

HGK

HRVATSKA GOSPODARSKA KOMORA

XV. međunarodna konferencija o akvakulturi

Zbornik sažetaka radova

Program i Zbornik sažetaka

15th International Aquaculture Conference

Book of Abstracts

Program and Book of Abstracts

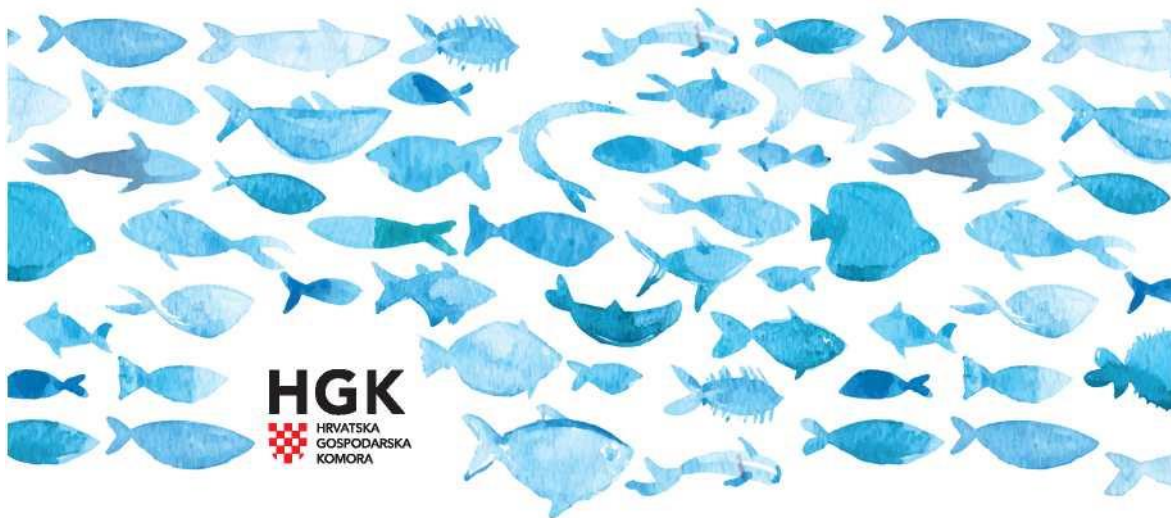


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**Zbornik sažetaka radova sa XV. međunarodne konferencije o
akvakulturi**

Vukovar, 02. – 04. travnja 2025.

Urednici:

Dragan Kovačević, Lav Bavčević, Rina Milošević

Nakladnik:

Sveučilište u Zadru

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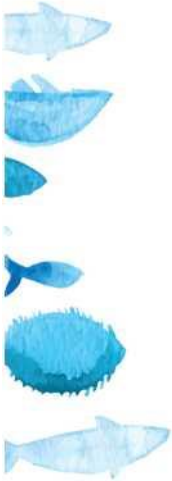
(Zbornik sažetaka XV. međunarodne konferencije o akvakulturi,
Vukovar, 2025)



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4 Program
▼ ZA RIBARSTVO i AKVAKULTURU



XV. međunarodna konferencija o akvakulturi

Hotel Lav / Vukovar, Hrvatska / 2. - 4. travnja 2025.

15th International Aquaculture Conference

Hotel Lav / Vukovar, Croatia / 2 - 4 April 2025



ORGANIZATOR / ORGANIZER

Hrvatska gospodarska komora

POKROVITELJI / PATRONS

Ministarstvo poljoprivrede, šumarstva i ribarstva

Ministarstvo zaštite okoliša i zelene tradicije Vukovarsko-srijemska županija

Grad Vukovar

SUORGANIZATORI / CO-ORGANIZERS

Agronomski fakultet Sveučilište u Zagrebu

Institut Ruđer Bošković

Fakultet agrobiotehničkih znanosti Osijek

Hrvatski veterinarski institut

Prehrambeno-biotehnološki fakultet Sveučilište u Zagrebu
Prehrambeno-tehnološki fakultet Osijek

Sveučilište u Dubrovniku

Veleučilište "Lavoslav Ružička" u Vukovaru

Veterinarski fakultet Sveučilište u Zagrebu

Sveučilište u Zadru

O konferenciji

Konferencija o akvakulturi je značajan susret gospodarstvenika iz sektora akvakulture, znanstvenika, državne administracije i ostalih dionika iz Republike Hrvatske, EU i susjednih zemalja, gdje se u međusobnom dijalogu potiče bolja suradnja kao i sinergija u rješavanju izazova i stvaranja boljih uvjeta za razvoj sektora akvakulture. Posvećena je prikazu trenutnog stanja i utvrđivanja bitnih strateških, tehnoloških, gospodarskih i znanstvenih spoznaja i rješenja nužnih za uspješan razvoj akvakulture, te rasprava izazova s kojima se ovaj značajni gospodarski sektor suočava u poslovanju.

Pred sektorom akvakulture je mnogo izazova: od klimatskih promjena do energetske i zelene tranzicije, digitalizacije, razvoja novih proizvoda i pokretanja novih proizvodnji. Stoga je danas više nego ikad važna suradnja sa znanstvenom i stručnom zajednicom. Sigurna opskrba hranom i energetska tranzicija postaju prioritet, a učinkovitije iskorištenje postojećih i budućih sredstava iz raspoloživih alokacija Europskih strukturnih i investicijskih fondova nikada nije bilo važnije.

Konferencija se od 2007. godine održava u Vukovaru, prvo pod nazivom Međunarodno savjetovanje o slatkovodnom ribarstvu, potom Međunarodni gospodarsko-znanstveni skup o ribarstvu, a prethodila su joj dva Nacionalna znanstveno-stručno savjetovanja s međunarodnim sudjelovanjem, koja su održana u Bizovcu u periodu 1999-2002.

Na prethodnim konferencijama o akvakulturi ostvarena je značajna suradnja s znanstvenim institucijama, gospodarstvenicima, resornim ministarstvima, inozemnim i nacionalnim asocijacijama gospodarstvenika u akvakulturi, te nekoliko međunarodnih institucija poput FEAP-a (Federation of European Aquaculture Producers) i Eurofish (International Organisation for the Development of Fisheries and Aquaculture in Europe). Predstavljeno oko 350 znanstvenih radova, a sudionici skupa dolazili su iz 15 zemalja.

About the Conference

The Vukovar Aquaculture Conference is an important meeting of producers, scientists and state administration from the aquaculture Sector of the Republic of Croatia, as well as other stakeholders from the EU and neighbouring countries, where mutual dialogue encourages better cooperation and synergy in solving challenges and creating better conditions for the development of the aquaculture sector. It is dedicated to presenting the current state and identifying essential strategic, technological, economic and scientific insights and solutions necessary for the successful development of aquaculture, as well as discussing the challenges that this important economic sector faces.

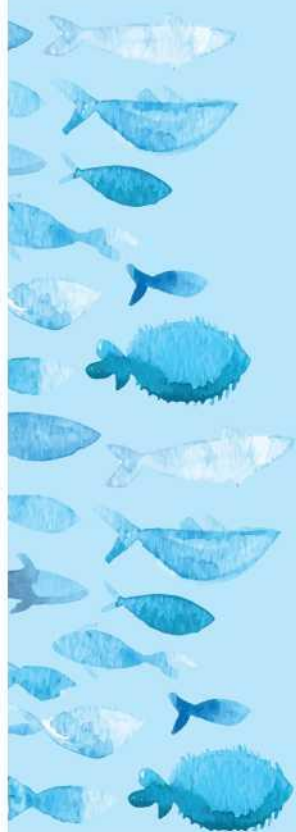
The aquaculture sector faces many challenges: from climate change to energy and green transition, digitalization, development of new products and launching new productions. Therefore, cooperation with the scientific and professional community is more important today than ever. Secure food supply and energy transition are becoming a priority, and more efficient use of existing and future funds from the available allocations of the European Structural and Investment Funds has never been more important.

The Conference has been held in Vukovar since 2007 and was preceded by two National Scientific and Professional Conferences with international participation, which were held in Bizovac in the period 1999-2002.

At previous conferences significant cooperation was achieved with scientific institutions, businessmen, state administration, foreign and national associations of businessmen in aquaculture, and several international institutions, such as FEAP (Federation of European Aquaculture Producers) and Eurofish (International Organisation for the Development of Fisheries and Aquaculture in Europe). Around 350 scientific papers were presented, and the participants of the conference came from 15 countries.



Program



RASPORED DOGAĐANJA

DAN	Srijeda 2. travnja 2025	Četvrtak 3. travnja 2023.	Petak 4. travnja 2025.
JUTRO		Otvaranje konferencije, pozdravni govori, konferencija za medije Radni dio	Radni dio
PAUZA ZA RUČAK		Pauza za ručak	Pauza za ručak
POSLIJEPODNE	Registracija	Radni dio	Završetak konferencije
VEČER	Večera dobrodošlice	Večera	

EVENT
SCHEDULE

DAY	Wednesday 2 April 2025	Thursday 3 April 2023	Friday 4 April 2025
MORNING		Registration of participants, welcome and opening remarks, press conference Plenary session	Plenary and Poster session
LUNCH BREAK		Lunch break	Lunch break
AFTERNOON	Registration	Plenary and Poster session	End of the conference
EVENING	Welcome dinner Dinner		

1. DAN | 2. TRAVNJA 2025.

od 16.00 Registracija sudionika

19.00 **Večera dobrodošlice**
Hotel Lav

2. DAN | 3. TRAVNJA 2025.

8.30 - 9.30 Registracija sudionika/ Servirana kava

9.00 - 9.30 Konferencija za novinare

9.30 - 10.00 Otvaranje Konferencije

Plenarna izlaganja

10.00 - 10.15 **Trenutno stanje akvakulture u Hrvatskoj**
Mario Jurašić, Ministarstvo poljoprivrede, šumarstva i ribarstva - Uprava
ribarstva

10.15 - 10.30 **Program za ribarstvo i akvakulturu RH - jačanje sektora akvakulture**
Irena Jahutka, Ministarstvo poljoprivrede, šumarstva i ribarstva - Uprava
ribarstva

DAY 1 | 2 APRIL 2025

from 16.00

Registration

19.00

Welcome dinner

Hotel Lav

DAY 2 | 3 APRIL 2025

8.30 - 9.30

Registration/ Coffee served

9.00 - 9.30

Press Conference

9.30 - 10.00

Welcome and opening remarks

Plenary Session

10.00 - 10.15

The current state of Croatian aquaculture

Mario Jurašić, Ministry of Agriculture, Forestry and Fisheries, Fisheries Directorate

10.15 - 10.30

Program for fishery and aquaculture of Croatia - strengthening for aquaculture sector ja

Irena Jahutka, Ministry of Agriculture, Forestry and Fisheries, Fisheries Directorate

10.30 - 10.45 **Akvakultura u Europi - aktualni tržišni tokovi** Toni Bartulin, EUROFISH

10.45 - 11.00 **Nova komunikacijska kampanja za promociju EU akvakulture, Online**
Predstavnik Europske komisije

11.00 - 11.15 **Kako pomoći razvoju hrvatskog slatkovodnog uzgoja - uloga vodnog gospodarstva**
Elizabeta Kos, Ministarstvo zaštite okoliša i zelene tranzicije - Uprava vodnoga gospodarstva i zaštite mora

11.15 - 11.30 **Zajednička akvakulturna politika**
Eugen Catalin Platon - ROMFISH, Rumunjska asocijacija uzgajivača ribe

11.30 - 11.45 **Potencijalni doprinos mađarskog sektora akvakulture sadašnjim ciljevima održivog razvoja**
Katalin Lefler Kinga, Árpád Hegyi, Zoltán Bokor, Gergő Gyalog, Bozánne Békefi Emese, Zsuzsanna Brlás-Molnár, Rita Fekete, Béla Urbány

11.45 - 12.00 Rasprava (svi sudionici)

12.00 - 12.15 Dodjela priznanja zaslužnim za razvoj hrvatske akvakulture i doprinos organizaciji Međunarodne konferencije o akvakulturi

12.15 - 12.45 Pauza

10.30 - 10.45	Aquaculture in Europe - production and current market trends Toni Bartulin, EUROFISH
10.45 - 11.00	New communication campaign to promote EU aquaculture, Online Representative of the European Commission
11.00 - 11.15	How to help the development of Croatian freshwater farming - the role of water management Elizabeta Kos, Ministry of environment protection and green transition - Directorate of Water Management and Marine Protection
11.15 - 11.30	Common Aquaculture Policy rationale Eugen Catalin Platon - ROMFISH Romanian Fish Farmers Association
11.30 - 11.45	The potential contribution of the Hungarian aquaculture sector to the sustainable development goals today Katalin Lefler Kinga, Árpád Hegyi, Zoltán Bokor, Gergő Gyalog, Bozánne Békefi Emese, Zsuzsanna Brás-Molnár, Rita Fekete, Béla Urbány
11.45 - 12.00	Discussion
12.00 - 12.15	Award ceremony - people responsible for the development of Croatian aquaculture and Vukovar International Aquaculture Conference
12.15 - 12.45	Coffe break

12.45 - 13.00	Klimatske promjene - rizik za akvakulturu Aljoša Duplić, Ministarstvo zaštite okoliša i zelene tranzicije, Zavod za zaštitu okoliša i prirode
13.00 - 13.15	Istraživanje pokazatelja ekološke učinkovitosti baziranih na uslugama ekosustava za toplovodni uzgoj Béla Halasi-Kovács, Tamás Bardócz, HUNATIP (Hungarian Aquaculture Technology and Innovation Platform)
13.15 - 13.30	Višestruka uloga slatkovodnih šaranskih ribnjaka u Hrvatskoj Milorad Mrakovčić, Branko Glamuzina, Matija Kresonja, Ivana Sučić
13.30 - 13.45	Mogućnost povećanja otpornosti šaranskog ribnjačarstava na klimatske promjene Tomislav Slaćanac, Jasna Ipša, Ana Gavrilović
13.45 - 14.00	Problem velikog kormorana - da li postoji ikakvo rješenje za velike toplovodne sustave? Michal Kratochvil, Udruženje ribarstva Češke Republike
14.00 - 14.15	Rasprava (svi sudionici)
14.15 - 15.15	Ručak
15.15 - 15.30	Energetska optimizacija u uzgoju ribe Anders Erlang Østergaard, BioMar, PROMO
15.30 - 15.45	Negativni utjecaj marikulture na morski okoliš u Hrvatskoj - stvarnost ili mit? Donat Petricoli, Tatjana Bakran-Petricoli

12.45 - 13.00	Climate change - a risk for aquaculture Aljoša Duplić, Ministry of environment protection and green transition, Institute for Environment and Nature
13.00 - 13.15	Investigation on the ecosystem service-based environmental performance indicators for pond aquaculture Béla Halasi-Kovács, Tamás Bardócz, HUNATIP (Hungarian Aquaculture Technology and Innovation Platform)
13.15 - 13.30	The multiple roles of freshwater carp ponds in Croatia Milorad Mrakovčić, Branko Glamuzina, Matija Kresonja, Ivana Sučić
13.30 - 13.45	The possibility of increasing the resilience of carp pond culture to climate changes Tomislav Slaćanac, Jasna Ipša, Ana Gavrilović
13.45 - 14.00	Great cormorant conflict - is there any solution for large pond systems? Michal Kratochvíl, Czech Fish Farmers Association
14.00 - 14.15	Discussion
14.15 - 15.15	Lunch break
15.15 - 15.30	Energy optimization in fish farming Anders Erlang Østergaard, BioMar, PROMO
15.30 - 15.45	Negative impact of mariculture on the marine environment in Croatia - reality or myth? Donat Petricioli, Tatjana Bakran-Petricioli

15.45 - 16.00 **Promicanje održive akvakulture kroz inovativne prakse - IMTA Hrvoje**
Čepnja, Ivan Župan, Tomislav Šarić, Slavica Čolak, Daniel Matulić

16.00 - 16.15 **Prostorna analiza marikulture u Hrvatskoj s posebnim naglaskom na važnost zaštićenih područja**
Tomislav Šarić, Ivan Župan, Zoran Šikić, Rina Milošević, Lav Bavčević, Slavica Čolak

16.15 - 16.30 **Utjecaj klimatskih promjena na akvakulturu u Sredozemnom moru**
Danijel Kanski, GFCM

16.30 - 16.45 **Akvakultura u Hrvatskoj u kontekstu Europske strategije za bjelančevine**
Lav Bavčević, Marijana Matek Sarić, Sveučilište u Zadru

16.45 - 17.00 **Rasprava (svi sudionici)**

15.15 - 19.00 **Poster sekcija**

20.00 **Zajednička večera, polazak autobusom u 18.00 ispred hotela**

15.45 - 16.00	Promoting Sustainable Aquaculture through Innovative Practices - IMTA Hrvoje Čepnja, Ivan Župan, Tomislav Šarić, Slavica Čolak, Dayiel Matulić
16.00 - 16.15	Spatial Analysis of Mariculture in Croatia with Special Emphasis on the Importance of Protected Areas Tomislav Šarić, Ivan Župan, Zoran Šikić, Rina Milošević, Lav Bavčević, Slavica Čolak
16.15 - 16.30	The impact of climate change on aquaculture in the Mediterranean Sea Dayijel Kanski, GFCM
16.30 - 16.45	Aquaculture in Croatia in the Context of the European Protein Strategy Lav Bavčević, Marijana Matek Sarić, University of Zadar
16.45 - 17.00	Discussion
15.15 - 17.00	Poster session
20.00	Departure by bus at 18.00 in front of the hotel

3. DAN | 4. TRAVNJA 2025.

9.00 -13.45 **Plenarna izlaganja**

9.00 - 9.15 **Laktokokoza nova prijetnja uzgoju lubina**
Dražen Oraić, Ivana Giovanna Zupčić, Dorotea Grbin, Matea Alfier,
Snježana Zrnčić

9.15 - 9.30 **Pojavnost jednorodnog metilja Sparicotyle chrisophri na uzgajanoj podlanici (Sparus aurata)**
Nižić Roko, Kolega Matko, Mejdandžić Danijel, Čolak Slavica

9.30 - 9.45 **Rastuća prevalencija infektivne hematopoetske nekroze (IHN) u uzgajalištima pastrva u Sjevernoj Makedoniji: Studija nadzora glavnih virusnih patogena u akvakulturi (2015.-2024.)** Trajchovski Aleksandar,
Popova Hristovska Zagorka, Grujovska Angela, Cvetkovikj Aleksandar

9.45 - 10.00 **Jačanje otpornosti i biosigurnosti u vodenim prehrambenim sustavima: preoblikovanje pripravnosti i odgovora na biološke opasnosti**
Fejzić Nihad, Veterinarski fakultet Sveučilišta u Sarajevu

10.00 - 10.15 **Projekt Marinet - preliminarni rezultati**
Zrnčić Snježana, Pleadin Jelka, Oraić Dražen, Krešić Greta, Zupčić Ivana
Giovanna, Arcangeli Giuseppe, Paolo Tome, Giuseppe Serra, Galeotti Marco

10.15 - 10.30 **Aдекватna primjena različitih dizajna RAS sustava u akvakulturi** Jurica
Jug-Dujaković, Ana Gavrilović

DAY 3 | 4 APRIL 2025

9.00 - 13.45 Plenary and Poster session

9.00 - 9.15 **Lactococcosis: A New Threat to European Seabass Farming** Dražen Oraić, Ivana Giovanna Zupičić, Dorotea Grbin, Matea Alfier, Snježana Zrnčić

9.15 - 9.30 **Prevalence of monogenean parasite *Sparicotyle chrisophrii* of cultured gilthead seabream (*Sparus aurata*)**
Nižić Roko, Kolega Matko, MejDaydžić Dayijel, Čolak Slavica

9.30 - 9.45 **Rising prevalence of infectious hematopoietic necrosis (IHN) in North Macedonian trout farms: A surveillance study of major viral pathogens in aquaculture (2015-2024)**
Trajchovski Aleksandar, Popova Hristovska Zagorka, Grujovska Angela, Cvetkovikj Aleksandar

9.45 - 10.00 **Strengthening Resilience and Biosecurity in Aquatic Food Systems: Reshaping Preparedness and Response to Biological Hazards** Fejzić Nihad, Veterinary Faculty University of Sarajevo

10.00 - 10.15 **Project "Marinet" Preliminary Results**
Zrnčić Snježana, Pleadin Jelka, Oraić Dražen, Krešić Greta, Zupičić Ivana Giovanna, Arcangeli Giuseppe, Paolo Tome, Giuseppe Serra, Galeotti Marco

10.15 - 10.30 **Adequate application of various RAS system designs in aquaculture**
Jurica Jug-Dujaković, Ana Gavrilović

10.30 - 10.45	Centar izvrsnosti MARBLE: Unaprjeđenje pomorske robotike i održive akvakulture kroz istraživanje i inovacije Nadir Kapetanović, Nikola Mišković, Matija Bumbak, Krešimir Kovač, Ivana Bujas Rupić
10.45 - 11.00	Naše iskustvo sa surogat tehnologijom kod riba: očekivanja nasuprot stvarnosti Ákos Horváth, Kinga Katalin Lefler, Réka Enikő Balogh, Nevena Kitanović, György Hoitsy, Simona Sušnik Bajec, Zoran Marinović
11.00 - 11.15	Nova saznanja o reproduktivnoj zrelosti i mrijestu atlantske plavoperajne tune Tanja Šegvić-Bubić, Barbara Zorica, Luka Žuvić, Jerko Hrabar, Igor Talijančić, Ivana Lepen Pleić, Klara Ivanišević, Leon Grubišić
11.15 - 11.30	Rasprava
11.30 - 11.45	Pauza
11.45 - 12.00	Prehrambene i zdravstvene tvrdnje prepakiranih proizvoda brancina i orada Jelka Pleadin, Hrvatski veterinarski institut
12.00 - 12.15	Primjena ozona za produljenje roka trajanja proizvoda ribarstva - studija na europskoj srdeli (<i>Sardina pilchardus</i>) Tibor Janči, Glorija Kovač, Vlado Crnek, Marin Matošić, Josip Čurko
12.15 - 12.30	Prikaz mogućnosti različitih obrada fileta ribe Kardum Maja, Cromaris d.d.

10.30 - 10.45	Center of Excellence MARBLE: Advancing Maritime Robotics and Sustainable Aquaculture through Research and Innovation Nadir Kapetanović, Nikola Mišković, Matija Bumbak, Krešimir Kovač, Ivana Bujas Rupić
10.45 - 11.00	Our experience with surrogate technology in fish: expectations vs. reality Ákos Horváth, Kinga Katalin Lefler, Réka Enikő Balogh, Nevena Kitanović, György Hoitsy, Simona Sušnik Bajec, Zoran Marinović
11.00 - 11.15	New Insights into the Reproductive Maturation and Spawning of Juvenile Atlantic Bluefin Tuna Tanja Šegvić-Bubić, Barbara Zorica, Luka Žuvić, Jerko Hrabar, Igor Talijančić, Ivana Lepen Pleić, Klara Ivanišević, Leon Grubišić
11.15 - 11.30	Discussion
11.30 - 11.45	Coffer break
11.45 - 12.00	Nutrition and health claims for prepackaged sea bass and gilthead sea bream products Jelka Pleadin, Croatian Veterinary Institute
12.00 - 12.15	Application of ozone for shelf life extension of fishery products - study on European sardine (Sardina pilchardus) Tibor Janči, Glorija Kovač, Vlado Crnek, Marin Matošić, Josip Ćurko
12.15 - 12.30	Presentation of various fish fillet processing options Kardum Maja, Cromaris d.d.

12.30 - 12.45	Korak prema kružnoj akvakulturi - Integracija vodene leće (Lemna ssp.) kao održivi izvor proteina Bartucz Tamás, Szabó István, Nagy Borbála, Kathi László, Ádám Róbert, Várkonyi Dávid, Berzi-Nagy László, Bokor Zoltán, Bernáth Gergely, Urbányi Béla, Csorbai Balázs
12.45 - 13.00	Utvrđivanje dnevnog obroka brancina (<i>Dicentrarchus labrax</i> L.) u uzgoju Števanja Toni, Cromaris d.d.
13.00 - 13.15	Kondicioniranje Mediteranske dagnje (<i>Mytilus galloprovincialis</i>) Petar Zuanović, Lav Bavčević, Tomislav Šarić, Ivan Župan
13.15 - 13.30	Rasprava
13.30 - 14.30	Ručak
14.30 - 14.45	Novi proizvodi od poznatih vrsta riba iz hrvatske tradicijske akvakulture Balaž Miroslav, Terzić Goran, Ivan Katavić
14.45 - 15.00	Jakobova kapica (<i>Pecten jacobaeus</i> L.) - potencijalni kandidat za akvakulturu? Valentina Šebalj, Tomislav Šarić, Lav Bavčević, Petar Zuanović, Ivan Župan
15.00 - 15.15	Pokazatelji kvalitete dagnji iz uzgoja: studija na primjeru uzgajališta u Limskom zaljevu - „Limska dagnja“ Bojan Hamer, Kristina Grozić, Luca Privileggio, Ivan Balković, Korana Hamer, Tibor Janči, Maja Maurić Maljković, Andrej Jaklin, Dijana Pavičić-Hamer

12.30 - 12.45	A step towards a circular aquaculture: integration of duckweed (<i>Lemna ssp.</i>) into as sustainable protein source Bartucz Tamás, Szabó István, Nagy Borbála, Kathi László, Ádám Róbert, Várkonyi Dávid, Berzi-Nagy László, Bokor Zoltán, Bernáth Gergely, Urbányi Béla, Csorbai Balázs
12.45 - 13.00	Determining the daily ratio of European sea bass (<i>Dicentrarchus labrax</i> L.) in farming conditions Števanja Toni, Cromaris d.d.
13.00 - 13.15	Conditioning of the Mediterranean mussel (<i>Mytilus galloprovincialis</i>) Petar Zuanović, Lav Bavčević, Tomislav Šarić, Ivan Župan
13.15 - 13.30	Discussion
13.30 - 14.30	Luch break
14.30 - 14.45	New products from well-known fish species from Croatian traditional aquaculture Balaž Miroslav, Terzić Goran, Ivan Katavić
14.45 - 15.00	The Mediterranean Scallop (<i>Pecten jacobaeus</i> L.) - potential aquaculture candidate? Valentina Šebalj, Tomislav Šarić, Lav Bavčević, Petar Zuanović, Ivan Župan
15.00 - 15.15	Quality indicators of farmed mussels: a case study of a farm in the Lim Bay - "Lim mussel" Bojan Hamer, Kristina Grozić, Luca Privileggio, Ivan Balković, Korana Hamer, Tibor Janči, Maja Maurić Maljković, Andrej Jaklin, Dijana Pavičić-Hamer

15.15 - 15.30 **Potencijalna uloga akvakulture u obnovi europske jegulje u Republici Hrvatskoj**
Branko Glamuzina, Milorad Mrakovčić, Sveučilište u Dubrovniku

15.30 - 16.00 **Trenutno stanje i perspektive razvoja uzgoja školjkaša na području Zadarske županije**
Župan Ivan, Šarić Tomislav, Bavčević Lav

16.00 **Kraj**

15.15 - 15.30 **The potential role of aquaculture in the recovery of European eel in the Republic of Croatia**
Branko Glamuzina, Milorad Mrakovčić, Sveučilište u Dubrovniku

15.30 - 16.00 **Current status and prospects for the development of bivalve farming in the Zadar County area**
Župan Ivan, Šarić Tomislav, Bavčević Lav

16.00 **End**





Poster sekcija

3. travnja 2025. | 15.15 – 19.00

4. travnja 2025. | 09.00 – 13.45

Poster session

3 April 2025 | 15.15 – 19.00

4 April 2025 | 09.00 – 13.45

-
- 1 Smanjenje mikroplastike u moru - promicanje prelaska na kružno gospodarstvo**
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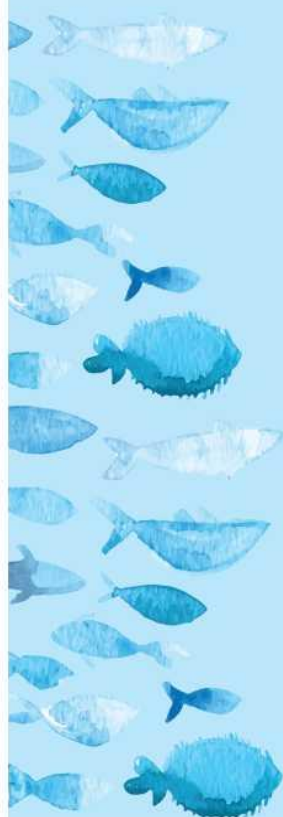
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A step towards a circular aquaculture: integration of duckweed (*Lemna* ssp.) into as sustainable protein source

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Abstract:

Fishmeal used in fish feed is produced from natural fisheries, yet it is unsustainable. Various insect meals like black soldier fly (*Hermetia illucens*) larvae (BSFL) meal offer an alternative to fishmeal as a source of protein. BSFL grows well on various organic wastes. Duckweed, the use of whom is unsolved, is a waste from aquaculture produced in large quantities. During the BSFL rearing experiment, two groups were set up. The control substrate was chicken feed (CF), while the experimental diet contained duckweed and maize (DW) in optimal ratio. After 5 days of rearing, the body weight of DW group was 99.51 ± 11.63 mg. The body weight of group CF was significantly higher, namely 123.1 ± 18.44 mg. The biomass/rack was also determined: biomass of CF group was significantly higher than in case of DW group. Having collected and processed larvae to defatted meal, they were formulated to the same grain size like fry feed. 8 days old African catfish larvae were stocked into 10 L tanks for the fry rearing experiment. The control (C) group was fed with commercial fry rearing feed. Commercial feed was replaced in 33% with DW larval meal and CF larval meal in the other two groups. During the 28 days of feeding trial, there was no significant difference between the three groups in body length, weight and biomass. Results showed that duckweed is suitable to be involved in BSFL rearing, but the technology needs further experiments to make the recycling of this waste more efficient.

Keywords: Circular economy, duckweed, black soldier fly, larvae, feeding, °C

Akvakultura u Hrvatskoj u kontekstu Europske strategije za bjelančevine

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Sažetak:

Bjelančevine su ključne za rast, razvoj i zdravlje ljudskog organizma. U Europskoj uniji (EU) prehrana se oslanja na bjelančevine životinjskog i biljnog podrijetla, pri čemu su biljne bjelančevine nužne i za ishranu životinja. Samodostatnost u proizvodnji bjelančevina procjenjuje se prema nutritivnim potrebama stanovništva i tržišnoj potražnji. U EU se proizvodi samo oko 75% potrebnih bjelančevina. Kako bi se smanjila ovisnost o uvozu, EU je razvila strategiju za bjelančevine koja podrazumijeva donošenje i nacionalnih strateških planova.

Riba je visokovrijedna namirnica jer, osim kvalitetnih bjelančevina, osigurava esencijalne masti, minerale i vitamine. Međutim, prema tržišnim kriterijima EUMOFA-e, EU dostiže samo 38 % samodostatnosti u proizvodima ribolova i akvakulture. Analizom nutritivnih potreba stanovništva (0,83 g bjelančevina/kg tjelesne mase) utvrđeno je da Republika Hrvatska (RH) pokriva oko 85% vlastite potrebe za bjelančevinama. U 2023. godini ukupni uzgoj i ulov ribe i drugih vodenih organizama, umanjen za 6996 tona za ishranu tuna, iznosio je 79.382,29 tona, što daje oko 43.000 tona hrane za ljude, odnosno približno 213 g po stanovniku tjedno.

Za samodostatnost zdrave prehrane, koja prema preporuci svjetske zdravstvene organizacije podrazumijeva konzumaciju 300-350 g ribe tjedno kroz dva obroka, u RH bi trebalo proizvesti još najmanje 32.000 tona vodenih organizama. Budući da su ribolovna ograničenja neizbježna, taj deficit moguće je nadoknaditi jedino razvojem akvakulture.

Ključne riječi: EU strategija za bjelančevine, Samodostatnost u proizvodnji bjelančevina u Hrvatskoj akvakultura

Aquaculture in Croatia in the Context of the European Protein Strategy

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Abstract:

Proteins are essential for human growth, development, and health. In the European Union (EU), nutrition relies on both animal and plant-based proteins, with plant proteins also being crucial for animal feed. Protein self-sufficiency is assessed based on the nutritional needs of the population and market demand. The EU currently produces only about 75% of its required protein. To reduce dependency on imports, the EU has developed a protein strategy, which includes the adoption of national strategic plans.

Fish is a highly valuable food source, providing not only high-quality proteins but also essential fats, minerals, and vitamins. However, according to EUMOFA market criteria, the EU achieves only 38% self-sufficiency in fisheries and aquaculture products. Analysing the nutritional needs of the population (0.83 g of protein/kg of body weight), it has been determined that the Republic of Croatia (RH) covers approximately 85% of its own protein needs. Nevertheless, in 2023, the total fish and aquatic organism production (both farmed and caught), reduced for 6,996 tons consumed for tuna feeding, amounted to 79,382.29 tons, providing only about 43,000 tons of food for human consumption—approximately 213 g per capita per week.

Given the WHO's recommendation that fish consumption should be 300-350 g per week through two meals, Croatia lacks at least 32,000 tons of aquatic organism production to achieve self-sufficiency. Since fishing limitations are inevitable, this deficit can only be compensated by developing aquaculture.

Keywords: EU protein strategy, Croatia protein self-sufficiency, aquaculture

Energy optimization in fish farming

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Abstract:

Energy optimization in fish farming is vital for improving sustainability, reducing costs, and minimizing environmental impacts. This involves implementing energy-efficient technologies, such as advanced aeration systems and low-energy pumps, increasing efficiency by up to 60%. Efficient farm design also plays a critical role in reducing energy consumption. By prioritizing energy optimization, fish farming can achieve higher productivity while contributing to a more sustainable and resilient food production system.

Promicanje održive akvakulture kroz inovativne prakse - IMTA

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Sažetak:

Održiva akvakultura obuhvaća interdisciplinarni pristup uzgoju vodenih organizama, uravnotežujući ekološke, ekonomske i društvene aspekte s ciljem smanjenja negativnih utjecaja na vodene ekosustave, osiguravanja ekonomske stabilnosti te prehrambene sigurnosti. U tom kontekstu, integrirana multitrofička akvakultura (IMTA) predstavlja inovativan model proizvodnje koji kombinira različite vrste organizama kako bi se povećala učinkovitost uzgoja i smanjili ekološki otisci. Unatoč velikom potencijalu, IMTA još nije komercijalno primijenjena u Hrvatskoj. Međutim, s obzirom na rastuću globalnu potražnju za morskim proteinima i potrebu za održivijim praksama u akvakulturi, ovaj pristup može postati ključan za budući razvoj sektora. Ovo istraživanje analizira biološke, tehničke i operativne izazove IMTA sustava te procjenjuje ekonomski isplative modele prilagođene Jadranskom moru. Aktivnosti uključuju karakterizaciju IMTA sustava, tehnno-ekonomsku analizu i izradu studije izvedivosti, pružajući temelje za daljnju implementaciju održivih akvakulturnih praksi.

Ključne riječi: održiva akvakultura, integrirana multitrofička akvakultura (IMTA), ekonomska isplativost, ekološki utjecaj, prehrambena sigurnost

Promoting Sustainable Aquaculture through Innovative Practices - IMTA

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Abstract:

Sustainable aquaculture encompasses an interdisciplinary approach to the cultivation of aquatic organisms, balancing ecological, economic, and social aspects to minimize negative impacts on aquatic ecosystems while ensuring economic stability and food security. In this context, Integrated Multi-Trophic Aquaculture (IMTA) represents an innovative production model that combines different species to enhance farming efficiency and reduce ecological footprints. Despite its great potential, IMTA has not yet been commercially implemented in Croatia. However, given the increasing global demand for marine proteins and the growing need for more sustainable aquaculture practices, this approach could become essential for the future development of the sector. This research analyzes the biological, technical, and operational challenges of IMTA systems and assesses economically viable models adapted to the Adriatic Sea. Activities include the characterization of IMTA systems, techno-economic analysis, and feasibility study development, providing a foundation for the further implementation of sustainable aquaculture practices.

Keywords: sustainable aquaculture, Integrated Multi-Trophic Aquaculture (IMTA), economic viability, ecological impact, food security.

Strengthening Resilience and Biosecurity in Aquatic Food Systems: Reshaping Preparedness and Response to Biological Hazards

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Abstract:

Biological hazards, including infectious diseases and biosecurity threats, significantly impact aquaculture and fisheries, posing risks to aquatic food systems, livelihoods, and global food security. Effective emergency management systems are essential to address these challenges. This study evaluates existing policies, guidelines, and tools for managing biological hazards in aquatic food systems, identifying critical gaps in harmonization, preparedness, and response frameworks. Key findings reveal insufficient alignment of biosecurity protocols, risk assessment methodologies, and training materials tailored to the unique needs of aquaculture and fisheries. Additionally, the lack of integrated hazard classification systems and simulation exercises limits the effectiveness of current emergency management efforts. To address these gaps, a phased set of recommendations is proposed, including the development of standardized guidelines, harmonized training programs, and improved surveillance mechanisms. These measures emphasize the One Health approach and advocate for multidisciplinary collaboration, fostering resilience in aquatic food systems against biological hazards. Implementing these strategies will strengthen preparedness, enhance biosecurity, and support coordinated responses at global, regional, and national levels, ensuring sustainable management of aquaculture and fisheries in the face of growing biological risks.

Keywords: biological hazards, aquaculture, fisheries, biosecurity, One Health

Potencijalna uloga akvakulture u obnovi europske jegulje u Republici Hrvatskoj

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Sažetak:

Europska jegulja, *Anguilla anguilla* je komercijalno važna vrsta u ribarstvu i akvakulturi. Prirodna populacije jegulje u zadnjih tridesetak godina uslijed različitih razloga doživjela je kolaps uz smanjenje komercijalnih ulova i do 95%. Slična sudbina pratila je i uzgoj jegulje, koji se s nekadašnjih 11000 tisuća tona pao na 4192 tona u 2023. godini. Slični trendovi ribarstva i uzgoja jegulje su značajke i Hrvatske, u kojoj je od nekadašnjeg ukupnog stoka u hrvatskim vodama procijenjenog na 1700 tona, danas preostalo oko 50 tona biomase svih stadija. Uzgoj jegulje koji je 2006. godine započelo Ribnjačarstvo Poljana iz Garešnice s potencijalnim kapacitetom proizvodnje od 100 tona godišnje, je uslijed povećanja cijene staklaste jegulje i smanjene profitabilnosti prekinut, iako je tehnologija proizvodnje u potpunosti usvojena. Jedan od tradicionalnih načina obnove stokova jegulje u Europi je poribljavanje s mladim jeguljama uzgojenih u akvakulturnim pogonima do veličine najpogodnije za poribljavanje s obzirom na veliku prirodnu smrtnost staklaste jegulje. Loš status populacije jegulje u Hrvatskoj i postojanje postrojenja u kojima bi se mogla uzgojiti do određene veličine, predstavlja potencijal koji je potrebno iskoristiti za obnovu stoka jegulje u jadranskom slivu i uzgoja u slavonskim ribnjacima. U radu se opisuju aktivnosti koje su potrebne za ostvarenje ovog pristupa uključivo mapiranje područja za obnovu prirodne populacije, izlova staklaste jegulje u hrvatskim rijekama, uzgoja mladi, razvoja metodologije poribljavanja i praćenja obnove stokova u izabranim područjima.

Ključne riječi: europska jegulja, jadranski sliv, obnova stoka

The potential role of aquaculture in the recovery of European eel in the Republic of Croatia

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Summary

The European eel, *Anguilla anguilla*, is a commercially important species for fisheries and aquaculture. The natural eel population has collapsed over the last thirty years for a variety of reasons, with commercial catches declining by up to 95%. Eel farming in Europe has suffered a similar fate, declining from 11,000 tons to 4,192 tons in 2023. Similar trends in fishing and eel farming are also characteristic of Croatia, where of the former total stock in Croatian waters, estimated at 1700 tons, only about 50 tons of all stages remain today. Eel farming, which was started in 2006 by Ribnjačarstvo Poljana, Garešnica with a potential production capacity of 100 tons per year, was discontinued due to the increase in the price of glass eels and lower profitability, although the production technology has been fully adopted. One of the traditional methods of eel recovery in Europe is restocking with young eels reared in aquaculture facilities to a size that is most suitable for restocking, given the high natural mortality of glass eels. The poor state of the eel population in Croatia and the existence of facilities in which eels up to a certain size can be reared represent a potential that must be utilized for the restoration of eel stocks in the Adriatic basin and rearing in Slavonian fishponds. The paper describes the activities needed to implement this concept, including mapping of areas for restoration of natural populations, glass eel fishing in Croatian rivers, rearing of juveniles, development of a restocking method and monitoring of stock recovery in selected areas.

Keywords: European eel, Adriatic basin, stock recovery

Pokazatelji kvalitete dagnji iz uzgoja: studija na primjeru uzgajališta u Limskom zaljevu - „Limska dagnja“

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Sažetak:

Ujednačeno uzorkovanje i adekvatna metodologija analize indeksa kondicije dagnji (*Mytilus galloprovincialis*) ključni su temelji za dugoročno praćenje što omogućava vrednovanje proizvoda, lokacija i proizvodnih zona. S obzirom na rastuću potrebu isticanja i definiranja kvalitete lokalno uzgojenih dagnji, provedena je studija sezonskog praćenja indeksa kondicije (2008. - 2024.) i određivanje nutritivnog sastava (svibanj 2023.) dagnji u uzgajalištu školjkaša u Limskom zaljevu. U tu svrhu određena je kvaliteta dagnji pomoću indeksa kondicije računanog na temelju odnosa osušenog mesa na masu ljuštura (CI), udjela mokrog (MYw), prokuhanog mesa (MYc) i ljuštura (SI) u ukupnoj masi dagnje, kao i osnovni kemijski sastav mesa dagnje (bjelančevine, masti, ugljikohidrati, pepeo i voda). Utvrđeno je sezonsko kolebanje indeksa kondicije (CI) 8,60 % - 18,28 %, udjela svježeg mokrog mesa (MYw) 16,54 % - 29,30 %, prokuhanog mesa (MYc) 14,92 % - 23,32 % i udjela ljuštura (SI) 30,17 % - 39,69 % uz prosječne godišnje vrijednosti (CI $10,96 \pm 1,91$; MYw $23,82 \pm 2,91$; MYc $19,06 \pm 2,33$ i SI $37,03 \pm 2,87$). Analiza svježeg mesa dagnji pokazala je sljedeći nutritivni sastav: $9,37 \pm 0,45$ % bjelančevina, $2,54 \pm 0,43$ % ugljikohidrata, $1,04 \pm 0,22$ % masti, $2,58 \pm 0,13$ % pepela i $83,05 \pm 1,52$ % vode. Godišnje srednje vrijednosti računatih indeksa te analiziranih nutritivnih komponenti ukazuju na zadovoljavajuću kvalitetu „Limske dagnje“ koja je usporediva i slična vrijednostima dagnji uzgojenih na drugim uzgojnim područjima regionalno i šire.

Ključne riječi: uzgoj školjkaša, kvaliteta dagnji, indeks kondicije, nutritivni sastav, Limski zaljev.

The Quality Indicators in Mussel Farming: Lim Bay Case Study - „Limska dagnja“

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Abstract:

Standardised sampling and a suitable methodology for analysing the condition index of the Mediterranean mussel (*Mytilus galloprovincialis*) are the most important basis for longterm quality monitoring, enabling quality assessment of products, sites, and production zones. Considering the growing need to highlight and define the quality of locally farmed mussels, a study was conducted to seasonally monitor the condition index (2008 - 2024) and determine the proximate composition (May 2023) of mussels in the Lim Bay. For this purpose, the quality of the mussels was determined using a condition index based on the percentage of dried meat in the mass of the shells (CI), wet meat (MYw), cooked meat (MYc) and the shell incidence (SI) in the total mass of the mussels and the proximate composition of meat (proteins, fats, carbohydrates, water, and ash). A seasonal variation in condition index (CI) from 8.60% to 18.28%, wet meat percentage (MYw) from 16.54% to 29.30%, cooked meat percentage (MYc) from 14.92% to 23.32%, and shell incidence (SI) from 30.17% to 39.69% was observed, with the average annual values of these four condition index calculations being CI 10.96 ± 1.91 ; MYw, 23.82 ± 2.91 ; MYc 19.06 ± 2.33 , and SI 37.03 ± 2.87 . The analysis of fresh mussel meat revealed the following proximate composition: $9.37 \pm 0.45\%$ proteins, $2.54 \pm 0.43\%$ carbohydrates, $1.04 \pm 0.22\%$ fat, $2.58 \pm 0.13\%$ ash and $83.05 \pm 1.52\%$ water. The annual mean values of the applied condition index calculations and nutritional composition indicate a satisfactory quality of the mussels from the Lim Bay „Limska dagnja“, which is comparable and similar to the values of mussels from other aquaculture areas, regionally and beyond.

Keywords: mussel farming, mussel quality, condition indices, proximate composition, Lim Bay.

Our experience with surrogate technology in fish: expectations vs. reality

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Abstract:

Surrogate technology allows the production of fish from donor-derived gametes produced by recipient individuals. Germline stem cells (GSCs) are typically transplanted into sterile recipient individuals, colonize their gonads, and give rise to donor-derived gametes. Our team has been working on surrogate technology in a number of fish taxa. We developed isolation and cryopreservation techniques for the gonads and GSCs of donor individuals and transplanted these into suitable recipients. Cryopreservation of GSCs from various fish species including cyprinids, sturgeons, salmonids, and European eel resulted in high post-thaw survival of cells. Surrogate production of fish, however, resulted in more controversial outcomes. While transplantation of spermatogonia in cyprinids worked well and resulted in donor-derived gametes and progeny, the technique was less successful in other taxa. In salmonids and sturgeons, transplanted GSCs were able to colonize the recipient gonads and were detected for up to 3 months post-transplantation; however in most instances, they failed to produce gametes. Thus, surrogate technology offers the potential of restoring valuable genetic resources, however, the careful selection of donors and recipients is inevitable.

Keywords: surrogate technology, species conservation, spermatogonia, oögonia, cryopreservation

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Novi proizvodi od poznatih vrsta riba iz hrvatske tradicijske akvakulture

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Sažetak

Dinamični način života s rastućom urbanizacijom drastično mijenja prehrambene navike potrošača, udaljavajući ih od izvornog primarnog proizvoda i dajući prednost dorađenim proizvodima koji su jednostavniji za korištenje i zahtijevaju kratko vrijeme za pripremu. Ovo „odvajanje“ dovelo je do nedostatka zanimanja ili čak animoziteta prema svježoj slatkovodnoj ribi koja se na tržište u pravilu plasira netom nakon izlova. Pored toga, ribe iz ribnjačarske proizvodnje se suočavaju s negativnim percepcijama praćenim atributima „koščatosti“, neukusa i nepoželjnog mirisa, a koji umnogome limitiraju njihov plasman na tržište. Očito je da takvi proizvodi nisu dovoljno prilagođeni očekivanjima potrošača, što je jedan od bitnih razloga kontinuirane stagnacije u proizvodnji nacionalnog slatkovodnog ribnjačarstva. Uobičajena je praksa u novije vrijeme da se riba kao jedna od najzdravijih namirnica prebaci na razne „praktične proizvode“ kao što je očišćena riba od utrobe i škrga, bez ljuski, riblji kotleti, filetirana riba i sl. U lancu vrijednosti ribe veliki supermarketi potiču metode zamrzavanja, soljenja, sušenja i dimljenja s ciljem dobivanja proizvoda produljenog roka trajanja. Nova inicijativa EK promovira strategiju dodavanja vrijednosti proizvodima ribarstva i akvakulture kojom se maksimizira tržišnu vrijednost proizvoda i potiče održivi lokalni razvoj, kapitalizirajući sve raspoložive resurse (ljudske, gospodarske, kulturne).

Tijekom 2024. godine u Hrvatskoj su kroz lanac supermarketa prezentirani novi proizvodi od slatkovodne ribe s dodanom vrijednošću koji su pobudili znatan interes potrošača slatkovodne ribe. Vukovarska tvrtka „Istar-Agro“ je na suvremenim metodama prerade ribe s dodanom vrijednošću ponudila četiri atraktivna proizvoda, poput ribljih odrezaka- burgera uključivo i one u obliku ribe namijenjeni djeci, ribljih čevapčića, i kobasica - ribasica. Sirovinska osnova za vrhunske brendove koji imaju ogromni potencijal, posebno u izvozno orijentiranoj industriji prerade ribe su tolstolobik (glavaš), *Hypophthalmichthys nobilis* i srodne ciprinidne vrste. Atraktivno dizajnirani proizvodi su dostupni u tri okusa - čili, začini, i klasični okus koji je bez dodatnih aroma. Sva tri proizvoda označena kao *picante*, *aromatico* i *classic* prodaju se pod markom *Panonica*. Na tom putu su savladani mnogi izazovi, poput pronalaženja partnera, podnošenja zahtjeva za financiranje, usklađivanje sa zdravstvenim i sanitarnim standardima, dobivanje pozajmnica i dr. Promotivni naponi koji su uslijedili imaju za cilj pobuditi interes potrošača za ribu uzgojenu u ribnjacima i ujedno

poduprijeti nacionalnu potrošnju ribe i zdravlje stanovništva. Posebni ciljevi su promovirati lokalnu zajednicu novostvorenim brendom koji ima budućnost, i omogućiti zapošljavanje lokalnog stanovništva. Također, poticanjem mlađih generacija da uključe ribu u svoju prehranu od predškolske i školske dobi moglo bi pridonijeti uspostavi jake i održive baze budućih potrošača slatkovodne ribe i riboprerađivačke industrije u R. Hrvatskoj. Daljnje promotivne aktivnosti će se usredotočiti na nove brendove i edukaciju potrošača o ekološkim prednostima ribnjačarske akvakulture koji proizvodi su u skladu s načelima kružnog gospodarstva.

Razvoj aktivnosti usmjerenih na dodavanje nove vrijednosti proizvodima slatkovodnog ribnjačarstva, uz zajamčenu kvalitetu, stalnu dostupnost i raznolik izbor trebaju biti važne komponente u strategiji sektora u cilju zadovoljenja sadašnjih i budućih gospodarskih izazova koji zaslužuju respekt i odgovarajuću podršku.

Ključne riječi: Akvakultura, slatkovodne ribe, dodana vrijednost, Panonica brand, Vukovar - Hrvatska

New products from well-known fish species of traditional Croatian aquaculture

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Abstract

A dynamic lifestyle with increasing urbanization is drastically changing the eating habits of consumers, moving them away from the original primary product giving preference in relation to refined one that is easier to use and require less time to be prepared. This separation has led to lack of interest or even animosity towards fresh fish, which are usually placed on the market immediately after being caught. In addition, fish from aquaculture face a negative perception accompanied by attributes of "boniness", tastelessness, and undesirable smell, that all limit their placement on the market. It is obvious that such a product is not sufficiently adapted to consumer expectations, which is one of the important reasons for the continuous stagnation in the production of national freshwater fish farming. In recent times, it is common practice to transfer fish, as one of the healthiest foods, to various "convenient products" such as gutted and gilded fish, without scales, fish cutlets, filleted fish, etc. In the fish value chain, large supermarkets encourage freezing, salting, drying and smoking methods with the aim of obtaining products with an extended shelf life. A new EC initiative promotes a strategy for adding value to fishery and aquaculture products that maximizes the market value of the product and encourages sustainable local development, capitalizing on all available resources (human, economic, cultural).

During 2024, new value-added freshwater fish products were presented in Croatian supermarket chains, which aroused significant interest among freshwater fish consumers. The Vukovar based company "Istar-Agro" used modern methods of value-added fish processing to offer the market four attractive products, such as fish steaks - burgers and those in the form of fish intended for children, fish kebab and fish sausages. The raw material basis for top brands that have enormous potential, especially in the export-oriented fish processing industry, is bighead carp (*Hypophthalmichthys nobilis*) and related cyprinid species. The attractively designed products are also available in three flavors - chili, spices and a classic flavor that is without additional flavors. All three products, labeled as *picante*, *aromatico* and *classic*, are sold under the *Panonica brand*. Many challenges have been overcome along the way, such as finding the partners, applying for financing, complying with health and sanitary standards, obtaining loans, etc. The promotional

efforts that followed aim to arouse consumer interest in fish raised in fish farms and at the same time support national fish consumption and the health of the population. Specific goals are to promote the local community with a newly created brand that has a future, and to enable employment for the local population. Also, encouraging younger generations to include fish in their diet from preschool and school age could help establish a strong and sustainable base of future consumers of freshwater fish and fish processing industry products in the Republic of Croatia. Further promotions will focus on new brands and consumer education about the ecological benefits of pond aquaculture, which products are in line with the principles of a circular economy.

The development of activities aimed at adding new value to freshwater aquaculture products, with guaranteed quality, constant availability and diverse choice, should be important components in the sector's strategy in order to meet current and future economic challenges that deserve respect and appropriate support.

Keywords: Aquaculture, freshwater fish, added value, Panonica brand, Vukovar - Croatia

Application of ozone for shelf life extension of fishery products - study on European sardine (*Sardina pilchardus*)

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Abstract:

Ozone is a powerful antimicrobial agent that can be used as a pre-treatment to reduce microbial counts and extend the shelf life of fish in refrigerated storage. However, its strong oxidizing properties can have a negative impact on fish quality.

The aim of this study was to determine the optimal ozone concentration and exposure time to reduce the microbial load while minimizing quality degradation in sardines. Parameters such as sensory score (QIM), TVBN, TBARS, aerobic mesophilic count, muscle pH and proteolytic index were evaluated immediately after treatment and during 7 days of storage at 0°C.

Results showed that 3 mg/L ozone effectively reduced microbial load without significantly affecting initial sensory scores or TVBN content, although prolonged exposure increased lipid oxidation. QIM models showed a theoretical shelf life of 6.6 days for the control sample, while all ozone-treated samples demonstrated longer shelf life. The longest shelf life (8.15 days) was observed in the group treated with 1 mg/L ozone for 5 minutes, which corresponds to an extension of 23%.

These results confirm that ozone treatment can extend the shelf life of sardines, emphasizing the need for optimized treatment conditions to achieve the best possible results with minimal impact on quality of treated fish.

Keywords: ozone, fish, shelf life, quality, QIM

Aдекватna primjena različitih dizajna RAS sustava u akvakulturi

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Sažetak:

Recirkulacijski akvakulturni sustav (RAS) testira se i razvija već nekoliko desetljeća. Osnovni razlozi za razvitak ovakvih sustava bili su redukcija potrošnje vode i upotrebe zemljišta te mogućnost kreiranja željenog okoliša u uzgojnom prostoru. U RAS-u se održava optimalna temperatura i kvaliteta vode, kreirajući okolinu bez stresa koja održava zdravlje i ubrzava rast uzgojnog organizma. Unatoč brojnim promašenim dizajnima i nerealnim kapitalnim troškovima uzgojni projekti koji uključuju RAS, postali su nezaobilazan odgovor klimatskim promjenama, nestašici vode, ograničenom korištenju zemljišta i morskih površina te sve strožim zakonima o očuvanju i korištenju prirodnih resursa. RAS se osim toga idealno uklapa u cirkularnu ekonomiju i održivu poljoprivrednu proizvodnju, a njegova zatvorenost omogućuje uzgoj stranih ekonomski isplativih vrsta. Nakon uspješnih inicijalnih istraživanja primarni je fokus bio u kreiranju, razvitku i komercijaliziranju tehnologije koja je u stanju proizvoditi ribu i ostale vodene organizme na ekonomski kompetitivnoj osnovi. Visoka tržišna cijena, neadekvatan dizajn i činjenica da se radi o zatvorenom sustavu koji zahtjeva čvrsti objekt zahtjevali su kapitalne troškove koji su većinu projekata recirkulacijske akvakulture učinili neprofitabilnim. Zadnjih desetak godina komponente recirkulacijskih sustava su pojeftinile zahvaljujući masovnoj proizvodnji i pojednostavljenim konstrukcijama, a značajan dio kompletnih sustava je uz pomoć kompetentnih stručnjaka prilagođen uzgoju različitih vrsta vodenih organizama. Ujedno su sakupljena iskustva omogućila razvitak novih kreativnih, pojednostavljenih i financijski opravdanih dizajna. U posljednjih nekoliko godina u ovom dijelu Europe, pa i u Hrvatskoj, značajno je porastao interes za uključivanjem RAS-a u projekte za uzgoj ribe. U radu je prikazano nekoliko dizajna prilagođenih uzgoju različitih vrsta riba ili njihovih razvojnih stadija koji mogu pronaći svoju primjenu u našim područjima.

Glavne riječi: tehnologija akvakulture, klimatske promjene, uzgoj ribe

Adequate application of various RAS system designs in aquaculture

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Abstract:

The recirculating aquaculture system (RAS) has been developed and tested for several decades. The main reasons for the development of such systems were the reduction of water consumption and land use and the possibility of creating the desired environment in the cultivation area. Optimal temperature and water quality are maintained in RAS, creating a stress-free environment that maintains health and accelerates the growth of the breeding organism. Despite numerous failed designs and unrealistic capital costs breeding projects that include RAS have become an inevitable response to climate changes, water shortages, limited use of land and sea surfaces, and increasingly strict laws on the conservation and use of natural resources. In addition, the RAS is ideally suited to the circular economy and sustainable agricultural production, and its closedness enables the cultivation of economically profitable foreign species. After successful initial research, the primary focus was on the creation, development and commercialization of technology capable of producing fish and other aquatic organisms on an economically competitive basis. The high market price, inadequate design and the fact that it is a closed system involving a solid building required capital costs that made most recirculating aquaculture projects unprofitable. In the last ten years, the components of recirculation systems have become cheaper thanks to mass production and simplified constructions, and a significant part of the complete systems has been adapted to the cultivation of various types of aquatic organisms, with the involvement of competent aquaculture experts. At the same time, the accumulated experiences enabled the development of new creative, simplified and financially justified designs. In the last few years, in this part of Europe, including in Croatia, there has been a significant increase in interest in including RAS in fish farming projects. The paper presents several designs adapted to the cultivation of different types of fish or their developmental stages that can find their application in our areas.

Keywords: aquaculture technology, climate changes, fish farming

Utjecaj klimatskih promjena na akvakulturu u Sredozemnom moru

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Sažetak

Klimatske promjene mijenjaju akvakulturu na području Sredozemnog mora, postavljajući složene izazove koji zahtijevaju koordinirani pristup svih regionalnih dionika. Ovaj rad analizira utjecaj klimatskih promjena na akvakulturu iz perspektive uzgajivača u Hrvatskoj, Tunisu i Cipru, naglašavajući stvarne posljedice promjene klime na proizvodne sustave. Glavni naglasci uključuju promjene u uzgojenim vrstama i strategijama, varijacije u stopama rasta te ekosustavne stresore uzrokovane porastom temperatura mora.

Cilj istraživanja

Glavni cilj rada je istražiti utjecaj klimatskih promjena na uzgoj akvakulturnih vrsta u području Sredozemnog mora te predstaviti konkretne strategije prilagodbe kako bi se osigurala održivost, ekonomska stabilnost i sigurnost hrane.

Rezultati istraživanja

1. Promjene u okolišnim uvjetima:

- Povišene temperature mora tijekom ljetnog perioda (26°C do 30°C) značajno utječu na smrtnost uzgajanih organizama.
- Intenzivnije pojave cvjetanja algi i smanjenja kisika u vodi mijenjaju uvjete uzgoja.

2. Utjecaj na uzgoj:

- Pad proizvodnje daganja u Tunisu za čak 95%.
- Predacija plavog raka u uzgoju kamenica.
- Visoki mortaliteti vrsta osjetljivih na stres (brancin)

3. Strategije prilagodbe:

- Napredni sustavi praćenja temperatura i kvalitete vode.
- Programi selektivnog uzgoja za povećanje otpornosti vrsta na visoke temperature.

- Primjena Integrirane Multi-trofičke akvakulture (IMTA) za povećanje stabilnosti ekosustava.
- Korištenje dubljih kaveza i prilagodba rasporeda nasadijanja i izlova.

4. Zakonski i edukativni aspekti:

- Naglašena je potreba za prilagodljivim zakonima, smanjenjem gustoće nasada te kontinuiranom edukacijom uzgajivača.

Zaključci

Ključni nalaz istraživanja je kašnjenje u razmjeni podataka u stvarnom vremenu između proizvođača i ostalih dionika, što otežava implementaciju efikasnih strategija. Brza razmjena informacija ključna je za održavanje stabilnosti sektora u uvjetima klimatskih promjena.

Predložene strategije i mjere mogu pomoći u ublažavanju utjecaja klimatskih promjena na akvakulturu u Sredozemnom moru. Međutim, daljnja istraživanja trebala bi obuhvatiti sveobuhvatne analize, uključujući scenarije promjene pH morske vode, štetna cvjetanja algi i ekstremne vremenske uvjete. Ove spoznaje trebaju biti temelj za donošenje nacionalnih i regionalnih politika prilagodbe i ublažavanja klimatskih promjena.

Ključne riječi: klimatske promjene, akvakultura, strategije prilagodbe, morski ekosustavi

The impact of climate change on aquaculture in the Mediterranean Sea

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Abstract:

Climate change is transforming aquaculture in the Mediterranean Sea, posing complex challenges that demand a coordinated approach from all regional stakeholders. This presentation examines the impact of climate change on aquaculture from the perspective of producers in Croatia, Tunisia, and Cyprus, highlighting the tangible effects of climate shifts on production systems. Key points include changes in cultivated species and strategies, variations in growth rates, and ecosystem stressors caused by rising sea temperatures.

Research Objective

The main aim of this study is to explore the impact of climate change on the production of aquaculture species in the Mediterranean region and to present specific adaptation strategies to ensure sustainability, economic stability, and food security.

Research Findings

1. Changes in Environmental Conditions:

- Elevated sea temperatures during summer (26°C to 30°C) significantly increase mortality of farmed species.
- More frequent algal blooms and reduced oxygen levels destabilize ecosystems.

2. Impact on Farming:

- Mussel production in Tunisia has declined by up to 95%.
- Predation by the invasive blue crab in oyster farming.
- High mortalities of stress sensitive species (sea bass)

3. Adaptation Strategies:

- Advanced systems for monitoring temperature and water quality.

- Selective breeding programs to enhance species resilience to high temperatures.
- Implementation of Integrated Multi-trophic aquaculture (IMTA) for ecosystem stability.
- Use of deeper cages and adjustments to seeding and harvesting schedules.

4. Legal and Educational Aspects:

- Emphasized the need for adaptable regulations, reduced seeding densities, and continuous education for farmers.

Conclusions

A key finding of the study is the delay in real-time data exchange between producers and other stakeholders, which hampers the implementation of effective strategies. Rapid information sharing is crucial for maintaining sector stability under climate change conditions.

The proposed strategies and measures can help mitigate the impact of climate change on aquaculture in the Mediterranean. However, further research should include comprehensive analyses, covering scenarios such as changes in seawater pH, harmful algal blooms, and extreme weather conditions. These findings should serve as the basis for the development of national and regional policies for climate change adaptation and mitigation.

Keywords: climate change, aquaculture, adaptation strategies, marine ecosystems

Centar izvrsnosti MARBLE: Unaprjeđenje pomorske robotike i održive akvakulture kroz istraživanje i inovacije

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Sažetak:

Centar izvrsnosti MARBLE istraživačka je organizacija koju je osnovao UNIZG-FER u Zagrebu u sklopu programa EU HE Teaming for Excellence. Njegovo sjedište obuhvaćat će 3.000 m² uredskog prostora, 660 m² prostora za start-upove te vrhunske otvorene laboratorije, uključujući laboratorij za prototipiranje, eksperimentalni bazen, leteću arenu, sobu za digitalne blizance i mobilni laboratorij. Osim toga, CoE MARBLE upravlja s tri pilot-lokacije: Pametna farma dagnji (Šibenik), Pametna marina (Rijeka) i Lokacija za autonomne pomorske sustave (Šibenik), koje su posvećene pomorskim istraživanjima, robotici i praćenju okoliša.

CoE MARBLE temelji se na prethodnim projektima u akvakulturi koji su potaknuli inovacije u autonomnim pomorskim sustavima. Projekt HEKTOR unaprijedio je AI tehnologije za autonomiju na moru, dok su Pametne bove omogućile praćenje okoliša u stvarnom vremenu. Projekt iVRŠA modernizirao je tradicionalne ribolovne vrše, poboljšavajući selektivnost i održivost ribolova. Ove su inicijative pružile stručnost u autonomnim sustavima, senzorima i ekološki prihvatljivom ribolovu, stvarajući temelje za istraživanja CoE MARBLE-a u pomorskoj robotici i akvakulturnim tehnologijama.

DIH AgriFood Hrvatska ključni je partner u ovom području, povezujući istraživanje i industriju kroz poticanje digitalnih i autonomnih rješenja u održivoj akvakulturi. Njihova ekspertiza u pametnoj poljoprivredi, IoT-u i automatizaciji podržava misiju CoE MARBLE-a u razvoju napredne pomorske robotike i ekološki odgovornih akvakulturnih sustava.

Ključne riječi: Pomorska robotika; Autonomni sustavi; Pametna akvakultura; Praćenje okoliša; Inovacije plave ekonomije

Center of Excellence MARBLE: Advancing Maritime Robotics and Sustainable Aquaculture through Research and Innovation

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Abstract:

The Centre of Excellence in Maritime Robotics and Technologies (CoE MARBLE) is a research organization established by UNIZG-FER in Zagreb under the EU HE Teaming for Excellence Programme. Its headquarters will feature 3,000 m² of office space, 660 m² for start-ups, and state-of-the-art open lab facilities, including a prototyping lab, experimental pool, flying arena, digital twin room, and mobile lab. Additionally, CoE MARBLE will operate three pilot sites: the Smart Mussel Farm (Šibenik), Smart Marina (Rijeka), and Autonomous Marine Vehicle Operation Site (Šibenik), all dedicated to maritime research, robotics, and environmental monitoring.

CoE MARBLE builds upon previous aquaculture projects that have driven innovation in autonomous marine systems. The HEKTOR project advanced AI-powered maritime autonomy, while Smart Buoys enabled real-time environmental monitoring. The iVRŠA project modernized traditional fishing traps, enhancing selectivity and sustainability. These initiatives provided expertise in autonomous systems, sensor networks, and ecofriendly fishing, forming the foundation for CoE MARBLE's research in maritime robotics and aquaculture technologies.

DIH AgriFood Croatia has been a key partner in this field, bridging research and industry by fostering digital and autonomous solutions in sustainable aquaculture. Their expertise in smart farming, IoT, and automation supports CoE MARBLE's mission to develop cutting-edge maritime robotics and environmentally responsible aquaculture systems.

Keywords: Maritime Robotics; Autonomous Systems; Smart Aquaculture; Environmental Monitoring; Blue Economy Innovation

Prikaz mogućnosti različitih obrada fileta ribe

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Sažetak:

Cilj ovog rada bio je diversificirati proizvode, proširiti portfolio i prilagoditi se potrebama tržišta kroz analizu različitih vrsta rezova fileta ribe.

Proces filetiranja može biti ručni ili strojni, pri čemu ručno filetiranje uključuje precizne rezove duž tijela ribe, dok se strojno filetiranje odvija na specijaliziranim strojevima prilagođenim veličini i vrsti ribe.

Fileti se mogu proizvoditi s kožom ili bez nje te se dodatno dorađuju uklanjanjem kostiju (PIN BONES) različitim tehnikama poput V-CUT i F-CUT, također se može odstraniti tanki dio fileta sa potrbušne strane što je N-CUT. Osim klasičnih fileta, postoje i posebni rezovi poput J-CUT i *butterfly cuts*, dok se kod ribe veće mase mogu primijeniti horizontalni i vertikalni rezovi. Raznovrsnost rezova omogućuje prilagodbu proizvoda tržišnim zahtjevima i preferencijama potrošača, čime se povećava konkurentnost i iskoristivost sirovine.

Ključne riječi: filetiranje ribe, rezovi fileta, PIN BONES, strojno filetiranje, ručno filetiranje, tržišni zahtjevi

Presentation of various fish fillet processing options

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Abstract:

The aim of this work was to diversify products, expand the portfolio and adapt to market needs through the analysis of different types of fish fillet cuts. The filleting process can be manual or with the help of a filleting machine, whereby manual filleting includes precise cuts along the body of the fish, while machine filleting is carried out on specialized machines adapted to the size and type of fish. Fillets can be produced with or without skin and are further processed by removing bones (PIN BONES) with different techniques like V-CUT and F-CUT, also you can remove a thin part of the fillet from the abdominal part, which is N-CUT. In addition to classic fillets, there are also special cuts such as J-CUT and *butterfly cuts*, while for larger fish, horizontal and vertical cuts can be applied. The variety of cuts allows the product to be adapted to market demands and consumer preferences, thereby increasing competitiveness and utilization of raw materials.

Keywords: fish filleting, fillet cuts, PIN BONES, machine filleting, hand filleting, market demands

The effects of algae supplementation on different age classes of common carp (*Cyprinus Carpio L.*) in rearing ponds

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Abstract:

In our research, we investigated the effects of algae-supplemented feed under pond rearing conditions. The experiments were conducted on common carp of three different age classes: advanced fry rearing, ongrowing, and second year growth phase. The aim of the study was to assess the applicability of algae-supplemented carp feed. During the nursing stage, feeding carp larvae were stocked into six ponds. Through the feeding trial, three groups (1% algae, 3% algae, control) were set. For the ongrowing experiment, three ponds were stocked with carp fingerlings. In two ponds traditional feed was used, while in the third, we used feed containing 1% algae. The second year growth stage was conducted in three ponds, where one-summer-old carp were divided into three feeding groups (1.: algae-enriched commercial feed, 2.: grain and traditional feed, 3.: grain). During the growth period, the stock was monitored through sample fishing. Through the two year growth experiment, the algae-supplemented feed resulted in significantly higher body length and weight values between nursing and two year growth stages. In case of fish meat and feed samples, the algae contained feed proved to be the most favorable in terms of antioxidant capacity and PUFAs during the nursing period. Positive effects, presumably due to algae supplementation, were also observed in antioxidant capacity and omega-6 fatty acid concentrations in feed and fish meat samples during the ongrowing and second year growth stages.

This work was supported by the project named "2020-1.1.2-PIACI-KFI-2020-00161 azonosítószámú, az „Egészségvédő pontyhús gazdaságos előállítása algával dúsított takarmánnyal”.

Keywords: pond, carp, algae, growth, meat quality

The potential contribution of the Hungarian aquaculture sector to the sustainable development goals today

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Abstract:

The diversity of the aquaculture sector is a major contributor to the Sustainable Development Goals (SDGs) and this contribution will continue to grow in the future. The sustainability of aquaculture is also a priority in Hungary, and its impacts can be assessed in environmental, economic and social terms. These impacts are well aligned with the Sustainable Development Goals (SDGs) set by the UN and adopted by the EU. The aquaculture sector plays an important role in food security, nutrition and livelihoods, but the starting point Agenda21 (Rio Declaration) does not clearly and explicitly address the role of the sector in economies and cultures. It is partly due to this shortcoming that in 2015, at the United Nations General Assembly, the countries of the world adopted the Sustainable Development Agenda and the 17 Sustainable Development Goals (SDGs), which set out the aspirations of the countries of the world for the future, as a first step towards 2030 (Agenda2030). An important task of the present is to interpret and identify the spatial-temporal scales of the sector's multiple functions and value creation in the freshwater aquaculture sector, to explore the potential of the freshwater aquaculture sector and to identify the current and future potential contribution of aquaculture to the SDGs.

Keywords: freshwater aquaculture, sustainable development goals, economic values, environmental values, social impact assessment

Višestruka uloga slatkovodnih šaranskih ribnjaka u Hrvatskoj

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Sažetak:

Analiziramo ekološke usluge koje pružaju šaranski ribnjaci u Hrvatskoj tijekom stoljeća razvoja šaranske kulture. Iako su slatkovodni šaranski ribnjaci prvotno stvoreni isključivo za proizvodnju ribe, do 1980. godine poluintenzivna šaranska kultura dosegla je svoj vrhunac. Nakon Domovinskog rata 1990. godine, gubitak tržišta, kapitala i ključnog znanja ozbiljno je utjecao na godišnju proizvodnju ribe. Napuštanje šaranskih ribnjaka moglo bi promijeniti lokalne ekosustave i smanjiti vodena staništa, uz potencijalnu promjenu napuštenih ribnjaka u šume tijekom narednih 50 godina. Dugotrajne melioracije i isušivanje prirodnih močvara povećali su ulogu šaranskih ribnjaka kao zamjenskih staništa, osobito za neke vrste ptica močvarica. Ministarstvo zaštite okoliša i zelene tranzicije kao i Ministarstvo poljoprivrede, šumarstva i ribarstva su prepoznali višefunkcionalnu ulogu šaranskih ribnjaka, koja donosi mnoge neizravne ekološke vrijednosti. Šaranski ribnjaci poboljšavaju kvalitetu vode, reguliraju poplave, podržavaju bioraznolikost (posebno određenih ptica, vodozemaca i sisavaca), olakšavaju kruženje hranjivih tvari i nude rekreativne aktivnosti poput obrazovanja, boravka u prirodi i ribolova. Slatkovodni šaranski ribnjaci su dinamični sustavi gdje su ulazi i izlazi hranjivih tvari uravnoteženi kroz složene interakcije različitih trofičkih razina. Osim toga, njihova sposobnost sekvenciranja ugljika važna je ekološka usluga koja doprinosi regulaciji klime, a ribnjaci su integralni dijelovi krajolika koji poboljšavaju povezanost staništa i heterogenost krajolika.

Ključne riječi: Šaranski ribnjaci, ekološke usluge, bioraznolikost, kruženje hranjivi

The multifaceted roles of freshwater carp ponds in Croatia

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Summary:

We analyze the ecological services provided by carp ponds in Croatia during centuries of carp culture development. Although freshwater carp ponds were originally created solely for fish production, by 1980, semi-intensive carp culture had reached its peak. By 1980, semi-intensive carp culture in Croatia had reached its peak. However, in 1990, after the Homeland War, the loss of markets, capital, and crucial knowledge severely impacted the annual production of freshwater fish. Abandoning carp ponds can alter local ecosystems and reduce aquatic habitats, potentially turning fishponds into forests within 50 years. The prolonged reclamation of natural wetlands increased the use of carp fishponds as substitute habitats. The Ministry of Environmental Protection and Green Transition and the Directorate for Water Management and Sea Protection soon recognized the multifunctional role of carp ponds, which brings many indirect values. Carp ponds improve water quality, regulate floods, support biodiversity (especially certain birds, amphibians, and mammals), facilitate nutrient cycling, and offer recreational activities such as education, nature stays, and fishing. Freshwater carp ponds are dynamic systems where nutrient inputs and outputs are balanced through complex interactions among different trophic levels. Their ability to sequester carbon is an important ecological service that contributes to climate regulation, and the ponds are integral parts of the landscape, contributing to habitat connectivity and landscape heterogeneity.

Keywords: Carp fishponds, ecological services, biodiversity, nutrient cycling

Pojavnost jednorodnog metilja *Sparicotyle chrisophri* na uzgajanoj podlanici (*Sparus aurata*)

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Sažetak:

Proizvodi marikulture imaju značajan udio u godišnjoj potrošnji ribe u Republici Hrvatskoj po glavi stanovništva. Ukupna proizvodnja iznosi 23 148 T. Podlanica (*Sparus aurata*) se proizvodi uspješno od početaka marikulture i njena proizvodnja je 2023. godine bila 8 922 T. Uzgoj se odvija u plutajućim mrežnim kavezima. Ova tehnologija uzgoja onemogućava kontrolu parametara uzgoja kao što su temperatura uzgoja i kontrola unosa uzročnika bolesti. Jednorodni metilj *Sparicotyle chrysophri* je škržni hematofagni nametnik, može biti odgovoran za značajnije pogoršanje rasta,

ozbiljne patologije škrga čak i kod umjerenog intenziteta infekcije i smrtnosti kod masivnih infekcija kod najosjetljivijih riba kao što je mlađ. Cilj istraživanja je bio utvrditi pojavnost i brojnost nametnika na škrgama ribe, te u odnosu na temperaturu mora pratiti jačinu infekcije nametnika *Sparicotyle chrysophrii*. Istraživanje se provodilo na Cromarisovom uzgajalištu koje se nalazi na otoku Ugljanu, točnije neposredno kraj uvala Lamjana, u razdoblju od nasada mlađi do prosječne mase podlanice od 150 g. Za potrebe ovog istraživanja se kroz navedeno razdoblje istraživanja uzimalo nasumično 100 jedinki iz četiri proizvodna kaveza. Biometrijskim mjerenjima obuhvaćena je masa, duljina i indeks kondicije ribe. Parazitološki pregledi škrga obavljani su na četiri škrga luka lijeve strane škrga. Evidentirala se prosječna pojavnost i brojnost nametnika. Povećanje prosječne pojavnosti i brojnosti nametnika bila je veća tijekom toplijih mjeseci. Povećana prosječna brojnost tijekom ljetnih mjeseci nije imala velik utjecaj na zdravstveno stanje podlanice.

Ključne riječi: marikultura, škrgni nametnik, hematofag, Cromaris

Prevalence of monogenean parasite *Sparicotyle chrysophrii* of cultured gilthead seabream (*Sparus aurata*)

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Summary:

Mariculture products have a significant share in the annual per capita fish consumption in the Republic of Croatia. Total production is 23,148 T. Gilthead sea bream (*Sparus aurata*) has been successfully produced since the beginning of mariculture and its production in 2023 was 8,922 T. Breeding takes place in floating net cages. This breeding technology makes it impossible to control breeding parameters such as breeding temperature and control of the entry of pathogens. *Sparicotyle chrysophrii* is a gill hematophagous parasite, it can be responsible for significant growth impairment, serious gill pathology even with moderate infection intensity and mortality with massive infections in the most sensitive fish stage such as juveniles. The aim of the research was to determine the occurrence and abundance of parasites on the gills of fish, and in relation to temperature. The research was conducted at the Cromaris fish farm located on the island of Ugljan, more precisely right next to the Lamjana bay, in the period from the planting of fry to the average mass of the sea bream of 150 g. For the purposes of this research, 100 individuals were randomly

taken from four production cages throughout the research period. Biometric measurements included the mass, length and condition index of the fish. Parasitological examinations of the gills were performed on four gill arches on the left side of the fish. The average occurrence and abundance of parasites were recorded. The increase in the average occurrence and abundance of parasites was greater during the warmer months. The increased average abundance during the summer months did not have a major impact on the health of the sea bream.

Keywords: mariculture, gill parasite, hematophagus, *Cromaris*

Laktokokoza: nova prijetnja uzgoju lubina

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Sažetak:

Laktokokoza je bakterijska bolest septikemijskog karaktera uzrokovana Gram pozitivnom bakterijom *Lactococcus garvieae*. Prvi opisani slučajevi bolesti riba uzrokovani Gram pozitivnim kokom su nazvani Streptokokokoze, a dijagnosticirani su u intenzivnom uzgoju kalifornijske pastrve u Japanu polovicom prošlog stoljeća. Početkom 90-tih bolest uzrokovana *Enterococcus seriolicida* je opisana u morske vrste, japanskog gofa (*Seriola quinqueradiata*). Prošlih desetljeća primjenom novih tehnika dijagnostike i identifikacije bakterija omogućena je reklasifikacija u rodove *Enterococcus*, *Lactococcus*, *Vagococcus* i *Carnobacterium*. Brojne vrste slatkovodnih i morskih vrsta riba su opisane kao primljive na infekciju s *L. garvieae*, a osim u riba, ova vrsta je izdvojena iz slatkovodnih kozica i morskih sisavaca, napose delfina. Opisani su poneki slučajevi u svinja, pasa i mačaka, a prvi izolat opisan kao *Streptococcus garvieae* je izdvojen iz slučaja subkliničkog mastitisa u krave.

Bolest u riba se opisuje kao akutna septikemija, sa simptomima tamne pigmentacije, nepravilnog plivanja, mršavljenja te egzoftalmije i to najčešće oba oka. Razudbom su opisane kongestije i krvarenja po jetri, slezeni, bubrežima, srcu, ribljem mjehuru, crijevima i mozgu. Dijagnoza se postavlja izdvajanjem i identifikacijom uzročnika temeljem morfoloških, kulturnih i biokemijskih karakteristika na komercijalnim kitovima za brzu identifikaciju te biomolekularnom dijagnozom metodama PCR, RT-PCR, 16SrRNA te sekvenciranjem.

Izvrješća o ovoj bakteriji kao uzročniku bolesti u lubina (*Dicentrarchus labrax*) u Sredozemlju su vrlo rijetka i nedavno je objavljen prvi opis slučaja iz ljeta 2023. godine. Visoki gubici uzrokovani ovom bolešću u uzgoju kalifornijske pastrve te u nekih drugih morskih vrsta riba upozoravaju na

ozbiljne gubitke te se po tome laktokokozi može definirati kao emergentnu bolest za uzgoj lubina u Jadranskom moru.

Ključne riječi: Laktokokoza, *Lactococcus garvieae*, bolesti riba, lubin, *Dicentrarchus labrax*

Lactococcosis: A New Threat to European Seabass Farming

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Abstract:

Lactococcosis is a septicemic bacterial disease caused by the Gram-positive bacterium *Lactococcus garvieae*. The first reported cases of fish diseases caused by Gram-positive cocci were termed Streptococcosis and were diagnosed in the intensive farming of rainbow trout in Japan in the mid-20th century. In the early 1990s, a disease caused by *Enterococcus seriolicida* was described in the marine species Japanese yellowtail (*Seriola quinqueradiata*). In recent decades, the use of new diagnostic and bacterial identification techniques has enabled the reclassification of these bacteria into the genera *Enterococcus*, *Lactococcus*, *Vagococcus*, and *Carnobacterium*. Numerous freshwater and marine fish species have been identified as susceptible to *L. garvieae* infection. Besides fish, this bacterium has been isolated from freshwater shrimp and marine mammals, particularly dolphins. Some cases have also been reported in pigs, dogs, and cats, while the first isolate, originally described as *Streptococcus garvieae*, was obtained from a case of subclinical mastitis in cows.

In fish, the disease manifests as acute septicemia, with symptoms including dark pigmentation, erratic swimming, weight loss, and exophthalmia, typically affecting both eyes. Necropsy findings include congestion and hemorrhages in the liver, spleen, kidneys, heart, swim bladder, intestines, and brain. Diagnosis is confirmed by isolating and identifying the pathogen based on its cultural, morphological and biochemical characteristics using commercial rapid identification kits and biomolecular diagnostic methods such as PCR, RT-PCR, 16S rRNA analysis, and sequencing.

Reports of this bacterium as a disease agent in European seabass in the Mediterranean are very rare, with the first documented case published in the summer of 2023. The high losses caused by this disease in farmed rainbow trout and some other marine fish species indicate significant economic impacts, leading to the classification of lactococcosis as an emerging disease for European seabass farming in the Adriatic Sea.

Keywords: Lactococcosis, *Lactococcus garvieae*, fish diseases, European sea bass, *Dicentrarchus labrax*

Negativni utjecaj marikulture na morski okoliš u Hrvatskoj - stvarnost ili mit?

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Sažetak:

Morska akvakultura, preciznije marikultura, jedna je od važnih rastućih djelatnosti na moru i uz more. Unatoč tome što je limitirana, prvenstveno tržištem, zatim ekološkim uvjetima mora u kojem se odvija uzgoj (u bliskoj budućnosti i povišenjem temperature mora iznad ekološkog optimuma uzgojnih organizama), zauzetošću prostora drugim djelatnostima na moru (turističke aktivnosti na i uz obalu, ispusti otpadnih voda, putničke, nautičke i trgovačke luke, itd.) te dobavom sirovina (ograničeni izvori životinjskih bjelančevina) još uvijek predstavlja sve značajniju profitnu djelatnost na moru. U Sredozemnom moru pa tako i u našem dijelu Jadranskog mora, uz školjkaše (dagnje i kamenice), uzgajaju se mesojedne ribe koje se ubrajaju u predatorne vrste (plavoperajna tuna, brancin, orada, hama i dr.). Zbog toga se teško može tvrditi da marikultura predstavlja samo „ekološku“ djelatnost. Ipak, visoko profitabilno korištenje morskog prostora, smanjenje utjecaja na slične „divlje“ vrste riba te nakon napuštanja djelatnosti, brzi povrat u ravnotežu s okolišem, mogu ovu djelatnost itekako opravdati u svjetlu liberalnog kapitalizma. Međutim, još uvijek, marikultura je u Republici Hrvatskoj u javnosti percipirana kao negativna i nadasve štetna djelatnost, što neupitno utječe na njen vrlo polagan i izazovan razvoj. Sadašnji uzgoj morskih organizama u teritorijalnom moru Republike Hrvatske, iako započet još u osamdesetim godinama prošlog stoljeća, jedva doseže dvadesetak tisuća tona godišnje. Zabilježeni su prosvjedi lokalnog stanovništva (Komiža, Cres), negativni napisi u mnogim tiskovinama, a čak se i neki stručnjaci ne libe koristiti svoje (ne)znanje o marikulturi kao podlogu za negativne istupe u javnosti. Cilj ovog priloga je ukazati na trenutno više od deset djelatnosti koje svojim postojanjem, a i radom, daleko negativnije utječu na Jadransko more nego marikultura. U prilogu će biti eksplicitno nabrojane djelatnosti te ukratko opisan (kvalitativno i po mogućnosti kvantitativno) njihov negativni utjecaj na Jadran. U cilju bržeg i kvalitetnijeg razvoja marikulture u Hrvatskoj te njenog objektivnijeg medijskog prikaza, predlaže se hitna intervencija/akcija.

Ključne riječi: razvoj marikulture, utjecaj na okoliš, Jadransko more

Negative environmental impact of mariculture in Croatia - reality or myth?

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Abstract:

Marine aquaculture, more precisely mariculture, is one of the important growing activities at sea and by the sea. Despite the fact that it is limited, primarily by the market, also by the ecological conditions of the sea where the cultivation takes place (in the near future with an increase in the temperature of the sea above the ecological optimum of the organisms in culture), occupation of space by other activities at sea (tourist activities on and along the coast, waste water discharges, passenger, nautical and commercial ports, etc.) and by supply of raw materials (limited sources of animal proteins), it still represents an increasingly important profitable activity at sea. In the Mediterranean Sea and also in Croatian part of the Adriatic Sea, along with shellfish (mussels and oysters), carnivorous predatory fish species (bluefin tuna, sea bass, sea bream, halibut, etc.) are grown. Therefore, it is difficult to claim that mariculture is only an "ecological" activity. Nevertheless, the highly profitable use of sea space, the reduction of the human impact on similar "wild" species of fish and, after leaving the activity, a relative quick return to balance with the environment, can fully justify this activity in the light of liberal capitalism. However, mariculture in the Republic of Croatia is still perceived by the public (locals) as a negative and above all harmful activity, which undoubtedly affects its very slow and challenging development. The current cultivation of marine organisms in the territorial sea of the Republic of Croatia, although started in the eighties of the last century, barely reaches twenty thousand tons per year. Protests by local residents (Komiža, Cres) and negative articles in media were recorded, and even some experts do not hesitate to use their (lack of) knowledge about mariculture as a basis for negative statements in the public. The aim of this contribution is to point out currently more than ten activities that, by their existence and work, have a far more negative impact on the Adriatic Sea than mariculture. Those activities will be explicitly listed and their negative impact on the Adriatic will be briefly described (qualitatively and preferably quantitatively). With the aim of faster and better development of mariculture in Croatia and its more objective media presentation, an urgent intervention/action is proposed.

Keywords: mariculture development, environmental impact, Adriatic Sea

Mogućnost povećanja otpornosti šaranskog ribnjačarstava na klimatske promjene

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Sažetak:

Posljedice klimatskih promjena u posljednjih su nekoliko godina sve uočljivije i na šaranskim ribnjačarstvima. Sve zamjetniji nedostatak vode i povišene temperature tijekom ljeta dovode do promjena u ekosustavu tradicionalnih zemljanih bazena što se negativno odražava na kvalitetu vode, a potencijalno i na pojavu bolesti. Sve navedeno ukazuje na potrebu prilagođavanja uzgojne tehnologije kako bi se izbjegli ekonomski gubici, koji su već značajni zbog šteta koje uzrokuju kormorani. Cilj ovog rada bio je usporediti brzinu rasta šaranske mlađi proizvedene i uzgajane tradicionalnom tehnologijom i one proizvedene izvansezonskim mrijestom, uzgajane mjesec dana u RAS-u rastilišta te potom prebačene u zemljane bazene. Izvansezonsko kondicioniranje matica šarana započelo je u mrjestilištu PP Orahovica početkom ožujka 2023., a izvansezonski mrijest je obavljen krajem istog mjeseca. Ličinke su potom držane mjesec dana u rastilištu RAS-a te nakon četiri tjedna, kada je temperatura vode u ribnjaku porasla, prebačene u zemljane bazene. Krajem listopada 2023. mlađ proizvedena u ožujku i držana u RAS-u četiri tjedna imala je prosječnu masu 1110 g, dok je prosječna masa mlađi izmriještene na tradicionalni način krajem svibnja 2023. imala svega 334 g. Prikazani preliminarni rezultati jasno ukazuju da se kombinacijom tradicionalne tehnologije uzgoja s izvansezonskim mrijestom i jednomjesečnim uzgojem mlađi u RAS-u, uzgojni ciklus može značajno skratiti. Ovakav uzgoj osigurava i veće preživljavanje, jer se u vanjsku sredinu naseljava mlađ koja je otpornija na ekstremne uvjete.

Ključne riječi: *Cyprinus carpio*, RAS, izvansezonski mrijest

The possibility of increasing the resilience of carp pond culture to climate changes

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The consequences of climate changes in the last few years are increasingly noticeable in carp fish farms. The increasingly notable lack of water and increased temperatures during the summer lead to changes in the ecosystem of traditional earthen ponds, which has a negative impact on water quality, and potentially on the occurrence of diseases. All the above points to the need to adapt breeding technology to avoid economic losses, which are already significant due to the damage caused by cormorants. The aim of this work was to compare the growth rate of juvenile carp produced and reared using traditional technology and those produced by off-season spawning, reared for one month in the RAS nursery and then transferred to earthen ponds. The off-season conditioning of carp broodstock began at the PP Orahovica hatchery at the beginning of March 2023, and the off-season spawning took place at the end of the month. The larvae were then kept for a month in the RAS nursery. After four weeks, when the temperature of the water in the pond rise, they were transferred to earthen ponds. At the end of October 2023, fish produced in March and kept in RAS for four weeks had an average weight of 1110 g, while the average weight of carp spawned in the traditional way at the end of May 2023 was only 334 g. The presented preliminary results clearly indicate that by combining traditional breeding technology with off-season spawning and one-month breeding in RAS, the production cycle can be significantly shortened. This type of carp breeding also ensures greater survival, because juveniles, which are more resistant to extreme conditions, are stocked in the external environment.

Keywords: *Cyprinus carpio*, RAS, off-season spawning

Prostorna analiza marikulture u Hrvatskoj s posebnim naglaskom na važnost zaštićenih područja

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Sažetak:

Zbog svoje razvedene obale i povoljnih ekoloških uvjeta, Republika Hrvatska ima značajan potencijal za daljnji razvoj marikulture. Aktualna istraživanja pokazuju da uzgajališta riba i školjkaša zauzimaju približno 0,056% unutarnjih morskih voda, pri čemu je 53% površine namijenjeno uzgoju školjkaša, a 47% uzgoju ribe. Geografski gledano, najveća površina uzgajališta nalazi se u Zadarskoj i Dubrovačko-neretvanskoj županiji koje zajedno obuhvaćaju nešto više od 75% površine svih uzgajališta. Nominalni intenzitet marikulture u Hrvatskoj, izražen u tonama po kilometru obale, niži je nego u drugim mediteranskim državama, što upućuje na potencijal za njezino povećanje, posebice u županijama gdje je marikultura trenutačno slabije zastupljena. Posebnu pozornost privlači činjenica da se oko 60% površina na kojima se odvija marikultura odvija unutar Natura 2000 područja, a oko 20 % u neposrednoj blizini tih područja. S obzirom na važnost morskih zaštićenih područja i ciljeve poput inicijative „30x30“, daljnji razvoj marikulture u Hrvatskoj zahtijeva sustavno planiranje. Otvoreni dijalog između proizvođača, stručnjaka za zaštitu prirode, znanstvenika i šire javnosti ključan je za usklađivanje gospodarskih interesa s očuvanjem bioraznolikosti. U nadolazećem razdoblju preporučuje se unapređenje postojećih proizvodnih tehnologija i istraživanje inovativnih praksi koje pridonose održivom i ekonomski isplativom razvoju marikulture, uz istodobno očuvanje ekosustava Jadranskog mora.

Ključne riječi: marikultura, prostorna raspodjela, zaštićena područja, Natura 2000

Spatial Analysis of Mariculture in Croatia with Special Emphasis on the Importance of Protected Areas

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Abstract:

Due to its highly indented coastline and favorable ecological conditions, the Republic of Croatia exhibits considerable potential for the further development of mariculture. Recent research indicates that fish and shellfish farming occupies approximately 0.056% of Croatia's internal marine waters, with 53% of that area devoted to shellfish culture and 47% to finfish farming. Geographically, the largest portion of mariculture sites is located in Zadar County and Dubrovnik-Neretva County, which together encompass slightly more than 75% of the total farmed area. The nominal intensity of mariculture in Croatia, expressed in tons per kilometer of coastline, remains lower than in other Mediterranean countries, suggesting potential for expansion, especially in counties where mariculture activity is currently less prevalent. Notably, around 60% of the mariculture area lies within Natura 2000 sites, while an additional 20% is situated in close proximity to these protected zones. Given the significance of marine protected areas and targets such as the "30x30" initiative, the further development of Croatian mariculture necessitates systematic planning. Open dialogue among producers, nature conservation specialists, scientists, and the broader public is essential to reconcile economic interests with biodiversity conservation. In the coming period, it is advisable to enhance existing production technologies and explore innovative practices that support sustainable and cost-effective mariculture while simultaneously preserving the Adriatic Sea's ecosystems.

Keywords: mariculture, spatial distribution, protected areas, Natura 2000

Jakobova kapica (*Pecten jacobaeus* L.) - potencijalni kandidat za akvakulturu?

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Sažetak:

Školjkaši na tržište dolaze glavinom iz marikulture, ali je ponuda ograničena na mali broj vrsta. U Jadranskom moru uglavnom se uzgajaju dagnje i kamenice. Jakobova kapica (*Pecten jacobaeus* L.) tražena je komercijalna vrsta iz ribolova koja postiže visoku tržišnu cijenu, što je čini kandidatom za akvakulturu. Prema Baždarić i sur. (2018) postiže tržišnu veličinu za 18 mjeseci, uz visoko preživljavanje. Najveći izazov u uzgoju pokazala se nedostupnost pouzdanog izvora mlađi za nasad.

Ovo istraživanje usmjereno je prema razumijevanju reprodukcije jakobove kapice te nabave mlađi za nasad radi uvođenja u akvakulturu. Uključuje praćenje reproduktivnog ciklusa i prikupljanje mlađi kolektorima iz prirode, te kondicioniranje matičnog jata, mrijest i uzgoj ličinki u mrjestilištu. Podaci na ušću rijeke Krke ukazuju da je mrijest najizraženiji u kasnoj zimi/proljeću. Prikupljanje mlađi iz prirode nije dostatno da podrži komercijalni uzgoj, te je nužna proizvodnja mlađi u mrjestilištu. Kondicioniranje matičnog jata je potaklo razvoj gonada, ali isto nije rezultiralo mrijestom, koji je postignut samo kod jedinki koje su uzete iz prirode. Nakon oplodnje praćeni su razvojni stadiji ličinki do faze trohofera tj. uginuća.

Za pokretanje uzgoja jakobove kapice, nužna su ulaganja u istraživanja usmjerena prema odgovarajućoj hranidbi i kondicioniranju u RAS-u, razvoj uspješnih tehnika mrijesta i oplodnje te uzgoja ličinki i proizvodnju mlađi u mrjestilištu za daljnji nasad ili repopulaciju.

Ključne riječi: marikultura, *Pecten jacobaeus*, gonadosomatski indeks, prikupljanje mlađi, kondicioniranje, mrijest

The mediterranean scallop (*Pecten jacobaeus* L.) - potential aquaculture candidate?

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Abstract:

Bivalves predominantly come to market from mariculture, but supply is often limited to a few species. In the Adriatic Sea, mussels and oysters are mainly farmed. The Mediterranean scallop (*Pecten jacobaeus* L.) is a sought-after commercial fishing species achieving a high market price, making it an aquaculture candidate. According to Baždarić et al. (2018), it reaches market size in 18 months, with high survival. The greatest challenge to its farming is the lack of a reliable seed source.

This research aims to enhance understanding of the reproduction of Mediterranean scallops and the procurement of seed for introduction into aquaculture. It includes monitoring the reproductive cycle and wild seed collection from nature, broodstock conditioning, spawning and rearing larvae in the hatchery. Data from the Krka River estuary indicates that spawning is most pronounced in the late winter/spring. Wild seed collection is insufficient for commercial production, so spat hatchery production is necessary. Broodstock conditioning stimulates gonad development but does not result in spawning, achieved only in individuals taken from nature. After fertilization, larvae's development stages were monitored up to the trochophore stage, i.e., death.

To initiate scallop aquaculture, research must be invested in improving feed and conditioning in RAS, developing successful spawning and fertilization techniques, rearing larvae and seed production in the hatchery for further farming or repopulation.

Keywords: mariculture, *Pecten jacobaeus*, gonadosomatic index, wild seed collection, conditioning, spawning

Nova saznanja o reproduktivnoj zrelosti i mrijestu atlantske plavoperajne tune

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Sažetak:

Plavoperajna tuna (*Thunnus thynnus*, BFT) je jedna od ekonomski najvažnijih morskih vrsta, kojom upravlja Međunarodna komisija za očuvanje atlantske tune. Unatoč opsežnim istraživanjima, podaci o reproduktivnim karakteristikama jedinki koji ulaze u prvu spolnu zrelost i dalje su ograničeni, ponajviše zbog regulatornih prostorno- vremenskih ograničenja u ribolovu i uzorkovanju. Uzgoja tune u Hrvatskoj temelji se na ulovu nedoraslih jedinki, što pruža priliku za istraživanje reproduktivne zrelosti i dinamike mrijesta populacija tuna koje ulaze u prvu spolni zrelost u uzgojnim uvjetima.

BFT je vrsta s asinkronim razvojem oocita koje oslobađa u više navrata tijekom sezone mrijesta s obzirom da je "batch spawner", a njena reproduktivna sezona usko je povezana s porastom temperature mora. Kao dio projekta Poboljšanje ekološke učinkovitosti kaveznog uzgoja morskih riba, financiranog od strane Hrvatske zaklade za znanost, cilj ovog istraživanja je bio procijeniti reproduktivni potencijal tune u uzgoju i moguće implikacije povezane s novačenjem tuna u Jadranskom moru. Tijekom sezone mrijesta (svibanj-lipanj), analizirani su ključni parametri, uključujući kondiciju ribe, zrelost gonada, trajanje mrijesta i fekunditet. Također, uzorkovan je ihtioplankton u blizini uzgajališta radi genetske identifikacije jaja tuna.

Dodatno, tijekom kolovoza i rujna provedeno je uzorkovanje mlađi vrsta iz porodice *Scombridae* radi određivanja dužinsko-starosne strukture nedoraslih tuna te njihove morfološke identifikacije. S obzirom na ograničeno razumijevanje strukture istočne populacije BFT i migracijskih obrazaca, očekuje se da će ovi nalazi doprinijeti poboljšanju modela novačenja i unaprjeđenju održivog upravljanja ribarstvom.

Ključne riječi: Plavoperajna tuna, reproduktivna zrelost, mrijest, uzgoj, novačenje

New Insights into the Reproductive Maturation and Spawning of Juvenile Atlantic Bluefin Tuna

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Abstract:

The Atlantic bluefin tuna (*Thunnus thynnus*, BFT) is one of the most economically significant marine species, subject to strict management by the International Commission for the Conservation of Atlantic Tunas. Despite extensive research, information on the reproductive characteristics of first-maturing individuals remains limited, largely due to regulatory constraints on fishing and sampling. The tuna farming industry in Croatia, where the capture of younger individuals is permitted, provides a unique opportunity to investigate reproductive maturation and spawning dynamics in floating net-pen cages.

BFT is a batch-spawning species with asynchronous oocyte development, and its reproductive period is closely linked to increases in sea surface temperature. As part of the project *Enhancing Environmental Performance of Net-Pen Marine Aquaculture*, funded by the Croatian Science Foundation, this study aims to assess the reproductive potential of farmed BFT and its implications for recruitment dynamics in the Adriatic Sea. During the spawning season (May-June), key parameters, including fish condition, gonadal maturation, spawning duration, and fecundity, were evaluated. Additionally, eggs were collected for genetic identification using mitochondrial DNA (control region).

To further assess recruitment patterns, bycatch of tuna-like species in commercial fisheries was monitored in August and September to estimate the age-length distribution of juvenile-of-the-year (YOY) BFT and to conduct morphological species identification. Given the limited understanding of the eastern BFT stock structure and migratory patterns, these findings are expected to contribute to the refinement of recruitment models and the advancement of sustainable fisheries management.

Keywords: Atlantic bluefin tuna, reproductive maturation, spawning, aquaculture, recruitment

Utvrđivanje dnevnog obroka brancina (*Dicentrarchus labrax* L.) u uzgojnim uvjetima

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Sažetak:

Brancin (*Dicentrarchus labrax*) se uspješno uzgaja u Republici Hrvatskoj više od 40 godine u plutajućim mrežnim kavezima. Održivi razvoj proizvodnje ovisi o kvaliteti hrane, hranidbi i uzgojnim uvjetima. Optimalna hranidba postiže se dnevnim obrokom koji je nešto manji od maksimalnog obroka. Maksimalni obrok je parametar većeg broja ponudnih bioenergetskih modela koji obuhvaćaju procjenu utroška hrane i rasta. Optimalna hranidba predstavlja kompromis maksimalni prirast uz minimalni indeks konverzije. Jedna od metoda utvrđivanja optimalnog obroka je povremena hranidba do sita nakon kojeg se obrok smanjuje za 10-20 %. Cilj ovog rada je procjena maksimalnog dnevnog obroka u kaveznom uzgoju brancina. Istraživanje je provedeno na uzgajalištu tvrtke „Cromaris d.d“. U četiri kaveza (4x225 m²) je ukupno nasađeno 40 000 jedinki brancina koji su godinu dana hranjeni sa dvije vrste komercijalne hrane. Jednom tjedno je riba hranjena do sita, a potom je šest dana obrok smanjen za 20%. Jednom mjesečno su uzimani uzorci ribe iz svakog kaveza radi prikupljanja biometrijskih podataka. Procjena maksimalnog dnevnog obroka (MDO) je provedena nelinearnom korelacijom za dva postojeća modela: $MDO (g/riba/dan) = q \cdot (T - T_f)^n \cdot W$; $MDO (g/riba/dan) = a \cdot W(g)^A \cdot b \cdot e^{c \cdot W^n}$ (W- masa ribe, T-temperatura °C). Model kojem su parametri procijenjeni s većom pouzdanošću je validiran ($R^2=0,87$) s rezultatima procjene u slijedećoj generaciji za koju je pokus proveden na jednak način.

Glavne riječi: akvakultura, brancin, hranidba riba, maksimalni obrok

Determining the daily ratio of European sea bass (*Dicentrarchus labrax* L.) in farming conditions

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Abstract:

Sea bass (*Dicentrarchus labrax*) has been successfully farmed in the Republic of Croatia for more than 40 years in floating net cages. Sustainable development of production depends on the quality of food, feeding and rearing conditions. Optimal feeding is achieved with a daily ration that is slightly less than the maximum ration. The maximum ration is a parameter of a large number of proposed bioenergetic models that include the assessment of feed consumption and growth. Optimal feeding represents a compromise between maximum gain and minimum conversion index. One method of determining the optimal ration is occasional feeding to the point of being full, after which the ration is reduced by 10-20%. The aim of this paper is to estimate the maximum daily ration in cage farming of sea bass. The research was conducted at the farm of the company "Cromaris d.d.". A total of 40,000 sea bass were stocked in four cages (4x225 m³) and fed with two types of commercial food for a year. The fish were fed to the point of being full once a week, and then the ration was reduced by 20% for six days. Fish samples were taken from each cage once a month to collect biometric data. The assessment of the maximum daily ration (MDO) was carried out by non-linear correlation for two existing models: $MDO (g/fish/day) = q_0(T - T_f) W$; $MDO (g/fish/day) = a \cdot W(g)^b \cdot e^{(c \cdot T)}$ (W - mass of fish, T - temperature °C). The model whose parameters were estimated with greater reliability was validated ($R^2=0.87$) with the results of the assessment in the next generation for which the experiment was conducted in the same way.

Keywords: aquaculture, sea bass, feeding, maximum ration

Rising prevalence of infectious hematopoietic necrosis (IHN) in North Macedonian trout farms: A surveillance study of major viral pathogens in aquaculture (2015-2024)

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Abstract:

Aquaculture in North Macedonia has become increasingly vulnerable to viral diseases, posing significant risks to fish health and the economic stability of the sector. This study investigated the presence of three major viral diseases: Viral Hemorrhagic Septicemia (VHS), Infectious Hematopoietic Necrosis (IHN), and Koi Herpesvirus Disease (KHVD) through active surveillance conducted from 2015 to 2024. A total of 1,551 samples for VHS and IHN from 57 trout farms and 2,985 samples for KHVD from 43 carp farms were analyzed using molecular diagnostic methods. All samples for VHS and KHVD tested negative. However, IHN cases were observed for the first time in 2018 on two fish farms. A significant increase in IHN cases was recorded in 2020, with 18 farms testing positive. The number of infected farms continued to rise in subsequent years, with two new cases in 2021, seven in 2022, six more in 2023 and 3 in 2024, bringing the total to 36 IHN-positive farms. The prevalence of IHN increased from 3.92% in 2018, when there were 51 active farms, to 72% in 2024, with 50 active fish farms. Genetic analysis revealed that the IHN virus isolates belong to clade E-1 of the European genogroup E. The growing prevalence of IHN underscores the urgent need to enhance biosecurity measures. Factors such as insufficient biosecurity protocols, high stocking densities, and poor water quality likely contributed to the virus's spread. This study emphasizes the importance of continuous surveillance, robust biosecurity practices, and a collaborative approach involving researchers, fish farmers, and regulatory bodies.

Kako će projekt “Marinet” unaprijediti marikulturu Jadrana: predstavljanje i preliminarni rezultati

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Sažetak:

Akvakultura je važna gospodarska djelatnost duž Jadranskih obala koja osigurava vrijednu hranu za lokalno, nacionalno i međunarodna tržišta. Međutim, klimatske promjene, eksploatacija mora i onečišćenje ugrožavaju sektor, koji mora prilagoditi metode uzgoja kako bi se zaštitila morska staništa, a istovremeno osigurala proizvodnja, sljedivost, sigurnost hrane i konkurentnost. Projekt MARINET nastoji odgovoriti na ove izazove poboljšanjem biosigurnosti, održivosti i gospodarstva prekograničnih regija Jadrana kroz inovativne prakse uzgoja ribe i školjkaša. Projekt razvija 10 inovativnih rješenja te u uzgoj ribe uvodi poboljšana cjepiva, probiotike i sustave procjene bolesti koristeći umjetnu inteligenciju, kao i modele biosigurnosti i analize troškova i koristi kako bi se poboljšala održivost i otpornost. U uzgoj školjkaša se uvode inovativni kolektori za prihvata mlađa, smjernice za uzgoj kamenica te marketinška strategija za diversifikaciju proizvodnje morske hrane u odgovoru na klimatske promjene. Projekt će osigurati analize nutritivne vrijednosti i produženja roka trajanja za uzgojenu ribu i školjke, s ciljem predlaganja poboljšanja u zakonodavstvu EU. Suradnja između znanstvenih i proizvodnih partnera potaknut će razmjenu znanja i inovacija u prekograničnim regijama, promovirajući ekološki prihvatljive tehnologije i jačajući povjerenje potrošača. U uvođenju inovacija MARINET će se temeljiti na prethodnim istraživanjima te se očekuje da ove inovacije stvore nove tržišne niše i poboljšaju konkurentnost marikulture.

Ključne riječi: marikultura, zajednička rješenja, procjena rizika, umjetna inteligencija

How the “Marinet” Project Will Improve Adriatic Mariculture: Presentation and Preliminary Results

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Abstract:

Aquaculture is an important economic activity along the Adriatic coast, providing valuable food for local, national, and international markets. However, climate change, marine exploitation, and pollution threaten the sector, which must adapt farming methods to protect marine habitats while ensuring production, traceability, food safety, and competitiveness. The MARINET project aims to address these challenges by improving biosecurity, sustainability, and the economy of cross-border Adriatic regions through innovative fish and shellfish farming practices. The project develops 10 innovative solutions, introducing enhanced vaccines, probiotics, and AI-based disease assessment systems in fish farming, along with biosecurity models and cost-benefit analyses to improve sustainability and resilience. Molluscs farming innovations include advanced spat collectors, oyster farming guidelines, and a marketing strategy to diversify seafood production in response to climate change. The project will also conduct analyses of the nutritional value and shelf-life extension of farmed fish and shellfish to propose improvements to EU legislation. Collaboration between scientific and production partners will foster knowledge exchange and innovation in cross-border regions, promoting environmentally friendly technologies and strengthening consumer trust. MARINET will build on previous research, with these innovations expected to create new market niches and enhance the competitiveness of mariculture.

Keywords: mariculture, shared solutions, risk assessment, artificial intelligence

Kondicioniranje Mediteranske dagnje (*Mytilus galloprovincialis*)

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Sažetak:

Klimatske promjene prijete održivom uzgoju Mediteranske dagnje (*Mytilus galloprovincialis*) u Jadranskom moru i utječu na njenu tržišnu kvalitetu. Jedna od mjera kvalitete je relativni udio jestivog dijela („meso“) koji se mjeri indeksom kondicije. Ljeti, u vrijeme najveće potražnje, visoke temperature i oscilacije dotoka vode s kopna mogu utjecati na smanjenu količinu hrane u prirodi i uzrokovati pad indeksa kondicije ($IK = \text{masa suhog mesa} / \text{masa ljuštore}$) uzgajanih dagnji. Vremenski ograničeni uzgoj školjkaša u recirkulacijskom sustavu, uz kontroliranu hranidbu predstavlja tehnološko rješenje za ublažavanje posljedica klimatskih promjena. U ovom radu je procijenjen utjecaj veličine dnevnog obroka, od 3%, 4,5% i 6% suhe tvari jednostanične alge (*Tisocrisis lutea*) po gramu suhe tvari mesa na IK dagnje, na tri temperature (12, 18 i 24°C). U svaki od 9 bazena od 120 l nasađeno je 105 jedinki dagnje. Po tri bazena su bila na jednom biofilteru s istom temperaturom mora, gdje je svaki bazen bio na jednom od tri režima hranidbe. Nakon provedene aklimatizacije (7 dana), nakon hranidbe u trajanju od 15 dana, i nakon gladovanja u trajanju od 15 dana, uzet je uzorak od po 15 jedinki iz svakog bazena radi mjerenja duljine, mase, mase suhog mesa i izračuna IK. Dobiveni rezultati su testirani dvosmjernom analizom varijance. Temperatura je imala znatno slabiji učinak od veličine dnevnog obroka. Najveći prosječni porast IK (48%) je ostvaren dnevnim obrokom od 6%, zatim 34% na obroku od (4,5%) i najmanji (6,5%) na obroku od 3%.

Cljučne riječi: *Mytilus galloprovincialis*, *Tisocrisis lutea*, indeks kondicije, klimatske promjene, recirkulacijski sustav

Conditioning of the Mediterranean mussel (*Mytilus galloprovincialis*)

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Abstract:

Climate change threatens the sustainable cultivation of the Mediterranean mussel (*Mytilus galloprovincialis*) in the Adriatic Sea and affects its market quality. One quality measure is the relative proportion of the edible part („meat“) measured by the condition index. In summer, at the time of highest market demand, high temperatures and fluctuations in water inflow from land can affect the reduced amount of food in nature and cause a drop in the condition index (CI=dry meat mass/shell mass) of cultured mussels. Timelimited shellfish farming in the recirculation system, along with controlled feeding, is a technological solution for mitigating the consequences of climate change. In this work, the influence of the size of the daily meal, of 3% ,4,5% and 6% dry matter of single-celled algae (*Tisocrisis lutea*) per gram of dry matter of meat on mussel CI, at three temperatures (12, 18 and 24°C), was evaluated. One hundred five mussels were planted in each of the nine pools of 120 l. Three pools were on one biofilter with the same sea temperature, and each pool was on one of three feeding regimens. After acclimatization (7 days), after feeding for 14 days, and after starvation for 14 days, a sample of 15 individuals was taken from each pool to measure the length, mass, and mass of dried meat and calculate CI. The results obtained were tested using ANOVA Main Effects. The temperature had a significantly weaker effect than the size of a daily meal. The highest average increase in CI (48%) was achieved with a daily meal of 6%, followed by 34% with a meal of (4.5%) and the lowest (6.5%) with a meal of 3%.

Keywords: *Mytilus galloprovincialis*, *Tisocrisis lutea*, fitness index, climate change, recirculation system

Trenutno stanje i perspektive razvoja uzgoja školjkaša na području Zadarske županije

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Sažetak:

Oko 70% ukupne proizvodnje u marikulturi RH odvija se na području Zadarske županije, dok je udio uzgoja školjkaša oko 15% od ukupne proizvodnje u RH. Uzgaja se gotovo isključivo dagnja, na 10 - ak lokacija, ponajviše u zoni Podvelebitskog kanala (zona Pisak - Seline) i Novigradskog mora. Primjetni su pozitivni pomaci u proteklom desetljeću, poput povećanje broja koncesija i ukupne proizvodnje, zaštita oznakom izvornosti Novigradske dagnje te planom za izgradnju Centra za školjkaše. Ipak, potpuni potencijal za unaprjeđenje ovog ekološki najodrživijeg vida akvakulture nije do kraja iskorišten. Prethodna istraživanja upućuju na vrlo dobar potencijal primjene integriranog uzgoja školjkaša i riba, te boljeg iskorištavanja brojnih obraštajnih organizama na uzgojnim instalacijama. Također, preliminarna istraživanja uzgoja kamenice i jakobske kapice u Novigradskom moru pokazala su izvrsne rezultate, kao i inovativni načini konzerviranja, poput brzog smrzavanja kamenice upotrebom IQF tehnologije. Kondicioniranje školjkaša u RAS-u ukazuje potencijal za pripremu školjkaša za tržište tijekom cijele sezone ali nužna su daljnja istraživanja. S druge strane, glavne prepreke u razvoju akvakulture školjkaša u Zadarskoj županiji su porast temperature mora i promjene donosa slatke vode te nagla uginuća, smanjenje kvalitete mora u uzgojnim područjima, predacija od strane komarče, zastarjele tehnologije uzgoja, neizdavanje novih koncesijskih odobrenja i neregulirano tržište. Potrebna je sinergija znanosti, struke i javne uprave u svrhu stvaranja boljih uvjeta za unaprjeđenje proizvodnje akvakulture školjkaša.

Ključne riječi: dagnja, kamenica, jakobska kapica, integrirana akvakultura

Current status and prospects for the development of bivalve farming in the Zadar County area

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Abstract:

This paper aims to present the current situation, including the potential and challenges in the development of shellfish farming in Zadar County. About 70% of the total mariculture production in the Republic of Croatia takes place in Zadar County, while shellfish farming accounts for about 15%. Almost exclusively, Mediterranean mussels are farmed at more than 10 locations, mostly in the Podvelebit channel zone (Pisak - Seline zone) and the Novigrad Sea stand out. Positive developments have been noticeable in the past decade, such as an increase in the number of concessions and total production, protection with designation of origin for the Novigrad mussel, and a plan to build a Shellfish Centre. However, the full potential for improving this most environmentally sustainable form of aquaculture has not been fully exploited. Previous research indicates a very good potential for the application of integrated shellfish and fish farming, as well as for the better exploitation of numerous fouling organisms on fish farming installations. Also, preliminary research on the cultivation of oysters and scallops in the Novigrad Sea showed excellent results, as well as innovative methods of preservation, such as quick freezing of oysters using IQF technology. Conditioning of bivalves in RAS shows potential for preparing bivalves for the market throughout the season, but further research is necessary. On the other hand, the main obstacles in the development of shellfish aquaculture in Zadar County are fluctuations in sea temperature and salinity and sudden mortalities, water quality deterioration, predation by sea bream, outdated farming technologies, non-issuance of new licenses, an unregulated market. A synergy of science, profession and public administration is needed to create better conditions for improving shellfish aquaculture production.

Keywords: mussel, oyster, scallop, integrated aquaculture



Poster sekcija

Poster session

Smanjenje mikroplastike u moru - promicanje prelaska na kružno gospodarstvo

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Sažetak:

Akvakultura je brzorastuća grana proizvodnje sa velikom ulogom u globalnoj potražnji za kvalitetnom hranom iz vodene sredine. Prema FAO, akvakultura i ribarstvo omogućuju sredstva za život gotovo 60 milijuna ljudi. Međutim, oba su sektora pod izravnim utjecajem plastike koja se koristi u proizvodnji ribolovnog pribora i alata, kaveza, plutača, ambalaže za transport te izradu i održavanje plovila. Nadalje, napušteni, izgubljeni ili na drugi način odbačeni ribolovni alati (ALDFG) smatraju se jednim od glavnih izvora plastike i mikroplastike. Opterećenje okoliša mikroplastikom rastući je ekološki problem koji povećava stres vodenim organizmima te je istraživanje njenog utjecaja u akvakulturi postalo vrlo važno. Stoga postoji izražena potreba za podizanjem razine ekološke svijesti i pronalaska rješenja za umanjivanje izvora i količine plastike u vodenom okolišu. *Pravilnikom o ambalaži i otpadnoj ambalaži, plastičnim proizvodima za jednokratnu uporabu i ribolovnom alatu koji sadržava plastiku* u naše su zakonodavstvo preneseni pravni akti EU kojima se regulira način gospodarenja otpadnim ribolovnim alatima. Vezano uz prihvata i gospodarenje takvim alatom, propisane su obaveze za profesionalne ribare, uzgajivače riba i školjkaša, operatore lučkih uređaja, sakupljače i obrađivače. Svrha je prikazati zakonski okvir i mjere sprječavanja nastanka otpadne ambalaže i smanjenje utjecaja plastičnih proizvoda na vodeni okoliš i zdravlje ljudi te promicanje prelaska na kružno gospodarstvo.

Ključne riječi: akvakultura, mikroplastika, otpadni ribolovni alati, zaštita okoliša

Molecular evaluation of xenotransplanted rainbow trout germline stem cells in sterile hybrid tiger trout

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Abstract:

The success of a previous xenotransplantation was evaluated with molecular techniques. Germline stem cells (GSCs) of rainbow trout (*Oncorhynchus mykiss*) were isolated and injected into the sterile hybrid tiger trout (*Salmo trutta* * *Salvelinus fontinalis*). Recipients were reared to maturity and one male produced sperm, which fertilized rainbow trout eggs, resulting in viable larvae. To assess the applicability of the lactate dehydrogenase enzyme-coding gene, PCR amplification was performed using Ldhx3F and Ldhx4R primers (McMeel et al., 2001) designed for brown trout, on DNA from rainbow trout, tiger trout, brown trout (*Salmo trutta*), and brook trout (*Salvelinus fontinalis*). We found that the length of the amplicon is clearly distinguishable in these species with gel electrophoresis, producing 380 bp, 370 bp + 440 bp, 440 bp, and 370bp long fragments, respectively. The nucleotide sequence of the amplicon was detected with Sanger sequencing and aligned with NCBI BLAST algorithm to the corresponding sequence in the gene bank, with 98% sequence homology for brown and brook trout, and 86% for rainbow trout. The gonads of all recipients, the sperm and the larvae were analysed with the Ldhx marker. The developed testis, the produced sperm and the larvae were confirmed to belong to the rainbow trout species. Additionally, three other recipients exhibited a rainbow trout-specific fragment, suggesting a possible GSC incorporation without developing a functional gonad.

Keywords: xenotransplantation, species identification, germ cells

Funding: National Research, Development, and Innovation Office of Hungary projects NKFIH K138425, FK142933; Flagship Research Groups Programme and Research Excellence Programme of the Hungarian University of Agriculture and Life Sciences

Supplementation of complete feed with black soldier fly (*Hermetia illucens*) larval meal for carp (*Cyprinus carpio*) fry

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Abstract:

Aquaculture is the fastest growing food-producing sector nowadays as fish consumption is rising in line with the world's ever-increasing population. In many areas of the world, fishmeal is the primary source of protein in feed mixes for farmed fish. The aquacultural sector is in dire need of a sustainable alternative to fishmeal. In our experiment, black soldier fly larvae meal was successfully incorporated into the diets of carp (*Cyprinus carpio*) fry to replace fishmeal-based feed mixtures. The feeding experiment was 28 days long. Four different groups were set up, 500 fish were stocked randomly into 10 L tanks in 5 replicates. Fry were fed four times a day, dead larvae were removed from the system and counted every day. At the end of the experiment, body weight and body length of 20 fish per group were measured and their survival rate was calculated. After 24 hours of drying, the air-dry body weight of the fish was determined. The main conclusion of the results is that fish in the 33% and 66% insect meal supplemented groups showed significantly better results in terms of body weight gain (329.3 ± 340 and 281 ± 203.8 mg) than the control group (230.7 ± 258 mg). For total body length, significantly better results were obtained in the 33% and 66% insect meal supplemented groups compared to the other groups. In terms of retention, the control group achieved the highest results ($71 \pm 12.22\%$), but regarding statistics, it did not show better results than the 33% and 100% groups.

Keywords: insect, black soldier fly, fry rearing, feeding, carp

Antimikrobna aktivnost ekstrakata mediteranskih biljaka prema najčešćim morskim patogenim mikroorganizmima

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Sažetak:

Mediterranska regija poznata je po svojoj bogatoj biološkoj raznolikosti, uključujući veliki izbor biljaka sa značajnim antimikrobnim svojstvima. Ove biljke, poput masline, majčine dušice, ružmarina i kadulje, sadrže bioaktivne spojeve poput eteričnih ulja ili neke pojedinačne spojeve kao što su fenoli, terpeni i fenolne kiseline koji pokazuju snažno antimikrobno djelovanje protiv niza

patogena koji se prenose hranom, uključujući bakterije, plijesni i kvasce. Dodatak ekstrakata ovih biljaka u premaze za hranu pokazao se kao obećavajuća prirodna strategija za produljenje roka trajanja kvarljive hrane. Inhibirajući rast mikroorganizama i odgađajući kvarenje, takvi premazi ne samo da povećavaju sigurnost hrane, već i smanjuju potrebu za sintetičkim konzervansima, pritom zadovoljavajući zahtjeve potrošača za prirodnim proizvodima.

Cilj ovog rada bio je ispitati antimikrobnu aktivnost ekstrakata odabranih vrsta mediteranskih biljaka prema najčešćim ribljim patogenima. Korištenjem testa difuzije u agaru, svaki biljni ekstrakt testiran je na šest ribljih patogena: *Aliivibrio fischeri*, *Vibrio alginolyticus*, *Yersinia ruckeri*, *Moraxella lacunata*, *Pseudomonas aeruginosa* i *Aeromonas hydrophila*. Inhibicija rasta varirala je ovisno o osjetljivosti bakterija, a najmanji rast svih ispitivanih patogena postignut je primjenom ekstrakta motara (*Crithmum maritimum*).

Ovi rezultati pružaju dobru osnovu za primjenu biljnih ekstrakata u jestivim premazima ili materijalima za pakiranje svježih ribe. Uključivanjem ovih prirodnih antimikrobnih sredstava moguće je smanjiti mikrobno opterećenje, odgoditi kvarenje i produžiti rok trajanja ribljih proizvoda.

Ključne riječi: biljni ekstrakti, antimikrobno djelovanje, patogeni mikroorganizmi, inhibicija rasta
Istraživanje je financirala Hrvatska zaklada za znanost u sklopu projekta IP-2022-10-1837

Antimicrobial activity of Mediterranean plant extracts against the most common marine pathogenic microorganisms

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Abstract:

The Mediterranean region is renowned for its rich biodiversity, including a wide variety of plants with significant antimicrobial properties. These plants, such as olive, thyme, rosemary, and sage, contain bioactive compounds like essential oils or some individual compounds like phenolics, terpenes, and phenolic acids that exhibit potent antimicrobial activity against a range of foodborne pathogens, including bacteria, fungi, and yeasts. Incorporating extracts from these plants into food coatings has emerged as a promising natural strategy to extend the shelf life of perishable foods. By inhibiting microbial growth and delaying spoilage, such coatings not only enhance food safety but also reduce the need for synthetic preservatives, aligning with consumer demand for clean-label products. The aim of this work was to utilize extracts from selected Mediterranean plants to investigate their antimicrobial potency against the most common fish pathogens. Using an agar

well diffusion assay, each plant extract was tested against six fish pathogens: *Aliivibrio fischeri*, *Vibrio alginolyticus*, *Yersinia ruckeri*, *Moraxella lacunata*, *Pseudomonas aeruginosa*, and *Aeromonas hydrophila*.

Growth inhibition varied depending on the sensitivity of the bacteria, but the best inhibition of all tested pathogens was achieved with the use of sea fennel extract (*Crithmum maritimum*). These results provide a good foundation for the application of plant-based extracts in edible coatings or packaging materials for fresh fish. By incorporating these natural antimicrobials, it is possible to reduce microbial load, delay spoilage, and extend the shelf life of fish products.

Keywords: plant extracts, antimicrobial activity, pathogenic microorganisms, growth inhibition

The research was funded by the Croatian Science Foundation as part of the project IP-2022-10-1837

XGain - Enhancing Competitiveness, Resilience and Sustainability of Remote Farming, Forestry and Rural Areas through Holistic Assessment of Smart XG, Last-mile and Edge Solutions' Gains

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Abstract:

The XGain project, a European Union initiative, is revolutionizing agriculture, aquaculture, and rural development in remote regions by leveraging cutting-edge Smart XG technologies such as 5G, satellite communication, and edge computing. These innovations address longstanding challenges like limited internet access, high logistics costs, and technological disparities, transforming them into opportunities for growth and sustainability.

XGain promotes digital transformation, enhances efficiency, and supports sustainability by enabling real-time data collection, analysis, and resource optimization. In agriculture, IoT sensors and drones help farmers in Greece and Spain monitor soil conditions and crop health, reducing water and pesticide use while increasing yields. In aquaculture, real-time water quality monitoring in Croatia and advanced fish behavior analysis in Norway are improving productivity and reducing waste. In rural areas, satellite connections in Romania and remote learning platforms in Lithuania are bridging the digital divide, providing access to education, healthcare, and global markets.

The project is not only a technological advancement but also a socio-economic catalyst, reducing poverty and inequality, promoting sustainability, and strengthening communities. By fostering collaboration among local stakeholders, XGain is creating a more inclusive and resilient society. Looking ahead, the project has the potential to address broader challenges such as climate change, energy sustainability, healthcare access, and educational inequality, while integrating emerging technologies like AI and big data to further enhance its impact. XGain is paving the way for a more connected, sustainable, and prosperous future for remote regions.

Project website: <https://xgain-project.eu/>

Prva procjena autentičnosti deklariranja morskih plodova u Hrvatskoj: Izazovi, poboljšanja i buduće perspektive

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Sažetak:

Rastuća globalna potražnja za ribom i morskim plodovima općenito je dovela do značajnih izazova u osiguravanju njihove ispravnosti i sljedivosti. Kako se tržište širilo, slučajevi pogrešnog označavanja postali su sve učestaliji, izazivajući zabrinutost u vezi s održivošću, sigurnošću hrane i poštenim trgovinskim praksama. Ovo istraživanje predstavlja prvu analizu točnosti označavanja morskih plodova na hrvatskom tržištu, pružajući ključnu osnovu za buduća istraživanja i regulatorna poboljšanja. Korištenjem DNA barkodiranja analizirali smo 109 uzoraka komercijalnih morskih plodova. Prema ukupnim rezultatima sekvenciranja i pretrage baza podataka, utvrdili smo da je 4,6% uzoraka pogrešno označeno, pri čemu je stopa pogrešnog označavanja iznosila 3% među ribljim uzorcima i 20% među uzorcima lignji. Relativno velik broj uzoraka (38,5%) bio je samo djelomično označen, sadreći samo znanstveni naziv, uobičajeni trgovački naziv ili čak samo oznaku "filet" bez preciznog opisa određene vrste. Sljedivost 19 uzoraka (17,4%) nije bila utvrđena, a zabrinjavajući udio uzoraka (32%) imao je nepoznatu zemlju podrijetla, što još jednom naglašava ključnu važnost pravilnog označavanja u ovom sektoru. Naši rezultati upućuju na potrebu za poboljšanjem mjera sljedivosti morskih plodova i strožim provođenjem propisa o označavanju. Posebna pozornost trebala bi se posvetiti vrstama visokog rizika i nedovoljno označenim proizvodima, osobito u restoranima i tržištima gotove hrane, gdje je pogrešno označavanje

učestalije. Uspostava jedinstvenih metodologija praćenja poboljšat će globalnu usporedivost i omogućiti učinkovitije praćenje prijevara vezanih ta morske plodove.

Ključne riječi: pogrešno označavanje morskih plodova, DNA barkodiranje, sljedivost, Hrvatska, regulatorna usklađenost, točnost označavanja

First Assessment of Seafood Mislabeling in Croatia: Challenges, Implications, and Future Perspectives

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Abstract:

The growing global demand for fish and seafood in general, has led to significant challenges in ensuring the integrity and traceability of these products. As the market expanded, instances of mislabeling have become increasingly prevalent, raising concerns about sustainability, food safety, and fair trade practices. This study represents the first investigation into the accuracy of seafood labeling in the Croatian market, providing a critical foundation for future research and regulatory improvements. Using DNA barcoding, we analyzed 109 commercial seafood samples. According to the overall results of our sequencing and database search analysis, we found that 4,6% samples were mislabeled, where mislabeling accuracy was 3% among fish samples, and 20% among squid samples. Relatively high number of samples, (38,5%), were only partially labeled containing only a scientific name, a common trade name, or even a "filet" designation that did not include a precise description of a particular species. The traceability of 19 samples (17,4%) was not obtained and concerning proportion of samples (32%) had an unknown country of origin, underscoring ones again the critical importance of proper labeling in this sector. Our findings call for enhanced seafood traceability measures and stricter enforcement of labeling regulations. Special attention should be given to high-risk species and inadequately labeled products, particularly in restaurants and ready-to-eat markets, where mislabeling is more prevalent. Establishing uniform tracking methodologies will improve global comparability and enable more effective monitoring of seafood fraud.

Keywords: Seafood mislabeling, DNA barcoding, traceability, Croatia, regulatory compliance,

Unaprjeđenje održive reciklacijske akvakulture: Ispitivanje izvedivosti istraživačkog centra za RAS-akvaponiku u Hrvatskoj

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Sažetak:

U skladu s Europskim zelenim planom, koji definira strategiju za ekološki održiv gospodarski rast kroz provedbu Akcijskog plana kružnog gospodarstva (CEAP), projekt ESCALATOR - Studija izvedivosti istraživačkog centra za reciklacijsku akvakulturu u Hrvatskoj s norveškim iskustvima promiče načelo uporabe resursa u akvakulturi. Financiran od strane Innovation Norway, projekt je procijenio izvedivost uspostave istraživačkog centra u Hrvatskoj koji bi integrirao sustave reciklacije u akvakulturi (RAS) s akvaponikom, gdje bi se hranjive tvari iz RAS otpadnih voda koristile za uzgoj biljaka.

Unatoč rastućoj potražnji za održivom proizvodnjom hrane, u Hrvatskoj ne postoji specijalizirani istraživački centar koji bi poticao razvoj tehnologija reciklacijske akvakulture. Projekt ESCALATOR ispitao je potencijal takvog centra analizirajući optimalni dizajn RAS-akvaponike, ekonomsku isplativost putem procjene kapitalnih ulaganja (CapEx), regulatorne zahtjeve i odabir lokacije. Rezultati istraživanja pokazuju da bi integracija RAS-a s akvaponikom mogla poboljšati učinkovitost proizvodnje, smanjiti utjecaj na okoliš i pridonijeti diversifikaciji hrvatskog sektora akvakulture.

ESCALATOR je pokazao da je uspostava takve infrastrukture ključan korak prema jačanju RAS akvakulture u Hrvatskoj, u skladu s nacionalnim strategijama za održiv rast. Namjenski istraživački centar potaknuo bi znanstvene inovacije, suradnju s industrijom te razvoj resursno učinkovitih uzgojnih tehnologija, čime bi se odgovorilo na ključne izazove održive proizvodnje hrane.

Advancing Sustainable Land-Based Aquaculture: Feasibility of an RAS-Aquaponics Research Facility in Croatia

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Abstract:

In line with the European Green Deal, which outlines a strategy for environmentally sustainable economic growth through the implementation of the Circular Economy Action Plan (CEAP), the *ESCALATOR - Feasibility Study of research facility for Landbased Aquaculture in Croatia from Norway* project promotes resource recovery principle in aquaculture. Funded by Innovation Norway, the project assessed the feasibility of establishing a research facility in Croatia integrating recirculating aquaculture systems (RAS) with aquaponics, where nutrients from RAS effluent support plant cultivation.

Despite the increasing demand for sustainable food production, Croatia lacks a dedicated research facility to advance land-based aquaculture technologies. The ESCALATOR project evaluated the potential of such a center by analyzing the optimal RAS-aquaponics design, economic feasibility through a capital expenditure (CapEx) assessment, regulatory requirements, and site selection. The findings indicate that integrating RAS with aquaponics could enhance production efficiency, reduce environmental impact, and contribute to the diversification of Croatia's aquaculture sector.

ESCALATOR demonstrated that establishing such infrastructure is a crucial step toward strengthening land-based aquaculture in Croatia, aligning with national strategies for sustainable growth. A dedicated research center would foster scientific innovation, industry collaboration, and the development of resource-efficient aquaculture technologies, addressing key challenges in sustainable food production.

Hydra as Holobiont in Aquaculture

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Abstract:

Holobiont principle represents a new and emerging concept in biology, emphasizing the interdependencies between a host organism and its associated microbiota. Green hydra (*Hydra viridissima* Pallas, 1766) is a freshwater cnidarian and as a model holobiont maintains endosymbiotic relationship with microalgae, placed in the gastrodermal myoepithelial cells of hydra. One individual of green hydra can contain only one microalgal species at time. Different green hydra individuals can maintain different microalgae. These microalgae can be isolated from the hydra host and present the basis for aqua/ culture of the particular microalgal species. Hydra as a holobiont represents a potential basis for innovative aquaculture systems. The role of hydra in symbiotic interactions, its ecological significance and holobiont nature could be utilized as a basis for the potential use of *Hydra* holobiont in aquaculture with a double-sided possibility: aquaculture of hydras itself and aquaculture of its isolated endosymbiotic microalgae.

Keywords: green hydra, endosymbiotic algae, holobiont, aquaculture

Effect of Mediterranean plant extracts on quality parameters and shelf life of chilled sardines

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Abstract:

Various Mediterranean plants contain bioactive compounds such as essential oils, terpenes and phenolic substances with proven antimicrobial and antioxidant effects. The use of extracts from these plant species, alone or in combination with different coating materials, has the potential to be an environmentally friendly strategy to extend the shelf life of fishery products, reduce the use of chemical preservatives and improve the properties of biodegradable or edible materials for food packaging.

In this work, sardines were treated with extracts of rosemary (*Salvia rosmarinus*) and sea fennel (*Crithmum maritimum*) and the quality characteristics (sensory score, TVBN, proteolytic index and TBARS) were analyzed during an 8-day cold storage. The samples treated with plant extracts showed lower lipid oxidation values (TBARS) and a longer shelf life, while no differences were found for TVBN and proteolytic index. Overall, better results were obtained with rosemary than with sea fennel extracts.

These results confirm the antioxidant and antimicrobial activity of the studied plant extracts and support their use to preserve quality attributes and extend the shelf life of fresh/ chilled sardines. Incorporating these compounds into edible coatings or biodegradable packaging for fresh fish could improve the overall results through the synergy of material properties, making them an important focus for future research.

The research was funded by the Croatian Science Foundation as part of the project IP- 2022-10-1837 "Sustainable concept in ACTIVE edible COatings development for shelf-life extension of fresh Adriatic FISH".

Keywords: plant extracts, fish quality, shelf life, chilled storage

Učestalost larvene anizakioze u ribi koja se prodaje u supermarketima u Sarajevu

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Sažetak:

Anizakioza, parazitarne bolesti izazvana L3 larvama iz porodice *Anisakis*, je kosmopolitiska zoonoza prisutna na svih pet kontinenata. Kod ljudi se manifestuje kroz gastrointestinalne smetnje i alergijske anafilaktičke napade. Osim zdravstvenih problema koje može izazvati kod ljudi, anizakioza ima i negativne ekonomske posljedice zbog promjena u organoleptičkim svojstvima proizvoda koji su namijenjeni za konzumaciju, a koji se zbog toga ocjenjuju kao neispravni za ljudsku ishranu i neškodljivo se uklanjaju. Prisustvo parazitskih oblika, L3 larvi *Anisakis* u mesu ribe i ribljim proizvodima izaziva gađenje kod potrošača, jer su paraziti vidljivi golim okom, ali ozbiljniji zdravstveni problemi mogu nastati konzumiranjem sirovog ili nedovoljno termički obrađenog mesa ribe i morskih plodova koje sadrži infektivne L3 larve.

Krajem 2023. i početkom 2024. godine uzorkovane su morske ribe i proizvodi od riba metodom slučajnog odabira u trgovačkim centrima i ribarnicama u Sarajevu, Bosna i Hercegovina. Cilj istraživanja je utvrđivanje prisustva L3 larvi fam. *Anisakidae* u ribi i ribljim proizvodima komercijalno dostupnim ljudskoj potrošnji, sa determinacijom parazita do vrste obzirom da pojedine vrste iz fam. *Anisakidae* mogu prouzrokovati zdravstvene probleme kod ljudi, a proizvode ocijeniti kao higijenski neispravne za ljudsku potrošnju.

Ukupno je uzorkovano i pretraženo 8 vrsta riba : oslić (*Merluccius merluccius*) (oslić bez glave i oslić filet), skuša (*Scomber scombrus*), lignja (*Loligo vulgaris*), girice (*Atherina hepsetus*), orada (*Sparus aurata*), lubin (*Dicentrarchus labrax*), srdela (*Sardina pilchardus*), škarpina (*Scorpaena scrofa*), kao i 14 konzervi (skuša, sardina, haringa).

Svi uzorci su ispitani adspekcijskim pregledom i metodom umjetne digestije. Izdvojeni paraziti mikroskopski su determinisani do familije. Pozitivno na L3 larve parazita *Anisakidae* su bila 23 uzorka ili 32,85%. U pretraženim konzervama nisu nađeni paraziti iz fam. *Anisakidae*. L3 larve fam. *Anisakidae* ustanovljene su u 3 vrste riba: oslić (bez glave), skuša i škarpina. Za izdvojene L3 larve fam. *Anisakidae* urađena je identifikacija do vrste metodom molekularne identifikacije (metoda real-time PCR). Korišteni su primeri i probe, specifični za vrste *Anisakis simplex*, *Anisakis*

pegreffii i *Pseudoterranova decipiens*.

Pretragom L3 larvi ustanovljenih parazita iz 23 pozitivna uzorka, identifikacijom do vrste je ustanovljeno pozitivno 22 uzorka (95,65%) na ispitivane vrste, a jedan (1) uzorak nije identificiran do vrste jer ne pripada traženim vrstama anisakida.

Prema vrsti ribe, vrsta *Anisakis pegreffii* je dijagnosticirana u 8 uzoraka oslića bez glave. U skuši utvrđen je pojedinačni nalaz vrste *Anisakis simplex* (1 uzorak), te u miješanoj infekciji *Anisakis simplex* sa *Anisakis pegreffii* u 12 uzoraka. U šarpini je ustanovljena miješana infekcija sa vrstama *Anisakis simplex* i *Anisakis pegreffii* u 1 uzorku.

Nalaz navedenih vrsta zahtjeva unaprijeđenje kvaliteta inspeksijskog nadzora nad ribom i proizvodima od riba u cilju poboljšanja sistema prevencije bolesti i zaštite stanovništva.

Ključne riječi: L3 larve fam. *Anisakidae*, *Anisakis simplex*, *Anisakis pegreffii*, javnozdravstveni značaj anizakijaze

Incidence of Larval Anisakiasis in Fish Marketed in Supermarkets in Sarajevo

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Abstract:

Anisakiosis, a parasitic disease caused by L3 larvae from the *Anisakis* family, is a cosmopolitan zoonosis found on all five continents. In humans, it manifests as gastrointestinal disturbances and allergic anaphylactic reactions. In addition to the health problems it can cause in humans, anisakiosis also has negative economic consequences due to changes in the organoleptic properties of products intended for consumption, which are deemed hygienically unsafe for consumption and are safely discarded. The presence of parasitic forms, L3 larvae of *Anisakis*, in fish and fish products causes disgust among consumers, as the parasites are visible to the naked eye. However, far more serious health problems can arise from ingesting infectious L3 larvae through the consumption of raw or undercooked fish and seafood.

In late 2023 and early 2024, marine fish and fish products were sampled through random selection from supermarkets and fish markets in Sarajevo, Bosnia and Herzegovina. The goal of the research was to determine the presence of L3 larvae from the *Anisakidae* family in fish and fish products commercially available for human consumption, and to identify the parasite to the species level, considering that certain species from the *Anisakidae* family can cause health problems in humans, making the products unsuitable for consumption.

A total of 8 fish species were sampled and examined: hake (*Merluccius merluccius*) (headless hake and hake fillet), Atlantic mackerel (*Scomber scombrus*), European squid (*Loligo vulgaris*), Mediterranean sand smelt (*Atherina hepsetus*), gilthead bream (*Sparus aurata*), European seabass (*Dicentrarchus labrax*), European pilchard (*Sardina pilchardus*), Red scorpionfish (*Scorpaena scrofa*), as well as 14 canned products (mackerel, pilchard, herring). All samples were examined through visual inspection and the artificial digestion method. The isolated parasites were microscopically identified to the family level. A total of 23 samples, or 32.85%, tested positive for L3 larvae of *Anisakidae* parasites. No parasites from the *Anisakidae* family were found in the canned products. L3 larvae from the *Anisakidae* family were identified in 3 fish species: hake (headless), mackerel, and scorpionfish.

Molecular identification was performed on the isolated L3 larvae of *Anisakidae* using realtime PCR method. Primers and probes specific to the species *Anisakis simplex*, *Anisakis pegreffii*, and *Pseudoterranova decipiens* were used.

Upon examination of the L3 larvae from the 23 positive samples, species identification revealed that 22 samples (95.65%) tested positive for the examined species, while one sample could not be identified to the species level as it did not belong to the targeted *Anisakidae* species.

Regarding the type of fish, the species *Anisakis pegreffii* was diagnosed in 8 samples of headless hake. A single finding of *Anisakis simplex* was identified in one mackerel sample, while a mixed infection of *Anisakis simplex* and *Anisakis pegreffii* was found in 12 samples. A mixed infection of *Anisakis simplex* and *Anisakis pegreffii* was detected in 1 sample of scorpionfish.

The finding of the presence of these species calls for an improvement in the quality of inspection and monitoring of fish and fish products, in order to enhance the disease prevention system and protect the population.

Keywords: L3 larvae of the family *Anisakidae*, *Anisakissimplex*, *Anisakispegreffii*, public health significance of anisakiasis

Biokemijski pokazatelji krvi uzgajanog gofa (*Seriola dumerili*)

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Sažetak:

Europska komisija identificirala je diversifikaciju vrsta u uzgoju u ciljevima razvoja što je podržano i u Nacionalnom strateškom planu razvoja akvakulture za razdoblje do 2027. godine. Dobrim kandidatom za novu vrstu smatra se gof (*Seriola dumerili*). Optimalna temperatura uzgoja za ovu vrstu je 26°C s rasponom od 17°C do 26 °C u kojem očekujemo dobar rast i iskorištavanje hrane. Biokemijski parametri krvi daju uvid u metaboličke procese, zdravlje, biologiju i ekologiju unutar pojedine vrste, kao i utvrđivanje razlika među njima. Cilj rada je bio provesti analize krvi gofa u uvjetima niskih i visokih temperatura mora kako bi se utvrdio utjecaj temperature mora na metabolizam i zdravlje. Istraživanje se provelo na srednjem Jadranu, nasumičnim odabirom zdrave ribe stare dvije godine u prosincu 2022. i ožujku 2023. godine. Uzorkovalo se 30 komada u svakom mjesecu, krv se izvadila iz kaudalne vene i nakon koagulacije odvojio se serum. Analizirali su se biokemijski pokazatelji: glukoza (GLU), albumini (ALB), analin aminotrasformaza (ALT), kolesterol (CHOL), i lipaza (LIPA). Utvrđene su značajne razlike u razini albumina (ALB), alanin aminotransformaza (ALT) i lipaze (LIPA) što ukazuje na promjene u metabolizmu. Istraživanje ukazuje na daljnju potrebu analiziranja biokemijskih parametara kako bi se utvrdile referentne vrijednosti za biokemijske parametre krvi važnih vrsta riba u akvakulturi na različitim temperaturama.

Ključne riječi: biokemijski parametri, serum, *Seriola dumerili*, akvakultura

Blood Biochemical Indicators of Farmed Greater Amberjack (*Seriola dumerili*)

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Abstract:

The European Commission has identified species diversification in aquaculture as a developmental goal, which is also supported by the National Strategic Plan for Aquaculture Development until 2027. Greater amberjack (*Seriola dumerili*) is considered a promising candidate for species diversification. The optimal rearing temperature for this species is 26°C, with a range of 17°C to 26°C, within which good growth and feed utilization are expected.

Blood biochemical parameters provide insight into metabolic processes, health status, biology, and ecology within a species, as well as differences among species. The aim of this study was to analyze the blood of *S. dumerili* under low and high seawater temperature conditions to assess the impact of temperature on metabolism and health.

The study was conducted in the central Adriatic Sea, using a random selection of healthy, two-year-old fish sampled in December 2022. and March 2023. A total of 30 individuals were sampled each month, and blood was drawn from the caudal vein. After coagulation, serum was separated.

The biochemical parameters analyzed included glucose (GLU), albumin (ALB), alanine aminotransferase (ALT), cholesterol (CHOL), and lipase (LIPA). Significant differences were observed in albumin (ALB), alanine aminotransferase (ALT), and lipase (LIPA) levels, indicating metabolic changes.

The study highlights the need for further biochemical parameter analysis to establish reference values for blood biochemical parameters of important aquaculture fish species under different temperature conditions.

Keywords: biochemical parameters, serum, *Seriola dumerili*, aquaculture

Adaptations of *Daphnia magna* as Prey in Freshwater Microcosm

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Abstract:

The freshwater water flea (*Daphnia magna* Straus, 1820) is widely used in laboratories and aquaculture. As prey for many predators, it is a very important component of food webs and possesses a wide range of strategies for defense, or avoidance of predation. Microcosm represents a simplified ecosystem in controlled conditions. Herewith, we showed two defensive mechanisms of *D. magna* to protect itself from predators *Hydra viridissima*, *Polycelis felina* and *Dugesia gonocephala* in freshwater microcosm. For the first time, we included interactions with the presence of the endosymbiotic microalgae isolated from *H. viridissima*. Each experiment lasted for 24 h and included five replicates of experimental groups set at 25 °C and 13.5 °C. One or five individuals of a particular predator species were introduced into in one microcosm, along with 10 individuals of *Daphnia*. With the presence of predators, *D. magna* defended itself by grouping in such a way that two or more individuals were grouped together (visual magnification). We also observed accelerated movement (high-speed movements/"bullet movement") of *D. magna*, which is a good escape mechanism from slow predators, and it also appeared with the presence of the microalgae only. These adaptations provided the valuable insights of interactions of *D. magna* with the environment and new information for a more comprehensive understanding of the interspecific relationships in systems that include both zooplankton and microalgal components.

Keywords: freshwater microcosm, *Daphnia*, grouping, accelerated movement, microalgae

Intra-laboratory variability of reproduction toxicity test results with freshwater snail *Planorbarius corneus* L.

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Abstract:

Aquatic toxicity test methods, among which are two reproduction tests with molluscs species are

designed to assess toxicological effects of pollutants to aquatic environment. The development of new test guidelines with molluscs is of significant interest because these invertebrates are sensitive to endocrine disrupting chemicals (EDCs), a wide group of chemicals which disrupt the reproduction of animals acting as hormones and can bioaccumulate. In aquaculture different types of EDCs are used for disease management, induced breeding and to boost productivity. That results in transmission of EDCs to consumers and release to aquatic environment. As variability is inherent to all test organisms, tests performed on identical chemicals in identical conditions on the same test species, when repeated do not usually yield identical results. The common measure of variability is coefficient of variability ($CV = \text{st.dev}/\text{mean} \times 100$). The lower CV in controls and tests means higher accuracy of performance and higher precision of the results. Here we present the variability in reproduction toxicity tests with another mollusc species, the freshwater snail *Planorbis cornutus* L. In controls, intra-replicate variability was 5.93% and inter-control variability was 12.48%; in snails exposed to chemicals intra-replicate variability was 14.51%, and inter-test variability was 21.98%.

These variability values are favourably comparable to other studies with other invertebrate species including molluscs.

Keywords: aquatic toxicity tests, molluscs, reproduction, variability

Uzgoj i izlov školjkaša u Republici Hrvatskoj: trendovi od 2018. do 2023. godine

izv. prof. dr. sc. Ines Kovačić*, dr.sc. Neven Iveša, izv. prof. dr. sc. Petra Burić, dr. sc. Moira Buršić, izv. prof. dr. sc. Gioconda Millotti, izv. prof. dr. sc. Emina Pustijanac

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Sažetak:

Pravilno osmišljeni programi praćenja ključni su alati za postizanje održivog rasta izlova i proizvodnje morskih školjkaša. Ova studija ima za cilj utvrditi trendove u marikulturi i divljem ulovu školjkaša u Hrvatskoj na temelju podataka EUSTAT-a za razdoblje od 2018. do 2023. godine. Ukupna potrošnja morskih organizama po stanovniku u Hrvatskoj povećana je s 18,06 kg u 2018. godini na 22,96 kg u 2023., što je usporedivo s prosjekom Europske unije od 22,3 kg po stanovniku. Većina proizvodnje morskih školjkaša u Hrvatskoj ($78,21 \pm 5,71\%$) dolazi iz akvakulture, dok $21,79 \pm 5,71\%$ potječe iz ulova. *Mytilus galloprovincialis* vodeća je vrsta uzgojnog organizma, čineći $87,96 \pm 4,82\%$ hrvatske proizvodnje. Slijede *Ostrea edulis* ($6,04 \pm 2,39\%$) i *Pecten jacobaeus* ($6,00$

$\pm 6,75\%$). Marikultura vrste *O. edulis* povećana je s 54 tone (5,43% proizvodnje) u 2018. godini na 93 tone (9,02% proizvodnje) u 2023., što je značajno doprinijelo ukupnom rastu proizvodnje na 1.031,00 tonu u 2023. godini. Međutim, tijekom istog petogodišnjeg razdoblja zabilježen je pad od 72% u izlovu vrste *O. edulis*. Nadalje, gospodarski izlov školjkaša pokazuje opadajući trend od 49,40%, smanjujući se s 393,00 tone u 2018. na 194,00 tone u 2023. godini za sve vrste. Najzastupljenije vrste školjkaša u izlovu bile su *Venus verrucosa* ($28,91 \pm 16,81\%$) i *P. jacobeus* ($17,59 \pm 7,83\%$). Između 2018. i 2023. godine zabilježen je porast izvoza (13.815,66 tona) i uvoza (2.109,29 tona) školjkaša. Najveći rast zabilježen je 2020. godine, kada su izvoz i uvoz porasli za 43,75% odnosno 73,14%. S obzirom na svoje prirodne resurse i snažnu tradiciju, Hrvatska ima značajan potencijal za daljnji razvoj uzgoja školjkaša.

Ključne riječi: marikultura, gospodarski ulov, školjkaši, Jadransko more, uvoz, izvoz

Shellfish Mariculture and Wild Fisheries in Croatia: trends from 2018 to 2023

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Abstract:

Properly designed monitoring programs are essential for achieving sustainable growth for marine shellfish production. This study aims to determine trends in mariculture and wild-captured shellfish in Croatia based on EUSTAT data sets from 2018 to 2023. The total seafood consumption per capita in Croatia increased from 18.06 kg in 2018 to 22.96 kg in 2023 comparable to the European Union average of 22.3 kg per capita. Most marine bivalve production in Croatia ($78.21 \pm 5.71\%$) originates from aquaculture, while $21.79 \pm 5.71\%$ comes from wild fisheries. *Mytilus galloprovincialis* is the most cultivated marine bivalve species, accounting for $87.96 \pm 4.82\%$ of Croatian production. This is followed by *Ostrea edulis* ($6.04 \pm 2.39\%$) and *Pecten jacobaeus* ($6.00 \pm 6.75\%$). The mariculture of *O. edulis* increased from 54 tonnes (5.43% of production) in 2018 to 93 tonnes (9.02% of production) in 2023, contributing significantly to the overall production growth of 1.031,00 tonnes in 2023. However, a 72% decrease in wild-captured *O. edulis* was observed during the same five-year period. Furthermore, wild bivalve fisheries exhibited a declining trend of 49.40%, decreasing from 393,00 tonnes in 2018 to 194,00 tonnes in 2023 across all species. The most prominent species in wild fisheries were *Venus verrucosa* ($28.91 \pm 16.81\%$) and *P. jacobaeus*

(17.59 ± 7.83%). Between 2018 and 2023, exports (13,815.66 tonnes) and imports (2,109.29 tonnes) of shellfish seafood increased. The highest growth occurred in 2020, with export and import increases of 43.75% and 73.14%, respectively. Considering its natural resources and strong tradition, Croatia has significant potential for the further development of shellfish farming.

Keywords: mariculture, wild catches, shellfish, Adriatic Sea, export, import

Održivost uzgoja kamenica (*Ostrea edulis*) i dagnji (*Mytilus galloprovincialis*) u odnosu na mikrobiološke parametre vode

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Sažetak:

Cilj ovog istraživanja bio je ispitati povezanost mikrobioloških parametara vode s indeksom kondicije kao pokazateljem rasta kamenica (*Ostrea edulis*) i dagnji (*Mytilus galloprovincialis*) u dva uzgajališta na području Jadranskog mora, Malostonskom zaljevu i Limskom kanalu.

Uzorkovanja morske vode su provedena tijekom šest vremenskih razdoblja, a analizirani su mikrobiološki indikatori prisutnosti bakterija na TCBS agaru pri 22°C i 35°C. Istodobno su uzorkovane kamenice i dagnje te je određen indeks kondicije kao omjer suhe težine mekih tkiva i ukupne težine školjke.

Rezultati su pokazali da je veća bakterijska kontaminacija na TCBS agaru pri 22°C i 35°C bila negativno povezana s rastom dagnji na obje lokacije. Utjecaj na rast kamenica je bio varijabilan, u Malostonskom zaljevu bio je negativan, dok je u Limskom kanalu pokazao pozitivnu povezanost.

Ovi nalazi ukazuju na potencijalne razlike u ekološkoj otpornosti dviju vrsta te mogu pridonijeti optimizaciji uzgojnih strategija u različitim okolišnim uvjetima.

Glavne riječi: akvakultura, *Ostrea edulis*, *Mytilus galloprovincialis*, indeks kondicije, mikrobiološki parametri, TCBS analiza

Sustainability of Oyster (*Ostrea edulis*) and Mussel (*Mytilus galloprovincialis*) Farming in Relation to Microbiological Water Parameters

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Abstract:

The aim of this study was to investigate the relationship between microbiological water parameters and the condition index as an indicator of growth in oysters (*Ostrea edulis*) and mussels (*Mytilus galloprovincialis*) at two farming sites in the Adriatic Sea, Malostonski Bay and Lim Channel.

Seawater sampling was conducted over six time periods, and microbiological indicators of bacterial presence were analyzed on TCBS agar at 22°C and 35°C. Simultaneously, oysters and mussels were sampled, and the condition index was determined as the ratio of dry soft tissue weight to total shell weight.

The results showed that higher bacterial contamination on TCBS agar at 22°C and 35°C was negatively correlated with mussel growth at both locations. The impact on oyster growth was variable, negative in Malostonski Bay but positively correlated in Lim Channel. These findings suggest potential differences in the ecological resilience of the two species and may contribute to the optimization of farming strategies under different environmental conditions.

Keywords: aquaculture, *Ostrea edulis*, *Mytilus galloprovincialis*, condition index, microbiological parameters, TCBS analysis

Razvoj senzorskih analiza za svježeg cijelog brancina (*Dicentrarchus labrax* L.) prema Torry metodi

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Sažetak:

Senzorička analiza ribe je znanstvena disciplina koja se koristi pri određivanju kvalitete i definiranju roka trajnosti svježe cijele ribe. Pri određivanju roka trajnosti koristi se modificirana Torry metoda prilagođena Cromaris kriterijima koja se temelji na ocjenjivanju karakterističnih promjena svojstava kojima se opisuje izgled, miris i konzistencija sirove ribe. Prema ovoj metodi definiran je vodič kojim se dodjeljuju tri indeksna boda 0, 5 i 10 za svaki ocjenjivani parametar, a aritmetička sredina tih ocjena daje ukupan rezultat senzoričke procjene.

Korištenjem ove metode i analizom prikupljenih podataka u proteklom periodu primijećeno je da je potrebno proširiti postojeći vodič za Cromaris brancina kako bi se mogla bolje opisati postupna degradacija svježe ribe tijekom roka trajnosti. Postojeći vodič proširen je uz pomoć rezultata senzorskih analiza od strane certificiranog senzorskog tima koji broji 9 članova. Članovi su ocjenama od 1-10 i pripadajućim opisnim karakteristikama definirali parametre: miris svježe ribe, oči, miris i izgled škrga, boja i vlažnost kože i konzistencija mesa i tako utvrdili jasne razlike unutar roka trajnosti. Pomoću novog vodiča mogu se preciznije opisivati i pratiti promjene na Cromaris brancinu tijekom roka trajnosti, a tako prikupljeni podaci otvaraju nove mogućnosti u praćenju vlastite proizvodnje i postavljanju novih ciljeva.

Ključne riječi: organoleptička analiza, određivanje roka trajnosti, Torry sustav bodovanja

Development of sensory analysis for fresh whole sea bass (*Dicentrarchus labrax* L.) according to the Torry method

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Abstract:

Sensory analysis of fish is a scientific discipline used to determine the quality and define the shelf life of fresh whole fish. In determining shelf life, a modified Torry method adapted to Cromaris criteria is used, which is based on assessing characteristic changes in properties describing the appearance, smell, and consistency of raw fish. According to this method, a guide has been defined in which three index points, 0, 5, and 10, are assigned to each evaluated parameter, and the arithmetic mean of these scores gives the overall result of the sensory assessment.

By using this method and analyzing the data collected over the past period, it has been noticed that the existing guide for Cromaris sea bass needs to be expanded to better describe the gradual degradation of fresh fish during shelf life. The existing guide was expanded with the help of sensory analysis results from a certified sensory team consisting of 9 members. The team members, using scores from 1 to 10 and corresponding descriptive characteristics, defined parameters such as: the smell of fresh fish, eyes, gill smell and appearance, skin color and moisture, and flesh consistency, thus identifying clear differences within the shelf life. With the new guide, it is now possible to more precisely describe and monitor changes in Cromaris sea bass during shelf life, and the data collected in this way open up new possibilities for monitoring internal production and setting new goals.

Keywords: Organoleptic analysis, determination of shelf life, Torry scoring system

Iskorištavanje nusproizvoda akvakulture i odbačenog ulova ribolova: Put do održive proizvodnje plodova mora u Hrvatskoj

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Sažetak

Istraživanje daje uvid u održivo iskorištavanje odbačenog ulova i nusproizvoda iz morskog ribarstva i akvakulture, s naglaskom na njihovu preradu u visokovrijedne proizvode poput hranu za životinje, bioaktivne spojeve, riblje brašno, riblje ulje i dr. Fokusirajući se na Republiku Hrvatsku, ističe se

potencijal ovih nusproizvoda za uvećanje učinkovitosti resursa, smanjenje ovisnosti o slobodnoživućim ulovljenim ribama i smanjenje otpada u sektoru ribarstva i prerade u akvakulturi. S obzirom na očekivani porast globalne potražnje za plodovima mora od 70% do 2050. godine, ključno je rješavanje značajnih količina nusproizvoda, koje u akvakulturi iznose između 20% i 60% sirovine. Istraživanje pokazuje da učinkovito upravljanje tim resursima može smanjiti otpad, povećati ekonomsku održivost te podržati principe kružnog gospodarstva. Međutim, biološki, tehnički i operativni izazovi otežavaju ovaj proces unutar hrvatskoga morskog gospodarstva. Ovaj rad pruža uvid u mogućnosti i izazove globalnog iskorištavanja odbačenog ulova i nusproizvoda akvakulture, nudeći smjernice za unapređenje održivosti hrvatske industrije plodova mora.

Ključne riječi: prerada plodova mora, obveza iskrcaja, potražnja, akvakultura, održivost

Utilization of aquaculture by-products and fisheries discards: The path to sustainable seafood production in Croatia

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Abstract:

This study examines the sustainable use of discards and side streams from marine fisheries and aquaculture, focusing on their conversion into valuable products such as animal feed, bioactive compounds, fishmeal and fish oil. The study focuses on Croatia and highlights the potential of these by-products to improve resource efficiency, reduce dependence on wild catches and minimize waste. With global demand for fish and seafood projected to increase by 70% by 2050, this is a critical issue as aquaculture generates significant amounts of waste (20-60% of raw materials). Research shows the potential for waste minimization, improved economic profitability and supporting circular economy principles through effective resource management. However, there are biological, technical and operational challenges in the Croatian maritime economy. This work highlights the opportunities and challenges of utilizing by-products and side streams on a global scale and provides a framework for improving the sustainability of the Croatian seafood industry.

Keywords: seafood processing, landing obligation, demand, aquaculture, sustainability

Usporedba utjecaja uzgoja školjkaša i riba na bentoske zajednice meiofaune

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Sažetak:

Velika potražnja za morskim proizvodima rezultirala je većom produktivnošću u sektoru akvakulture na globalnoj razini, što je dodatno povećalo pritisak na morski okoliš. Neki od glavnih utjecaja intenzivnog uzgoja vidljivi su u vidu promjena u kvalitativnom i kvantitativnom sastavu zajednica poput meiofaune i makrofaune sedimenta. Cilj ovog istraživanja je bio usporediti utjecaj uzgajališta školjkaša (*Mytilus galloprovincialis*) sa kaveznim uzgojem lubina i komarče smještenih u srednjem dijelu istočnog Jadranskog mora na morski okoliš kroz promjene brojnosti i sastava strukture zajednica meiofaune u sedimentu. Uzorci sedimenta prikupljeni su autonomnim ronjenjem na tri postaje: na rubu uzgajališta (P1), neposredno ispod uzgajališta (P2) te na referentnoj postaji (P REF). Prilikom uzorkovanja prikupljeni su popratni fizikalno-kemijski parametri vodenog stupca mora. Preliminarni rezultati ovog istraživanja pokazali su najveću ukupnu brojnost meiofaune na postaji P2, dok je najveća bioraznolikost zabilježena na REF postaji na uzgajalištu dagnji. Ipak, nisu pronađene razlike u broju rijetkih svojti na uzgajalištu dagnji, dok je veći broj evidentiran na referentnoj postaji kaveznog uzgoja ribe. To ukazuje na promjene u brojnosti i strukturi zajednica meiofaune uzrokovane taloženjem organske tvari u sedimentu ispod uzgajališta, ističući time važnost provođenja redovitog monitoringa te korištenja meiofaune kao dodatnog indikatora za praćenje stanja okoliša i promjena uzrokovanih antropogenim utjecajem.

Ključne riječi: akvakultura, meiofauna, kavezni uzgoj, uzgoj školjkaša, Jadransko more

Comparison of the impact of shellfish and fish farming on benthic meiofauna communities

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Abstract:

Growing demand for marine products has resulted in higher productivity in the aquaculture sector globally, further increasing the pressure on the marine environment. One of the impacts of intensive aquaculture production is variability in qualitative and quantitative composition of meiofaunal and macrofaunal community structure. The aim of this study was to compare the impact of Mediterranean mussel farm (*Mytilus galloprovincialis*) with cage farming of European seabass and gilthead seabream located in the central part of the eastern Adriatic Sea on the marine environment through changes in the abundance and composition of meiofauna communities. Sediment samples were collected by SCUBA diving at three stations: at the edge of the cages (ST 1) directly below the farm cages (ST 2) and at the control station (CTRL ST). Physical-chemical parameters of water column were recorded during the sampling. Preliminary results of this study showed the highest total abundance of meiofauna at station P2, while the highest biodiversity was recorded at CTRL station at the mussel farm. However, no differences were found in the number of rare taxa at the mussel farm, while higher number was recorded at the fish farm CTRL station. This indicates changes in the abundance and meiofauna communities structure caused by the deposition of organic matter in the sediment beneath the fish farms highlighting the importance of conducting regular monitoring and using meiofauna as an additional bioindicator for monitoring the state of the environment and changes caused by anthropogenic impact.

Keywords: aquaculture, meiofauna, fish farming, mussel farming, Adriatic Sea

Nova generacija biosigurnosti: biomolekularne inovacije za održivu akvakulturu

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Sažetak:

Inicijativa COST BioAqua naglašava ulogu naprednih molekularnih dijagnostika, poput *real-time* PCR i CRISPR alata, u postizanju brze i precizne detekcije patogena. Također, strategije genetskog inženjeringa, uključujući selektivno uzgajanje za otpornost na bolesti, te upotreba probiotika i modulacija mikrobioma, značajno doprinose poboljšanju imunoloških odgovora i općeg zdravlja riba. Nadalje, cjepiva nove generacije i antimikrobni peptidi pojavljuju se kao ključne alternative antibioticima, smanjujući rizike od antimikrobne rezistencije. Biosigurnost je temeljna komponenta upravljanja akvakulturom, koja je ključna za prevenciju izbijanja bolesti, smanjenje ekonomskih gubitaka i osiguranje održivosti. Međutim, brojne prepreke - od nedostatnih zdravstvenih regulacija do razvijajućih prijetnji patogena - otežavaju provedbu učinkovitih mjera biosigurnosti. Ključni problem i dalje ostaje nedostatak sveobuhvatnih regulatornih okvira u akvakulturi, što otežava ribarima usvajanje standardiziranih protokola biosigurnosti. Integriranjem biomolekularnih inovacija s regulatornim poboljšanjima, akvakultura može poboljšati svoju otpornost na prijetnje bolestima, štiteći kako produktivnost, tako i okolišnu održivost.

Ključne riječi: biosigurnost u akvakulturi, biomolekularne inovacije, molekularne dijagnostike

Next-generation biosecurity: biomolecular innovations for sustainable aquaculture

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Abstract:

The COST BioAqua initiative highlights the role of advanced molecular diagnostics, such as real-time PCR and CRISPR-based tools, in achieving rapid and precise pathogen detection. Additionally, genetic engineering strategies, including selective breeding for disease resistance, and the use of probiotics and microbiome modulation, contribute to enhanced immune responses and overall fish health. Furthermore, next-generation vaccines and antimicrobial peptides are emerging as vital alternatives to antibiotics, mitigating the risks of antimicrobial resistance. Biosecurity is a fundamental component of aquaculture management, essential for preventing disease outbreaks, reducing economic losses, and ensuring sustainability. However, numerous challenges—ranging from inadequate health regulations to evolving pathogen threats—hinder the implementation of effective biosecurity measures. A critical issue remains the lack of comprehensive regulatory frameworks in aquaculture, making it difficult for fish farmers to adopt standardized biosecurity protocols. By integrating biomolecular innovations with regulatory improvements, aquaculture can enhance its resilience to disease threats, safeguarding both productivity and environmental sustainability.

Keywords: aquaculture biosecurity, biomolecular innovations, molecular diagnostics

Bolesti riba u 2024. godini: trendovi i izazovi

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Sažetak:

Bolesti riba i dalje predstavljaju značajan izazov za globalnu akvakulturu, utječući na učinkovitost proizvodnje, ekonomsku održivost i ukupnu održivost industrije. U 2024. godini, novi i ponovno pojavljujući vodeni patogeni, antimikrobna rezistencija i bolesti uzrokovane klimatskim

promjenama dodatno su zakomplicirali upravljanje zdravljem riba. Ovaj rad istražuje najnovije trendove u bolestima riba, ističući ključne patogene od interesa, evoluciju epidemioloških obrazaca i utjecaj promjena u okolišu i regulatornim okvirima na izbijanje bolesti. Također se raspravlja napredak u dijagnostičkim tehnologijama, razvoju cjepiva i mjerama biosigurnosti, s naglaskom na njihovu ulogu u smanjenju rizika od bolesti. Osim toga, rad analizira praznine u trenutnim strategijama upravljanja zdravljem riba i predlaže buduće pravce za poboljšanje prevencije i kontrole bolesti. Integriranjem znanstvenih inovacija s unaprijeđenim regulatornim okvirom i suradnjom s industrijom, sektor akvakulture može poboljšati otpornost na bolesti riba, osiguravajući održivu i odgovornu proizvodnju u godinama koje dolaze.

Ključne riječi: bolesti riba, vodeni patogeni, upravljanje bolestima, održiva akvakultura

Fish diseases in 2024: trends and challenges

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Abstract:

Fish diseases continue to pose significant challenges to global aquaculture, affecting production efficiency, economic viability, and sustainability. In 2024, emerging and reemerging aquatic pathogens, antimicrobial resistance, and climate change-driven disease dynamics have further complicated fish health management. This paper explores the latest trends in fish diseases, highlighting key pathogens of concern, evolving epidemiological patterns, and the impact of environmental and regulatory changes on disease outbreaks. Advances in diagnostic technologies, vaccine development, and biosecurity measures are also discussed, emphasizing their role in mitigating disease risks. Additionally, the paper examines gaps in current fish health management strategies and proposes future directions for improving disease prevention and control. By integrating scientific innovations with improved regulatory frameworks and industry collaboration, the aquaculture sector can enhance resilience against fish diseases, ensuring sustainable and responsible production in the years ahead.

Keywords: fish diseases, aquatic pathogens, disease management, sustainable aquaculture

Napredna akvakultura: uvođenje efikasnih mjera biosigurnosti za održiv rast

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Sažetak:

Biosigurnost je temeljna komponenta održive akvakulture, ključna za prevenciju izbijanja bolesti, smanjenje ekonomskih gubitaka i očuvanje dugoročne održivosti ribogojilišta. Unatoč sve većem prepoznavanju njegove važnosti, akvakultura se suočava s različitim izazovima, uključujući povećani rizik od prijenosa patogena, nedostatak usklađenih zdravstvenih regulacija i poteškoće u implementaciji učinkovitih mjera biosigurnosti. Inicijativa COST BETTER ima za cilj poboljšanje biosigurnosti kroz inovativne strategije prevencije i kontrole bolesti. Ovaj rad istražuje ključne aspekte biosigurnosti u akvakulturi, naglašavajući potrebu za poboljšanim nadzorom patogena, procjenom rizika i proaktivnim regulatornim okvirima. Bez jasnih smjernica, mnogi proizvođači u akvakulturi teško implementiraju odgovarajuće protokole biosigurnosti, što dovodi do stalnih rizika od bolesti. Adresiranje tih praznina ključno je za sljedeće desetljeće. Napredak u molekularnoj dijagnostici, biosenzorima i tehnologijama za stvarnu detekciju patogena omogućuju brzu i preciznu identifikaciju bolesti, poboljšavajući strategije ranih intervencija. Osim toga, cjepiva nove generacije, probiotici, modulacija mikrobioma i genetski odabir za otpornost na bolesti istražuju se kao obećavajuća rješenja za jačanje otpornosti akvakulture. Ova studija također naglašava najbolje prakse upravljanja i regulatorne okvire koji mogu podržati razvoj održive akvakulture. Jačanje strategija biosigurnosti ne samo da će poboljšati dobrobit riba i učinkovitost proizvodnje, već će također doprinijeti globalnoj stabilnosti akvakulture kao vitalnog izvora hrane.

Ključne riječi: biosigurnost u akvakulturi, održiva akvakultura, upravljanje bolestima

Advanced aquaculture: implementing effective biosecurity measures for future growth

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Abstract:

Biosecurity is a fundamental component of sustainable aquaculture, essential for preventing disease outbreaks, reducing economic losses, and maintaining the long-term viability of fish farming operations. Despite growing recognition of its importance, aquaculture faces diverse challenges, including the increased risk of pathogen transmission, lack of harmonized health regulations, and difficulties in implementing effective biosecurity measures. The COST BETTER initiative aims to enhance biosecurity through innovative disease prevention and control strategies. This paper explores key biosecurity aspects in aquaculture, emphasizing the need for improved pathogen surveillance, risk assessment, and proactive regulatory frameworks. Without clear guidelines, many fish farmers struggle to implement adequate biosecurity protocols, leading to persistent disease risks. Addressing these gaps is crucial for the next decade. Advancements in molecular diagnostics, biosensors, and real-time pathogen detection technologies provide rapid and precise disease identification, improving early intervention strategies. Additionally, next-generation vaccines, probiotics, microbiome modulation, and genetic selection for disease resistance are explored as promising solutions to strengthen aquaculture resilience. Strengthening biosecurity strategies will not only enhance fish welfare and production efficiency but also contribute to the global stability of aquaculture as a vital food source.

Keywords: aquaculture biosecurity, sustainable aquaculture, disease management

Borba protiv cijanobakterijskih cvjetanja: održiva rješenja za unaprjeđenje kvalitete vode i ekosustava

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Sažetak:

Rastući problem toksičnih cijanobakterijskih cvjetanja, potaknut ljudskim zagađenjem hranjivim tvarima, ozbiljna je prijetnja našim izvorima vode, zdravlju vodenih ekosustava i gospodarstvima koja ovise o njima. Nagla bujanja cijanobakterija ne samo da kontaminiraju vodu, čineći je nesigurnom za ljude i životinje, već ometaju ribolov, rekreaciju i biološku raznolikost. Iako postoje metode za kontrolu cvjetanja unutar jezera, one same nisu dovoljne za dugoročna rješenja bez rješavanja korijenskih uzroka u okolnim zemljištima i slivnim područjima. Ključ za sprječavanje naglih bujanja leži u smanjenju otjecanja hranjivih tvari kroz održivije poljoprivredne prakse i poboljšano upravljanje zemljištem. Projekt CA23160 CYANOACTION radi na jačanju europskog pristupa upravljanju jezerima, stvarajući mrežu istraživača, donositelja politika i vodnih menadžera kako bi surađivali na rješenjima. Razvijanjem sustava za rano upozoravanje, procjena rizika i alata za donošenje odluka, projekt ima za cilj pomoći upraviteljima vodnim resursima u odabiru najboljih preventivnih i korektivnih mjera za svako jedinstveno vodno tijelo. Također, inicijativa nastoji zatvoriti jaz između recentnih vrsnih istraživanja i praktičnih strategija, osiguravajući bolju zaštitu jezera za buduće generacije.

Ključne riječi: cijanobakterijsko cvjetanje, upravljanje, sliv, sigurnost, preventivne mjere

Tackling cyanobacterial blooms: sustainable solutions for improving water quality and ecosystems

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Abstract

The growing problem of toxic cyanobacterial blooms, fueled by human-driven nutrient pollution, is a serious threat to our water supply, the health of aquatic ecosystems, and the economies that depend on them. These blooms not only contaminate water, making it unsafe for both people and animals, but they also disrupt fishing, recreation, and biodiversity. While some methods exist to control these blooms within lakes, they are not enough on their own for long-term solutions without addressing the root causes in the surrounding land and catchment areas. The key to preventing these blooms lies in reducing nutrient runoff through more sustainable farming practices and improved land management. The CA23160 CYANOACTION project is working to strengthen Europe approach to managing lakes, creating a network of researchers, policymakers, and water managers to collaborate on solutions. By developing early warning systems, risk assessments, and decision-making tools, the project aims to help water managers choose the best preventive and corrective actions for each unique water body. Ultimately, this initiative seeks to bridge the gap between cutting-edge research and practical, real-world strategies, ensuring that lakes are better protected for future generations.

Keywords: cyanobacterial blooms, management, catchment, safety, preventive measures

AquaSoc - model za društveno odgovornu održivu marikulturu

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Sažetak:

Razvoj marikulture na Jadranskom moru ima značajne posljedice na gospodarski razvitak, morski prostor te svakodnevni život lokalnih zajednica. Kako bi se uspješno pokrenuo uzgoj u marikulturi na nekom području, osim poslovno-tehničkih procesa, potrebno je razmotriti i šire društvene

faktore. U tu svrhu, razvijen je AquaSoc model koji se temelji na empirijskom istraživanju provedenom na 4 lokacije na Jadranskom moru, intervjuima sa više od 30 sudionika (od lokalnih aktera do znanstvenika i stručnjaka na nacionalnoj razini), analizom sekundarnih podataka te analizom raznih događaja i društvenih momenata povezanih sa razvojem akvakulture na Jadranu. Model služi za uspješno implementiranje održive marikulture u određenom morskom području te u svrhu razrješavanja mogućih izazova koji se mogu pojaviti u kompleksnim odnosima sa lokalnim zajednicama, raznim nevladinim organizacijama, medijima i sličnim akterima.

AquaSoc model sastoji se od 5 ključnih dimenzija: a) PROSTOR, b) ESTETIKA, c) OKOLIŠ, d) EKONOMIJA i e) SURADNJA, sastavljenih od različitih elemenata, koje je potrebno uzeti u obzir u svrhu uspješnog pokretanja društveno odgovorne održive marikulture te razrješavanja određenih izazova koji se mogu pojaviti u razvoju marikulture na nekom području. Istraživanje je dio projekta "Održivo ribarstvo: društveni odnosi, identitet i zajedničko upravljanje jadranskim ribolovnim resursima", koji financira Hrvatska zaklada za znanost.

Ključne riječi: akvakultura, lokalne zajednice, održivost, morski prostor, Jadransko more

AquaSoc - model for socially responsible sustainable mariculture

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Abstract:

The development of mariculture in the Adriatic Sea has significant implications for economy, maritime space and the daily lives of local communities. To successfully initiate mariculture in a specific area, besides business and technical processes, it is necessary to consider broader social factors. For this purpose, the AquaSoc model has been developed, based on empirical research conducted at 4 locations in the Adriatic Sea, interviews with over 30 participants (ranging from local stakeholders to scientists and national-level experts), secondary data and various events analysis related to the development of aquaculture in the Adriatic. The model serves for successful implementation of sustainable mariculture in a maritime area and to address potential challenges that may arise in complex relationships with local communities, various non-governmental organizations, the media and other stakeholders.

The AquaSoc model consists of 5 key dimensions: a) SPACE, b) AESTHETICS, c) ENVIRONMENT, d) ECONOMY, and e) COOPERATION, made up of different elements that

must be taken into account to launch socially responsible sustainable mariculture successfully and to address challenges that may arise in the development of mariculture in a given area. The research is part of the project "Sustainable fishing: social relations, identity and co-management of Adriatic fishery resources", funded by the Croatian Science Foundation.

Keywords: aquaculture, local communities, sustainability, marine space, Adriatic Sea

The investigation of black soldier fly larvae (*Hermetia illucens*) as a food source for hybrid African catfish (*Clarias gariepinus* x *Heterobranchus longifilis*)

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Abstract:

In aquaculture, finding sustainable protein sources for fish feed is a key challenge. Black soldier fly (BSF) is a popular protein source, but its larvae require a lot of energy to process. Using whole, unprocessed (BSF) larvae as fish feed could reduce the financial cost of fish production. In our trials african catfish (320/tank) with 83,6±16 g body weight were stocked in 4 (2m²) tanks (2-2) each group connected to a recirculation aquaculture system. In Trial 1, the 15% of control feed's dry matter (crude protein 42%, crude fat 11%, crude fibre 1.7%) was replaced by BSF unprocessed larvae and the control group was fed with the control feed mentioned above. In Trial 2, the 15% replacement rate from Trial 1 was replicated and a higher 30% rate was set due to positive results. Fish body weight and total length were measured on days 0, 14 and 28. Data was used to calculate the following parameters: specific growth rate (SGR), condition factor (CF), feed conversion ratio (FCR). Results of Trial 1 control group were SGR 2,4%, CF 0,72, FCR 1,06. Results of Trial 1 15% group were SGR 2,65%, CF 0,76, FCR 0,93. Results of Trial 2 15% group were SGR 2,79%, CF 0,68, FCR 1,03. Results of Trial 2 30% group were SGR 2,98%, CF 0,72, FCR 0,93. There were no significant differences between the control and treated groups. The results showed that replacing the feed with 15% and 30% BSF larvae had no negative effect on fish SGR, CF and FCR regarding to the control group.

Keywords: nutrition, insect, black soldierfly, african catfish, cost efficiency,

Proizvodnja afričkog soma u RAS sustavu na ribnjaku PP Orahovica

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Sažetak:

Pilot projekt uzgoja ribe u RAS (recirkulacijski sustav) PP Orahovice započeo je 2022. godine zbog potrebe stjecanja nova iskustava i znanja o ovom obliku proizvodnje, te da se popune kapaciteti tvornice za preradu ribe tijekom cijele godine. RAS na ribnjaku Grudnjak veličine je 110m³, koristi bunarsku vodu za punjenje i osvježavanje sustava i dizalicu topline za grijanje vode. Za uzgoj je odabrana vrsta Afrički som (*Clarias gariepinus*) zbog mogućnosti uzgoja pri velikim gustoćama po jedinici volumena i velike tolerancije vrste na kvalitetu vode. Od pokretanja proizvodnje prepravcima sustava osigurani su uvjeti za stabilnu proizvodnju i zadovoljavanje minimalnih ambijentalnih uvjeta za održavanje dobrobiti životinja. Cilj projekta je bio odrediti maksimalnu godišnju proizvodnju s obzirom na tehničke karakteristike sustava te dužinu proizvodnog procesa od ličinke do konzumne ribe. Utvrđen je maksimalan kapacitet sustava od 80 tona, uz utrošak oko 80 tona riblje hrane godišnje. Potrebno je 7 do 9 mjeseci za proizvodnju od ličinke do konzumne veličine, ovisno o zahtjevima tržišta. Utvrđen je FCR (faktor konverzije hrane) za različite uzrasne kategorije, cijena proizvodnje po kilogramu prirasta i udio pojedinih troškova u cijeni proizvodnje. Dodatnim ulaganjima u automatizaciju procesa hranidbe i mehaničke filtracije vode, te uz ispitivanje tržišta na preferencije potrošača u konzumiranju ribe manje težine ostvarila bi se profitabilnija proizvodnja i bolji rezultati.

Ključne riječi: Afrički som, RAS, ribnjak Grudnjak, FCR

African catfish production in the RAS system at the fishpond PP Orahovica

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Abstract:

The pilot project of fish farming in the RAS (Recirculating aquaculture system) of PP Orahovica started in 2022 due to the need to gain new experience and knowledge about this form of production and to fill the capacities of the fish processing factory throughout the year. The RAS system on the Grudnjak pond is 110m³ in size, it uses well water to fill and refresh the system and a heat pump to heat the water. The species African catfish (*Clarias gariepinus*) was chosen for rearing due to the possibility of rearing at high densities per unit volume and the species' high tolerance to water quality. Since the start of production, system modifications have ensured stable production conditions and meeting the minimum ambient conditions for maintaining animal welfare. The goal of the project was to determine the maximum annual production with regard to the technical characteristics of the system and the length of the production process from larvae to the consumption category of fish. The maximum system capacity of 80 tons was established, with the consumption of about 80 tons of fish food per year. It takes 7 to 9 months to produce from fish larvae to consumption size, depending on market demand. The FCR (feed conversion ratio) for different age categories, the production price per kilogram of growth and the share of individual costs in the production price were determined. Additional investments in the automation of the feeding process and mechanical filtration of water, as well as market research on consumer preferences for consuming lighter weight fish, would lead to more profitable production and better results.

Keywords: African catfish, RAS, fishpond Grudnjak, FCR

Usporedba tehnika uzorkovanja za DNA metabarkodiranje sadržaja želuca atlantske plavoperajne tune

Luka Žuvić, mag. ing. agr.^{1*}, Klara Bakarić, dr. med. vet.¹, Klara Ivanišević, mag. biol. exp.¹, dr.sc. Igor Talijančić¹, dr.sc. Leon Grubišić¹, dr.sc. Iva Žužul Vrgoč¹, dr.sc. Jerko Hrabar¹, dr.sc. Tanja Šegvić-Bubić¹

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Sažetak:

Atlantska plavoperajna tuna (BFT) *Thunnus thynnus* jedan je od ključnih morskih grabežljivaca i ključna vrsta za ribarstvo i akvakulturu, posebice u Hrvatskoj, gdje je većinski udio državne godišnje kvote namijenjena akvakulturi. Za bolje razumijevanje njihove trofodinamike i hranidbenih

mreža ključna je sveobuhvatna studija njihove ekologije ishrane. Ekstrahirana DNA dobivena je iz želučanog soka (ŽS) i homogenata želučanog sadržaja (HŽS) od 41 BFT, uključujući nedoraste i odrasle jedinke, prikupljene u istočnom Jadranskom moru. Djelomični fragment regije COI gena umnožen je s univerzalnim početnicama za metazoe i sekvenciran na Illumina platformi. Bioinformatički rezultati pokazali su razlike u očitavanjima sekvencera između tehnika uzorkovanja, sa ~60% očitavanja koja potječu od domaćina u slučaju ŽS-a, nasuprot 34% u slučaju HŽS-a. Za obje tehnike uzorkovanja, najbrojnije vrste plijena bile su male plave ribe (HŽS ~44 %, ŽS ~25 %), glavonošci (HŽS ~12 %, ŽS ~11 %) i pridnene vrste riba (HŽS ~7 %, ŽS ~3 %). Veće taksonomsko bogatstvo i rezolucija, sa 32 taksona i 34 OTU-a koji su anotirani do razine vrste, dobiveni su iz HŽS-a, za razliku od 26 taksona i 29 OTU-a u slučaju ŽS-a. Osim toga, devet jedinstvenih taksona identificirano je iz HŽS-a u usporedbi sa tri iz ŽS-a. Zaključno, podaci dobiveni iz HŽS-a dali su veću točnost i stoga su vrijedniji za analizu odnosa predator-plijen nego podaci dobiveni iz uzoraka ŽS-a.

Ključne riječi: Atlantska plavoperajna tuna, DNA metabarkodiranje, COI, homogenat želučanog sadržaja, želučani sok

Comparison of sampling techniques for DNA metabarcoding of Atlantic bluefin tuna stomach contents

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Abstract:

Atlantic bluefin tuna (BFT) *Thunnus thynnus* is one of the key marine predators and a key species for fisheries and aquaculture, especially in Croatia, where the majority share of the state's annual quota is destined for aquaculture. A comprehensive study of their feeding ecology is essential to better understand their trophodynamics and food webs. Extracted DNA was obtained from gastric juice (GJ) and homogenate of stomach contents (HSC) of 41 BFT, including both juveniles and adults, collected in the eastern Adriatic Sea. A partial fragment of the COI gene region was amplified with universal primers for metazoans and sequenced on the Illumina platform. Bioinformatics results showed differences in sequencing reads between sampling techniques, with

~60% of reads emanating from the host in the case of GJ, opposite to 34% in the case of HSC. For both sampling techniques, the most abundant prey species were small pelagic fish (HSC ~44 %, GJ ~25 %), cephalopods (HSC ~12 %, GJ ~11 %) and demersal fish species (HSC ~7 %, GJ ~3 %). The greater taxonomic richness and resolution, with 32 taxa and 34 OTUs assigned to species level, were obtained from HSC, as opposed to 26 taxa and 29 OTUs in the case of GJ. In addition, nine unique taxa were identified from HSC compared to three in GJ. In conclusion, the data obtained from HSC provided greater accuracy and are therefore more valuable for predator-prey analysis than the data obtained from GJ samples.

Keywords: Atlantic bluefin tuna, DNA metabarcoding, COI, homogenate of stomach contents, gastric juice

Effects of fish meal and fish oil replacement with alternative sources in diet for sea bass (*Dicentrarchus labrax*)

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Abstract:

Availability of fish meal and fish oil for feed production is constantly decreasing making the pressure to find alternative raw materials. The competition for vegetable sources between food and feed production drives the need for finding cheaper vegetable alternatives. The inclusion of alternative vegetable sources in carnivorous marine fish feed is demanding. Three diets high in alternative sources were tested on sea bass (*Dicentrarchus labrax*) grown in sea cages dimensions 5 m x 9 m x 5 m to find the best combination of ingredients for fish growth.

Three diets were tested with fish meal (FM) replacement of 70-80%. In all diets replacement of FM consisted of 40% of land animal proteins (LAP) while 60% of FM replacement were three different combinations of soybean meal/concentrate, corn gluten, rapeseed meal, sunflower meal and hydrolysed fish protein. Fish oil was replaced with rapeseed or soybean oil.

Higher weight and growth rate had bass on diet rich in soybean meal. The difference was significant after 90 days of feeding up to the harvest. Ratios of omega 3/omega 6 in fish flesh was lower at diet high with soybean oil than at both diets with lower level of replacement of rapeseed oil.

Range of vegetable meals can provide satisfying growth at the level of 70% of substitution of fish

meal. Sunflower meal of 20% FM replacement can have negative effect on growth if the inclusion rate of other vegetable sources, rich in essential amino acids such as soybean meal/concentrate, is not high.

Keywords: fish meal, LAP, soy, sea bass, feed.

Promjena indeksa kondicije (IK) brancina *Dicentrarchus labrax* ovisno o razdoblju mrijesta

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Sažetak:

Indeks kondicije (IK) je odnos mase i duljine ribe te se koristi za opisivanje gojidbenog stanja ribe u uzgoju. Brojni čimbenici utječu na IK riba, uključujući temperaturu mora, godišnje doba (fotoperiod), sastav hrane i hranidba, uzrast, zdravstveno stanje i spolna zrelost.

Cilj ovog istraživanja bio je prikazati promjene IK brancina (*Dicentrarchus labrax*) u uzgoju prije i poslije mrijesta. Brancin se počinje mrijestiti početkom siječnja i mrijest traje dva do tri mjeseca. Prilikom mrijesta, ribe dio energije i tvari dobivene iz hrane utroše za proizvodnju mliječi i ikre. Mjerenjem IK brancina koji su izlovljeni u periodu 2020. do 2024. godine, utvrđene su više vrijednosti IK prije mrijesta dok nakon mrijesta vrijednosti opadaju, što ukazuje da fiziološke promjene povezane sa mrijestom imaju značajan utjecaj na IK. Također, prikazana je razlika vrijednosti IK kod brancina tijekom mrijesta gdje je vidljiv utjecaj mase gonada i gonadosomatskog indeksa na vrijednost IK. Kako je rast riba temeljni cilj samog uzgoja, potrebno je uzeti u obzir utjecaj mrijesta kao limitirajućeg biološkog faktora na vrijednosti IK te prilagoditi hranidbeni režim uzimajući u obzir i ostale faktore na koje kavezni uzgajivač ne može utjecati poput temperatura mora i fotoperiod.

Ključne riječi: brancin, indeks kondicije, mrijest

Change in the condition index (CI) of sea bass *Dicentrarchus labrax* depending on the spawning period

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Abstract:

The condition index (CI) is the ratio of fish mass to length and is used to describe the growth status of fish in farming. Numerous factors influence the condition index of fish, including sea temperature, season (photoperiod), food composition and nutrition, age, health status, and sexual maturity. The aim of this study was to show changes in the CI of sea bass (*Dicentrarchus labrax*) in culture before and after spawning. Sea bass begins to spawn in early January, and spawning lasts two to three months. During spawning, fish use part of the energy and substances obtained from food to produce milt (sperm) and eggs. By measuring the CI of sea bass caught between 2020 and 2024, higher CI values were determined before spawning, while the values decreased after spawning, indicating that physiological changes associated with spawning have a significant impact on the CI. Additionally, the difference in CI values in sea bass during spawning is shown, where the influence of gonad mass and the gonadosomatic index on CI values is evident. Since fish growth is the fundamental goal of breeding, it is necessary to consider the influence of spawning as a limiting biological factor on CI values and adjust the feeding regimen accordingly, taking into account other factors that the cage farmer cannot influence, such as sea temperature and photoperiod.

Keywords: sea bass, condition index, spawning

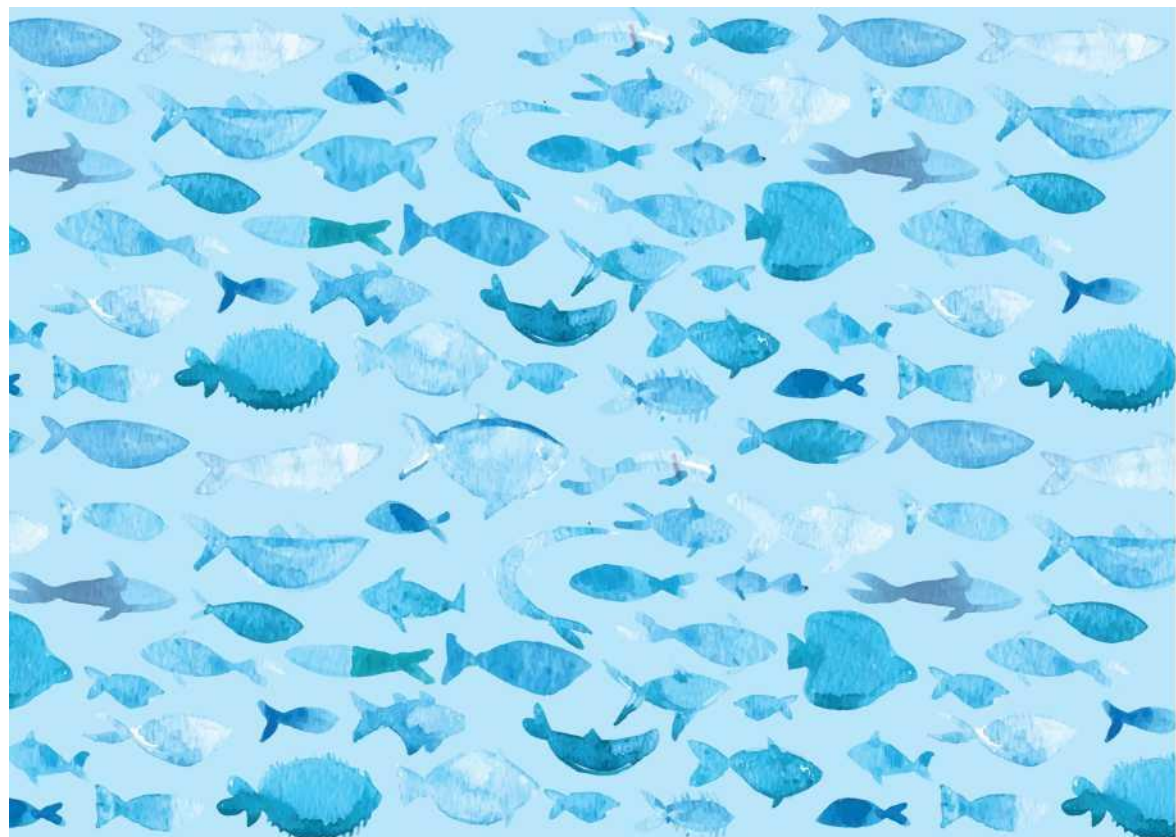
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