractus brachipomus*, the present study evaluates the virulence genes of *Aeromonas* spp isolated from Amazonian fish and lethality in *P. brachipomus*.

Bacteria (n=17) isolated from diseased Peruvian Amazonian fish were previously biochemically and molecularly identified by API 20E, and the analysis of 16S rRNA and *gybB* genes, respectively. From DNA extractions of the isolates, the presence of eight virulence genes: aerolysin (*aer*), cytotoxic enterotoxin (*altA*), cytotoxic enterotoxin (*act*), hemolysin (*hly*), serine protease (*ser*), lipase (*lip*), flagellin (*fla*) and elastase (*ahyB*), were evaluated. PCR amplified products were analyzed by electrophoresis and evaluated for their presence (+), or absence (-) in agarose gels. For experimental infection, *P. brachipomus* (9 ± 1 cm), acclimatized and kept in tanks under controlled conditions were infected intraperitoneally with 0.1 µL of bacterial inoculum in 0.85% saline solution, for 2 treatments, equivalent to 10⁶, 10⁷ and 10⁸ CFU/fish. The control group was injected with 0.1 µL of saline. The experiments were carried out at 28 °C, for 20 days.

It was observed that *fla* and *ahyB* genes were present in all the isolates evaluated, the *lip* gene was present in all bacteria except in one *A. caviae*. *A. dhakensis* and four *A. hydrophila* had the highest number of virulence genes and caused high mortality (> 90%) in *P. brachipomus* from the lowest doses (10⁶ CFU/fish), compared to other bacterial species in this study. *A. veronii* (with 5 virulence genes +) and one *A. caviae* isolate (4 genes +) produced mortality (60 and 30%, respectively) from 10⁷ CFU/fish. *A. jandaei* (3 genes +) and *A. caviae* (2 genes +) isolates caused mortality only at the 10⁸ CFU/fish dose. The results showed that bacteria harboring more virulence genes were associated with high mortality. An exception was two *A. hydrophila* isolates that produced high mortality (> 90%) and harbored two virulence genes. Other components involved in *A. hydrophila* virulence will help to explain this observation.

Given the importance of native fish aquaculture in Peru, this study highlights the ability of species of the genus *Aeromonas* to harbor several virulence genes, especially *A. hydrophila* and *A. dhakensis*, and to cause high mortality in paco. It also highlights the pathogenic potential of *A. caviae*, *A. veronii* and *A. jandaei*, bacterial species that could constitute a threat in the future for Peruvian native Amazonian fish.

Acknowledgment: This work was funded by the National Council of Science and Technology - CONCYTEC, Contract 129-2020 FONDECYT, and PpR - 2022, Meta 03 Desarrollo Tecnológico, IMARPE, Ministerio de la Producción.

eDNA FOR PATHOGENES IDENTIFICATION IN WATER FROM FISH FARM OF RAINBOW *Oncorhynchus mykiss*, CULTIVATED IN PERU

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Perú is the fifth most important rainbow trout farming country in the world, with Puno being the main regional exporter. The cultivation of fish from imported eggs, different culture conditions, as well as environmental variations can alter the diversity of the bacterial community causing the predominance of certain pathogens during some periods of the year. DNA metabarcoding is a tool that offers important advantages for rapid monitoring of bacterial communities, including the identification and tracking of those that are not easy to cultivate in the laboratory.

In this sense, the present study sought to identify pathogenic bacteria present in water bodies from three rainbow trout farms in three localities (Arapa, Lagunillas and Yunguyo) located in the Lake Titicaca basin (Puno). Water samples were collected and filtered (1 L) at different times of the year (rain in March and dry in September). For the identification of bacterial species, the analysis of the hypervariable region V1-V3 of gene RNAr 16S, was performed. The ASVs were obtained using QIIME2 pipeline with DADA2 package. The taxonomic assignment of the ASVs was performed using the sklearn classification method based on the latest SILVA r16S database. Rarefaction was performed to 10.000 reads. MEGAN metagenomic analysis platform allows the analysis of ASVs by performing the distribution at taxonomic levels, and taxonomic clustering analysis was performed (at the family level) using the Neighbor-Joining method. Pathogenic bacterial families were identified in the different sampling localities such as: Yersiniaceae in Yunguyo, Pseudomonadaceae in Lagunillas (during March), and Rickettsiaceae in Arapa (during rainy season and both seasons). This method is recommended for monitoring pathogens in fish farms, in order to contribute in improving cultures of rainbow trout.

Acknowledgment: This work was funded by PpR-2019 and 2022, Meta 03 Desarrollo Tecnológico, IMARPE, Ministerio de la Producción.

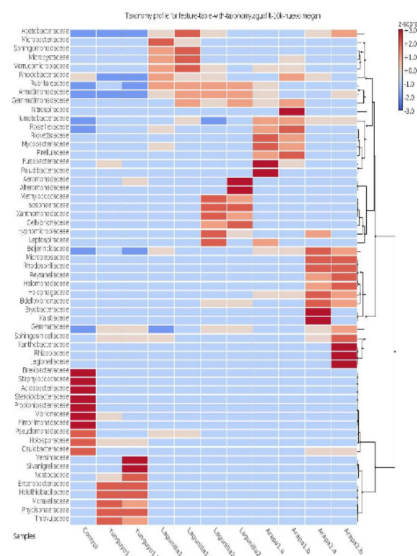


Fig. 1. Heat map of the main families. Determined by the z-score that

AN OVERVIEW OF COBIA FEEDING AND NUTRITION

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Aquaculture scientists and the industry concur that the long-term sustainability and profitability of the farming of cobia and other marine fish of high commercial value is conditioned on the successful development of practical, cost-effective and environmentally sustainable diets.

Development of practical and sustainable diets for new target species such as cobia (*Rachycentron canadum*) is at the top of the list of problems to resolve. A lack of knowledge about the nutritional requirements and digestibility of nutrient ingredients at the various life stages of most commercially important species being cultured has been identified as the major problem to be addressed and solved.

Researchers and the industry are tackling these major issues by focusing on identifying the nutritional requirements at different life stages of each species targeted, aiming at formulating and manufacturing economically viable and ecologically efficient aquafeeds. In this paper, we will summarize the current status of Cobia nutrition and provide an updated overview.

ANESTHESIA PROTOCOL FOR THE MANAGEMENT OF COMMON SNOCK BREEDERS: HEMATOLOGIC AND ETHOLOGICAL INDICATORS

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The white sea bass, *Centropomus undecimalis*, is a species of fishing importance with high potential for cultivation. Proper management of fish breeders requires validated anesthesia protocol that allow monitoring of reproductive maturation (cannulation), and the application of hormonal implants to induce spawning, without affecting the physiological and health status of the organisms.

The present work aims to determine the effect of sedation time on anesthesia in *C. undecimalis* breeders. Twenty organisms cultivated in the marine fish area of the UNAM-Sisal were used. To perform sedation (calm state), clove oil (0.003 mL per L) was used directly in the pond water. The organisms were exposed for a short (25 to 75 min) and long (100 to 125 min) sedation time, prior to exposing them to an anesthetic concentration of 0.1 mL of clove oil per L. The blood sample was obtained by puncture in the caudal vein. Plasma metabolites were evaluated using clinical diagnostic kits to determine the concentration of cortisol, glucose, lactate, hematocrit, hemoglobin concentration, and hemagglutinating activity.

A paired analysis was performed to compare the effect of sedation time. Hematological components and the time required for anesthesia (lack of response to a physical sensation), indicate similar responses ($P > 0.05$) in the fish of the two-sedation treatment, that is, that the sedation exposition did not generate a cumulative narcotic effect.

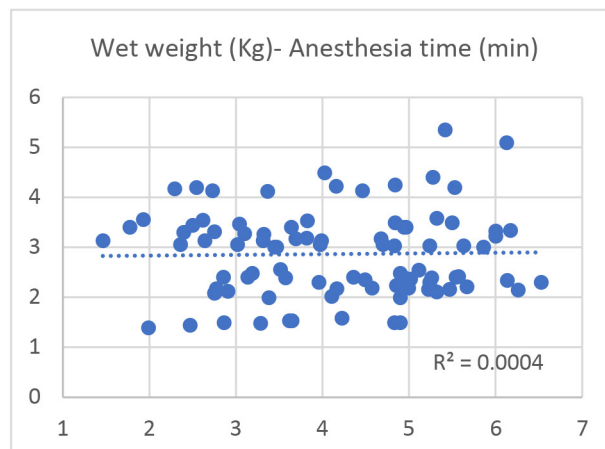
This protocol was probed in brood-stock of UNAM during maturation period.

Results indicate that there is no relationship between the size of the reproducers (1.2 to 6.8 kg, N=93) and the time required to reach the plane of anesthesia.

Sedation with clove oil (0.003 mL per L), prior to anesthesia, facilitated docile management of the breeders and adequate protocol for obtaining blood and gonad samples.

Acknowledgments

Financial support of National Autonomous University of Mexico (PAPIIT IN217322; IT201621)



SUSTAINABLE AQUACULTURE FEEDS

Dr Albert G.J. Tacon

Whilst the aquaculture sector continues to grow and make an ever-increasing contribution to world food supplies, there is a need to ensure that the sector continues to develop in a socially, economically and environmentally sustainable manner, in line with the United Nations sustainable development goals. The present paper focusses on the major perceived sustainability issues related to feed inputs for finfish and crustacean aquaculture species, including sustainability issues related to feed formulation and ingredient selection, feed manufacture and feed quality, on-farm feed use and impacts, and fish quality and food safety.

GROWTH AND LIPOGENESIS INDICATORS OF AMAZON TAMBAQUI (*Colossoma macropomum*) FED DIFFERENT VEGETAL INGREDIENTS

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Tambaqui (*Colossoma macropomum*) is a freshwater fish species native to the Amazon and Orinoco river basins of South America. It is the most produced native species in Brazil and its total aquaculture production in 2021 was 262,370 t. The frugivorous regime of this species renders it particularly tolerant to dietary incorporation of fruits and seeds/nuts. Furthermore, carbohydrates are the least expensive dietary energy source and an interesting way to spare some dietary protein for growth. The present study evaluated the growth performance and lipogenesis indicators of juvenile tambaqui fed different energetic vegetal ingredients.

A total of 192 tambaqui (131.6 ± 1.9 g) were distributed in 24 aquaria and fed with 6 diets (4,000 kcal/kg) containing (30%): corn, sorghum, corn starch, wheat bran, rice bran and broken rice. Fish were fed for 57 days, until apparent satiation, in four meals a day. In the final biometry, the fish were weighed and measured, and blood aliquots were taken for later determination of metabolites in the blood. Then, the fish were sacrificed (eugenol, 10 g/L) for removal and weighing of visceral fat and liver. The experiment was carried out in a completely randomized design with 6 treatments and 4 replications. The results were submitted to ANOVA and Tukey's test at 5%.

No mortality was recorded. No difference on growth performance of tambaqui was observed. On the other hand, fish fed corn starch displayed an increased lipogenesis. This is probably related to the concentration and availability of glucose from the starch.

Table 1. Growth performance of tambaquis fed vegetal energetic ingredients for 57 days.

Variables	Corn	Sorghum	Starch	Wheat bran	Rice bran	Broken rice	P value
Final length, cm	22.7	22.6	22.8	22.6	22.0	22.9	0.38
Weight gain, g	68.5	64.7	75.4	60.6	53.1	68.1	0.08
Feed consumption, g	834.5	832.6	830.8	813.0	839.2	831.0	0.64
Food conversion	1.5	1.6	1.4	1.6	2.1	1.5	0.10

Data are mean values (n=4). Means in the same line with different letters are different by Tukey's test (P<0.05).

Table 2. Blood metabolites and somatic indexes of tambaquis fed vegetal energetic ingredients for 57 days.

Variables	Corn	Sorghum	Starch	Wheat bran	Rice bran	Broken rice	P value
Cholesterol, mmol/L	2.8 c	3.1 ab	3.2 a	2.9 bc	3.4 a	3.2 ab	0.002
Triglycerides, mmol/L	2.3 bc	2.4 b	3.1 a	2.1 c	2.1 c	2.3 bc	<0.001
Glucose, mmol/L	8.6	9.3	9.4	10.1	8.5	9.3	0.12
Hepatosomatic index, %	1.2 c	1.4 a	1.5 a	1.5 ab	1.4 bc	1.5 ab	0.004
Mesenteric fat index, %	0.7	0.6	0.6	0.5	0.4	0.7	0.06

Data are mean values (n=4). Means in the same line with different letters are different by Tukey's test (P<0.05).

DOES AN ACUTE DOSE OF SOY SAPONIN DISRUPT FISH GUT HOMEOSTASIS?

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Gut health and integrity has been associated to an effective nutrient uptake and is involved in the modulation of fish immune system and antioxidant status. A disruption in the fish intestinal permeability and homeostasis may result in reduced growth and feed efficiency, lower resistance to stressors and diseases, and overall poorer health status.

Soy saponin (SAP) has been shown to provoke mild to severe intestinal inflammatory processes in fish. This study aimed to assess this compound as a potential disruptor of intestinal permeability and homeostasis in gilthead seabream juveniles by evaluating the intestinal response to different doses of SAP at 48 and 72 h after intake. The expression of genes coding for antioxidant response (catalase – *cat* and glutathione peroxidase – *gpx*), paracellular permeability (occludin – *ocl*, claudin 12 – *cldn12* and tight junction protein 2 – *tjp2*), and immune response (cyclooxygenase 2 – *cox2* and immunoglobulin M – *IgM*) was evaluated to identify molecular markers linked to homeostatic disruption in the gut.

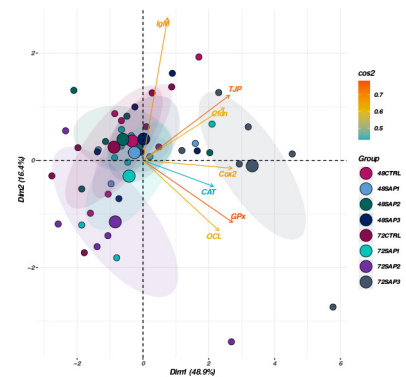
Gilthead seabream juveniles (body weight \pm 152 g) were fed gelatine capsules by the “assisted-feeding” technique. Fish were fed either empty (CTRL) or capsules containing soy saponin at 125 mg (SAP1), 350 mg (SAP2) and 700 mg (SAP3). Eighteen fish per treatment were transferred to two 100 L cylindrical-conical tanks and maintained at optimal conditions.

At 48 h, the intestine of three fish per treatment were sampled to evaluate histopathology parameters. Also, 48 and 72 h after intake, intestine from six fish per treatment were sampled for gene expression.

After 48 h, histology and gene expression analyses were not significantly different among treatments. However, 72 h after ingestion, fish from the SAP3 treatment presented a differential response revealed by principal component analysis (PCA), being the differential expression of *gpx*, *tjp2* and *cox2* the main loadings responsible for clustering SAP3 observations.

These results suggest that the oral administration of 700 mg of SAP may provoke a mild disruption of intestinal homeostasis in gilthead seabream after 72 h. Nevertheless, the administration of a higher dose of dietary SAP for a longer period is being evaluated to provoke an acute gut inflammatory reaction. This method will allow to assess the potential of functional feeds in fish intestinal recovery and health.

This work was funded through Project FICA, co-financed by COMPETE 2020, CRESC Algarve 2020, Portugal 2020 and the European Union through ERDF under reference ALG-01-0247-FEDER-047175. This study received Portuguese national funds from FCT – Foundation for Science and Technology through projects UIDB/04326/2020, UIDP/04326/2020 and LA/P/0101/2020 to CCMAR.



PRODUCTIVE PERFORMANCE OF PACIFIC WHITE SHRIMP *Litopenaeus vannamei* FED WITH A BOTANICAL FEED SUPPLEMENT

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Optimizing gut integrity and barrier function is an important strategy to prevent disease, promote gut health and improve the productive performance of shrimp. In this regard, an interesting concept is the use of feed supplements that can strengthen the immune system and the intestinal tract. Of particular interest are botanical supplements that can enhance non-specific (innate) immune responses by improving intestinal functions, increasing survival and weight gain. Botanical supplements containing actives with immunomodulatory properties are promising candidates for immune system modulation and as productivity enhancers. Therefore, the botanical plant extract used in this trial has the potential not only to prevent disease, but also to increase the animal's ability to cope with any event that occurs during its productive cycle.

The objective of this study was to evaluate the effect of a botanical feed supplement on the productive performance of pacific white shrimp (*Litopenaeus vannamei*), under experimental conditions. The trial consisted in five treatments depending on botanical inclusion level (g/ton): Control; T1-AVT100; T2-AVT150; T3-AVT200 and T4-AVT250. All feeds were formulated with same ingredients to match the nutritional requirements of shrimps.

FIGURE 1. Weight gain of shrimps fed with different levels of inclusion of botanical feed supplement.

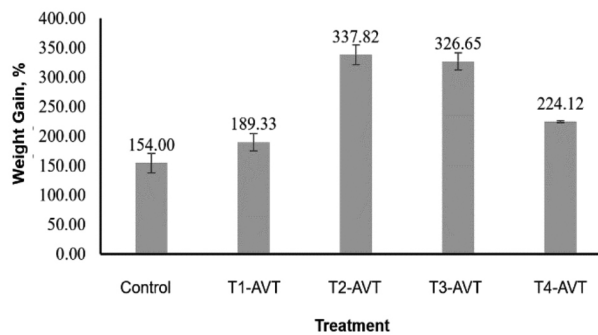


FIGURE 2. FCR of shrimps fed with different levels inclusion of botanical feed supplement.

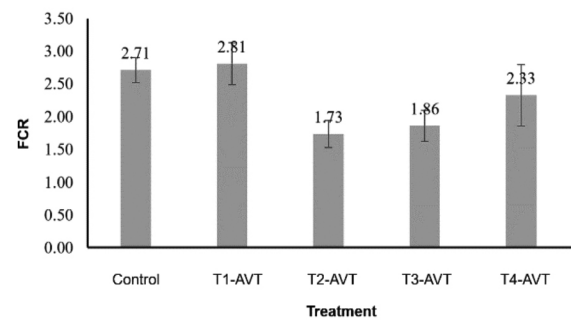
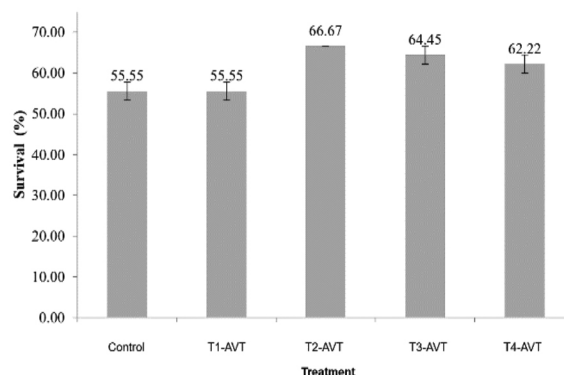


FIGURE 3. Survival rate of shrimps fed with different levels inclusion of botanical feed supplement.



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After completion of 60 days feeding trails, the weight gain % showed significant ($P<0.05$) difference between the control and treatment group (Fig.1).

Animals fed with T2-AVT and T3-AVT showed higher growth rate compared to the control and other treatment groups.

Though FCR, did not show significant ($P<0.05$) difference between the control and treatment group (Fig.2), but a noticeable trend was recorded. Better FCR was recorded in the T2-AVT and T3-AVT group.

Survival rate of shrimps showed a significant ($P<0.05$) difference between the control and treatment group (Fig 3). Lowest survival rate was recorded in the Control and T1-AVT.

We can conclude that the botanical feed supplement tested in this study improved the productive parameters of shrimps at a dose of 150 g/ton of feed.

EFFICIENCY OF A BOTANICAL IMMUNOMODULATOR IN PACIFIC WHITE SHRIMP *Litopenaeus vannamei* CHALLENGED WITH VIBRIO *Vibrio parahaemolyticus*

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Shrimps are unique in that they do not have adaptive immunity; therefore, they rely on innate immune responses to protect them from pathogenic infection. The lack of acquired immunity means that vaccination cannot be used as a prevention strategy in shrimp production. Rather, optimizing innate immunity – including the integrity of the intestine and barrier function – is an important strategy to preventing disease. In this regard, an interesting emerging concept is the use of feed supplements that can support the immune system. Of particular interest are botanical supplements that can improve non-specific (innate) immune responses and recovery of disease when an outbreak does occur. Botanical supplements containing actives that have immunomodulatory properties are promising candidates for prevention. Therefore, the plants extract present in this botanical tested have the potential to not only prevent disease but also to increase the animal's ability to cope if and when disease does strike.

The objective of this experiment was to evaluate the efficiency of a botanical feed supplement on disease resistance of pacific white shrimp (*Litopenaeus vannamei*) challenged with vibrio, *V. parahaemolyticus*. Five treatments were considered, depending on botanical inclusion level (g/ton): Control; T1-AVT100; T2-AVT150; T3-AVT200 and T4-AVT250. After 60 days of feeding trial, 8 shrimps per treatment were injected with vibrio at 10^6 CFU/mL and were kept under observation for 10 days post infection.

Based on microbiological analysis, it was confirmed that mortality of shrimp was caused due to *V. parahaemolyticus* infection. Treatments T2-AVT and T4-AVT had a lower cumulative mortality percentage compared to the Control group (Fig. 1).

That could be explained due the positive effect on immunomodulation of shrimps fed with the botanical supplement.

Relative percentage survival increased proportionately with inclusion level of botanical immunomodulator in the diet (Fig. 2). Shrimps in the treatments T2-AVT150 and T4-AVT250 had higher relative percentage survival.

Botanical immunomodulator proved to be efficient in reducing mortality and increasing survival in shrimps challenged with *Vibrio parahaemolyticus* at inclusion dose of 150 g/ton of feed.

FIGURE 1. Cumulative mortality (%) of *Litopenaeus vannamei* following an experimental *Vibrio parahaemolyticus* infection.

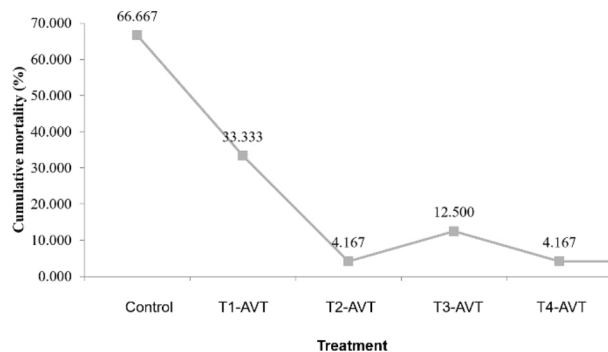
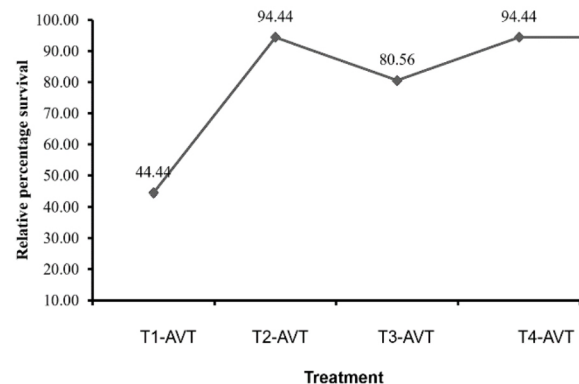


FIGURE 2. Relative percentage survival of *Litopenaeus vannamei* following an experimental *Vibrio parahaemolyticus* infection.



STUDY ON THE FUNCTIONAL ROLE OF FISH TRANSIENT RECEPTOR POTENTIAL MELASTATINE 2 CHANNEL

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Pollutants such as reactive oxygen or nitrogen species (ROS or RNS) in wastewater released into the aquatic environment cause serious impacts on fish health. In different animal species, transient receptor potential (TRP) proteins have been well known to form sensor cation channels for detection of a variety of environmental stimulants. To elucidate sensing mechanisms that allow fish to avoid pollutants in the environment, we here characterize the zebrafish (*Danio rerio*) homologue of TRPM2, whose mammalian homologue has been reported to show prominent sensitivity to ROS, especially to hydrogen peroxide (H₂O₂). Our results showed that the zebrafish TRPM2 (drTRPM2) protein forms a Ca²⁺-permeable cation channel activated by H₂O₂. Strikingly, in contrast to mammalian TRPM2, drTRPM2 responds to nitric oxide (NO) and nitrite (NO₂⁻). This distinctive RNS sensitivity of drTRPM2 channels is mediated by cooperative action of ADP ribose (ADPR) and cGMP-dependent protein kinase (PKG), and sensitivity is mediated mainly by ADPR. In addition, homozygous TRPM2 knock out zebrafish generated using the CRISPR/Cas9 system fails to show repellent behaviors against H₂O₂ and NO. Thus, TRPM2 channel plays an important role for fish to sense to the polluted environment.

STUDY ON THE INFECTION AND EFFECT OF SAUDAU (*Azadirachta indica*) EXTRACTION ON FISH LICE (*Caligus spp*) PARASITICS ON RABBIT FISH (*Siganus guttatus*)

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The research was conducted to identify the infection level of fish-lice (*Caligus spp*) on Rabbitfish (*Siganus guttatus*) which cultures in Thua Thien Hue province, and to clarify the effect of extraction from Saudau (*Azadirachta indica*) plant on the fish lice. The total of rabbit fish that were used for experiments is 120 fish, and fish were collected in 6 months at two different sites. The extraction of the Saudau plant was collected from leaf, and seed and then concentrated for experiments at ppm (0; 10; 50; 100; 500; and 1000) to evaluate the effect of extraction on fish lice. The results showed that the infection rate of fish lice on rabbit fish is 62,5% and infection intensity averaged at 19,2 lice/fish. Based on the collection data, it was clearly shown that in January, February, and March, fish lice were found much more than in other months ($p < 0.05$). After fish lice were treated with the extraction from leaf and seed for 30 hours, we found that the half effective concentration (EC_{50}), and 90% effective concentration (EC_{90}) of leaf extraction are 148ppm and 928ppm, respectively. The EC_{50} and EC_{90} of seed extraction are 62ppm and 397ppm, respectively. The results from our research frankly show the potential of using extraction from Saudau leaf and seed to treat the parasite disease caused by fish lice on Rabbitfish.

SITE SELECTION FOR SEAWEED CULTURE IN SOUTHERN COASTAL REGION OF SRI LANKA

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Introduction

Sea weeds are widely used as a raw material in cosmetics, fertilizers, agar algin and carrageenan production industry [4]. Therefore, Seaweed cultivation has become one of the popular Mari-culture. However, finding a suitable site for sea weed culture is a challenge. Several important factors are to be concerned during site selection. Less total suspended solids (TSS), optimum sea surface temperature (SST) and the calm water sheltered from waves, strong currents and predators are identified as best sites for culturing sea weeds [2]. As a coastal nation, the government of Sri Lanka has introduced seaweed cultivation to benefit the coastal community [1]. However, finding best sites is still challenging due to lack of information. Therefore, we focused on introducing a GIS and Remote sensing-based method to identify the suitable areas for sea weeds culture. For that, we selected the Southern coast of Sri Lanka where commercially valuable seaweed species are found along the coast [3].

Methodology

We carried out the study along the southern coastal belt of Sri Lanka from 6°25'7.45"N and 79°59'38.35"E to 6°30'38.46"N and 81°42'27.59"E, covering a distance of approximately 292 kilometers. Since the continental shelf off the southern coast of Sri Lanka is narrower than other coastal regions, a 10 km wide strip was selected for our study (Figure 1).

Sea Surface Temperature (SST), Total Suspended Matter (TSM) and Bathymetry were extracted from Landsat 8 (OLI) images taken from United States Geological Survey (USGS). Wind and current data for 2018 and 2019 were obtained from European Centre for Medium-Range Weather Forecasts with 0.1250*0.1250 resolutions as Network Common Data Form (NetCDF). The NetCDFs data were converted to raster data for extracting the wind direction and velocity & current direction and velocity Using Arc GIS 10.1 Software.

Band reflectance was calculated for Landsat 8 images followed by Atmospheric and radiometric corrections with ArcGIS software. Modified Normalized Difference Water Index (MNDWI) was used to extract the open water information from the land and cirrus clouds present in the Landsat 8 image. After extracting open water, a buffer zone was created from 5-10 km away from the shoreline to make a boundary to the coastal area for the suitability analysis. Normalized Suspended Material Index (NSMI) and Band ratio between green and blue bands were used for the extraction of TSM.

SST was calculated based on brightness temperature (Cahyono, et al., 2016), and the bathymetry was calculated based on log ratio model (El-Sayed, 2018). U and V 10 m wind components data were downloaded to extract wind velocity and direction. Eastward seawater velocity and northward seawater velocity data were used to extract current velocity and direction. Resampling technique was used to increase the resolution.

Temperature, depth and water samples were taken with respect to the relevant coordinates of 30 sampling points for ground truthing.

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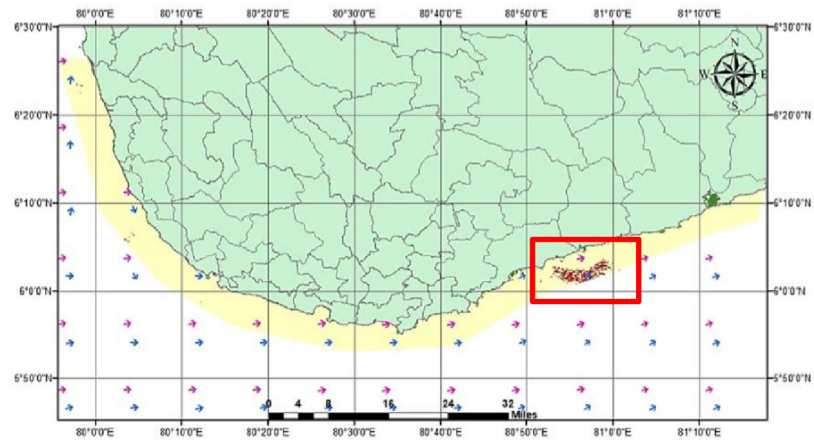


Figure 4: Area suitability in 2018 during south-west monsoon period.

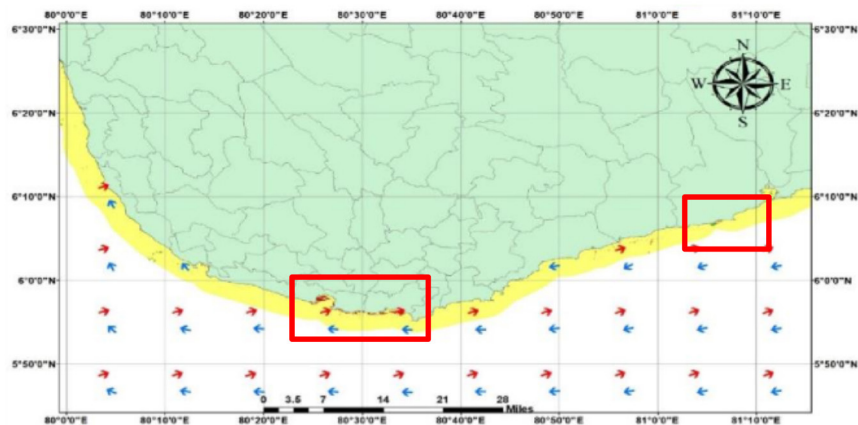


Figure 5: Area suitability in 2019 during south-west monsoon period.

After extracting all the relevant data, area suitability analysis was performed using ArcGIS 10.1 software based on the criteria given in Table 1. Pearson correlation analysis was conducted to determine the accuracy between in-situ data and satellite derived data using IBM SPSS statistical software version 25.

Results and Discussion

Area suitability. The most suitable area for seaweed culture was identified based on conditions given in Table 1. The temperature, wind, and ocean current were considerable factors that changed significantly with monsoon seasons.

During the inter-monsoon and north-east monsoon period in 2018, 31000 hectares of the coastal area seems to be suitable for seaweed culture (Figure 2).

In 2019, about 19200 hectares area was identified as a suitable for seaweed culture during the inter-monsoon and north-east monsoon period (Figure 3). However, about 1500 hectares of the coastal area was available for seaweed cultivation during the south-west monsoon in 2018 (Figure 4) and in 2019 it was 570 hectares (Figure 5). Our results indicated that Tangalle and Ambalanthota are the most suitable areas for seaweed culture based on the observations in 2018 and 2019. Previous studies showed that the suitable area during 2008 and 2012 are 3728.87 hectares (Sulma et al., 2008) and 1780.06 hectares (de Sousa et al., 2012) respectively. Nevertheless, the results of this study, suggests that only about 570 hectares area is suitable for the seaweed culture regardless the monsoons. However, in 2018 and 2019 the moderately suitable locations were mostly abundant due to significance variation occurred in wind and ocean current velocity in monsoon seasons.

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Correlation Analysis. A significant Positive correlation of 0.91 ($P < 0.05$) was observed between in-situ TSM data and satellite derived TSM data, elucidating that there is no notable difference between the in-situ TSM data and satellite derived TSM data. In addition, bathymetry data which were derived from the satellite images and in-situ depth data also did not show significant difference since they showed a positive correlation of 0.88 ($p < 0.05$). Only the satellite derived SST and actual SST had a positive correlation of 0.35 ($p > 0.05$) which was not significant. Thus, the respective results from the correlation analysis clearly show that there is no any notable difference between the in-situ and satellite derived data for the physical parameters which highly influence the habitat selection of sea weeds in a tropical environment.

Conclusion

The suitability analysis revealed that Ambalanthota and Tangalle have the highest potential for sea weed cultivation during both monsoons period. It was identified that the best time to implement seaweed cultivation techniques in these regions is from October to April. Galle, Weligama, Matara, Hikkaduwa, and Bentota were identified as moderately suitable areas for seaweed cultivation. A significant correlation was observed between observed data and remote sensed data supporting the accuracy of the data retrieved from satellite images in our study. The future field validations will require to assess the accuracy of the proposed method to identify the suitable areas for sea weed cultivation.

Table 1. The criteria that used to select suitable sites for sea weed culture

Bathymetry (m)	Breakpoint	Reclassification
Minimum value -2	2	3
2-6	6	1
6-11	11	2
11-maximum value	Maximum value	3
Temperature ($^{\circ}$C)	Breakpoint	Reclassification
Minimum value -24	24	3
24-26	26	2
26-28	28	1
28-30	30	2
30- maximum value	Maximum value	3
TSM: NSMI	Breakpoint	Reclassification
Minimum value-0.210	0.210	1
0.210-0.272	0.272	2
0.272-maximum value	Maximum value	3
TSM: Band ratio	Breakpoint	Reclassification
Minimum value-0.926	0.926	1
0.926-1.046	1.046	2
1.046-maximum value	Maximum value	3
Current velocity	Breakpoint	Reclassification
Minimum value-19	19	2
19-41	41	1
41-maximum value	Maximum value	3
Wind velocity	Breakpoint	Reclassification
Minimum value-5	5	1
5- maximum value	Maximum value	3

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Acknowledgment

I would like to express my heartfelt gratitude to all the academic and non-academic staff of the Department of Fisheries and Aquaculture and the Department of Limnology and Water Technology, Faculty of Fisheries and Marine Sciences and Technology, University of Ruhuna, for facilitating me to carry out this research.

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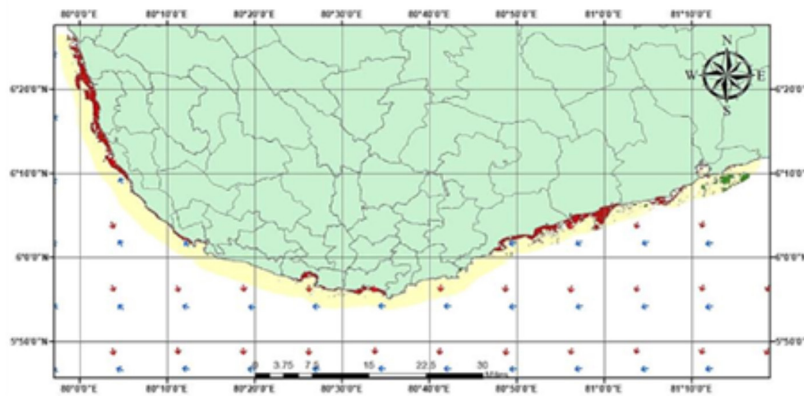


Figure 3: Area suitability in 2019 during inter-monsoon and north-east monsoon period.

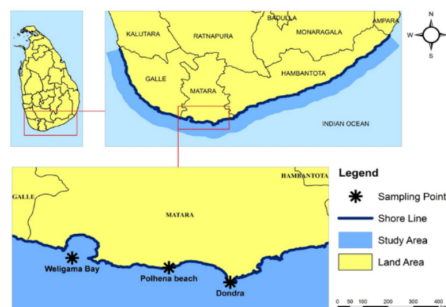


Figure 1: The Study Area.

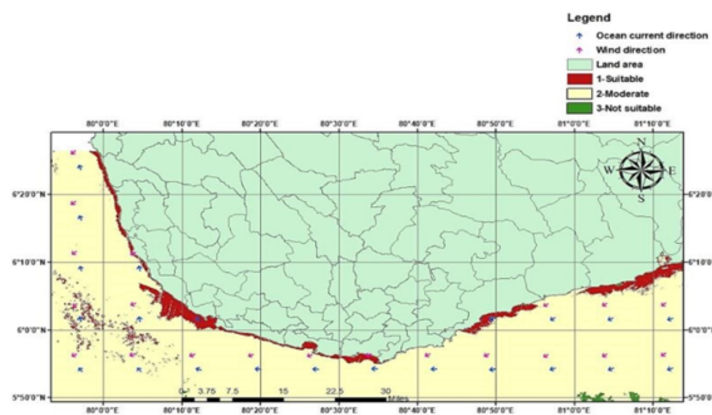


Figure 2: Area suitability in 2018 during inter-monsoon and north-east monsoon period.

DETECCIÓN DE *Vibrio parahaemolyticus* EN POST-LARVAS DE CAMARÓN BLANCO *Litopenaeus vannamei* COLECTADOS EN LOS TANQUES DE TRANSPORTE, PREVIA SIEMBRA EN MÉXICO

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La camaronicultura es un sector sumamente importante en la producción de alimento a nivel mundial, considerando que el mayor problema al que se enfrentan son los brotes de enfermedades. Al género *Vibrio*, se le acuñen diversas infecciones, que causan mortalidades significativas desde los primeros días de cultivo, logrando eliminar hasta el 100% de la población. Las cepas encargadas de transmitir esta enfermedad son aquellas que codifican las toxinas binarias Pir A y B. El objetivo del presente estudio fue determinar la presencia de *Vibrio parahaemolyticus* toxígeno en post-larvas de camarón blanco (*Litopenaeus vannamei*) colectados en los tanques de transporte provenientes de laboratorios, mediante métodos bacteriológicos, moleculares e histopatológicos obteniendo una mitigación en las mortalidades los primeros días de cultivo en México.

La detección de *V. parahaemolyticus* toxígeno se llevó a cabo mediante cuatro procesos. El último proceso se realizó en tres fases (Fig. 1).

Se obtuvieron 13 casos, provenientes de seis laboratorios ubicados en los estados de Sonora y Sinaloa. Seis de los de los cuales dieron positivos a *V. parahaemolyticus* toxígeno (Fig. 2).

El hepatopáncreas es el órgano más afectado por *V. parahaemolyticus* causándole desprendimientos celulares masivos y agudos. Con los métodos histológicos se puede observar el grado o fase de la lesión (Fig. 3).

Se concluye que las post-larvas de camarón blanco (*L. vannamei*) se infectan de la bacteria *V. parahaemolyticus*, en estadios larvales antes de que estas sean ingresadas algún sistema de cultivo o tengan algún contacto con estanques de engorda.

INNOVATIVE FUNCTIONAL APPLICATIONS FOR ADVANCED MICRO-ENCAPSULATED LIQUID LARVAL SHRIMP FEEDS

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Larval shrimp nutrition has come a long way. While we are still fine-tuning our knowledge of the nutritional requirements of larval shrimp, our knowledge-base has developed to the point where hatcheries have many high quality larval feeds to choose from. Nevertheless, many challenges remain. Shrimp diseases continue to be the biggest challenge for the shrimp industry and many of these diseases originate in hatcheries. Vibriosis, in particular, is a challenge for hatchery operators. It is well-documented that live feeds such as *Artemia* are an important vector for the introduction *Vibrio* into the larval rearing tank. Treating vibriosis and other bacterial pathogens with antibiotics leads to antibiotic resistance and is not a sustainable strategy.

Zeigler researchers have been working on developing feeds to supplement or replace live feeds with functional feeds that support the shrimp immune system, contribute to a healthy gut microbiome, limit the development of populations of pathogenic bacteria, and improve digestive efficiency. Research efforts at Zeigler Bros. are focused on how to incorporate function feed ingredients such as probiotics, immunostimulants, organic acids, essential oils, and antioxidants into larval diets to maximize their efficacy in promoting shrimp health. Micro-encapsulated liquid feeds provide an ideal vehicle to deliver these functional feed ingredients in a premium larval diet. The low temperature manufacturing process allows probiotics and other temperature sensitive ingredients to be included in the diets with no loss in viability effectiveness. Microencapsulation prevents the leaching of ingredients into the water, ensuring delivery into the guts of the shrimp where their effectiveness is maximized. Ingredients targeted for the gut can be incorporated in the microcapsules, while ingredients for targeting the tank environment can be incorporated into the liquid fraction.

Microencapsulated liquid feeds are ideal for replacing live feeds. It is well-documented that *Artemia* nauplii are a major vector for the introduction of *Vibrio* and the supply of cysts is at risk due to the drying up of saline lakes where *Artemia* cysts are harvested. Liquid micro-encapsulated diets can successfully replace 100% of the *Artemia* in larval shrimp diets and significantly reduce *Vibrio* loads in larval rearing systems. While high quality algae are essential in the early larval stages, maintaining an adequate volume of high-quality algae can be challenging, especially during certain months of the year. A major research focus for Zeigler Bros. is the development of cost-effective liquid feeds that allow for significant reduction in the amount of algae required for successful production of post-larvae. Micro-encapsulated liquid feeds can be manufactured with nutritional profiles that are nearly identical to the nutritional profiles of diatoms like *Thalassiosira*, and with very small particle sizes that allow the capsules to be readily consumed by early stage zoea larvae. Nutrition research is leading the way to more biosecure and sustainable larval rearing systems and healthier larvae, without antibiotics.

***Francisella nouatonensis* AND BETANODAVIRUS IN WILD MIGRATIONAL AND STATIONARY ATLANTIC COD *Gadus morhua* IN NORWAY**

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Atlantic cod (*Gadus morhua* L.) has been the an important food source and one of the main reasons for population settlement along the Norwegian coasts. Because cod fishery in Norway is seasonal between January and April, in addition and there is yearly variation in the cod fishing quota, the start of commercial cod aquaculture was encouraged. Cod farming bloomed in the mid-2000 reaching 533 farming licenses in 2008 and a total production of 21 240 tons in 2010. However, this industry was not to last, and the production started to drop until a total collapse in 2014. Several reasons led to this dramatic failure; juvenile deformities and early sexual maturation induced mediocre growth rates and elevated mortalities. In addition, disease outbreaks were also an important contributing reason to the collapse of cod farming in Norway. Two notifiable diseases dominated, francisellosis and viral nervous necrosis (VNN). Bacterial disease francisellosis caused by *Francisella noatunensis* resulted in massive losses with no effective vaccine or treatment available. VNN caused by betanodavirus had similar consequences. The aim of this study was to screen migrating and stationary wild cod for these two pathogens to evaluate the risk of transmission to farmed cod before attempting the restoration of large-scale cod aquaculture.

Sampling: Sampling of migrating Atlantic cod was conducted from 2019 to 2021 by Nord University staff along the coast of Norway from Ålesund (n=200), Myre (n=1200) and Båtsfjord (n=200). Sampling of stationary wild cod at 8 sites from Bergen in the south to Tromsø in the north was performed in 2022 (n=500). Brain (for betanodavirus) and head-kidney (for *Francisella*) samples were collected for qPCR analysis. RNA extraction from brain and kidney samples was performed using E.Z.N.A.® Total RNA Kit (Omega BIO-TEK) according to manufacturer's recommendations, and RNA were kept in -80°C until RT-qPCR analysis.

Oligonucleotide primers and hybridization probes: Assays for screening utilized in the study comprised of betanodavirus (Korsnes et al. 2005), *Francisella nuatonensis* (Ottem et al. 2008). In addition, a reference gene (elongation factor) was used as quality control of RNA (Mittelholzer et al. 2008). The amplification was performed using a one-step mastermix (qScript™ XLT One-Step RT-qPCR ToughMix® Quantabio). All RT-qPCR reactions were performed on a LightCycler 96 (Roche) and results analyzed by instrument software.

Prevalence of pathogens was low. So far, out of 1 600 kidney samples from migrating cod, only 10 came out positive for *Francisella* and none for nodavirus. Results from stationary cod are under processing. Complete set of results will be presented.

Acknowledgements

The study is part of the SmitteRisk research project, funded by RFF Nordland.

ACONDICIONAMIENTO REPRODUCTIVO DE LA ALMEJA ESTUARINA AMENAZADA, *Polymesoda arctata* (Deshayes, 1954)

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Polymesoda arctata es una almeja estuarina del Caribe que se encuentra actualmente amenazada por sobreexplotación y pérdida del hábitat. Con el fin de contribuir a desarrollar la tecnología para su cultivo y reproducción controlada, se evaluó el desarrollo gonadal de ejemplares en su medio natural y acondicionados reproductivamente en laboratorio.

A lo largo de 4 meses de la época seca (diciembre a marzo) se monitoreó la madurez gonadal de ejemplares colectados del medio natural (Ciénaga Grande de Santa Marta), así como de 2 grupos mantenidos en acondicionamiento reproductivo en laboratorio bajo 2 temperaturas (26 y 29°C) y 2 regímenes de salinidad, constante a 5 o 15 ‰, y cambiante (de 5 a 15 ‰ o de 15 a 5 ‰). Se pudo establecer una escala de maduración cualitativa mediante evaluación de frotis gonadal y examen macroscópico, la cual se ajustó bien a lo observado histológicamente, exceptuando los estadios inmaduro y desovado solo se diferenciaron por histología. Se encontraron ejemplares maduros o en proceso de maduración para todos los meses muestreados, una proporción 1:1 de machos y hembras en la población, así como un mayor tamaño promedio de las hembras que de los machos y una ausencia de hermafroditas. Mayores frecuencias de almejas maduras fueron obtenidas luego de entre 2 y 7 semanas de acondicionamiento reproductivo, manteniéndolas a baja temperatura (26°C) y con un régimen de salinidad constante o descendente.

Los animales mantenidos en los tratamientos con régimen de salinidad ascendente no progresaron en su madurez gonadal. Los resultados sugieren que el acondicionamiento reproductivo de esta especie es biológica y técnicamente viable, y su implementación puede permitir incrementar el éxito en los desoves y en la producción de juveniles en laboratorio ya sea con fines de acuicultura como de repoblación.

POST-GRADO EN ACUICULTURA EN LA UNIVERSIDAD FEDERAL DO RIO GRANDE – FURG, BRASIL

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El Programa de Posgrado en Acuicultura de la Universidad Federal de Río Grande - FURG se localiza en la ciudad de Río Grande, en el estado de Rio Grande del Sur, Brasil. El programa es considerado una referencia por el gobierno brasileño en el sector de acuicultura. Actualmente cuenta con 19 profesores y 55 estudiantes inscritos de varias nacionalidades.

El programa cuenta con líneas de investigación en diversas líneas de producción acuícola, como producción de camarones marinos, peces marinos y de peces de agua dulce, micro y macroalgas, moluscos, nutrición de organismos acuáticos, genética y biotecnología aplicada a la acuicultura.

Durante la presentación en el Congreso de Lacqua se presentarán los siguientes puntos: 1) la estructura donde se elaboran las investigaciones en acuicultura; 2) el perfil académico de los estudiantes que ingresan al programa; 3) las líneas de investigación; 4) los requisitos para la admisión de los estudiantes; 5) las oportunidades de becas.

EFFECTS OF *Nannochloropsis oceanica* AND *Porphyridium cruentum* IN THE ROTIFER *Brachionus plicatilis* PRODUCTION

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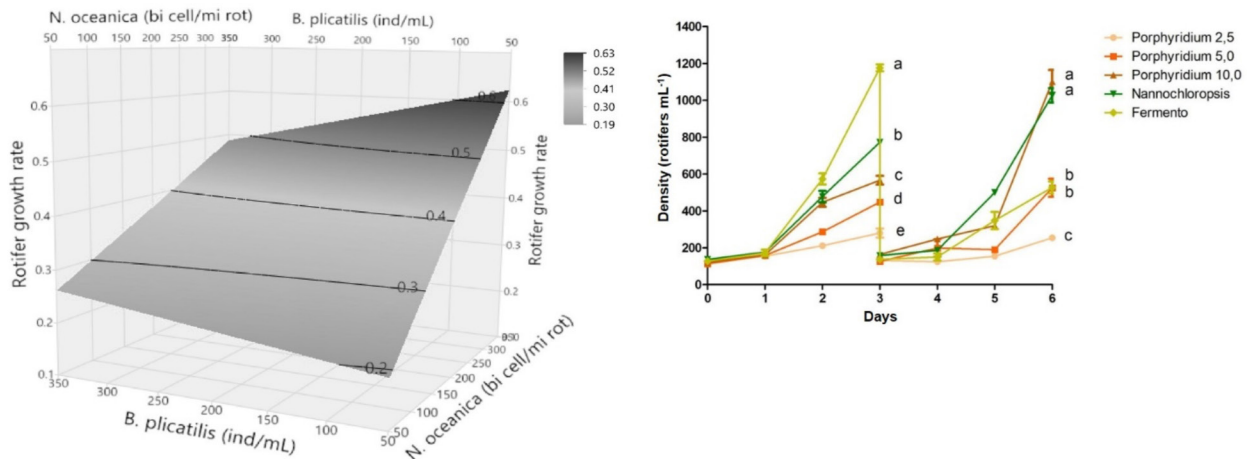
The production of *Brachionus plicatilis* rotifers is essential for the development of marine fish larviculture, since it is commonly used as the first food for larvae. The use of the microalga as food enables good quality of rotifers large-scale production. Thus, new species of microalgae have been tested due to their nutrient profiles, mainly lipids, minerals and pigments.

The first experiment was conducted to evaluate *N. oceanica* on rotifers production. The trial was delineated from the factorial statistical model of Central Composite Rotatable Design. The rotifers were stocked at different densities (59, 100, 200, 300 and 341 rot mL⁻¹) and fed with different amounts of concentrated *N. oceanica* (59, 100, 200, 300 and 341 × 10⁹ cell rot⁻¹ day⁻¹).

The second experiment evaluated three concentrations (2,5, 5 and 10 × 10⁹ cell/ 1 × 10⁶ rot⁻¹ day⁻¹) of *P. cruentum* as food for rotifers, plus two controls treatments fed with 200 × 10⁹ cell 10⁶ rot⁻¹ day⁻¹ of *N. oceanica*, and 0,7 g of baker yeast 10⁶ rot⁻¹ day⁻¹.

After the experiment 1, a surface response graph (Figure 1) was generated for the results of population growth rate. While the results of rotifer population growth in rotifers fed with *P. cruentum* are shown in the Figure 2.

In conclusion, in order to obtain a maximized population growth rate of the rotifer *B. plicatilis*, it is recommended to use a *N. oceanica* concentration of 300 × 10⁹ cell 10⁶ rot⁻¹ day⁻¹ and a rotifer stocking density of 100 rot mL⁻¹. The concentration of *P. cruentum* must be kept at 10 × 10⁹ cell/ 10⁶ rot⁻¹ day⁻¹.



THE REUSE OF BIOFLOC MATURE WATER IN SHRIMP CULTURE OF *Litopenaeus vannamei* IN SUPERINTENSIVE BFT SYSTEM

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In the biofloc technology culture system (BFT System) the water reuse, with a well-established microbial community is important to obtain a better stability of nitrogen compounds throughout a new production cycle. The aim of this study is evaluate the zootechnical performance and water quality parameters in treatments with different levels of inoculum (mg L^{-1}) in order to determine the minimum inoculum necessary for a rapid stabilization of nitrogen compounds in a new culture cycle of *L. vannamei*.

The experiment was carried out in 18 tanks with a volume of 400 L, in six treatments, with different initial concentrations of total suspended solids (inoculum): 0 mg L^{-1} , 2.5 mg L^{-1} , 5 mg L^{-1} , 10 mg L^{-1} , 20 mg L^{-1} and 40 mg L^{-1} . During the experiment no water changes were made. *L. vannamei* juveniles were stocked ($0.8\text{g}\pm 0.1$), at a density of $400 \text{ shrimp m}^{-3}$. The animals were fed twice a day with specific commercial feed (38% CP). The water with mature bioflocs, it means, was collected from a raceway with *L. vannamei* culture in progress. Sugarcane molasses, with about 36% of carbon in its composition, was used as a source of organic carbon in the experimental units when the ammonia exceeded 1 mg L^{-1} . The study lasted 45 days, until the nitrification cycle was completed in the control treatment with the detection of nitrate in the culture water.

There was no significant difference between the physicochemical parameters of water, except for nitrogen. Ammonia and nitrite were higher in the control and lower in the treatments with the addition of inoculum, and nitrate showed an inverse pattern, it was lower in the control treatment and higher in the inoculum treatments. More sugarcane molasses and water changes were used in the control treatment. The use of molasses was inversely proportional to the inoculum concentration, the higher the inoculum concentration, the lower the use of molasses. Regarding the zootechnical performance of shrimp, survival was lower in the control treatment, followed by the 2.5 mg L^{-1} treatment. In treatments 5, 10, 20 and 40 mg L^{-1} , survival ranged from 93 to 95%. Final weight was higher in treatments with lower survival and the opposite was observed for FCR (Feed conversion rate). Biomass and productivity were higher where inoculum was used, with better results in the 5 mg L^{-1} treatment.

The use of a mature inoculum at the beginning of a new culture was essential to avoid the oscillation of nitrogen compounds. This stabilization of nitrogen compounds directly reflected the better zootechnical performance of shrimp and the lower use of water and molasses to maintain water quality. The results demonstrate that an inoculum concentration of 5 mg L^{-1} used in the starting of the culture of *L. vannamei* in a biofloc system, maintains water parameters more stable, uses fewer inputs of water and molasses and obtains a better zootechnical performance of shrimps.

CURCUMIN SUPPLEMENTATION PROMOTES TURBOT POSTLARVAE GROWTH PERFORMANCE

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Turbot larvae stages are still characterized by high mortalities and low resistance to environmental challenges. Curcumin (diferuloylmethane), a polyphenol extract from the roots of *Curcuma longa* have been gaining attention as promoter of growth and robustness in some marine larval fish species. The aim of this study was to understand how growth performance and redox status of turbot postlarvae is modulated by dietary inclusion of curcumin.

Three dietary treatments were tested in triplicates ($n = 3$): Control group were fed a diet without curcumin supplementation (CTRL) and two treatments were fed a diet with low or high inclusion of curcumin (LOW and HIGH). The experiment was carryout in two phases, first a growth trial, where 30 days after hatching (DAH) turbot were reared for one month under optimal conditions, until 60 DAH and fed one of the three experimental diets. The second phase, the thermal challenge, took place at the end of the growth trial where the seawater temperature was increased by $\pm 5^{\circ}\text{C}$ for 24h (acute expose). Growth performance was assessed along fish development (43, 50 and 60 DAH) and the antioxidant status were analysed at the end of the experiment and after thermal stress.

At 43 DAH fish from LOW diet presented a similar dry weight (DW) to CTRL and HIGH fish, however HIGH fish were smaller than CTRL fish. The postlarvae from LOW showed the best condition factor (K) compared to the fish from CTRL and HIGH. At 50 DAH the dietary treatments had no impact in K and DW, however the fish from LOW treatment present a significant higher length than the CTRL fish. At the end of the experiment, 60 DAH, the LOW fish presented a higher DW and K than the CTRL fish. Regarding the antioxidant capacity, the dietary treatments had no influence in the biomarkers tested. However, the data of antioxidant status after the acute stress are still under analyses.

To conclude, the supplementation of antioxidants such as curcumin can enhance turbot postlarvae growth, as previously observed in Senegalese sole. However, no clear effect was observed of dietary curcumin as promoter of fish antioxidant capacity during the growth phase. There are still some knowledge gaps in understanding the pathways of action of curcumin in fish physiology.

This work is part of MAXIMUS.PT project (ref. 69769) supported by Portugal and the European Union through FEDER, COMPETE 2020 and CRESC Algarve 2020, in the framework of Portugal 2020; and co-financed by the Portuguese Foundation for Science and Technology through projects UIDB/04326/2020, UIDP/04326/2020 and LA/P/0101/2020 to CCMAR.

CONTROL EFFORT BY PERU AGAINST THE TILAPIA LAKE VIRUS (TiLV)

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El Organismo Nacional de Sanidad Pesquera (SANIPES) reportó la presencia del Virus de la tilapia del Nilo (TiLV) en febrero del 2018, causando una pérdida del 40% en la producción. Ante ello, SANIPES priorizó acciones, a fin de identificar factores de riesgo y protección para mitigar el TiLV.

Las medidas de control aplicadas como la desinfección de unidades productivas (-0.730) y fómites (-0.417), se consideran factores de protección ante el virus, debido a que presentaron una correlación negativa frente a la presencia de TiLV en los hatcheries evaluados entre junio 2021- febrero 2022. Por otro lado, en los centros de engorde evaluados, la presencia de TiLV presentó una correlación positiva con la mortalidad (0.589) y antecedentes positivos en los semilleros proveedores (0.124), constituyendo factores de riesgo para TiLV.

SANIPES implementó una vigilancia específica en tres niveles de diagnóstico: i) Lesiones macroscópicas y comportamiento, ii) Histopatología y iii) Diagnóstico molecular, para diferenciar la infección de la enfermedad por TiLV, obteniendo una prevalencia de 1.8% en 2021 en el departamento de San Martín, en comparación al 2018 con una mayor prevalencia del 5.18%. Se observó una mayor prevalencia durante la estación seca, posiblemente debido al estrés generado por la alteración de los parámetros fisicoquímicos del agua de cultivo.

A pesar de que TiLV ya es una enfermedad endémica en el país, la implementación de estrategias de control tiene un impacto positivo en la recuperación de la actividad acuícola, las mismas que deben incluir la participación de los operadores y la autoridad sanitaria.

ADDENDUM

BIOLOGICAL RESPONSES OF OYSTER *Crassostrea gasar* WHEN EXPOSED TO DIFFERENT CONCENTRATIONS OF TOTAL SUSPENDED SOLIDS IN A BIOFLOC SYSTEM: BEHAVIORAL AND BIOCHEMICAL ANALYSIS

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Introduction

Oysters are known filter feeders and can play a role as consumers of bioflocs in integrated farming with other species (IMTA system). However, the tolerance of these bivalves to the high levels of total suspended solids (TSS) characteristic of cultures in biofloc systems is not known. Thus, the aim of the present study was to evaluate the biological responses of the oyster *Crassostrea gasar* when exposed to different concentrations of total suspended solids in biofloc culture systems, based on behavioral and biochemical analyses.

Methodology

Oysters with an initial weight of 54.18 ± 13.45 g; height of 68.2 ± 4.44 mm; length of 50.4 ± 3.50 mm and width of 24.1 ± 5.02 mm and were cultivated for 28 days in 100L tanks. Four treatments were studied. Phyto: control treatment supplied daily with the microalgae *Chaetoceros muelleri* at a concentration of 16×10^4 cel/ml; Low BFT treatment – with maintenance of approximately 100 mg/l of TSS; Medium BFT treatment – maintained above 100 to 200 mg/l TSS; High BFT treatment – maintained above 200 mg/l TSS, each with 4 replicates.

The oyster valve activity was monitored using Hall effect sensors according to the methodology of Guterres et al. (2020). The total antioxidant capacity against peroxy radicals (ACAP) was determined according to the methodology of (Amado et al., 2009).

Results

The use of aperture sensors indicated that there was a significant difference between treatments. The BFT High treatment had a shorter valve opening time, followed by the BFT Medium, BFT Low and control (Fito) treatments (Table 1). Table 1 shows the frequency (%) with which oysters open their valves and were classified as “Closed”, “Slightly Open”, Open and “Fully Open” (Table 1).

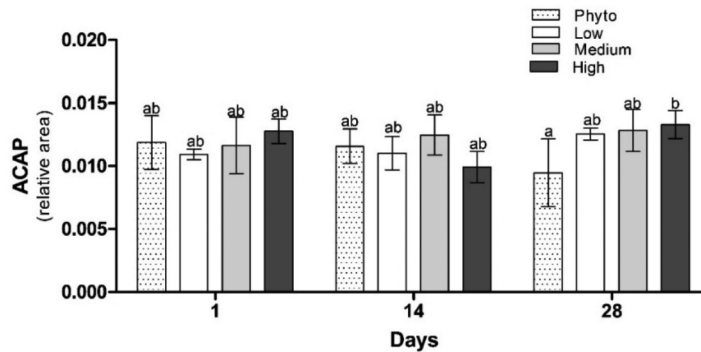
Table 1: Frequency (%) of valve opening of *C. gasar* oysters submitted to control, Low, Medium and High TSS treatments.

Treatment	Oyster valve opening classification			
	Closed	Slightly Open	Open	Fully Open
Phyto	66.97 ± 15.14^a	0.03 ± 0.02^{ab}	3.77 ± 3.25	28.05 ± 12.88^a
Low BFT	79.97 ± 4.93^{ab}	0.04 ± 0.01^{ab}	2.99 ± 2.77	16.44 ± 7.64^{ab}
Medium BFT	79.67 ± 4.57^{ab}	0.12 ± 0.05^a	4.83 ± 2.95	14.14 ± 2.09^{ab}
High BFT	85.10 ± 6.29^b	0.01 ± 0.01^b	5.66 ± 8.08	9.04 ± 3.91^b

Lowercase letters in the same column represent statistically differences between treatments.

(Continued on next page)

Figure 1: Antioxidant capacity (relative area) in the gills of *C. gasar* oysters in the different treatments over a four-week experiment. The bars represent the mean values and vertical lines at the top of the bars represent the standard deviation of the values. Lower case letters in different days and treatments represent significant differences ($p < 0.05$).



Regarding the total antioxidant capacity against peroxy radicals (ACAP), there was a significant difference between treatments at the end of the experiment. The BFT High treatment showed a larger average area than the Fito, while the BFT Low and BFT Medium treatments showed no differences between the other treatments (Figure 1).

Discussion

The results demonstrate that oysters remain closed longer when the concentrations of total suspended solids are high. Although the high concentrations are within the ideal range for shrimp culture in a biofloc system (Samocha and Prangnell, 2019), for oyster insertion in an integrated system with shrimp, for example, these values should be kept at up to 200 mg/L. Stressful conditions in culture tanks can cause physiological changes including metabolic changes, decreased antioxidant capacity and oxidative stress, with consequences that can lead to the death of organisms (Romano and Zeng, 2013). After 28 days of culture, a reduction in the total antioxidant capacity (ACAP) of oyster gills in the BFT Alto treatment was also recorded, showing a break in the normality pattern compared to the control. Possibly, the valve closing behavior in the High BFT treatment resulted in the reduction of the total antioxidant capacity, when at week 3 there were limitations in the opening of the oyster valves, and influencing the biochemical responses of the bivalves.

Acknowledgements

This work was developed as part of the ASTRAL (All Atlantic Ocean Sustainable, Profitable and Resilient Aquaculture) project. This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N° 863034.

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METHODS FOR DETECTING AND CHARACTERIZING MICROBIAL COMMUNITIES IN AQUACULTURE SYSTEMS

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Microbial interactions in aquaculture industries are often thought of in a disease context. Indeed, diagnostic screening programs are applied throughout production cycles to detect commonly reported pathogens. For example, screening for *Renibacterium salmoninarum* in broodstock is routine for most salmon hatcheries while diagnostics for infectious salmon anemia virus (ISAV), among other viruses and bacteria, is common for pre-smolts prior to seawater entry. In shrimp, testing for *Vibrio parahaemolyticus*, white spot syndrome virus (WSSV), and infectious hypodermal and hematopoietic necrosis virus (IHHNV), among others are common for stock transfers and when mortalities are observed in culture systems. These examples of targeted screening programs have dramatically decreased incidences of disease outbreaks in aquaculture; however, there are limits on the practicality and capacity of these programs to cover the full scope of potentially problematic microbes affecting host species. Given the extensive diversity of microbes that can contribute to inefficiencies in production, exploratory diagnostic approaches are useful when gross pathology, abnormal behaviour, or mortality is observed and beginning to trend, yet the cause is unknown, the observations unexpected, and common pathogens have been ruled out. Further, understanding the entire composition of bacterial communities in aquaculture systems, including pathogens through to commensals, is proving to be invaluable. In this presentation, methodologies for sampling and detecting bacteria, ciliates, and dinoflagellates in aquaculture systems will be discussed using examples from fish and shrimp production. Molecular descriptions of opportunistic pathogens, off-flavor producing bacteria, novel ciliates, toxin-producing dinoflagellates, and the causative agent of purple salmon eggs, among others will be discussed. A particular focus on the amplification of conserved DNA loci from microbes will be examined in the context of improving efficiency and animal welfare in aquaculture.

PIRAPITINGA (*Piaractus brachypomus*), UMA OPÇÃO PARA A AQUICULTURA LATINOAMERICANA. METODOLOGIA PARA CONFIRMAR A PRESENÇA DE ESPINHAS INTRAMUSCULARES EM ESTÁGIOS INICIAIS DE DESENVOLVIMENTO

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A pirapitinga (*Piaractus brachypomus*), originária da bacia do rio Amazonas, se considera a espécie nativa principal produzida na Colômbia. Sua comercialização e consumo têm se visto limitados devido à grande presença de espinhas intramusculares (EIM) em forma de Y na região dorsal e na região ventro-caudal, fato que dificulta o processamento e consumo do filé. Têm sido feitos estudos sobre caracterização, conformação do sistema esquelético e confirmação da presença de EIM nos peixes a través de Raios-x, ultrassom e tomografia axial computadorizada. Dos anteriores, o ultrassom foi determinado como uma ferramenta de imagens diagnósticas não invasiva para realização em campo, como foi apresentado pelo nosso grupo de pesquisa no WAS 2021 em Mérida. Este projeto objetiva realizar o seguimento ultrassonográfico e de Raios-x em juvenis a partir de 3g até a identificação das espinhas intramusculares.

Para a identificação da presença de EIM em *P. brachypomus*, foi realizado ultrassom e raios-x em 100 indivíduos de pirapitinga acompanhando o seu crescimento periodicamente as 3, 15 e 30g (o projeto visa continuar com o acompanhamento nos pesos 50, 100, 200, 300 e 600 g e as suas implicações na qualidade do filé). Para o diagnostico inicial em laboratório, se utilizou um ultrassom portátil CTS-800 de alta definição com transdutor lineal de 10 a 14 MHz. Posteriormente, foram realizadas as imagens diagnósticas com Raios-x. Os estudos foram realizados sob anestesia geral a traves da diluição de Eugenol em agua a 50-100 ppm de acordo com o tamanho do peixe, para indução e 30 ppm para manutenção.

Nos indivíduos de 3 g se identifica uma linha branca (hiperecogénica) no lugar de localização das possíveis EIM, porém, com um transdutor de alta definição utilizado, não se diferenciam (figura 1). A partir das 15 g se identificam EIM a traves do ultrassom (figura 1). Aparentemente a identificação da presença das espinhas a través de Raios-x é possível a partir das 50 g (figura 2). O Ultrassom identifica antes dos Raios-x a presença de EIM. A pesar de que a través de Raios-x a identificação da presença das espinhas é possível a partir das 50 g, precisa-se mais evidência. Este é um trabalho em fase de desenvolvimento.

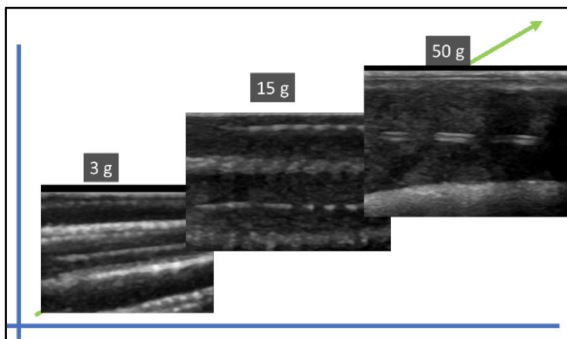


Figura 1. Ultrassom em *P. brachypomus* aos 3, 15 e 50 g

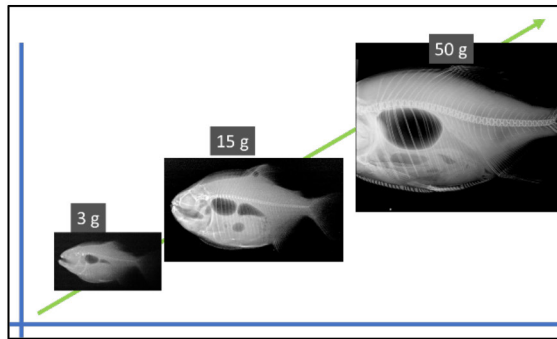


Figura 2. Raios-x em *P. brachypomus* aos 3, 15 e 50 g

ANÁLISIS BIOQUÍMICO DE EXTRACTOS DE *Randia echinocarpa* PARA SU USO CONTRA BACTERIAS CAUSANTES DE ESTREPTOCOCOSIS EN TILAPIA

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Se plantea el uso de plantas medicinales en el tratamiento contra enfermedades que impactan la acuicultura, debido a que sintetizan y acumulan sustancias fisiológicamente activas promotoras de inhibición de patógenos (antimicrobiana, antivirales, antifúngicas, antioxidantes). Por este motivo, el objetivo será evaluar la concentración y capacidad inhibitoria de los compuestos fitoquímicos en extractos vegetales de *Randia echinocarpa* y la supervivencia de peces infectados con estreptococos.

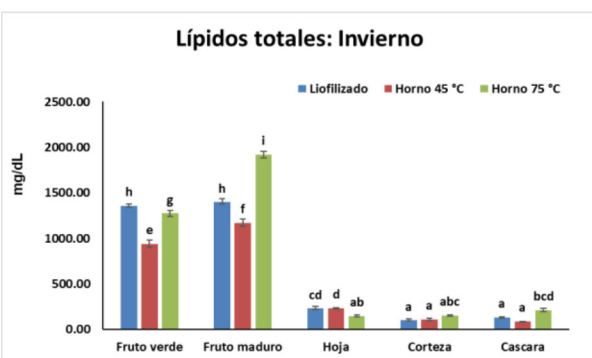
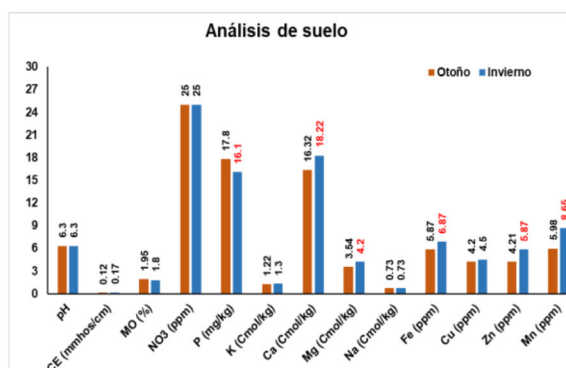
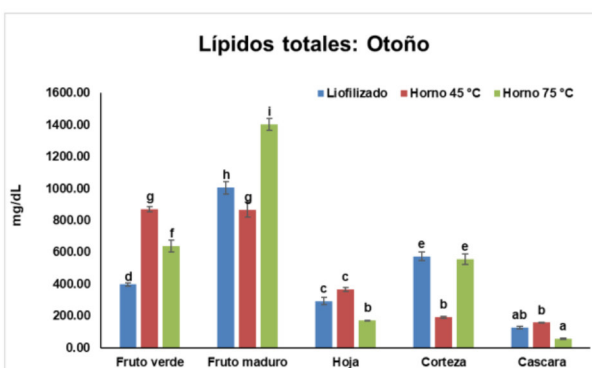
Se analizaron lípidos totales en cinco tejidos de *R. echinocarpa* en dos estaciones del año (Otoño e invierno) con tres variaciones de secado (Liofilizado, Horno 45 °C y 75 °C).

Se determinó mayor concentración de lípidos en el fruto maduro y verde con respecto a hoja, corteza y cascara. Encontrando mayores concentraciones de lípidos en fruto maduro con el secado en horno a 75 °C tanto en otoño como en invierno siendo significativamente mayores a las concentraciones de lípidos en los demás tejidos.

Asimismo, se analizó el suelo en las dos estaciones (Otoño e invierno) para conocer las propiedades donde se desarrolla *R. echinocarpa*.

Se encontró disminución de fósforo en el invierno, pero un aumento considerable en Calcio, Magnesio, Hierro, Zinc y Manganeso en el invierno con respecto a los valores encontrados en otoño.

Se realizarán análisis de capacidad inhibitoria, perfil fitoquímico, análisis organolépticos y prueba de supervivencia de tilapia suplementadas con *R. echinocarpa* infectadas con estreptococos.



Referencias												
pH	CE	MO	NO3	P	K	Ca	Mg	Na	Fe	Cu	Zn	Mn
6.6-7.3	<2.0	<1.5	66	<10	0.9-1.75	14-20	>4.0	1.0-1.5	>9	>1.3	>1.5	>8
Neutro	Muy bajo	Bajo	Bajo	Alto	Alto	Muy alto	Alto	Adecuado	Adecuado	Adecuado	Adecuado	Adecuado

ANÁLISIS DE LA PRESENCIA DE MICROPLÁSTICOS EN ESTÓMAGOS DE LA LISA *Mugil Cephalus* Linnaeus, 1758 EN EL SISTEMA LAGUNAR LAS GRULLAS, SINALOA

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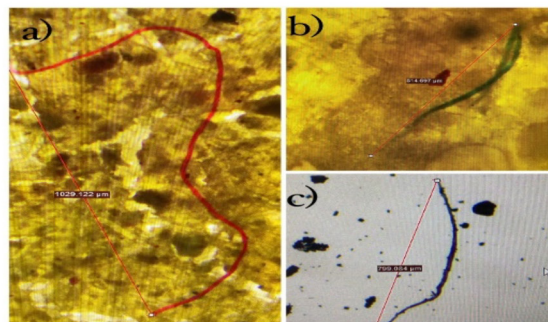
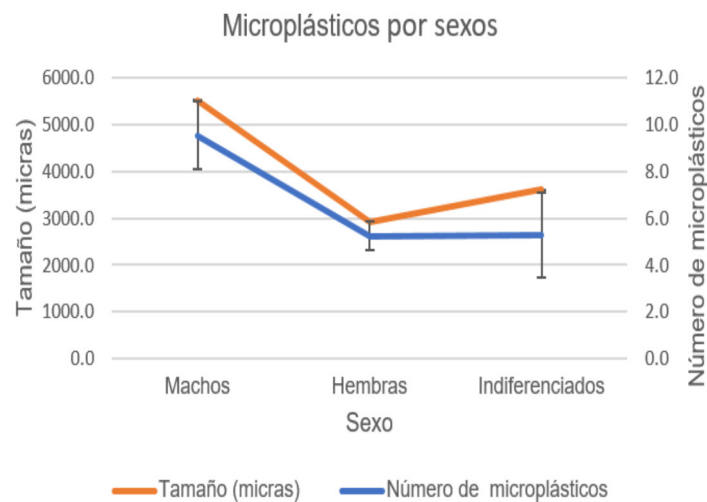
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La lisa *Mugil Cephalus* es un recurso pesquero abundante a nivel mundial, tiene un alto consumo en las comunidades pesqueras. Además, juega un papel importante en el ecosistema costero ayudando a mantener el equilibrio ecológico. Por este motivo el objetivo fue analizar la presencia de microplásticos en el tracto digestivo de esta especie por contaminación antropogénica en el sistema lagunar.

Se muestrearon dos puntos del sistema lagunar Las Grullas Margen Derecho, en dos estaciones (otoño e invierno) y dos temporadas. El contenido del estómago fue digerido con peróxido de hidrogeno al 50% para desintegrar la materia orgánica, los restos fueron filtrados, posteriormente cada muestra se colocó en cajas Petri y secadas a 50°C por 24 h. Los microplásticos encontrados se clasificaron en categoría (fibras) y por color (a-Rojo, b-azul, c- negro).

Se encontro mayor presencia de microplasticos en el tracto digestivo en la temporada de otoño con respecto al invierno.

Asimismo, se comparó la mayor presencia de microplásticos entre los sexos donde se encontró que predominaron los machos, tomando en cuenta el tamaño (micras). Es preocupante lo encontrado, y es necesario realizar colectas en las estaciones restantes.



ANÁLISIS MORFOFISIOLÓGICO Y BIOQUÍMICO DE *Lisa Mugil cephalus* EN EL SISTEMA LAGUNAR LAS GRULLAS MARGEN DERECHO

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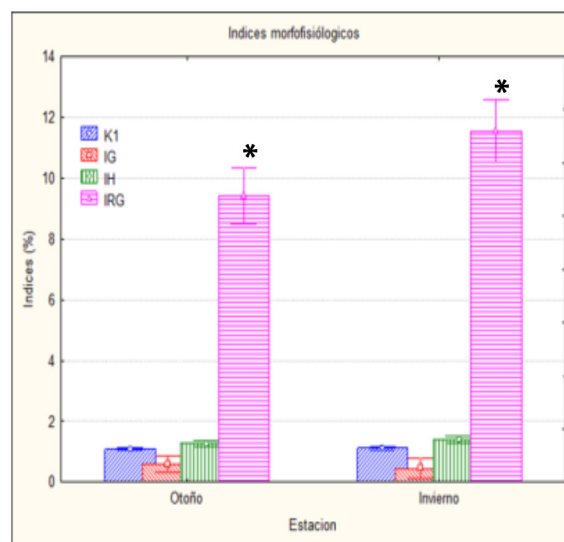
La lisa (*Mugil cephalus*) se encuentra distribuida comúnmente en las costas de todo el mundo. El estudio de la bioquímica y la morfofisiología de este organismo es importante para comprender mejor su fisiología y el papel que juega en el ecosistema, asimismo, comprender la fisiología y metabolismo, permite desarrollar estrategias para manejar y proteger mejor a la especie y asegurar su supervivencia a largo plazo.

El objetivo de este trabajo fue conocer la fisiología y bioquímica de *Mugil cephalus*. Para esto se realizaron dos muestreos en el sistema lagunar Las Grullas Margen Derecho, la colecta se realizó de diciembre 2022 a febrero de 2023.

Se tomaron en cuenta dos puntos de colecta, los peces del punto A fueron capturados en Bahía del perro y el punto B de La Robalera, en dos estaciones del año (otoño e invierno).

Se determinó el porcentaje de proteína, glucosa, lípidos, lactato y triglicéridos, posterior a esto se realizó la morfofisiología en la cual se hicieron biometrías de cada uno de los organismos (longitud y peso), en seguida se realizó la disección para la extracción de gónada, hígado y estómago de los cuales se tomó su peso individual, para determinar factores de condición (K1), índice gonádico (IG), índice hepatosomático (IH) e índice de repleción gástrica (IRG).

Se encontraron diferencias significativas en el IRG con respecto a los demás índices fisiológicos, esto hace referencia a la cantidad de alimento que se encuentra en el interior del estómago, es decir a mayor cantidad de alimento consumido y alojado en el estómago, mayor índice de repleción gástrica.



HISTOLOGÍA EN HÍGADOS Y GÓNADAS DE LISA *Mugil cephalus* EN EL SISTEMA LAGUNAR LAS GRULLAS MARGEN DERECHA, AHOME, SINALOA

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Mugil cephalus habita en las aguas costeras de la mayoría de las regiones tropicales y subtropicales. Son peces de importancia para el consumo humano en muchos países, ya que constituyen parte fundamental de la dieta de las comunidades aledañas a los sistemas lagunares durante la época de reproducción. Durante el periodo de reproducción, las lisas se congregan en cardúmenes para emigrar a la zona pelágica costera a realizar el desove.

El objetivo del presente trabajo fue conocer los aspectos reproductivos de la lisa *Mugil cephalus* para su manejo sustentable, para ello se realizaron dos muestreos en el sistema lagunar Las Grullas Margen Derecho, los cuales abarcaron dos distintos puntos de muestreo y dos estaciones (otoño e invierno).

Se capturaron 20 organismos en cada punto, con una red de enmalle “chinchorro”. Se tomó una muestra de sangre con una jeringa de 3 ml previamente preparada con 0.5 ml de heparina, luego se depositaban en tubos eppendorf y el pez se colocaba en una bolsa etiquetada y hielo para llevar a laboratorio y realizar la disección.

Se tomaron gónadas y hígado y se colocaron en unicassettes, posteriormente se fijaron en solución Davidson durante 24 h, se prepararon para ser depositados en un carrusel deshidratador de tejido durante 14 a 16 h.

Posteriormente, se fijaron en parafina. Se realizaron cortes histológicos a 4.5 μm de espesor con un micrótopo semiautomático, luego se depositó en un baño de flotación que contenía 1 g de gretina para la adhesión del tejido al portaobjetos, a 42-45 °C y se dejó secar.

Se continuo con la tinción de Hematoxilina-Eosina-Floxina la cual se llevó alrededor de 1:30 minutos por carrusel, al terminar la tinción se observó en un microscopio óptico (LEICA modelo DM4000).

