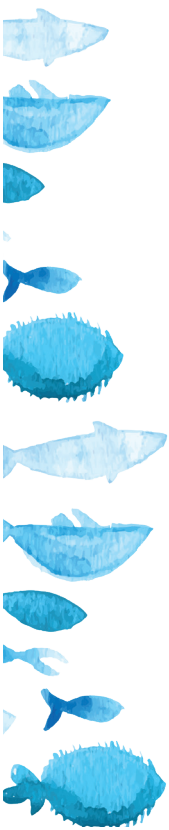
HGK 1852
HRVATSKA GOSPODARSKA KOMORA

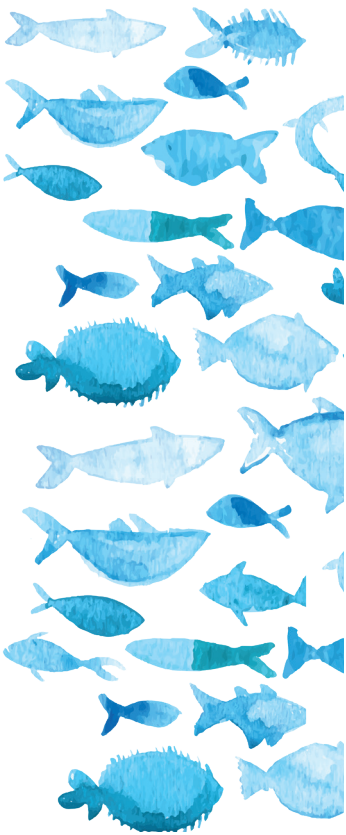
XIV.
međunarodna konferencija o akvakulturi

Zbornik sažetaka radova
Program i Zbornik sažetaka

14th
International Aquaculture Conference

Book of Abstracts
Program and Book of Abstracts





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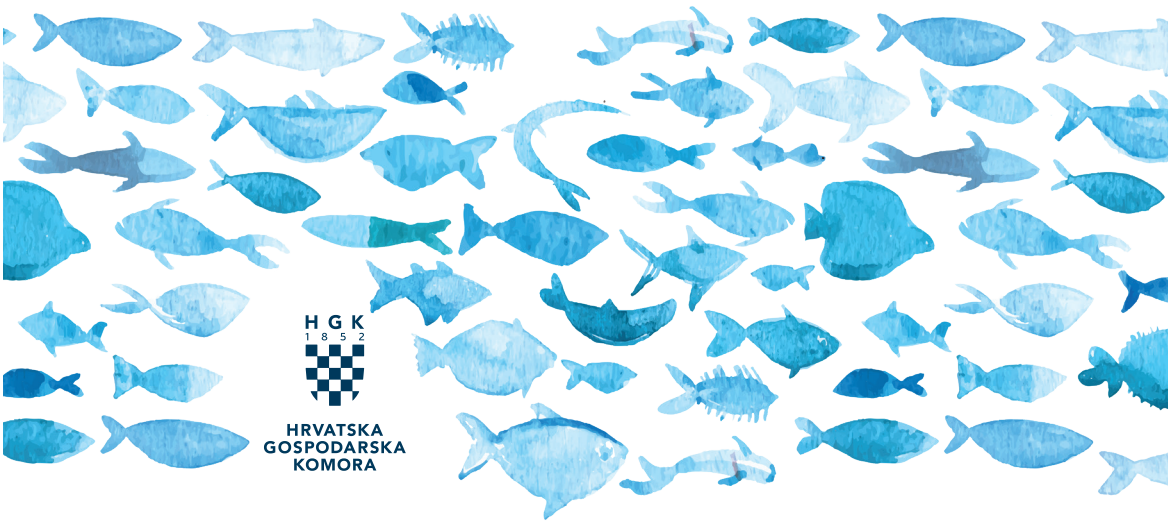
Operativni program ZA POMORSTVO I RIBARSTVO

Sufinancirano sredstvima EU iz Europskog fonda za pomorstvo i ribarstvo



HRVATSKA GOSPODARSKA KOMORA

Izrada ovog zbornika radova/sažetaka sufinancirana je sredstvima Europske unije iz Europskog fonda za pomorstvo i ribarstvo.

Kontakt podaci korisnika:

Hrvatska gospodarska komora
Sektor za poljoprivredu
Rooseveltov trg 2, 10000 Zagreb
Tel: +385 1 4826 066
E-mail: poljoprivreda@hgk.hr
www.hgk.hr

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Europska unija

Sufinancirano sredstvima EU iz Europskog fonda za pomorstvo i ribarstvo

Operativni program ZA POMORSTVO I RIBARSTVO

XIV. međunarodna konferencija o akvakulturi

Hotel Lav / Vukovar, Hrvatska / 29. – 31. ožujka 2023.

14th International Aquaculture Conference

Hotel Lav / Vukovar, Croatia / 29 – 31 March 2023

ORGANIZATOR / ORGANIZER

Hrvatska gospodarska komora

POKROVITELJI / PATRONS

Ministarstvo poljoprivrede

Vukovarsko-srijemska županija

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

O konferenciji

Konferencija o akvakulturi u Vukovaru je značajan susret proizvođača, znanstvenika i državne administracije te ostalih dionika iz sektora akvakulture Republike Hrvatske, EU i susjednih zemalja. Posvećena je prikazu trenutnog stanja i utvrđivanju bitnih strateških, tehnoloških, gospodarskih i znanstvenih spoznaja te, u međusobnom dijalogu, iznalaženju rješenja nužnih za uspješan i održivi razvoj akvakulture.

Poseban naglasak daje se na odnos i interakciju sa prirodom, zaštitu bioraznolikosti (naročito u ribnjačarstvu), te podizanju svijesti o ovisnosti o zdravom okolišu.

Konferencija se u Vukovaru održava od 2007. pod nazivom Međunarodno savjetovanje o slatkovodnom ribarstvu, potom Međunarodni gospodarsko – znanstveni skup o ribarstvu i na kraju ustalila se kao Međunarodna konferencija o akvakulturi.

Ostvarena je podrška i suradnja sa nacionalnim asocijacijama gospodarstvenika u akvakulturi, te krovnim organizacijama poput FEAP-a (Federation of European Aquaculture Producers) i Eurofish (International Organisation for the Development of Fisheries and Aquaculture in Europe).

Kao potpora razvoju akvakulture Konferencija je imala više inicijativa kao što je prijedlog osnivanja Hrvatskog instituta za slatkovodno ribarstvo i akvakulturu, putem Grupacije akvakulture HGK upućen je prijedlog FEAP-u za uvrštenje uzgoja tuna u djelatnost akvakulture, uz potporu Eurofish-a ostvaren je prijevod na engleski jezik knjige Hranidba riba prof. Boguta. U tijeku je i priprema prijedloga bolje valorizacije potencijala vukovarskog položaja na Dunavu putem uspostave Centra za oporavak i reintrodukciju dunavskih vrsta jesetre u okviru Dunavskog projekta.

Konferencija se održava svake dvije godine i obuhvaća sve teme od interesa za akvakulturu. Prihvaćeni radovi, prezentacije i posteri objavljuju se na mrežnoj stranici Konferencije (https://hgk.hr/14-medunarodna-konferencija-o-akvakulturi-najava), a dosad su sakupljeni i objavljeni radovi sa prethodnih 12 Konferencija.

Konferencija se tradicionalno odvija u gradu i županijskom sjedištu Vukovaru, obrazovnom, kulturnom i zdravstvenom i turističkom središtu. Grad je to bogate kulturne baštine i povijesnog naslijeđa, smješten na obali Dunava sa važnom lukom na polovici plovnog puta do Crnog mora.

Koordinator konferencije

mr.sc. Želimir Filić

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. The Coference is dedicated to the presentation of the current state of the Sector to establish important strategic, technological, economic, and scientific knowledge and, in mutual dialogue, to find a solution necessary for the successful and sustainable development of aquaculture.

Special emphasis is placed on the relationship and interaction with nature, the protection of biodiversity (especially in pond fish farming) and raising awareness of the dependence on a healthy environment.

The conference has been held in Vukovar since 2007. Support and cooperation with national Producers Associations in aquaculture and umbrella organizations such as FEAP (Federation of European Aquaculture Producers) and Eurofish (International Organization for the Development of Fisheries and Aquaculture in Europe) has been achieved.

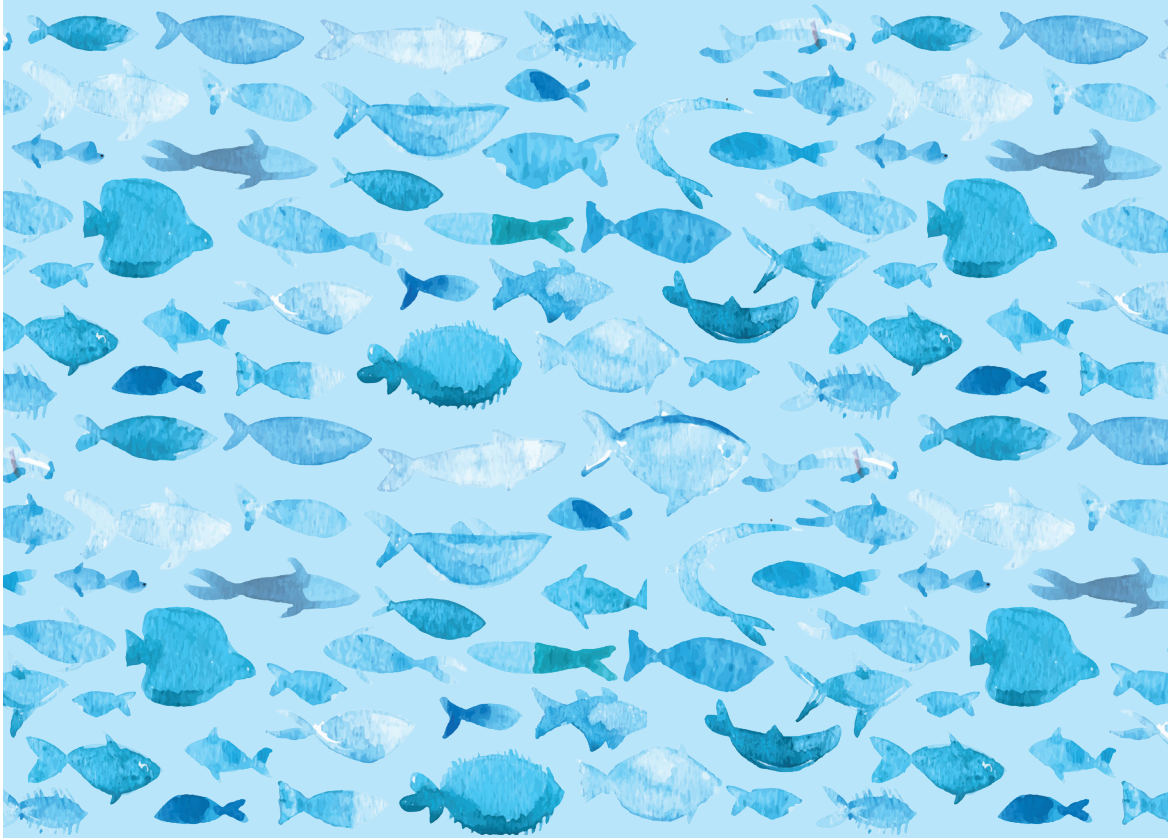
In order to support the development of aquaculture, the Conference had several initiatives, such as the proposal to establish the Croatian Institute for Freshwater Fisheries and Aquaculture, through the HGK Aquaculture Producers Group a proposal for the inclusion of tuna farming in aquaculture was sent to FEAP, with the support of Eurofish a translation into English of the Prof. Bogut book Fish feeding was made,for better valorisation of the potential of Vukovar's cite placement on the Danube, underway is the preparation of a proposal, within the Danube project, for the establishment of a Center for the Recovery and Reintroduction of danube sturgeon species.

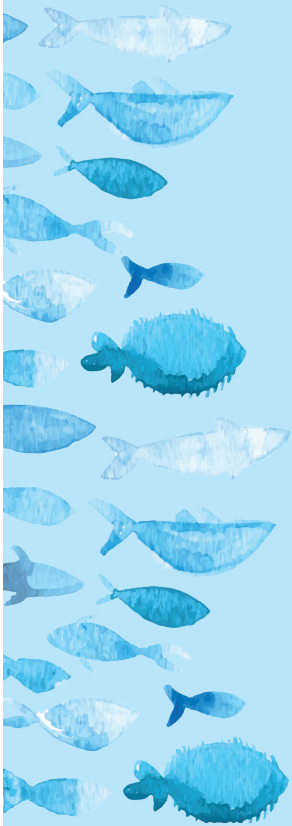
The conference takes place every two years and covers all topics of interest for aquaculture Accepted papers, presentations and posters are published on the Conference's website (https://hgk.hr/14th-international-aquaculture-conference-announcement) and, so far, papers from the previous 12 Conferences have been collected and published.

The conference traditionally takes place in the city of Vukovar, which is also the county seat as well as an educational, cultural, health and a tourist center. It is a city of rich cultural and historical heritage, located on the Danube bank with an important harbour on the halfway point of the waterway to the Black Sea.

Conference coordinator

mr.sc. Želimir Filić





Program

RASPORED DOGAĐANJA

DAN	Srijeda **29. ožujka 2023.**	Četvrtak **30. ožujka 2023.**	Petak **31. ožujka 2023.**
JUTRO		Otvaranje konferencije, pozdravni govori, konferencija za medije Radni dio	Radni dio Okrugli stol
PAUZA ZA RUČAK		Pauza za ručak	Pauza za ručak
POSLIJEPODNE	Registracija	Radni dio	Završetak konferencije
VEČER	Večera dobrodošlice	Večera	

EVENT **SCHEDULE**

DAY	Wednesday **29 March 2023**	Thursday **30 March 2023**	Friday **31 March 2023**
MORNING		Registration of participants, welcome and opening remarks, press conference Plenary session	Plenary and Poster session Roundtable
LUNCH BREAK		Lunch break	Lunch break
AFTERNOON	Registration	Plenary and Poster session	End of the conference
EVENING	Welcome dinner	Dinner	

1. DAN | 29. OŽUJKA 2023.

16.00 – 20.00	**Registracija sudionika**
20.00	**Večera dobrodošlice** Hotel Lav, Vukovar

2. DAN | 30. OŽUJKA 2023.

08.30 – 09.30	**Registracija sudionika**
09.30 – 10.00	**Otvaranje Konferencije** Plenarna izlaganja
10.00 – 10.10	**O Konferenciji** Želimir Filić, koordinator 14. Međunarodne konferencije o akvakulturi
10.10 – 10.30	**Does European freshwater aquaculture have a future?** Eugen Catalin Platon, predsjednik Rumunjske nacionalne asocijacije uzgajivača ribe Romfish
10.30 – 10.50	**Hrvatska akvakultura – stanje** Tatjana Boroša Pecigoš, Ministarstvo poljoprivrede, Uprava ribarstva
10.50 – 11.10	**Potpore sektoru akvakuture u RH** Irena Jahutka, Ministarstvo poljoprivrede, Uprava ribarstva

DAY 1 | 29 MARCH 2023

16.00 – 20.00	**Registration of participants**
20.00	**Welcome dinner** Hotel Lav, Vukovar

DAY 2 | 30 MARCH 2023

08.30 – 09.30	**Registration of participants**
09.30 – 10.00	**Welcome and opening remarks** Plenary session
10.00 – 10.10	**About the Conference – introduction** Želimir Filić, Conference coordinator
10.10 – 10.30	**Does European freshwater aquaculture have a future?** Eugen Catalin Platon, President, ROMFISH Romanian Fish Farmers Association
10.30 – 10.50	**Croatian aquaculture – overview** Tatjana Boroša Pecigoš, Ministry of Agriculture, Fisheries Directorate
10.50 – 11.10	**Support in the aquaculture sector in the Republic of Croatia** Irena Jahutka, Ministry of Agriculture, Fisheries Directorate

11.10 – 11.30	**Money, money, money – insight into the aquaculture subsidy system in the Czechia** Michal Kratochvil, direktor Udruženja ribarstva Češke Republike
11.30 – 11.50	**Recent developments in the EU market of fish and fish products from aquaculture (with introduction about Eurofish and activities)** Marco Frederiksen, direktor; Toni Bartulin, projekt Manager; Eurofish (International Organisation for the Development of Fisheries and Aquaculture in Europe)
11.50 – 12.10	**Rasprava** Svi sudionici
12.10 – 12.30	**Pauza**
12.30 – 12.50	**Innovations in hungarian aquaculture** Béla Halasi-Kovács, direktor Istraživačkog instituta za ribarstvo i akvakulturu HAKI iz Sarvaša u Mađarskoj, potpredsjednik FEAP-a
12.50 – 13.05	**Korištenje voda u revitalizaciji slatkovodnog uzgoja** Elizabeta Kos, Ministarstvo gospodarstva i održivog razvoja, Uprava vodnoga gospodarstva i zaštite mora
13.05 – 13.20	**Otpadne vode postrojenja za proizvodnju u akvakulturi – problem ili prilika?** Mirna Habuda-Stanić, Ana Gavrilović, Jurica Jug-Dujaković
13.20 – 13.30	**Rasprava** Svi sudionici
13.30 – 14.30	**Ručak**

11.10 – 11.30	**Money, money, money – insight into the aquaculture subsidy system in the Czechia** Michal Kratochvil, Director, Czech Fish Farmers´ Association
11.30 – 11.50	**Recent developments in the EU market of fish and fish products from aquaculture (with introduction about Eurofish and activities)** Marco Frederiksen, Director; Toni Bartulin, project manager; Eurofish (International Organisation for the Development of Fisheries and Aquaculture in Europe)
11.50 – 12.10	**Discussion** All participants
12.10 – 12.30	**Coffee break**
12.30 – 12.50	**Innovations in Hungarian aquaculture** Béla Halasi-Kovács, Director, Research Institute for Fisheries and Aquaculture, Szarvas, Hungary, Chairman of the Environment Commission, FEAP
12.50 – 13.05	**Water use in the revitalization of freshwater farming** Elizabeta Kos, Ministry of Economy and Sustainable Development, Directorate of Water Management and Sea Protection
13.05 – 13.20	**Aquaculture wastewater – problem or opportunity?** Mirna Habuda-Stanić, Ana Gavrilović, Jurica Jug-Dujaković
13.20 – 13.30	**Discussion** All participants
13.30 – 14.30	**Lunch break**

14.30 – 14.45	**Kontrola hrane za ribe** Silvia Križanac, Cromaris d.d.
14.45 – 15.00	**Potencijal iskorištenja otpada iz prerade slatkovodne ribe** Andreja Kovačević, Krešimir Mastanjević; PP Orahovica d.o.o.
15.00 – 15.15	**Prednosti i izazovi plutajućih solarnih panela – moguća uporaba na šaranskim ribnjacima** Daniel Matulić, Marko Karoglan, Željko Andabaka, Sanja Radman, Goran Fruk, Josip Leto, Tea Tomljanović
15.15 – 15.30	**Primjena otpada riblje industrije u uklanjanju mikotoksina FB1** Iva Čanak, Ksenija Markov, Željko Jakopović, Deni Kostelac, Renata Barić, Martina Ivešić, Željka Pavlek, Jadranka Frece
15.30 – 15.45	**Inovacije za razvoj održive marikulture: projekt I-MORE** Ivan Župan, Tomislav Šarić, Lav Bavčević, Bosiljka Mustać, Bruna Petani, Slavica Čolak, Petar Zuanović
15.45 – 16.00	**Rasprava** Svi sudionici
16.00 – 16.15	**Pauza**
16.15 – 16.30	**Mikobakterioze slatkovodnih riba kao zoonoze** Emil Gjurčević, Valerija Benko, Ljiljana Žmak, Andrea Gudan Kurilj, Nevijo Zdolec, Krešimir Matanović; Zavod za biologiju i patologiju riba i pčela, Veterinarski fakultet Sveučilišta u Zagrebu
16.30 – 16.45	**Overview of Freshwater Fish Diseases Situation in Western Balkans – Serbia, North Macedonia, and Bosnia and Herzegovina** Vladimir Radosavljević, Almedina Zuko, Aleksandar Cvetkovikj

14.30 – 14.45	**Fish feed control** Silvia Križanac, Cromaris d.d.
14.45 – 15.00	**Perspective of waste utilization in freshwater fish industry** Andreja Kovačević, Krešimir Mastanjević, PP Orahovica d.o.o.
15.00 – 15.15	**Advantages and challenges of floating photovoltaics – possible application on freshwater ponds** Daniel Matulić, Marko Karoglan, Željko Andabaka, Sanja Radman, Goran Fruk, Josip Leto, Tea Tomljanović
15.15 – 15.30	**Application of fish industry waste in the removal of mycotoxin FB1** Iva Čanak, Ksenija Markov, Željko Jakopović, Deni Kostelac, Renata Barić, Martina Ivešić, Željka Pavlek, Jadranka Frece
15.30 – 15.45	**Innovations for development of sustainable aquaculture in Croatia: project I-MORE** Ivan Župan, Tomislav Šarić, Lav Bavčević, Bosiljka Mustać, Bruna Petani, Slavica Čolak, Petar Zuanović
15.45 – 16.00	**Discussion** All participants
16.00 – 16.15	**Coffee break**
16.15 – 16.30	**Mycobacteriosis of freshwater fish as zoonoses** Emil Gjurčević, Valerija Benko, Ljiljana Žmak, Andrea Gudan Kurilj, Nevijo Zdolec, Krešimir Matanović; Department for Biology and Pathology of Fish and Bees - Faculty of Veterinary Medicine, University of Zagreb
16.30 – 16.45	**Overview of Freshwater Fish Diseases Situation in Western Balkans – Serbia, North Macedonia, and Bosnia and Herzegovina** Vladimir Radosavljević, Almedina Zuko, Aleksandar Cvetkovikj

16.45 – 17.00	**Biosigurnost u šaranskoj proizvodnji** Miloš Pelić, Dušan Lazić, Nikolina Novakov, Vladimir Radosavljević, Ana Gavrilović, Jurica Jug-Dujaković, Milica Živkov Baloš, Dragana Ljubojević Pelić
17.00 – 17.15	**Upravljanje zdravljem u akvakulturi** Dražen Oraić, Ivana Giovanna Zupičić, Snježana Zrnčić
17.15 – 17.30	**Nove spoznaje o ekološkim zahtjevima uzročnika saprolegnioze, te razvoj metoda praćenja i ekološki prihvatljivih metoda suzbijanja bolesti** Ana Bielen, Dora Pavić, Anđela Miljanović, Dorotea Grbin
17.30 – 17.45	**Pojavnost virusa zarazne nekroze gušterače salmonida u Bosni i Hercegovini** Amina Jažić, Toni Eterović, Almedina Zuko, Adnan Jažić
17.45 – 18.00	**Bolesti koje ugrožavaju školjkaše u Jadranskom moru** Ivana Giovanna Zupičić, Dražen Oraić, Snježana Zrnčić
18.00 – 18.15	**Pokusna proizvodnja i primjena autolognih cjepiva u uzgoju lubina (*Dicentrarchus labrax*)** Snježana Zrnčić, Ivana Giovanna Zupičić, Dražen Oraić
18.15 – 18.30	**Bolesti u kaveznom uzgoju zubaca** Danijel Mejdandžić, Cromaris d.d.
18.30 – 19.00	**Rasprava** Svi sudionici
14.30 – 19.00	**Poster sekcija**
20.00	**Zajednička večera** Polazak autobusom u 19.45 ispred hotela

16.45 – 17.00	**Biosafety in carp production** Miloš Pelić, Dušan Lazić, Nikolina Novakov, Vladimir Radosavljević, Ana Gavrilović, Jurica Jug-Dujaković, Milica Živkov Baloš, Dragana Ljubojević Pelić
17.00 – 17.15	**Health Management in Aquaculture** Dražen Oraić, Ivana Giovanna Zupičić, Snježana Zrnčić
17.15 - 17.30	**Novel insights into monitoring, ecological requirements and methods for environmentally acceptable control of saprolegniosis** Ana Bielen, Dora Pavić, Anđela Miljanović, Dorotea Grbin
17.30 – 17.45	**Occurrence of Infectious Pancreatic Necrosis Virus of Salmonids in Bosnia and Herzegovina** Amina Jažić, Toni Eterović, Almedina Zuko, Adnan Jažić
17.45 – 18.00	**Diseases threatening mollusks in the Adriatic Sea** Ivana Giovanna Zupičić, Dražen Oraić, Snježana Zrnčić
18.00 – 18.15	**Experimental production and application of autologous vaccines in European seabass (*Dicentrachus labrax*) farming** Snježana Zrnčić, Ivana Giovanna Zupičić, Dražen Oraić
18.15 – 18.30	**Diseases in cage farming of Common dentex** Danijel Mejdandžić, Cromaris d.d.
18.30 – 19.00	**Discussion** All participants
14.30 – 19.00	**Poster session**
20.00	**Dinner** Departure by bus at 19.45 in front of the hotel

3. DAN | 31. OŽUJKA 2023.

09.00 – 13.00	**Plenarna i poster izlaganja**
09.00 – 09.15	**Akvakultura i interakcija s okolišem** Aljoša Duplić, Zavod za zaštitu okoliša i prirode
09.15 – 09.30	**Farming and conservation: two sides of the same coin?** Paolo Bronzi, predsjednik, Svjetsko udruženje za zaštitu jesetre (WSCS)
09.30 – 09.45	**LIFE-Boat4Sturgeon and the implementation of the Pan-EU AP for Sturgeons in the Danube River Basin** Thomas Friedrich, University of Natural Resources and Life Sciences, Vienna, Institute of Hydrobiology and Aquatic Ecosystem Management, Austria
09.45 – 10.00	**Mogućnosti za uzgoj jesetarskih riba u akvakulturi Srbije** Nikolina Novakov, Miloš Pelić, Dušan Lazić, Dragana Ljubojević Pelić, Brankica Kartalović, Vladimir Radosavljević
10.00 – 10.15	**Može li uzgoj tune biti održiv?** Ivan Katavić, Institut za oceanografiju i ribarstvo
10.15 – 10.30	**Označavanje plavoperajnog tuna (*Thunnus t*hynnus) mikročipovima za potrebe utvrđivanja individualnog rasta u kaveznom uzgoju** Leon Grubišić, Ivan Katavić, Jasna Maršić Lučić, Marino Urlić, Tanja Šegvić-Bubić

DAY 3 | 31 MARCH 2023

09.00 – 13.00	**Plenary and Poster sessions**
09.00 – 09.15	**Aquaculture and interaction with the environment** Aljoša Duplić, The Institute for Environmental and Nature Protection
09.15 – 09.30	**Farming and conservation: two sides of the same coin?** Paolo Bronzi, President, WSCS (World Sturgeon Conservation Society)
09.30 – 09.45	**LIFE-Boat4Sturgeon and the implementation of the Pan-EU AP for Sturgeons in the Danube River Basin** Thomas Friedrich - University of Natural Resources and Life Sciences, Vienna, Institute of Hydrobiology and Aquatic Ecosystem Management, Austria
09.45 – 10.00	**Potential of sturgeon farming in Serbian aquaculture** Nikolina Novakov, Miloš Pelić, Dušan Lazić, Dragana Ljubojević Pelić, Brankica Kartalović, Vladimir Radosavljević
10.00 – 10.15	**Can tuna farming be sustainable?** Ivan Katavić, Institute of Oceanography and Fisheries
10.15 – 10.30	**Tagging of bluefin tuna (*Thunnus thynnus*) with microchips for the needs of individual growth estimate in cage culture** Leon Grubišić, Ivan Katavić, Jasna Maršić Lučić, Marino Urlić, Tanja Šegvić-Bubić

10.30 – 10.45	**Kavezni uzgoj gofa (*Seriola dumerili)* u Sredozemlju: smjernice za održivo upravljanje** Tanja Šegvić-Bubić, Igor Talijančić, Iva Žužul, Luka Žuvić, Leon Grubišić, David Izquierdo-Gomez
10.45 – 11.00	**Nutritivna kvaliteta morske ribe uzgojene u Jadranskom moru** Jelka Pleadin, Greta Krešić, Dražen Oraić, Tina Lešić, Ana Vulić, Nina Kudumija, Snježana Zrnčić
11.00 – 11.15	**Pauza**
11.15 – 11.30	**Integrirani sustav uzgoja alternativnih vrsta školjkaša u uvjetima klimatskih promjena** Jadranka Frece, Prehrambeno-biotehnološki fakultet Sveučilišta u Zagrebu
11.30 – 11.45	**Rizici za hrvatsko školjkarstvo uslijed invazije stranih vrsta u Jadranskom moru** Branko Glamuzina, Sveučilište u Dubrovniku
11.45 – 12.00	**Korištenje microgAMBI indeksa za brzu procjenu ekološkog stanja u uvjetima akvakulture** Anamarija Kolda, Ana Gavrilović, Jurica Jug-Dujaković, Angel Borja, Zrinka Ljubešić, Mansour El-Matbouli, Atle Lillehaug, Semir Lončarević, Lorena Perić, Kristina Pikelj, Brigita Hengl, Dražen Knežević, Darija Vukić Lušić, Damir Kapetanović
12.00 – 12.15	**Istraživanje okolišnih uvjeta unutar dva važna područja uzgoja školjkaša na istočnoj obali Jadrana** Lorena Perić, Damir Kapetanović, Karla Orlić, Jakša Bolotin, Valter Kožul, Vedrana Nerlović, Svjetlana Bobanović-Ćolić, Fran Barac, Petra Burić, Sandra Marinac-Pupavac, Željko Linšak, Sanda Antunović, Paula Žurga

10.30 – 10.45	**Net-pen culture of *Seriola dumerili* in Mediterranean: implications for the sustainable management** Tanja Šegvić-Bubić, Igor Talijančić, Iva Žužul, Luka Žuvić, Leon Grubišić, David Izquierdo-Gomez
10.45 – 11.00	**Nutritional quality of marine fish grown in the Adriatic Sea** Jelka Pleadin, Greta Krešić, Dražen Oraić, Tina Lešić, Ana Vulić, Nina Kudumija, Snježana Zrnčić
11.00 – 11.15	**Coffee break**
11.15 – 11.30	**Integrated Growing System for Alternative Shellfish species in Climate Change Terms** Jadranka Frece, Faculty of Food Technology and Biotechnology, University of Zagreb
11.30 – 11.45	**Potential risks for Croatian shellfish culture due to the invasion of non-native species in the Adriatic Sea** Branko Glamuzina, The University of Dubrovnik
11.45 – 12.00	**Use of microgAMBI index for fast ecological assessment of aquaculture environment** Anamarija Kolda, Ana Gavrilović, Jurica Jug-Dujaković, Angel Borja, Zrinka Ljubešić, Mansour El-Matbouli, Atle Lillehaug, Semir Lončarević, Lorena Perić, Kristina Pikelj, Brigita Hengl, Dražen Knežević, Darija Vukić Lušić, Damir Kapetanović
12.00 – 12.15	**A survey of environmental conditions at two distinct eastern Adriatic bivalve aquaculture sites** Lorena Perić, Damir Kapetanović, Karla Orlić, Jakša Bolotin, Valter Kožul, Vedrana Nerlović, Svjetlana Bobanović-Ćolić, Fran Barac, Petra Burić, Sandra Marinac-Pupavac, Željko Linšak, Sanda Antunović, Paula Žurga

12.15 – 12.30	**Dinamika i raznolikost bakterijske zajednice Vibrio u akvakulturi školjkaša s naglaskom na antibiotsku rezistenciju** Karla Orlić, Snježana Kazazić, Damir Kapetanović, Irena Vardić-Smrzlić, Anamarija Kolda, Jakša Bolotin, Valter Kožul, Tonka Buha, Vedrana Nerlović, Svjetlana Bobanović-Ćolić, Lorena Perić
12.30 – 12.45	**Onečišćenje morskog i obalnog ekosustava mikroplastikom – utjecaj na akvakulturu** Mihaljević Željko, Ivan Sršen, Osvin Pečar, Miroslav Benić, Šimun Naletilić
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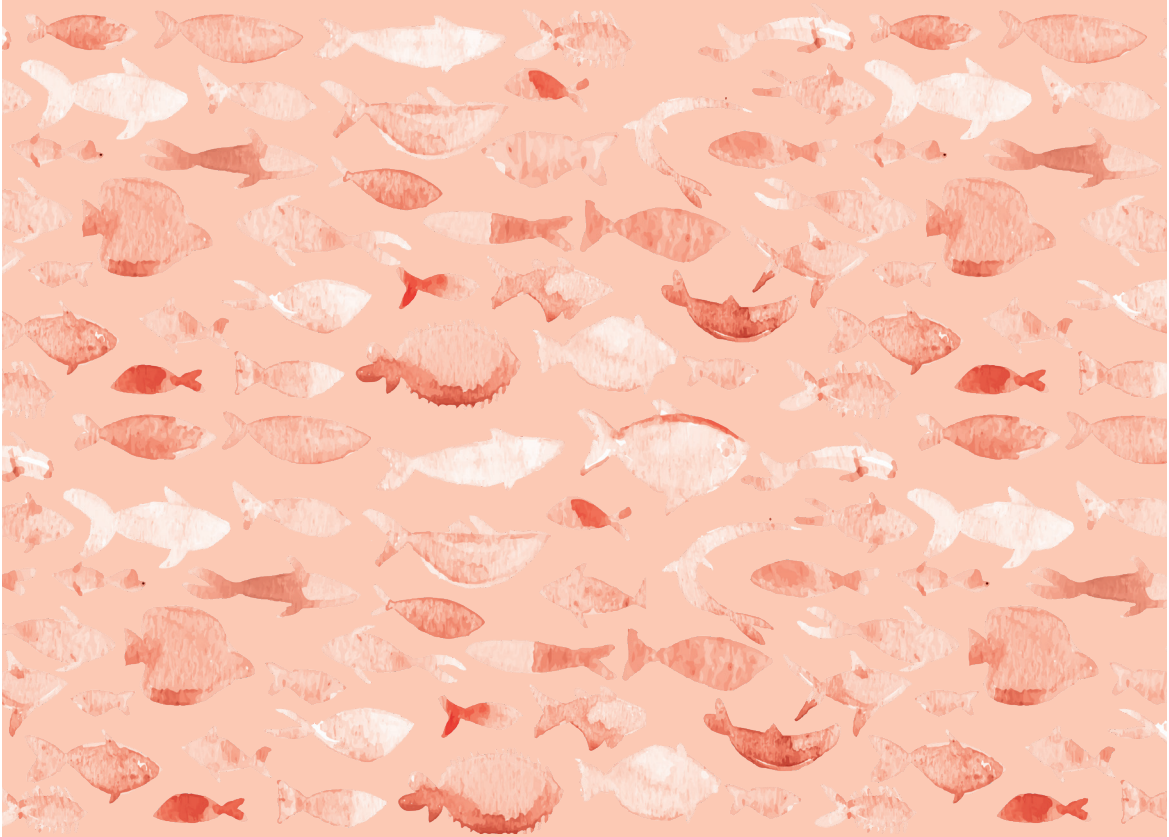
13.00 – 14.00	**Okrugli stol** Zatvaranje konferencije
14.00	**Ručak**

12.15 – 12.30	**Dynamics and diversity of Vibrio community in bivalve aquaculture with focus on antibiotic resistance** Karla Orlić, Snježana Kazazić, Damir Kapetanović, Irena Vardić-Smrzlić, Anamarija Kolda, Jakša Bolotin, Valter Kožul, Tonka Buha, Vedrana Nerlović, Svjetlana Bobanović-Ćolić, Lorena Perić
12.30 - 12.45	**Microplastic pollution of marine and coastal ecosystems – impact on aquaculture** Mihaljević Željko, Ivan Sršen, Osvin Pečar, Miroslav Benić, Šimun Naletilić
12.45 - 13.00	**Diagnostics of fish viral diseases in freshwater aquaculture** Dušan Lazić, Miloš Pelić, Vladimir Radosavljević, Nikolina Novakov
13.00 – 14.00	**Roundtable** Closing of the conference
14.00	**Lunch**

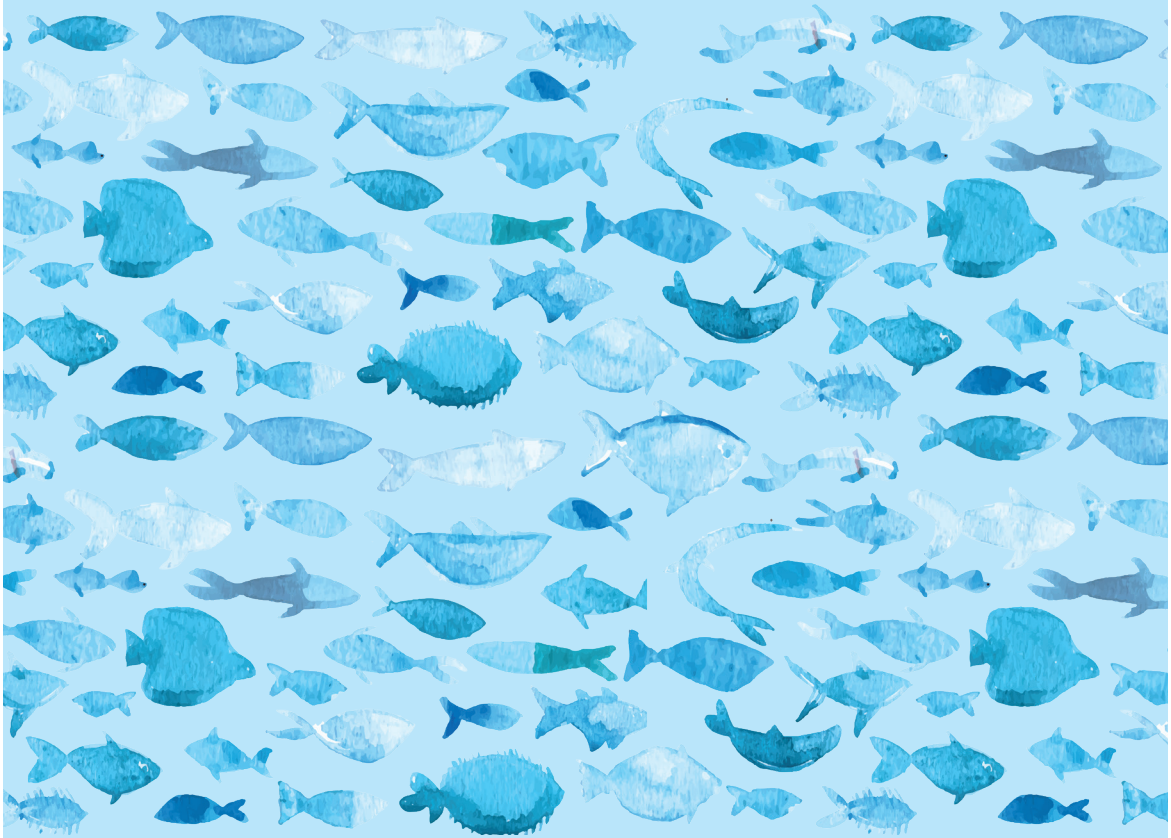


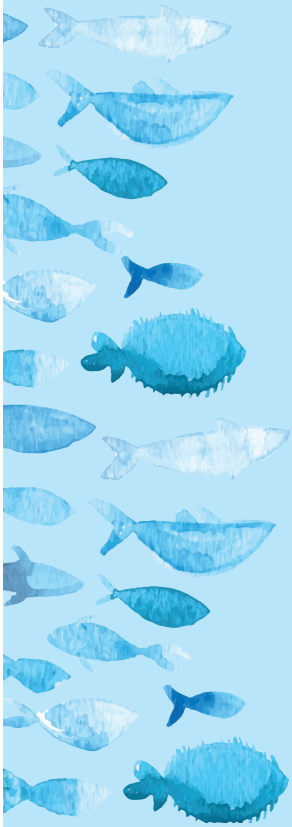
Poster sekcija

30. ožujka 2023. | 14.30 – 19.00
31. ožujka 2023. | 09.00 – 13.00

Poster session

30 March 2023 | 14.30 – 19.00
31 March 2023 | 09.00 – 13.00





Zbornik sažetaka

Book of Abstracts

Does European freshwater aquaculture have a future?

Eugen Cătălin Platon

ROMFISH – Romanian Fish Farmers' Association, Bd. Nicolae Iorga nr. 12A, et. 1, bir. 2. Iaşi, RO-700224, Romania
e-mail: asromfish@gmail.com

Abstract

In the last decades, aquaculture started to be seen as a viable complementary source to capture fisheries in providing high-quality protein for human consumption. It could seem that this direction is new, and aquaculture is an activity that has caught the eyes of policymakers and business developers. But aquaculture has, in Europe also, a millennial tradition and was developed to provide local communities with aquatic food in a duly manner, when needed and with a high degree of freshness. It has built up slowly and steadily throughout the centuries based on farmers' empirical knowledge, failures and successes, either on direct or mediated communication, organically integrated into the social, environmental and economic society fabric. Thus, pond aquaculture developed aqua-ecosystems (aquaculture-based ecosystems) for which research done recently identified 41 potential Ecosystem Services (10 provisioning, 20 regulation, and maintenance, 11 cultural). These types of wetlands are amongst the most productive ecosystems on earth and are of great economic and cultural importance to mankind.

It is considered that after WWII, aquaculture was the fastest-growing food system, and many thought that such a promising start might have brought a role not to complement capture fisheries but to replace it. However, Europe, after 1990, registered the most modest growth rate among the other continents. Just 27.82% of EU aquatic food consumption comes from aquaculture, and only about half of it comes from EU aquaculture. Efforts have been made in the last decade to understand the causes of this and how to boost EU aquaculture production. Several bottlenecks were identified, such as unjustified administrative burden, demanding access to freshwater and marine space, low aquaculture literacy of the general public and administrative decision makers, and low attractivity for young people and investors. Above all, these two structural hindrances are distinguished: firstly, the lack of similar development tools as in agricultural CAP, mainly related to Pillar 1, and secondly, the overcrowded institutional regulatory environment for aquaculture. As

a general conclusion emerging from this analysis, it could be stated that the future of EU aquaculture relies on the institutional capacity to make it attractive for the next generation, similar to other agricultural activities.

Keywords: aquaculture, policies

Otpadne vode postrojenja za proizvodnju u akvakulturi – problem ili prilika?

prof. dr. sc. Mirna Habuda-Stanić[1], izv. prof. dr. sc. Ana Gavrilović[2], dr. sc. Jurica Jug-Dujaković[3]*

[1] Sveučilište Josipa Jurja Strossmayera u Osijeku, Prehrambeno-tehnološki fakultet Osijek, Franje Kuhača 18, 31000 Osijek, Hrvatska
[2] Sveučilište u Zagrebu, Agronomski fakultet, Svetošimunska cesta 25, 10000 Zagreb, Hrvatska
[3] Sustainable Aquaculture Systems Inc., 715 Pittstown Road, Frenchtown, NJ 08825, Sjedinjene Američke Države
[*] e-mail: habudastanic@gmail.com

Sažetak

Otpadna voda nastala u izgrađenim proizvodnim pogonima za uzgoj vodenih organizama specifičnog je sastava kojeg karakteriziraju visoki udjeli spojeva dušika te produkti metabolizma vodenih organizama i ostatci nepojedene hrane. Težnja k održivosti i nužno usklađivanje svih proizvodnih grana sa smjernicama Europskog Zelenog plana, rezultirala je sve rjeđim ispuštanjem navedenih visokoopterećenih otpadnih voda u okoliš te iznalaženjem mogućnosti za njihovu ponovnu upotrebu. U ovom radu opisane su prednosti i nedostatci zbrinjavanja otpadnih voda koji nastaju tijekom uzgoja u akvakulturi. Opisan je postupak direktne aplikacije otpadne vode na poljoprivredna zemljišta koja, uslijed nastanka neugodnih mirisa i primamljivanja insekata te velikog rizika za biosigurnost, nije dozvoljena u zemljama Europske unije, no ima učestalu primjenu na globalnoj razini. Navedena je i primjena otpadne vode u bioplinskim postrojenjima gdje se otpadna voda miješa s ostalim poljoprivrednim otpadom i koristi kao sirovina za proizvodnju bioplina. Opisana je mogućnost korištenja umjetnih močvara (tzv. Reed Bed tehnologija) dizajniranih za pročišćavanje otpadnih voda djelovanjem složenih bioloških, kemijskih i fizikalnih mehanizama. Također je opisana mogućnost zbrinjavanja otpadne vode iz proizvodnje u akvakulturi kod akvaponskih sustava gdje se kombinira konvencionalni sustav uzgoja u akvakulturi i hidroponija koja za biljnu proizvodnju ne koristi tlo, već se biljke uzgajaju u vodenoj otopini hranjivih tvari.

Ključne riječi: otpadne vode, akvakultura, akvaponski sustavi, proizvodnja bioplina

Aquaculture wastewater – problem or opportunity?

Mirna Habuda-Stanić, PhD, Full Prof.[1], Ana Gavrilović, PhD, Assoc. Prof.[2], Jurica Jug-Dujaković, PhD[3]*

[1] University of Josip Juraj Strossmayer in Osijek, Faculty of Food Technology Osijek, Franje Kuhača 18, Osijek, Croatia
[2] University of Zagreb Faculty of Agriculture, Svetošimunska cesta 25, 10000 Zagreb, Croatia
[3] Sustainable Aquaculture Systems Inc., 715 Pittstown Road, Frenchtown, NJ 08825, United States of America
[*] e-mail: habudastanic@gmail.com

Abstract

The wastewater generated in the production plants built for the cultivation of aquatic organisms has a specific composition characterized by high proportions of nitrogen compounds formed as products of the metabolism of cultivated organisms and remains of uneaten food. The pursuit of sustainability and the necessary alignment of all production branches with the guidelines of the European Green Plan, resulted in a significant reduction in the release of the aforementioned highly loaded wastewater into the environment and in finding opportunities for their reuse.This paper describes the advantages and disadvantages of the disposal of wastewater generated during aquaculture production processes. The procedure of direct application of wastewater to agricultural land is described, which, due to the creation of unpleasant odors and the attraction of insects and the high risk for biosecurity, is not allowed in the countries of the European Union, but is frequently used in a global level, then the application of wastewater in biogas plants where wastewater is mixed with other agricultural waste and used as a raw material for the production of biogas. There is the possibility of using aquaculture wastewater in artificial wetlands (so-called Reed Bed technology) intended for wastewater purification through the action of complex biological, chemical and physical mechanisms, as well as the possibility of wastewater disposal in aquaponic systems that combine conventional aquaculture production with hydroponics that does not use soil for plant production, but plants are grown in an aqueous solution of nutrients.

Keywords: wastewater, aquaculture, aquaponics, biogas production

Kontrola kvalitete riblje hrane

Silvia Križanac

Cromaris d.d., Gaženička cesta 4b, Zadar; e-mail: silvia.krizanac@cromaris.hr

Sažetak

Razvoj vlastitih formulacija riblje hrane u Cromarisu započeo je 2016. godine te napravio potpuni zaokret novim pristupom i odmakom od industrijske hrane. Vizija i inovativnost ogledaju se u ideji razvoja vlastite riblje hrane kojom se može postići nutritivno uravnotežen gotov proizvod unificiranog sastava. Cromaris na taj način svojim potrošačima omogućuje ribu bogatu omega-3 masnim kiselinama, s povoljnim omjerom omega-3 i omega-6 masnih kiselina te vitaminima i visokoprobavljivim proteinima. Receptura riblje hrane kontinuirano se optimizirala kako prema specifičnim potrebama pojedine vrste tako prema dostupnosti održivih sirovina. Posljednjih godina povećan je udio održivih sirovina, posebno ribljeg brašna i ulja od ribljih nusproizvoda. Znatno se smanjuje i količina ribljeg ulja od ribe iz ulova, na 8 % s prijašnjih 10 – 13 %.

Najviša razina kvalitete riblje hrane, kontrola i zaštita vlastitih formulacija provodi se na četiri razine: redovitim provjerama dobavljača kroz audite, kontrolom hrane u vlastitom laboratoriju, kontrolom hrane u vanjskim akreditiranim laboratorijima, krajnjom kontrolom ispitivanja hrane na eksperimentalnoj platformi na uzgajalištu.

Pokretanjem vlastitog laboratorija za kontrolu kvalitete riblje hrane povećali smo sukladnost hrane do 95% u odnosu na tehničke specifikacije. Svake se godine radi na istraživanju i implementaciji novih metoda za kontrolu kemijskih i fizikalnih parametara riblje hrane. Posljednja metoda koja je uvedena su kemijske analize udjela amino i masnih kiselina, što pridonosi boljem razumijevanju i kontroli sirovina uključenih u riblju hranu.

Znatan porast cijena sirovina koje se upotrebljavaju u proizvodnji riblje hrane prepoznat je kao jedan od ključnih ekonomskih utjecaja za poslovanje Cromarisa. Cijene najvažnijih sirovina za proizvodnju riblje hrane aktivno se prate još od 2012. godine. Od početka praćenja, a posebno je to izraženo tijekom 2021. godine, sve sirovine bilježe konstantan rast cijena. Pandemija koronavirusa dodatno je narušila lance opskrbe te je zabilježen manjak pojedinih sirovina na tržištima. Sve navedeno zahtijeva pravovremenu reakciju Cromarisovih stručnjaka i fleksibilnost u izmjenama formulacija kako bi se zadržala nutritivna vrijednost hrane uz optimalne troškove.

Fish feed quality control

Silvia Križanac

Cromaris d.d., Gaženička cesta 4b, Zadar; e-mail: silvia.krizanac@cromaris.hr

Abstract

The development of specific fish feed formulations in Cromaris started in 2016. It took a complete turn with a new approach and took us away from industrial fish feed. Vision and innovation are reflected in the idea of developing our own fish feed, which can achieve a nutritionally balanced finished product with a unified composition. In this way, Cromaris provides its consumers with fish rich in omega-3 fatty acids, with a favorable ratio of omega-3 and omega-6 fatty acids, as well as vitamins and highly digestible proteins. The recipe for fish feed has been continuously optimized both according to the specific needs of each species and according to the availability of sustainable raw materials. In recent years, the share of sustainable raw materials has increased, especially fish meal and oil from fish by-products. The amount of fish oil from the catch is also significantly reduced to 8% from the previous 10-13%.

The highest level of fish feed quality, control and protection of our own formulations is carried out on four levels: regular checks of suppliers through audits, feed control in our own laboratory, feed control in external accredited laboratories, final control of feed testing on the experimental platform at the farm.

With the implementation of our laboratory for quality control of fish feed we increased conformity on feed up to 95% according to technical specifications. We are researching and implementing new methods for chemical and physical parameters control of the feed every year. The latest method that was implemented is the chemical analysis of amino and fatty acids profiles for fish feed, which contributes to a better understanding and the control of raw materials included in the feed.

A significant increase in the prices of raw materials used in the production of fish feed is recognized as one of the key economic influences for the business of Cromaris. The prices of the most important raw materials for the production of fish feed have been actively monitored since 2012. Since the beginning of monitoring, and this was especially pronounced during 2021, all raw materials have recorded a constant increase in prices. The coronavirus pandemic further disrupted supply chains, and a shortage of certain raw materials was recorded on the markets. All of the above requires the preparedness of Cromaris' experts, flexibility in changing formulations, but also a timely reaction in order to maintain the nutritional value of food at optimal costs.

Potencijal iskorištavanja otpada iz prerade slatkovodne ribe

mag. ing. proc. Andreja Kovačević[1], izv. prof. dr. sc. Krešimir Mastanjević[2]*

[1] PP Orahovica d.o.o., Pustara 1, 33 513 Zdenci, Croatia
[2] Josip Juraj Strossmayer University of Osijek, Faculty of Food Technology, Franje Kuhača 20, 31 000 Osijek, Croatia
[*] e-mail: andreja.kovacevic@agroinvestgrupa.hr

Sažetak

Šaran (*Cyprinus carpio*), tolstolobik (*Hypophthalmichthys molitrix V.*), amur (*Ctenopharyngodon idella*) i som (*Silurus glanis*) dominantne su vrste slatkovodne ribe koja se uzgaja u tvrtki PP Orahovica, a koje prerađuje više od 2.000 t ribe godišnje. U sljedećih nekoliko godina taj broj se planira povećati za barem 50%. Kao rezultat tako velike proizvodnje i prerade slatkovodne ribe, dostupna je velika količina otpada, poput otpadnih voda i krutog otpada. Aktivnosti prerade slatkovodne ribe stvaraju potencijalno velike količine organskog otpada i nusproizvoda iz nejestivih dijelova ribe. Međutim, sav nejestivi riblji otpad mogao bi se iskoristiti, a ne odlagati kao otpad. Gospodarenje ribljim otpadom prepoznato je kao značajan problem koji ima velik utjecaj na okoliš. Obrađeni riblji otpad može se koristiti kao hrana za životinje, prirodnim pigmentima (nakon ekstrakcije), kozmetici (kolagen), za izolaciju enzima, imobilizaciju Cr, kao gnojivo u tlu i za održavanje vlage u hrani (hidrolizati) ili čak za proizvodnju biodizela/bioplina. Stoga je ova studija imala za cilj istražiti metodu za najoptimalniju preradu otpada u tvornici za preradu slatkovodne ribe te odrediti nutritivni sastav ribljeg otpada uključujući proteine, lipide i ugljikohidrate kao i sadržaj vlage i pepela. Tri metode/tehnologije odabrane su kao najzanimljivije za tvrtku PP Orahovica: ekstrakcija kolagena/želatine iz ribljeg otpada, proizvodnja hidrolizata ribljih proteina, te proizvodnja ribljeg brašna, ribljeg ulja, komposta, biognojiva i sl.

Ključne riječi: slatkovodna riba, otpad, hidrolizati proteina, riblje brašno, kolagen

Prespective of waste utilization in freshwater fish industry

Andreja Kovačević[1], mag. ing. proc, izv. prof. dr. sc. Krešimir Mastanjević[2]*

[1] PP Orahovica d.o.o., Pustara 1, 33 513 Zdenci, Croatia
[2] Josip Juraj Strossmayer University of Osijek, Faculty of Food Technology, Franje Kuhača 20, 31 000 Osijek, Croatia
[*] e-mail: andreja.kovacevic@agroinvestgrupa.hr

Abstract

Common carp (*Cyprinus carpio*), silver carp (*Hypophthalmichthys molitrix*), grass carp (*Ctenopharyngodon idella*) and Wels catfish (*Silurus glanis*) are dominant species of freshwater fish produced and processed in company PP Orahovica, which processes more than 2.000 t of fish per year. In the next few years, this number is planned to be higher for at least 50%. As a result of such high production and processing of freshwater fish, a large amount of organic waste, such as wastewater and solid waste, is available. Freshwater fish processing activities generate potentially large quantities of organic waste and by-products from inedible fish parts. However, all inedible fish waste could be utilized rather than disposed as waste. Fish waste management has been recognized as a significant problem having a great impact on the environment. Treated fish waste can be utilized as animal feed, in dietetic products (chitosan), natural pigments (after extraction), food-packaging applications (chitosan), cosmetics (collagen); for enzyme isolation, Cr immobilisation, soil fertiliser and moisture maintenance in foods (hydrolysates) or even for biodiesel/ biogas production. Thus this study aimed to investigatewaste utilization of freshwater fish industry at freshwater fish factory in order to determine the most applicable technology for waste management and to approximately analyze and determine the nutritional composition of fish waste including protein, lipid, and carbohydrates as well as moisture and ash content. Three methods/technologies were selected as the most interesting for the company PP Orahovica: extraction of collagen/gelatine from fish waste, production of fish protein hydrolysates, and production of fish meal, fish oil, compost, bio-fertilizer etc.

Keywords: freshwater fish, waste, protein hydrolysates, fish meal, colagen

Prednosti i izazovi plutajućih solarnih panela – moguća uporaba na šaranskim ribnjacima

Izv.prof.dr.sc. Daniel Matulić, Prof.dr.sc. Marko Karoglan, Izv.prof.dr.sc. Željko Andabaka, Izv.prof.dr.sc. Sanja Radman, Izv.prof.dr.sc. Goran Fruk, Prof.dr.sc. Josip Leto, Prof.dr.sc. Tea Tomljanović*

Sveučilište u Zagrebu Agronomski fakultet, Svetošimunska 25, Zagreb, Hrvatska
** e-mail: dmatulic@agr.hr*

Sažetak

Značajno povećanje potražnje za električnom energijom, ubrzano iscrpljivanje fosilnih goriva i zabrinutost za ekologiju okoliša diljem svijeta doveli su do velike potražnje za obnovljivim izvorima energije. Među ostalim obnovljivim izvorima, solarna energija je čist i neiscrpan oblik obnovljivog izvora energije koji se može iskoristiti putem fotonaponskih (PV) sustava. Poznato je da instalacija solarnih panela zahtijeva veliki prostor. PV sustavi tradicionalno se postavljaju na tlo ili krovove, dok su se posljednjih godina razvili i plutajući fotonaponski (FPV) sustavi na vodenim površinama. Kombinacija plutajućih solarnih panela i akvakulture ('akvavoltik') nudi potencijalne koristi za oba sektora, uz brojne izazove. Svjetska populacija je u porastu a proporcionalno i kompeticija za zemlju te time koncepti dvostruke namjene u poljoprivredi i akvakulturi postaju ključna rješenja. 'Akvavoltik' tehnologija omogućuje proizvodnju električne energije i provođenje akvakulture na istom području, značajno poboljšavajući ukupnu produktivnost po jedinici površine u usporedbi s tradicionalnim korištenjem zemljišta. Pri usporedbi s kopnenim PV sustavima, a zbog prednosti hlađenja koju pruža vodena površina, prinos električne energije FPV sustava moguće je i poboljšati. Jedan od glavnih sinergijskih učinaka spajanja PV sustava s akvakulturom je ušteda vode smanjenjem isparavanja. U sustavima akvakulture koji imaju veliku propusnost vode, sprječavanje gubitka vode velika je prednost i s ekonomskog i s ekološkog gledišta. 'Akvavoltik' sustavi stvaraju hlad na vodenoj površini ribnjaka, dok blokiranu svjetlost apsorbiraju solarni paneli i pretvaraju u iskoristivu energiju. Ako se zasjenjenje panelima nekontrolirano povećava, rast algi, vegetacija i mikrobna gustoća vodenog sustava može se smanjiti, utječući tako na cijeli hranidbeni lanac sve do organizma u uzgoju. To dakako ovisi i o mnogim dodatnim varijablama kao što su vrsta i kategorija riba te intenzitet uzgoja, odabran FPV sustav, itd.

Vjerojatno je da će svaki scenarij za implementaciju FPV sustava na šaranske ribnjake morati biti pojedinačno analiziran i procijenjen kako bi se osiguralo da možebitne koristi nadmašuju potencijalne negativne utjecaje. Stoga, nužna su daljnja istraživanja utjecaja FPV sustava na kvalitetu vode i vodene organizme.

Ključne riječi: akvakultura, energija, okoliš, plutajući fotonaponski sustav, 'akvavoltik', sinergija

Advantages and challenges of floating photovoltaics – possible application on freshwater ponds

Daniel Matulić, Marko Karoglan, Željko Andabaka, Sanja Radman, Goran Fruk, Josip Leto, Tea Tomljanović*

University of Zagreb Faculty of Agriculture, Svetošimunska 25, Zagreb, Croatia
** e-mail: dmatulic@agr.hr*

Abstract

A significant increase in electricity demand, rapid depletion of fossil fuels, and environmental concerns around the world have led to a great need for renewable energy sources. Among other renewables, solar energy is a clean and inexhaustible source of energy that can be harnessed through photovoltaic (PV) systems. It is well known that the installation of solar panels requires a large amount of space, and while PV systems have traditionally been mounted on the ground or on roofs, in recent years floating photovoltaic (FPV) has developed on the surface of the water. The combination of photovoltaics and aquaculture, as represented by aquavoltaics, offers potential benefits for both sides, in addition to many challenges. As the world's population grows and competition for land increases, dual-use concepts in agriculture and aquaculture are becoming essential solutions. Aquavoltaic technology allows electricity to be generated and aquaculture to be carried out in the same land area, significantly improving overall productivity per unit area compared to traditional land use. Compared to land-based PV systems, the electricity yield may also be slightly improved, likely due to the cooling advantage provided by the underlying water surface. One of the main synergistic effects of coupling PV systems with aquaculture is the saving of water by reducing evaporation. In aquaculture systems that have a high water throughput, the prevention of water loss is of great advantage from both an economic and environmental point of view. Aquavoltaic systems provide shade on the water surface of the fish pond, and the blocked light is absorbed by the solar panels and converted into usable energy. If shading increases uncontrolled, algal growth, general plant life, and microbial density can decrease, affecting the entire food chain all the way to the fish that are to be cultured. This depends on many variables, such as fish species and categories, culture intensity, FPV system, etc. It is likely that each scenario for FPV deployment in carp ponds will need to be analyzed and evaluated

individually to ensure that the potential benefits outweigh any potential negative impacts. Therefore, more research is needed to understand the effects of the floating photovoltaic system on aquatic life.

Keywords: aquaculture, energy, environment, floating photovoltaic, aquavoltaics, synergistic

Primjena otpada riblje industrije u uklanjanju mikotoksina FB_1

dr.sc. Iva Čanak[1], prof.dr.sc. Ksenija Markov[1], dr.sc. Željko Jakopović[1], dr.sc. Deni Kostelac[1], dr.sc. Renata Barić[2], dr.sc. Martina Ivešić[3], Željka Pavlek, dipl.ing.[3], prof.dr.sc. Jadranka Frece[1]*

[1] Prehrambeno-biotehnološki fakultet, Pierottijeva 6, 10000, Zagreb
[2] Cromaris d.d., Gaženička ul. 4b, 23000, Zadar
[3] Nastavni zavod za javno zdravstvo „Dr. Andrija Štampar" Mirogojska cesta 16, 10000, Zagreb
[*] e-mail: iva.canak@pbf.unizg.hr

Sažetak

Mikotoksini su toksični sekundarni metaboliti filamentoznih plijesni s dokazano negativnim učincima na zdravlje. Mikotoksini mogu kontaminirati hranu i poljoprivredne proizvode u bilo kojoj fazi proizvodnje, tijekom prerade, transporta ili skladištenja. Fumonizin B_1 najčešće se pojavljuje u kukuruzu i kukuruznim proizvodima koji su uključeni u prehranu peradi. Postojeće metode uklanjanja dijele se na fizikalne, kemijske i biološke, međutim nisu u potpunosti efikasne ili njihova primjena u industriji nije praktična. Biosorpcija je novi način uklanjanja mikotoksina koji nudi visoku selektivnost i specifičnost, nisku cijenu i ekološki je prihvatljiv. Stoga su u ovom istraživanju kao biološki adsorbensi ispitane kosti i ljuske brancina i orade te njihova sposobnost vezanja FB_1 u dvije vrste pufera te u simuliranim uvjetima gastrointestinalnog trakta peradi. Sva tri adsorbensa pokazala su dobro vezanje FB_1 u fosfatnom (pH 7) i citratnom puferu (pH 3), dok je u simuliranim uvjetima probavnog trakta peradi zabilježena niža adsorpcija, što ukazuje na potrebu za daljnjim istraživanjima i modifikacijom adsorbensa. Dobiveni rezultati nude značajan doprinos u istraživanju uklanjanja mikotoksina te održivosti gospodarenja ribljim otpadom.

Ključne riječi: fumonizin B_1, riblji otpad, biosorpcija

Application of fish industry waste in the removal of mycotoxin FB_1

Iva Čanak, PhD[1], Ksenija Markov, PhD, Full professor[1], Željko Jakopović, PhD[1], Deni Kostelac, PhD[1], Renata Barić, PhD[2], Martina Ivešić, PhD[3], Željka Pavlek, MSc.[3], Jadranka Frece, PhD, Full professor[1]*

[1] *Faculty of Food Technology and Biotechnology, Pierottijeva 6, 10000, Zagreb*
[2] *Cromaris d.d., Gaženička ul. 4b, 23000, Zadar*
[3] *Teaching Institute of Public Health "Dr. Andrija Štampar", Mirogojska cesta 16, 10000, Zagreb*
[*] *e-mail: iva.canak@pbf.unizg.hr*

Abstract

Mycotoxins are toxic secondary metabolites of filamentous molds with a proven negative effect on health. Mycotoxins can contaminate food and agricultural products at any stage of production, during processing, transport, or storage. Fumonisin B_1 is most often found in corn and corn products that are included in poultry feed. Existing removal methods are divided into physical, chemical, and biological, however, they are not completely efficient and their application in industry is not practical. Biosorption is a new method of mycotoxin removal that offers high selectivity and specificity, low cost, and is environmentally friendly. Therefore, in this research, bones and scales of sea bass and sea bream were tested as biological adsorbents and well as their ability to bind FB_1 in two types of buffers and in simulated conditions of the gastrointestinal tract of poultry. All three adsorbents showed good binding of FB_1 in phosphate (pH 7) and citrate buffer (pH 3), while lower adsorption was recorded in simulated conditions of the digestive tract of poultry, which indicates the need for further research and modification of the adsorbent. The obtained results offer a significant contribution to research on the removal of mycotoxins and the sustainability of fish waste management.

Keywords: fumonisin B_1, fish waste, biosorption

Inovacije za razvoj održive marikulture: projekt I-MORE

izv. prof. dr. sc. Ivan Župan[1], izv. prof. dr. sc. Tomislav Šarić[1], izv. prof. dr. sc. Lav Bavčević[1], prof. dr. sc. Bosiljka Mustać[1], doc. dr. sc. Bruna Petani[1], doc. dr. sc. Slavica Čolak[1], mag. ing. agr. Petar Zuanović[1]*

[1] Odjel za ekologiju, agronomiju i akvakulturu, Sveučilište u Zadru, Trg Kneza Višeslava 9, 23 000 Zadar, Hrvatska
[*] e-mail: zupan@unizd.hr

Sažetak

Prema Nacionalnoj razvojnoj strategiji Republike Hrvatske do 2030. godine, koju je donio Hrvatski sabor u veljači 2021. godine, težište se stavlja na četiri posebna cilja*: 1) povećanje proizvodnosti i otpornosti proizvodnje u akvakulturi na klimatske promjene 2) jačanje konkurentnosti sektora akvakulture 3) jačanjem sektora akvakulture doprinijeti obnovi gospodarstva te unaprjeđenju uvjeta života u ruralnim i obalnim područjima 4) poticanje inovacija u sektoru akvakulture*. Uzgoj školjkaša u RH unatoč dugoj povijesti u usporedbi s uzgojem bijele ribe se razvija nedovoljno brzo, unatoč dobrim potencijalima. Prema NRS 2030, sektor uzgoja školjkaša karakteriziraju sljedeće slabosti: dominacija malih proizvođača koji koriste zastarjelu uzgojnu tehnologiju, nedostatak komercijalnog mrjestilišta za školjkaše, prodaja isključivo svježih proizvoda, izostanak diversifikacije proizvoda i dodane vrijednosti, nepostojanje suradnje sa znanstvenim institucijama, nedostatak kapaciteta za preradu te nezainteresiranost za korištenje modernih tehnologija. Kod uzgoja bijele ribe koji se puno brže razvija, jedna od prilika je daljnji razvoj i komercijalizacija vrsta koje imaju potencijal za razvoj marikulture, poput gofa. Projekt I-MORE odobren od strane Uprave za ribarstvo pri Ministarstvu poljoprivrede a financiran iz EMMF –a, cilj je upravo na navedene slabosti i prilike hrvatske akvakulture. Specifični ciljevi projekta su:

- Istraživanje različitih metoda uzgoja školjkaša prilagođenih specifičnostima uzgojnim područjima u RH u svrhu smanjenja korištenja različitih vrsta plastike u uzgoju te unosa iste u morski okoliš (Kontinuirana linijska proizvodnja bez korištenja plastičnih mrežastih crijeva; Uzgoj na splavi – smanjenje korištenja plastičnih plutača za pričvršćivanje uzgojnih linija i polietilenskih konopa i u svrhu povećanja proizvodnje po jedinici površine, odnosno učinkovitijeg iskorištavanja resursa)
- Praćenje različitih okolišnih (temperatura, kisik) i uzgojnih parametara (gustoća nasada, FCR, SGR) u svrhu osiguranja dobrobiti uzgajanog gofa

- Razvoj tehnika kondicioniranja kamenica u uvjetima RAS-a
- Praćenje kemijskog sastava i indeksa kondicije kamenica kako bi se optimiziralo vrijeme njihovog izlova, te upotreba različitih tehnologija pakiranja i konzerviranja kako bi se produžila njihova trajnost.

U projektu se nastoji postići suradnja znanstvenika i uzgajivača te prerađivača, kako bi se dobila saznanja o inovativnim tehnologijama s potencijalom primjene u hrvatskim uvjetima, a s ciljem daljnjeg razvoja akvakulture u smislu količine i kvaliteta.

Innovations for development of sustainable aquaculture in Croatia: project I-MORE

Assoc. prof. Ivan Župan[1], Assoc. prof. Tomislav Šarić[1], Assoc. prof. Lav Bavčević[1], Full prof. dr. sc. Bosiljka Mustać[1], Ass. prof. Bruna Petani[1], Ass. prof. Slavica Čolak[1], mr. Petar Zuanović[1]*

[1] Department of ecology, agronomy and aquaculture, University of Zadar, Trg Kneza Višeslava 9, 23 000 Zadar, Croatia
[*] e-mail: zupan@unizd.hr

Abstract

According to the National Development Strategy of the Republic of Croatia until 2030, adopted by the Croatian Parliament in February 2021, the focus is on four specific goals: 1*) increasing the productivity and resilience of aquaculture production to climate change 2) strengthening the competitiveness of the aquaculture sector 3) by strengthening the aquaculture sector, contribute to the restoration of the economy and the improvement of living conditions in rural and coastal areas 4) encouraging innovation in the aquaculture sector.* Shellfish farming in the Republic of Croatia, despite its long history, is not developing fast enough compared to white fish farming, despite its good potential. According to NRS 2030, the shellfish farming sector is characterized by the following weaknesses: dominance of small producers using outdated farming technology, lack of commercial hatchery for shellfish, sale of only fresh products, absence of product diversification and added value, lack of cooperation with scientific institutions, lack of processing capacity and lack of interest for the use of modern technologies. In the case of white fish farming, which is developing much faster, one of the opportunities is the further development and commercialization of species that have potential for the development of mariculture, such as gopher. The I-MORE project, approved by the Directorate for Fisheries at the Ministry of Agriculture and financed by EMMF, aims precisely at the mentioned weaknesses and opportunities of Croatian aquaculture. The specific goals of the project are:

- *Research of different methods of shellfish farming adapted to the specifics of farming areas in the Republic of Croatia in order to reduce the use of different types of plastic in farming and its introduction into the marine environment (Continuous line production without the use of plastic mesh hoses; Farming on rafts - reducing the use of plastic buoys for attaching farming lines and polyethylene ropes and for the purpose of increasing production per unit area, i.e. more efficient use of resources)*

- *Monitoring of various environmental (temperature, oxygen) and breeding parameters (plantation density, FCR, SGR) to ensure the well-being of the cultivated gopher*
- *Development of oyster conditioning techniques under RAS conditions*
- *Monitoring the chemical composition and condition index of oysters in order to optimize their harvesting time, and the use of different packaging and preservation technologies in order to extend their durability.*

The project aims to achieve cooperation between scientists and growers and processors, to gain knowledge about innovative technologies with the potential for application in Croatian conditions, with the aim of further developing aquaculture in terms of quantity and quality.

Mycobacteriosis of freshwater fish as a zoonosis

Emil Gjurčević[1], Valerija Benko[1], Ljiljana Žmak[2,3], Andrea Gudan Kurilj[4], Nevijo Zdolec[5], Krešimir Matanović[1]

[1] Department for Biology and Pathology of Fish and Bees, Faculty of Veterinary Medicine, University of Zagreb
[2] National/Supranational Reference Laboratory for tuberculosis, Croatian Institute of Public Health
[3] School of Medicine, University of Zagreb
[4] Department of Veterinary Pathology, Faculty of Veterinary Medicine, University of Zagreb
[5] Department of Hygiene, Technology and Food Safety, Faculty of Veterinary Medicine, University of Zagreb

Abstract

Mycobacteriosis is a chronic progressive disease of fish, both wild and farmed, caused by several species of the genus *Mycobacterium*, such as *M. marinum*, *M. fortuitum* and *M. chelonae*. All fish species should be considered susceptible. Disease outbreaks in farmed fish have been usually associated with high mortality and significant economic losses. Most of these outbreaks appear to be related to high stocking density, poor diet and water quality. The present study contains data on mycobacteriosis caused by *M. marinum* and *M. chelonae* in farmed and aquarium freshwater fish from Croatia. As such, it contributes significantly to current knowledge about mycobacteriosis in fish and will be of particular interest to the veterinarians, aquaculturists and to all concerned with human health.

Overview of Freshwater Fish Diseases Situation in Western Balkans – Serbia, North Macedonia, and Bosnia and Herzegovina

Radosavljevic Vladimir[1], Cvetkovikj Aleksandar[2], Zuko Almedina[3], Jazic Adnan[3], Markovic Zoran[4]*

[1] Institute of Veterinary Medicine of Serbia, Janisa Janulisa 14, 11000 Belgrade, Serbia
[2] Faculty of Veterinary Medicine - Skopje, Ss. Cyril and Methodius University in Skopje, Lazar Pop-Trajkov 5-7, 1000 Skopje, North Macedonia,
[3] Faculty of Veterinary Medicine University of Sarajevo, Zmaja od Bosne 90, 71000 Sarajevo, Bosnia and Herzegovina
[4] Faculty of Agriculture University of Belgrade, Nemanjina 6, 11081 Belgrade, Serbia
[*] e-mail: vladimiradosavljevic@yahoo.co.uk

Abstract

The aim of this overview is to discuss the most threatening diseases occurring in freshwater aquaculture of the three neighbouring countries - Serbia, North Macedonia, and Bosnia and Herzegovina. Occurrence of fish diseases in the Western Balkans has increased over the past few years, primary due to expansion and intensification of aquaculture, especially in the carp and trout industry. Therefore, the characteristics, affected host species and the geographical distribution of each detected disease, are described. Also, the current status in the development of prevention strategies for the recorded diseases is addressed.

Keywords: aquaculture, fish diseases, Western Balkans

Biosigurnost u šaranskoj priozvodnji

Miloš Pelić[1], Dušan Lazić[1], Nikolina Novakov[2], Vladimir Radosavljević[3], Ana Gavrilović[4], Jurica Jug-Dujaković[5], Milica Živkov Baloš[1], Dragana Ljubojević Pelić[1]*

[1] Naučni Institut za veterinarstvo "Novi Sad", Zavod za bezbednost hrane, Novi Sad, Republika Srbija
[2] Univerzitet u Novom Sadu, Poljoprivredni fakultet, Departman za veterinarsku medicinu, Novi Sad, Republika Srbija
[3] Naučni institut za veterinarstvo Srbije, Beograd, Republika Srbija
[4] Univerzitet u Zagrebu, Poljoprivredni fakultet, Zagreb, Republika Hrvatska
[5] Sustainable Aquaculture Systems Inc., Frenchtown, New Jersey, USA
[*] e-mail: milosp@niv.ns.ac.rs

Sažetak

Sve veći zahtevi tržišta za ribom, trend smanjenja proizvodnje ribe na godišnjem nivou i povećanje cene ribe na tržištu su samo mali broj problema sa kojima se susreće ribarska proizvodnja u Srbiji. Biosigurnost u akvakulturi je od krucijalne važnosti kako bi se osigurala zdravstveno bezbedna proizvodnja. Prilikom izrade plana biosigurnosti potrebno je obuhvatiti i uzeti u obzir specifinosti proizvodnje za koju se plan pravi, ali i pocenu ekonomske opravdanosti izrade istog. Glavni ciljevi biosigurnosti obuhvataju adekvatno upravljanje zdravljem gajenih riba, upravljanje javnim zdravljem i inkorporacija dobre biosigurnosne prakse u sistem proizvodnje. Uvođenje nacionalnih programa biosigurnosti je od izuzetne važnosti kako bi se prvo idetifikovali potencijalni načini unošenja i širenja bolesti u zemlji i regioni, ali što je još važnije da se tačno preciziraju mere kontrole koje bi uticale na smanjenje rizika povezanog sa vrstom bolesti za svaku proizvodnju posebno. Cilj rada je da se naglasi uloga biosigunosti u razvoju i unapređenju šaranske proizvodnje i proizvodnji ribe kao bezbedne i kvalitetne namirnice. Implementacija adekvatnih programa biosigurnosti je neophodna u svim zemljama koje odgovorno pristupaju zaštitu zivotne sredine, zaštiti i unapređenju poljoprivredne proizvodnje i zaštiti biodiverziteta.

Ključne reči: ribarska proizvodnja, bolesti riba, preventivne mere, analiza rizika, održiva akvakultura

Biosafety in Carp production

Miloš Pelić[1], Dušan Lazić[1], Nikolina Novakov[2], Vladimir Radosavljević[3], Ana Gavrilović[4], Jurica Jug-Dujaković[5], Milica Živkov Baloš[1], Dragana Ljubojević Pelić[1]*

[1] Scientific Veterinary Institute Novi Sad, Department of Food Safety, Novi Sad, Republic of Serbia
[2] University of Novi Sad, Faculty of Agriculture, Department of Veterinary Medicine
[3] Scientific Institute of Veterinary Medicine of Serbia, Belgrade, Serbia
[4] University of Zagreb, Faculty of Agriculture, Zagreb, Croatia
[5] Sustainable Aquaculture Systems Inc., Frenchtown, New Jersey, USA
[*] e-mail: milosp@niv.ns.ac.rs

Abstract

The increasing demands of the market for fish, the trend of decreasing fish production on an annual level and the increase in the price of fish on the market are just a few of the problems faced by the fishing industry in Serbia. Biosecurity in aquaculture is of crucial importance to ensure healthy production. When creating a biosecurity plan, it is necessary to include and take into account the specifics of the production for which the plan is being created, as well as the assessment of the economic justification. The main objectives of biosecurity include adequate management of farmed fish health, public health management and incorporation of good biosecurity practices into the production system. The introduction of national biosecurity programs is of utmost importance in order to first identify the potential ways of introduction and spread of diseases in the country and regions, but more importantly to precisely specify the control measures that would affect the reduction of the risk associated with the type of disease for each production separately. The aim of the work is to emphasize the role of biosecurity in the development and improvement of carp production and fish production as a safe and quality food. The implementation of adequate biosecurity programs is necessary in all countries that responsibly approach the protection of the environment, the protection and improvement of agricultural production and the protection of biodiversity.

Key words: fish production, fish diseases, preventive measures, risk analysis, sustainable aquaculture

Upravljanje zdravljem u akvakulturi

Dr.sc. Dražen Oraić, dr.med.vet.[1], Dr. sc. Ivana Giovanna Zupičić, dr.med.vet.[1], Dr.sc. Snježana Zrnčić, dr.med.vet.[1]*

[1] Hrvatski veterinarski institut, Savska cesta 143, Zagreb, Hrvatska
[*] e-mail: oraic@veinst.hr

Sažetak

Opći veterinarski principi upravljanja zdravljem životinja u akvakulturi usporedivi su s onima za druge životinje u uzgoju, posebno u peradarstvu. Kao i u uzgojima drugih vrsta životinja i u akvakulturi je prevencija bolesti uvijek bolja od liječenja. Osnovu minimiziranja rizika izbijanja bolesti u uzgoju čini plan biosigurnosti pojedinog uzgajališata s uključenim univerzalnim mjerama čišćenja, dezinfekcije, praćenja ponašanja životinja te skupa upravnih i tehničkih mjera nacionalnog plana biosigurnosti. Glavni ciljevi plana biosigurnosti su da se opasnosti unosa uzročnika bolesti na uzgajalište, širenja bolesti unutar uzgajališta te sprečavanja opasnosti da bolesna životinja ili uzročnik bolesti napusti uzgajalište spuste na najnižu moguću razinu. Plan sigurnosti koji sadrži principe brige o uzgajanim životinjama od nabave te dan za danom, mjere upravljanja rizicima unosa bolesti, programe edukacija o biosigurnosti svih uključenih u proizvodnju doprinijeti će zdravlju uzgajanih životinja. U nekim slučajevima, unatoč primjeni dobre proizvođačke prakse, brizi i unaprjeđenju kvalitete okoliša, primjeni optimalne hranidbe i podizanju zdravstvenog statusa životinja, pojavljuju se bolesti. Za ublažavanje posljedica često su potrebni veterinarsko medicinski proizvodi (VMP). Liječenje bolesti akvatičnih životinja u uzgoju izazovno je logistički, uključuje parametre okoliša, vrste i broj životinja u uzgoju, način primjene kemoterapeutika, te zbog farmakološke i zakonske složenosti korištenja VMP-a u akvakulturi.

Ključne riječi: akvakultura, biosigurnost, bolesti, liječenje

Health Management in Aquaculture

Dražen Oraić PhD DVM[1], Ivana Giovanna Zupičić PhD DVM[1], Snježana Zrnčić PhD DVM[1]*

[1] Croatian Veterinary Institute, Savska cesta 143, Zagreb, Hrvatska
[*] e-mail: oraic@veinst.hr

Abstract

General veterinary approach to aquatic animal health management is similar as for other farmed animals, especially poultry farming. Same as in the breeding of other animal species, in aquaculture, disease prevention is always better than treatment. The biosecurity plan for each farm includes common measures like cleaning, disinfection, monitoring of animal behavior and a set of administrative and technical measures of the national biosecurity plan minimizing the risk of disease outbreaks in aquatic animals farming. The main goals of the biosecurity plan are to reduce the risk of the introduction of disease agents into the farm, the spread of disease within the farm, and the prevention the risk of a sick animal or disease agent leaving the farm to the lowest possible level. A safety plan that contains the principles of taking care for farmed animals from the purchase and day by day care, measures to manage the risks of disease introduction, biosecurity education programs for everyone involved in production process will contribute to the health of farmed animals. Sometimes, despite the application of good production practices, which includes improvement of the environment quality, application of optimal nutrition and good condition, diseases occur. Veterinary medicinal products (VMP) are often required to mitigate the production losses. The treatment of diseases of aquatic animals in farming is logistically challenging, it includes environmental parameters, species and number of animals in farming, the method of chemotherapeutics application, due to the pharmacological and legal complexity of VMP use in aquaculture.

Key words: Aquaculture, Biosecurity, Diseases, Treatment

Nove spoznaje o ekološkim zahtjevima uzročnika saprolegnioze, te razvoj metoda praćenja i ekološki prihvatljivih metoda suzbijanja bolesti

Izv. prof. dr. sc. Bielen Ana[1]; Pavić Dora, mag. oecol.[1]; Dr. sc. Miljanović Anđela[1]; Dr. sc. Grbin Dorotea[1,2]

[1] Prehrambeno-biotehnološki fakultet, Sveučilište u Zagrebu, Pierottijeva 6, 10000 Zagreb, Hrvatska; e-mail: ana.bielen@pbf.unizg.hr; dora.pavic@ pbf.unizg.hr; andela.miljanovic@ pbf.unizg.hr
[2] Prirodoslovno-matematički fakultet, Sveučilište u Zagrebu, Rooseveltov trg 6, 10000 Zagreb, Hrvatska; e-mail: dorotea.polovic@biol.pmf.hr

Sažetak

Vodena plijesan *Saprolegnia parasitica* uzročnik je saprolegnioze te razlog velikih ekonomskih gubitaka u salmonidnoj akvakulturi. Prikazat će se rezultati projekta InteractOomyc tijekom čije su provedbe istraženi različiti aspekti ovog patogena.

Razvijen je brz, osjetljiv i specifičan digital droplet PCR-test prikladan za detekciju i kvantifikaciju patogena *S. parasitica* u uzorcima iz okoliša, tj. DNA iz vode, s kože i površine ikre pastrve, itd.

Nadalje, utvrđeno je da uzgajališta pastrva mogu djelovati kao izvor širenja uzročnika saprolegnioze u nizvodne okoliše. Osim toga, količina DNA vrste *S. parasitica* u uzorcima vode bila je pozitivno korelirana s nekim parametrima vode kao što su električna vodljivost i koncentracija kalcijevih iona, dok je organska tvar poticala proizvodnju zoospora. Ovi rezultati prvi su korak prema identifikaciji okoliša s povećanom vjerojatnošću izbijanja saprolegnioze. Nadalje, količina DNA vrste *S. parasitica* bila je značajno viša na koži ozlijeđenih nego zdravih pastrva što potvrđuje da se radi o široko rasprostranjenom oportunističkom patogenu.

Konačno, utvrđeno je da neki bioaktivni biljni proizvodi (tj. propolis i eterična ulja) i bakterije iz roda *Pseudomonas* mogu inhibirati razvoj patogena *S. parasitica in vitro*. U tijeku su istraživanja mogućnosti njihove *in vivo* primjene kao ekološki prihvatljive metode prevencije i/ili liječenja saprolegnioze u akvakulturi.

Ključne riječi: okolišna DNA, eterična ulja, propolis, *Pseudomonas* spp., *Saprolegnia parasitica*

Novel insights into monitoring, ecological requirements and methods for environmentally acceptable control of saprolegniosis

Assoc. prof. Bielen Ana, PhD[1]; Pavić Dora, MSc[1]; Miljanović Anđela, PhD[1]; Grbin Dorotea, PhD[1,2]

[1] Faculty of Food Technology and Biotechnology, University of Zagreb, Pierottijeva 6, 10000 Zagreb, Croatia; e-mail: ana.bielen@pbf.unizg.hr; dora.pavic@pbf.unizg.hr; andela.miljanovic@pbf.unizg.hr
[2] Faculty of Science, University of Zagreb, Rooseveltov trg 6, 10000 Zagreb, Croatia; e-mail: dorotea.polovic@biol.pmf.hr

Abstract

Saprolegnia parasitica causes saprolegniosis and incurs high economic losses in salmonid aquaculture. The results of the InteractOomyc project, in which this pathogen was studied from several angles, will be presented.

First, we have developed a rapid, sensitive and specific *S. parasitica* digital droplet PCR assay suitable for the detection and quantification of the pathogen in environmental samples, i.e. DNA isolated from water, trout skin, the surface of eggs, etc.

We have also shown that trout farms can serve as a source for the spread of *Saprolegnia* species to downstream areas. In addition, *S. parasitica* load in water samples was found to correlate positively with some water parameters such as electrical conductivity and calcium content, while organic matter promoted its sporulation. These results are a first step towards identifying environments with increased likelihood of disease outbreaks. *Saprolegnia parasitica* skin load was significantly higher in injured trout than in healthy ones, confirming that it is a widespread opportunistic pathogen that thrives on the skin of injured fish.

Finally, we have shown that bioactive plant products (i.e. propolis, essential oils) and *Pseudomonas* bacteria can inhibit the development of *S. parasitica in vitro*. We continue the possibilities of their *in vivo* application for the environmentally friendly prevention and/or treatment of saprolegniosis in aquaculture.

Keywords: environmental DNA, essential oils, propolis, pseudomonads, *Saprolegnia parasitica*

Pojavnost virusa zarazne nekroze gušterače salmonida u Bosni i Hercegovini

Jažić Amina, DVM[1], mr.sc. Eterović Toni, prof.dr.sc. Zuko Almedina, prof.dr.sc. Jažić Adnan*

Sveučilište u Sarajevu, Veterinarski fakultet, Zmaja od Bosne 90, 71000 Sarajevo, Bosna i Hercegovina
[*] e-mail: amina.jazic@vfs.unsa.ba

Sažetak

Zarazna nekroza gušterače (ZNG) je jedna od prvih opisanih i najviše istraživanih virusnih bolesti riba u svijetu jer uzrokuje velike ekonomske štete u akvakulturi. Ekonomski utjecaj uzrokovan ZNG-om je direktan (veliki mortalitet) i indirektan (troškom preventivnih mjera i kontrola kao što su zdravstvene inspekcije, nadzori, dijagnostika) što indicira da su indirektne ekonomske posljedice mnogo veće od samog mortaliteta. Virus zarazne nekroze gušterače salmonida je čest patogen u akvakulturi BiH. Dijagnosticiran je kod kalifornijske pastrve (*Oncorhynchus mykiss*), potočne pastrve (*Salmo trutta*), potočne zlatovčice (*Salvelinus fontinalis*), jezerske zlatovčice (*Salvelinus alpinus*) i mekousne pastrve (*Salmo obtusirostris*). Ribe kod kojih je ustanovljen virus ZNG nisu manifestirale kliničku sliku bolesti, te je infekcija protekla asimptomatski, a iz anamnestičkih podataka sa farmi nije se bilježio povećan mortalitet. U 2017. godini ispitano je 47 farmi od čega su samo dvije bile pozitivne na virus ZNG (4,26%), 2018. godine od 72 ispitane farme njih 4 (5,56%) su bile pozitivne, dok je već 2019. godine od 59 ispitanih farmi njih 15 bilo pozitivno na virus ZNG (25,42%). Slično kao i 2019. godine, u 2020. godini je 12 od 57 ispitanih farmi (21.05%) bilo pozitivno na virus ZNG, a postotak pozitivnih farmi opada u 2021. godini kada je od 33 ispitane farme njih 5 (15,15%) bilo pozitivno, te u 2022. godini pozitivnih 6 od 48 ispitanih farmi (12,5%). Od sedam salmonidnih vrsta koje su ispitivane (kalifornijska pastrva, potočna pastrva, potočna zlatovčica, jezerska zlatovčica, glavatica, mekousna pastrva i mladica), kalifornijska pastrva je vrsta kod koje se najčešće dijagnosticira zarazna nekroza gušterače, a kod mladice i glavatice nismo utvrdili prisustvo ZNG. Iz provedenih analiza, na osnovu višegodišnjeg nadzora nad virusnim bolestima salmonidnih vrsta riba, utvrdilo se da virus zarazne nekroze gušterače kontinuirano perzistira na ribogojilištima u Bosni i Hercegovini.

Ključne riječi: salmonidi, virus, ZNG

Occurrence of Infectious Pancreatic Necrosis Virus of Salmonids in Bosnia and Herzegovina

Jažić Amina, DVM, mr.sc. Eterović Toni, prof.dr.sc. Zuko Almedina, prof.dr.sc. Jažić Adnan*

University of Sarajevo, Faculty of Veterinary Medicine, Zmaja od Bosne 90, 71000 Sarajevo, Bosnia and Herzegovina
** e-mail: amina.jazic@vfs.unsa.ba*

Abstract

Infectious pancreatic necrosis (IPN) is one of the first described and most researched viral fish diseases in the world as it causes strong economic damage in aquaculture. There are two types of negative economic impacts caused by IPNV: direct negative impact through high mortality and indirect negative impact based on the preventive measure and control costs such as health inspections, surveillance, and diagnostics. The latter impact type clearly has greater consequences on the aquaculture economy than mortality itself. The IPNV of salmonids is a common pathogen in aquaculture in Bosnia and Herzegovina. It was diagnosed in rainbow trout (*Oncorhynchus mykiss*), brown trout (*Salmo trutta*), brook charr (*Salvelinus fontinalis*), arctic charr (*Salvelinus alpinus*), and softmouth trout (*Salmo obtusirostris*). The fish in which the IPNV was detected did not show a clinical picture of the disease, so the infection was asymptomatic, and from the anamnestic data taken at the farms, no increased mortality was recorded. In 2017, 47 farms were examined, of which only two were IPNV-positive (4.26%). In 2018, out of 72 farms examined, 4 of them (5.56%) were positive, while already in 2019 out of 59 examined farms, 15 were IPNV-positive (25.42%). Similar to 2019, in 2020, 12 out of 57 examined farms (21.05%) were IPNV-positive. The percentage of positive farms decreased in 2021, only 5 out of 33 surveyed farms (15.15%) were IPNV-positive, and in 2022, 6 out of 48 examined farms (12.5%) were IPNV-positive. Of the seven salmonid species examined (rainbow trout, brown trout, brook charr, arctic charr, marble trout, softmouth trout, and Danube salmon), the rainbow trout is the species with the most infectious necrosis of the pancreas disease cases, while we did not detect the presence of IPNV in Danube salmon and marble trout. Based on thorough analysis and many years of monitoring viral diseases of salmonid fish species, we have concluded that the infectious pancreatic necrosis virus continuously persists in fish farms in Bosnia and Herzegovina.

Keywords: salmonidae, virus, IPN

Bolesti koje ugrožavaju školjkaše u Jadranskom moru

Dr. sc. Ivana Giovanna Zupičić, dr.med.vet.[1], Dr.sc. Dražen Oraić, dr.med.vet.[1], Dr.sc. Snježana Zrnčić, dr.med.vet.[1]*

[1] Hrvatski veterinarski institut, Savska cesta 143, Zagreb, Hrvatska
[*] e-mail: zupicic@veinst.hr

Sažetak

Na području Jadrana živi oko 240 vrsta školjkaša. Prema podacima FAO-a, u Hrvatskoj se prvenstveno uzgajaju dvije vrste školjkaša: kamenice (*Ostrea edulis*) i dagnje (*Mytilus galloprovincialis*). Godišnja proizvodnja dagnji je oko 854 tone, a kamenica oko 56 tona. Prisutne su i četiri zaštićene vrste školjkaša od kojih je jedna i plemenita periska (*Pinna nobilis*). Međunarodna unija za očuvanje prirode (IUCN) je u listopadu 2019. godine plemenitu perisku svrstala u kategoriju „kritično ugroženih vrsta".

Školjkaši su dio ekološkog sustava kojem pripadaju i u međudjelovanju su sa živim i neživim čimbenicima tog sustava. Međusobni utjecaj članova ekološkog sustava je različit tako da je sve veća pažnja usmjerena na proučavanju bolesti te njihovoj prevenciji. Da bi se povećala proizvodnja školjkaša te očuvale zaštićene vrste u Hrvatskoj, prijeko je potreban kontinuirani monitoring kako bi se uočili prvi znakovi promjena i brzo reagiralo na prve znakove bolesti. Osim kontinuiranog monitoringa i provođenja mjera biosigurnosti potrebno je poznavati uzročnike bolesti i njihov životni ciklus u određenom akvatoriju.

Prema Provedbenoj uredbi Komisije (EU) 2018/1882 infekcije parazitima *Mikrocytos mackini*, *Perkinsus marinus*, *Bonamia exitiosa*, *Bonamia ostreae* i *Marteilia refringens* spadaju u kategoriju bolesti koje se obavezno prijavljuju Nadležnim tijelima. Međutim s obzirom na veliki pomor plemenith periski i dagnji u posljednje vrijeme veliki naglasak se stavlja i na istraživanje infekcije uzrokovane parazitima iz porodice *Haplosporidiidae* u koju spadaju *Haplosporidium pinnae* i *Minchinia mytili*. Od virusnih bolesti značajan je Ostreid Herpesvirus tipa 1 (OsHV-1) na kojeg je prijemljiva europska kamenica *O. edulis*. Značajne bakterijske bolesti školjkaša koje uzrokuju mortalitete su *Vibrio splendidus* i *V. aestuarianus*.

Ključne riječi: školjkaši, *O. edulis*, *Mytilus galloprovincialis*, *Pinna nobilis,* kontrola zdravlja školjkaša

Diseases threatening mollusks in the Adriatic sea

Dr. sc. Ivana Giovanna Zupičić, dr.med.vet.[1], Dr.sc. Dražen Oraić, dr.med.vet.[1], Dr.sc. Snježana Zrnčić, dr.med.vet.[1]*

[1] Croatian Veterinary Institute, Savska cesta 143, Zagreb, Croatia
[*] e-mail: zupicic@veinst.hr

Abstract

About 240 species of mollusks live in the Adriatic Sea. According to FAO data, two types of mollusks are primarily farmed in Croatia: oysters (*Ostrea edulis*) and mussels (*Mytilus galloprovincialis*). The annual production of mussels is about 854 tons, and of oysters about 56 tons. There are also four endangered species of mollusks, one of which is the noble penshell (*Pinna nobilis*). In October 2019, the International Union for Conservation of Nature (IUCN) classified the noble penshell in the category of a "critically endangered species".

Mollusks are part of the ecological system to which they belong and interact with. The mutual influence of the members of the ecological system is different, so more and more attention is focused on the study of diseases and their prevention. In order to increase mollusk production and protect endangered species in Croatia, continuous monitoring is urgently needed to detect the changes and for reaction to the first signs of disease. In addition to continuous monitoring and implementation of biosecurity measures, it is necessary to know the causative agents of diseases and their life cycle in a certain area.

According to Commission Implementing Regulation (EU) 2018/1882, infections with the parasites *Mikrocytos mackini*, *Perkinsus marinus*, *Bonamia exitiosa*, *Bonamia ostreae*, and *Marteilia refringens* belong to the category of diseases that must be reported to the competent authorities. However, because of the mass mortality of noble penshell and mussels, a lot of emphases has recently been placed on the research of infection caused by parasites from the *Haplosporidiidae* family, which includes *Haplosporidium pinnae* and *Minchinia mytili*. Regarding to the viral diseases, Ostreid Herpesvirus type 1 (OsHV-1) is significant because of susceptibility of European oyster *O. edulis*. Significant bacterial diseases of mollusks that cause mortality are *Vibrio splendidus* and *V. aestuarianus*.

Keywords: molluscs, *O. edulis*, *Mytilus galloprovincialis*, *Pinna nobilis*, molluscs health control

Pokusna proizvodnja i primjena autolognih cjepiva u uzgoju lubina (*Dicentrarchus labrax*)

Dr.sc. Zrnčić Snježana dr.med.vet[*]*, Dr.sc. Zupičić Ivana Giovanna dr.med.vet, Dr.sc. Oraić Dražen dr.med.vet.*

Hrvatski veterinarski institut, Laboratorij za patologiju riba, Savska cesta 143, 10000 Zagreb
[*] *e-mail: zrncic@veinst.hr*

Sažetak

Uzgoj morskih vrsta riba u Hrvatskoj kontinuirano raste ali se istodobno suočava s pojavom bolesti zbog klimatskih promjena, međunarodne trgovine i intenzifikacije uzgoja. Bolesti izazivaju ogromne ekonomske gubitke te nepovoljno utiču na morski okoliš i kvalitetu uzgajane ribe. Tradicionalni pristup liječenju bolesti počinje opažanjem bolesne ribe, uzorkovanjem, dijagnostikom uzročnika i posljedičnim liječenjem. Taj pristup zahtjeva vrijeme i često se liječenju pristupa kad su gubici veliki, oboljela riba ne uzima hranu što pogoršava okolišne uvjete i uzrokuje razvoj antimikrobne rezistencije. Održivu akvakulturu treba temeljiti na mjerama biosigurnosti i preventivi bolesti. Najvažniji element preventive je cijepljenje protiv bakterijskih bolesti. Dostupna su komercijalna cjepiva protiv bakterija *Vibrio anguillarum* i *Photobacterium damselae* subsp. *piscicida*, ali ne i *Vibrio harveyi* i *Tenacibaculum maritimum* koji izazivaju gubitke u uzgoju. Stoga smo pristupili pripremi autolognih cjepiva protiv ovih dviju bakterijskih bolesti. Autologno cjepivo je cjepivo proizvedeno od uzročnika izdvojenog na određenom uzgajalištu i primjenjeno na tom istom uzgajalištu. Cjepiva od formalinom inaktiviranih uzročnika testirali smo u laboratorijskim uvjetima uranjanjem i i/p primjenom i dobili zadovoljavajuće rezultati relativnog postotka preživljavanja (RPP) od 66-100 za *V. harveyi* i 67,5-100 za *T. maritimum*. Testirali smo ekspresiju ciljanih gena imunosti i količinu IgM u serumu cijepljenih riba.

Ključne riječi: lubin, *Vibrio harveyi*, *Tenacibaculum maritimum*, autologno cjepivo, relativni postotak preživljavanja

Experimental production and application of autologous vaccines in European seabass (*Dicentrachus labrax*) farming

Zrnčić Snježana PhD DVM [*], Zupičić Ivana Giovanna PhD DVM, Oraić Dražen PhD DVM

Croatian Veterinary Institute, Laboratory for Fish Patology, Savska cesta 143, 10000 Zagreb
[*] e-mail: zrncic@veinst.hr

Abstract

Quantities of farmed marine fish in Croatia are is continuosly growing in last decade. However, industry is faced with disease occurence due to climate change, transboundary trade and intensification of farming. Diseases are causing economic losses and impact environment and food quality. Traditional approach in the health management consists of symptoms, sampling, diagnostics and treatment. It implies slow process with increased losses, deterioration of environmental conditions and development of antimicrobial resistance. Sustainable aquaculture should be based on biosecurity and disease prevention. The most important preventive measures are vaccination against bacterial diseases. Vaccines against *Vibrio anguillarum* and *Photobacterium damselae* subsp. *piscicida* are commercially available but not against two economically important pathogens *Vibrio harveyi* and *Tenacibaculum maritimum*. Therefore, we produced autologous vaccines against mentioned two bacterial pathogens. Autologous vaccine is vaccine produced of the pathogen isolated in the infected farm and applied on the same farm. Vaccines prepared of formalin killed pathogen were tested in laboratory condition using bath and i/p application and we obtained satisfactory results of the relative percentage of survival (RPS) of 66-100 for *V. harveyi* and 67,5-100 for *T. maritimum.* Additionally, we tested expression of targeted genes and quantities of IgM in sera as marker of immune response.

Keywords: European seabass, *Vibrio harveyi*, *Tenacibaculum maritimum*, autologous vaccine, relative percentage of survival

Bolesti u kaveznom uzgoju Zubaca

Danijel Mejdandžić, Renata Barić*

Cromaris d.d., Gaženička cesta 4b, Zadar
** e-mail: danijel.mejdandzic@cromaris.hr*

Sažetak

Zubatac (*Dentex dentex*) je jedna od novih mediteranskih vrsta koja je zbog svoje kvalitete i prepoznatljivosti postala kandidat za kavezni uzgoj. Pripada obitelji ljuskavki (*Sparidae*) i smatra se vrlo kvalitetnom i cijenjenom ribom kod potrošača. Zbog potrebe diverzifikacije tržišta bijele ribe mnogi uzgajivači na Mediteranu pokušali su s uzgojem mlađi i konzumne ribe. Od ranih 90-tih počinju istraživanja vezana za uzgojne potrebe ove vrste. Cromaris je danas jedini uspješan proizvođač sa zadovoljavajućim preživljavanjem i opravdanim troškovima proizvodnje. Ostali uzgajivači su odustali od proizvodnje prvenstveno zbog gubitaka u uzgoju i ekonomske neisplativosti. Vrlo je specifična vrsta sa izraženim predatorskim nagonom te je sklon kanibalizmu. Bakterijske bolesti uz kanibalizam trenutno su najveći ograničavajući faktor u uzgoju. Zubatac je relativno jaka i otporna riba ali u uzgoju pokazuje smanjenu otpornost na bakterijske infekcije. Vibrioza je jedna od najčešćih bolesti u uzgoju te zajedno sa Tenacibakulozom, Epiteliocistisom i pojedinim parazitarnim infestacijama nosi gubitke koji mogu biti vrlo visoki. Moderni trendovi u akvakulturi se više fokusiraju na održivost, očuvanje prirode, zelenu tranziciju i uzgoj bez antibiotika. Prilagodba uzgajivača novim trendovima je posebno teška kod novih vrsta za koje svi parametri vezani za uzgoj nisu još posve istraženi. Zbog manjka znanja i mogućih profilaktičkih mjera održivost uzgoja je upitna. Istraživanja se intenziviraju i nove tehnologije postupno mijenjaju stare. Za bolju budućnost uzgoja i održivosti u ekološkom i ekonomskom smislu potrebni su dodatni napori u istraživanjima koja bi donijela nove spoznaje, a potom i ideje za pozitivne tehnološke iskorake.

Ključne riječi: Zubatac, uzgoj, bakterijske bolesti, profilaksa

Diseases in cage farming of Common dentex

Danijel Mejdandžić, Renata Barić*

Cromaris d.d., Gaženička cesta 4b, Zadar
e-mail: danijel.mejdandzic@cromaris.hr

Abstract

The Common dentex (*Dentex dentex*) is one of the new Mediterranean species which, due to its quality and recognition, has become a candidate for cage farming. It belongs to the family (*Sparidae*) and is considered a very high-quality and valued fish by consumers. Due to the need to diversify the white fish market, many farmers in the Mediterranean have tried to breed fry and consumable fish. From the early 90s, research related to the farming needs of this species began. Today, Cromaris is the only successful producer with satisfactory survival and justified production costs. Other farmers gave up production primarily due to losses in cages and economic unprofitability. It is a very specific species with a pronounced predatory instinct and is prone to cannibalism. Bacterial diseases, along with cannibalism, are currently the biggest limiting factor in cage farming. Common dentex is a relatively strong and resistant fish, but in farming conditions shows reduced resistance to bacterial infections. Vibriosis is one of the most common diseases and, together with Tenacibaculosis, Epitheliocystis and certain parasitic infestations, it causes losses that can be very high. Modern trends in aquaculture focus more on sustainability, nature conservation, green transition and antibiotic-free farming. Adaptation of farmers to new trends is especially difficult with new species for which all parameters related to farming have not yet been fully explored. Due to the lack of knowledge and possible prophylactic measures, the sustainability of farming is questionable. Research is intensifying and new technologies are gradually replacing old ones. For a better future of farming and sustainability in the ecological and economic sense, additional efforts are needed in research that would bring new knowledge, and then ideas for positive technological advances.

Keywords: Common dentex, farming, bacterial diseases, prophylactic measures

Farming and conservation: two sides of the same coin?

Paolo Bronzi

WSCS (World Sturgeon Conservation Society), via Lombardia, 32, 20853 Biassono (MB) Italy
e-mail: aerespe@me.com

Abstract

All over the world, and particularly in Eurasia, sturgeons are at serious risk of extinction, and consequently *ex situ* measures including the safeguarding of remaining genetic diversity and supporting the recovery of the populations in the wild, are essential.

Sometimes, where public structures destined for this purpose are not available, in order to be able to carry out recovery programs and restocking operations it is necessary to make use of the broodstock, the competences and the facilities of farmers who keep already in their farms sturgeons of different species suitable for the reproduction.

However, the targets and rearing practices between commercial rearing and conservation rearing differ substantially in terms of characteristics of the facilities, those of reared animals and of their fitness, and it's important to identify the options and reciprocal benefits for a close collaboration between commercial farms and recovery projects.

Therefore, the essential prerequisites, advantages and disadvantages of such a strategic collaboration as well as the possible options for its implementation have to be assessed and common activities identified, also considering the similarities and differences regarding the methods used, recalling the need to establish a completely different approach in aquaculture for conservation compared to commercial aquaculture, with evident greater commitments by the farmers of structures, time and money, as well as the need to learn particular techniques that are not normally used in commercial aquaculture.

Different specific actions and choices required in aquaculture for conservation compared to commercial aquaculture for each stage of the process are presented, from the choice of reproducers to the production of subjects to be released, as well as the mutual benefits, also for the farmers, which sometimes do not appear so evident, and the need to recognize their effective collaboration in different ways.

LIFE-Boat4Sturgeon and the implementation of the Pan-EU AP for Sturgeons in the Danube River Basin

DI Dr. Thomas Friedrich

University of Natural Resources and Life Sciences, Vienna, Institute of Hydrobiology and Aquatic Ecosystem Management, Gregor-Mendel-Straße 33, 1180 Wien, Austria
e-mail: thomas.friedrich@boku.ac.at

Abstract

The project LIFE-Boat 4 Sturgeon builds upon the methods and results of the LIFE-Sterlet project and implements multiple actions included in the Pan-European Action Plan for Sturgeons. It has the aim to establish a genetically diverse captive broodstock of mature animals for all four remaining Danube sturgeon species in at least two locations (AT and HU). These living gene banks will be maintained over the long-term to preserve the gene pool and to support all four species through releases genetically diverse, autochthonous and fit juveniles. In Austria, a floating rearing station in the Danube in the Vienna will be built in addition to the existing hatchery container. A mating scheme to enable high genetic diversity and guarantee genetic lineages from the Danube River Basin will be implemented.

Existing monitoring efforts are to be continued and intensified temporally and spatially to seven countries along the Danube to document the development of the populations. For the whole Danube Region and other European catchments, a long-term database and manual for ex situ actions and monitoring in sturgeon conservation will be provided. Further objectives are the coordination with fishing authorities and communities along the Lower Danube and Black Sea to reduce IUU fishing and to raise public awareness.

Mogućnosti za uzgoj jesetarskih riba u akvakulturi Srbije

Novakov Nikolina[1], Pelić Miloš[2], Lazić Dušan[2], Ljubojević Pelić Dragana[2], Kartalović Brankica[2], Radosavljević Vladimir[3]*

[1] Poljoprivredni fakultet Novi Sad, Trg Dositeja Obradovića 8, 21000 Novi Sad, Srbija
[2] Naučni institut za veterinarstvo »Novi Sad«, Rumenački put 20, 21000 Novi Sad, Srbija
[3] Naučni institut za veterinarstvo Srbije, Vojvode Toze 14, 11000 Beograd, Srbija
[*] e-mail: nikolina@polj.uns.ac.rs

Sažetak

Jesetre spadaju u jednu od najvrjednijih skupina riba, kako zbog kavijara, tako i zbog kvalitetnog mesa koje ne sadrži kosti već samo hrskavicu. Međutim, jesetre su među najugroženijim ribama zbog prekomjernog izlova, krivolova, gubitka staništa itd. Proizvodnja jesetri u akvakulturi započela je 1960-ih u bivšem Sovjetskom Savezu, dok je u Europi krenula 1980-ih. Ulaskom Kine u industriju akvakulture, ova zemlja sada trenutno čini oko 78% svjetske proizvodnje mesa jesetri. Proizvodnja jesetri u Srbiji je u povojima, a trenutno je službeno registrirano pet ribnjaka. Najčešće vrste koje se gaje u Srbiji su kečiga (*Acipenser ruthenus*) i sibirska jesetra (*Acipenser baerii*) i uzgajaju se uglavnom u recirkulacijskim akvatičnim sustavima (RAS). RAS, uz prostornu korist, ne zahtijeva veliku količinu vode, koja se tijekom proizvodnog procesa pročišćava bez gubitaka i ponovno koristi. Za kontrolu organske tvari i viška kisika u sustavu potrebno je osigurati odgovarajuće biofiltere. Također je važno osigurati mehaničke filtere i kolektore koji su zaduženi za prikupljanje dekompenzirane hrane i suspendiranih tvari. Osim dovoljne količine otopljenog kisika, ograničavajući faktor proizvodnje i povoljnog zdravstvenog stanja riba je odgovarajuća koncentracija amonijevih iona i amonijaka u vodi, što zahtijeva kontinuirano praćenje navedenih parametara. Također treba voditi računa o sprječavanju ulaska i širenja zaraznih agenasa kao što su bakterije, virusi, gljivice i paraziti. RAS se mogu izraditi s malim kapacitetom, što osigurava realan plasman ribe koja se može prodati tijekom cijele sezone i postići bolju cijenu od šarana. Pogodni su za početnike kao školski sustavi, tako da se njihov stvarni kapacitet može povećati s vremenom.

Ključne riječi: jesetre, kečige, uzgoj, akvakultura, RAS

Potential of sturgeon farming in Serbian aquaculture

Novakov Nikolina[1], Pelić Miloš[2], Lazić Dušan[2], Ljubojević Pelić Dragana[2], Kartalović Brankica[2], Radosavljević Vladimir[3]*

[1] Faculty of agriculture Novi Sad, Trg Dositeja Obradovića 8, 21000 Novi Sad
[2] Research veterinary institute Novi Sad, Rumenački put 20, 21000 Novi Sad, Srbija
[3] Scientific veterinary institute of Serbia, Vojvode Toze 14, 11000 Beograd, Srbija
[*] e-mail: nikolina@polj.uns.ac.rs

Abstract

Sturgeons belong to one of the most valuable groups of fish, both because of the caviar and the meat quality, fish do not contain bones but only cartilage. However, sturgeons are among the most threatened fish due to overfishing, poaching, habitat loss, etc. Sturgeon aquaculture production began in the 1960s in the former Soviet Union, while it took off in Europe in the 1980s. With China's entry into the aquaculture industry, this country now amount around 78% of the world's sturgeon meat production. Sturgeon production in Serbia is in its beginning, and five ponds are currently officially registered. The most common species cultivated in Serbia are starlet (*Acipenser ruthenus*) and Siberian sturgeon (*Acipenser baerii*), and they are cultivated mainly in recirculatory aquaculture systems (RAS). RAS, in addition to the spatial benefit, does not require a large amount of water, which is purified during the production process without loss and reused. To control organic matter and excess oxygen in the system, it is necessary to provide appropriate biofilters. It is also important to provide mechanical filters and collectors that are responsible for collecting decompensate food and suspended substances. In addition to a sufficient amount of dissolved oxygen, the limiting factor for production and the favorable health status of fish is the appropriate concentration of ammonium ions and ammonia in the water, which requires continuous monitoring.. Care should also be taken to prevent the entry and spread of infectious agents such as bacteria, viruses, fungi and parasites. RAS can be made with a small capacity, which ensures a realistic placement of fish that can be sold throughout the season and reach a better price than carp. They are suitable for beginners as school systems, so their actual capacity can be increased over time.

Keywords: sturgeon, sterlet, farming, aquaculture, RAS

Može li uzgoj tune biti održiv?

Dr Ivan Katavić, redoviti sveučilišni profesor

Institut za oceanografiju i ribarstvo, Split, R. Hrvatska
e-mail: katavic@izor.hr

Sažetak

Kao jedan od najvažnijih ribolovnih resursa, prirodni stok nekolicine vrsta tuna podvrgnut je intenzivnom iskorištavanju što je uzrokovalo smanjenje njihovih prirodnih biozaliha i dovodi u pitanja biološku i ekonomsku održivost ovakve prakse. S druge strane, ekspanzija aktivnosti uzgoja tuna temeljena na ribolovu stvorila je rastuću potrebu za daljnjim zahvaćanjem u prirodne stokove tuna. Stoga je jedan od glavnih razloga za zabrinutost u svezi s ovom rastućom potražnjom trenutačni i potencijalni pretjerani izlov mnogih prirodnih stokova tuna. Važan korak prema odgovornom i održivom ribolovu učinjen je kroz mjere očuvanja i upravljanja koje provode regionalne organizacija za upravljanje ribarstvom (RFMO). Problem uzgoja tune koji se temelji na ulovu nije samo u tome što se proizvodnja temelji na prikupljanju divlje ribe u svrhu uzgoja s ciljem povećanja mase i tkivne masti (tov i višegodišnji uzgoj), već i potpuna ovisnost takvog uzgoja o prirodnim zalihama sitne plave ribe, a što u konačnici može rezultirati njihovim daljnjim iscrpljivanjem, kolapsom stokova i drugim povezanim problemima u složenom morskom lancu ishrane. Uzgoj tuna je nerijetko kritiziran zbog negativnog utjecaja na okoliš uzrokovan nepojedenim ostacima hrane i nakupljanjem različitih metaboličkih proizvoda s visokim udjelom topivih hranjivih tvari. Uspješna demonstracija hranidbe s vodostabilnm peletima biljne proteinske osnove pokazala je ekonomsku i ekološku korisnost, i mnogo manje problema povezanih s nakupljanjem nepojedene hrane na morskom dnu. Dugoročno gledano, nema sumnje da bi zatvaranje životnog ciklusa i kontrolirana proizvodnja mlađi tune u kombinaciji s formuliranom hranom temeljenoj na dugoročno održivim hranidbenim sastavnicama moglo preokrenuti trenutne trendove i zadovoljiti rastuće tržišne potrebe za proizvodima tuna u budućnosti. Baveći se ishranom i reprodukcijom tune u ovom radu bavimo se ključnim problemima održive akvakulture.

Ključne riječi: uzgoj tuna, održivost, prehrana ribom, biljna prehrana, kontrolirana reprodukcija, ekonomska korisnost, utjecaj na okoliš

Can tuna farming be sustainable?

Ivan Katavić, PhD, Full University Professor

Institute of Oceanography and Fisheries, Split, Croatia
e-mail: katavic@izor.hr

Abstract

Being one of the most important fisheries resources natural stocks of tuna species is subjected to an intense exploatation which has caused reduction in the biomass and raised the questions concerning its biological and economic sustainability. On the other side the expansion of tuna farming activities based on fishing have generated a further growing demand for wild tuna socks. Hence, one of the main concerns about this demand is the current and potential overfishing of many tuna socks. An important step towards responsible and sustainable fishing is to enforce the conservation and management measures of the regional fisheries management organisations (RFMOs). The problem of capture-based tuna farming is not only that production is based on collection of wild fish for growing purposes aiming to increase their weight and fat content of flesh (fattening and farming), but also its dependence on small pelagic resources that may lead to stock depletion, stock collapse or other related problems in the marine food chain. Tuna aquaculture has also received a lot of criticism regarding the environmental impact caused by uneaten fraction of baitfish and accumulation of diverse metabolic products with a high proportion of soluble nutrients. Successful feeding demonstration with plant-based and water-stable formulated diets showed both economic and environmental benefit with much less problems associated with accumulation of wasted feed on the sea floor. In the long run there should be no doubt that closing life cycles of farmed tuna, and securing pelletized feed based on sustainable feeding sources may reverse current trends and satisfied the growing market for tuna products in the future. By addressing tuna nutrition and reproduction we deal with key issues for sustainable aquaculture.

Keywords: tuna aquaculture, sustainability, baitfish, plan-based diet, controlled reproduction, economoc benefit, environmental impact

Označavanje plavoperajnog tuna (*Thunnus thynnus*) mikročipovima za potrebe utvrđivanja individualnog rasta u kaveznom uzgoju

Doc.dr.sc. Leon Grubišić[1], prof.dr.sc. Ivan Katavić[1], dr.sc. Jasna Maršić Lučić[1], Marino Urlić[2], dr.sc.Tanja Šegvić-Bubić[1]*

[1] Institut za oceanografiju i ribarstvo, Šetalište I. Meštrovića 63, 21000, Split, Hrvatska
[2] Pelagos Net Farma, Gaženička cesta 28B, 23000 Zadar, Hrvatska
[*] e-mail: leon@izor.hr

Sažetak

Održivo upravljanje ribljim stokovima namijenjenim daljnjem uzgoju u kaveznim sustavima predstavlja značajan izazov za sve dionike. Stroga kontrola iskorištavanja ulovnih kvota onemogućena je nedostatkom stvarnih podataka o ulovnoj biomasi i broju riba jer su podaci dostupni tek nakon završetka uzgojnog ciklusa. Označavanje jedinki mikročipom često je primjenjivana metoda za utvrđivanje individualne stope rasta ribe, a u slučaju tuna u uzgoju nužna je za izradu modela procjene biomase na početku uzgoja. Cilj predmetnog rada uključuje prikaz protokola i rezultata istraživanja gdje se po prvi put primijenila metoda označavanja mikročipom u uzgoju tuna. Ukupno je označeno 208 plavoperajnih tuna s rasponom mase od 7,2 do 25,2 kg, starosnih skupina 2+ i 3+. Detaljno je opisan postupak rukovanja živom ribom, apliciranje mikročipa, saniranje ozljeda i preveniranje infekcija, kao i gubici riba nakon označavanja. S završetkom uzgojnog ciklusa, uspješno je identificirano 158 označenih jedinki od ukupno 208. Zaključno, za potrebe znanstvenih istraživanja iskusna i educirana ekipa je u mogućnosti provesti masovno označavanje juvenilnih tuna uz razmjerno male gubitke.

Ključne riječi: Plavoperajna tuna, marikultura, označavanje mikročipovima

Tagging of bluefin tuna (*Thunnus thynnus*) with microchips for the purpose of individual growth estimation in cage culture

Doc.dr.sc. Leon Grubišić[1], prof.dr.sc. Ivan Katavić[1], dr.sc. Jasna Maršić Lučić[1], Marino Urlić[2], dr.sc. Tanja Šegvić-Bubić[1]*

[1] Institute of Oceanography and Fisheries, Šetalište I. Meštrovića 63, 21000, Split, Croatia,
[2] Pelagos Net Farma, Gaženička cesta 28B, 23000 Zadar, Croatia
[*] e-mail: leon@izor.hr

Abstract

Sustainable management of fish stocks destined for further farming in cages is a challenge for all stakeholders. Strict control of catch quotas is hampered by the lack of real data on catch biomass and numbers of fish, as these data are only available after the farming cycle. Tagging individuals with a microchip is a common method for determining individual fish growth rate and, in the case of farmed tuna, is necessary to create a model for estimating biomass at the beginning of the farming cycle. This paper presents the protocol and results of the study in which the tagging method was used for the first time in tuna farming. A total of 208 bluefin tunas of ages 2+ and 3+ weighing between 7,2 and 25,2 kg were tagged. The handling of live fish, microchip application, wound care and infection prevention, and fish losses after tagging are described in detail. At the end of the farming cycle, 158 out of a total of 208 tagged fish were successfully identified. In summary, an experienced and trained team is able to perform mass tagging of juvenile tuna for scientific research purposes with reasonable losses.

Keywords: Bluefina tuna, mariculture, tagging with microcips

Kavezni uzgoj gofa *Seriola dumerili* u Sredozemlju: smjernice za održivo upravljanje

Tanja Šegvić-Bubić[1], Igor Talijančić[1], Iva Žužul[1], Luka Žuvić[1], Leon Grubišić[1], David Izquierdo-Gomez[2,3]*

[1] Institut za oceanografiju i ribarstvo, Šetalište I. Meštrovića 63, 21000, Split, Croatia
[2] College STEE (Sciences and Technologies of the Energy and the Environment), University of Pau and the Adour Region (UPPA), Pyrenees Atlantiques, France
[3] Norwegian Institute of Food, Fisheries and Aquaculture Research (NOFIMA), Muninbakken 9-13, Breivika, 9291 Tromsø, Norway
[*] e-mail: tanja.segvic@izor.hr

Sažetak

Komercijalni uzgoj gofa *Seriola dumerili* nedavno je započeo u mediteranskim zemljama. Kako bi se marikultura nosila s klimatskim promjenama, gof kao toploljubna vrsta pruža priliku za popunjavanje novonastalih niša u kaveznom uzgoju. Ipak, oluja Gloria (siječanj 2020.) koja je razorila većinu kavezno-uzgojnih sustava na zapadnoj obali Sredozemlja i oko 70% španjolske proizvodnje riba, bila je prekretnica za uvođenje mjera upravljanja za nove vrste u akvakulturi, budući da su tisuće jedinki gofa po prvi put pobjegli u divljinu. Kako prebjegle ribe iz uzgoja mogu imati brojne ekološke utjecaje na divlje populacije riba, predmetno istraživanje je imalo za cilj sagledati koje se morfološke i genetske karakteristike mogu koristiti za razlikovanje podrijetla gofa. Točna identifikacija divlje ili uzgojene ribe može spriječiti prijevare u prodaji ili pad cijene zbog iskrcavanja velike biomase vrste koja se obično događa nakon bijega. Tri tehnike, geometrijska morfometrija, mikrosatelitski markeri i kombinacija obje u nadziranom sustavu strojnog učenja, primijenjene su na ukupno 490 riba iz divljeg i uzgojnog podrijetla iz zapadnog i središnjeg Sredozemnog mora. Zbog razlika u obliku tijela, profilu glave i položaju usta između divljih i uzgojenih riba, te značajne genetske udaljenosti, primijenjene metode pokazale su se uspješnim u prepoznavanju podrijetla. Slijedom toga, raspravlja se o adaptivnim planovima za sprječavanje, ublažavanje i kontrolu potencijalnih negativnih učinaka bijega ribe u divljini.

Ključne riječi: Gof, marikultura, bijeg ribe, obalno upravljanje

Net-pen culture of *Seriola dumerili* in Mediterranean: implications for the sustainable management

Tanja Šegvić-Bubić[1], Igor Talijančić[1], Iva Žužul[1], Luka Žuvić[1], Leon Grubišić[1], David Izquierdo-Gomez[2,3]*

[1] Institute of Oceanography and Fisheries, Šetalište I. Meštrovića 63, 21000, Split, Croatia
[2] College STEE (Sciences and Technologies of the Energy and the Environment), University of Pau and the Adour Region (UPPA), Pyrenees Atlantiques, France
[3] Norwegian Institute of Food, Fisheries and Aquaculture Research (NOFIMA), Muninbakken 9-13, Breivika, 9291 Tromsø, Norway
[*] e-mail: tanja.segvic@izor.hr

Abstract

Commercial mariculture of greater amberjack *Seriola dumerili* recently started in Mediterranean countries. To cope with climate change, the greater amberjack provides an opportunity to fill emerging niches in marine warm water cage culture. Nevertheless, storm Gloria (January 2020), which devastated most marine net cage systems on the west coast of the Mediterranean and about 70% of Spanish finfish production, was a turning point for the introduction of management measures for new species in aquaculture, as thousands of greater amberjack escaped into the wild for the first time. Because fish that have escaped from marine net pens can have numerous ecological impacts on their wild counterparts, this study investigated what morphological and genetic characteristics can be used to distinguish the origin of the greater amberjack. Accurate identification of wild or farmed fish can prevent fraud in sales or a drop in price due to the landing of large biomasses of the species that typically occur after an escape event. Three techniques-geometric morphometrics, microsatellite markers, and a combination of both in a supervised machine learning system-were applied to a total of 490 fish from wild and farmed stocks from the western and central Mediterranean Sea. Due to differences in body shape, head profile, and mouth position between wild and farmed stocks associated with high genetic differentiation, the applied methods proved successful in correctly assigning of fish. Consequently, adaptive contingency plans to prevent, mitigate, and control potential negative effects of escape events in the wild are discussed.

Keywords: Greater amberjack, Mariculture, Escapes, Coastal management

Nutritivna kvaliteta morske ribe uzgojene u Jadranskom moru

prof. dr. sc. Jelka Pleadin[1], prof. dr. sc. Greta Krešić[2], dr. sc. Dražen Oraić[3], dr. sc. Tina Lešić[1], dr. sc. Ana Vulić[1], dr. sc. Nina Kudumija[1], dr. sc. Snježana Zrnčić[3]*

[1] Hrvatski veterinarski institut, Laboratorij za analitičku kemiju, Savska cesta 143, 10000 Zagreb, Hrvatska
[2] Fakultet za menadžment u turizmu i ugostiteljstvu, Sveučilište u Rijeci, Katedra za hranu i prehranu, Primorska 46, 51410 Opatija, Hrvatska
[3] Hrvatski veterinarski institut, Laboratorij za patologiju riba, Savska cesta 143, 10000 Zagreb, Hrvatska
[*] e-mail: pleadin@veinst.hr

Sažetak

Riblje meso smatra se prehrambenom namirnicom visoke nutritivne vrijednosti budući da sadrži značajan udio bjelančevina, ukučujući esencijalne aminokiseline, ima poželjan sastav lipida te sadrži brojne vrijedne mikronutrijente. Nutritivni sastav ribe uvelike varira ovisno o dobi i spolu ribe, okolišu i sezoni uzgoja. U ovom istraživanju ispitivana je nutritivna kvaliteta lubina i komarče (n = 120) uzgojenih u Jadranu, po sezonama tijekom dvogodišnjeg razdoblja. Analiziran je osnovni i masno-kiselinski sastav, količina makro- i mikro- minerala, vitamina A i E te su određene vrijednosti indeksa nutritivne kvalitete masti. Utvrđeno je značajno ($p < 0.05$) variranje udjela ukupne masti po sezonama, ujedno dokazujući da su uzgojene vrste po pitanju masno-kiselinskog sastava bogat izvor omega-3 višestruko nezasićenih dugolančanih masnih kiselina (n-3 LC PUFA). Vrijednosti indeksa nutritivne kvalitete masti udovoljavale su tijekom cijelog razdoblja istraživanja preporukama međunarodnih zdravstvenih organizacija. Po pitanju mineralnog sastava, utvrđene su značajno najveće količine kalija te fosfora, te potom natrija, kalcija i magnezija. Sadržaj vitamina A i E kod obje vrste riba značajno je varirao po sezonama, pri čemu je vitamin E imao vršne vrijednosti tijekom zime, a vitamin A tijekom ljeta. Zbog svojeg visoko vrijednog nutritivnog sastava, morska riba treba predstavljati integralnu sastavnicu prehrane potrošača putem koje u organizam dospijevaju iskoristivi i visoko vrijedni makro- i mikro- nutrijenti.

Ključne riječi: uzgojena riba, lubin, komarča, Jadran, nutritivna kvaliteta

Nutritional quality of marine fish grown in the Adriatic Sea

Prof Ph D Jelka Pleadin[1], Prof Ph D Greta Krešić[2], Ph D Dražen Oraić[3], Ph D Tina Lešić[1], Ph D Ana Vulić[1], Ph D Nina Kudumija[1], Ph D Snježana Zrnčić[3]*

[1] *Croatian Veterinary Institute, Laboratory for Analytical Chemistry, Savska cesta 143, 10000 Zagreb, Croatia*
[2] *Faculty of Tourism and Hospitality Management, University of Rijeka, Department of Food and Nutrition, Primorska 46, 51410 Opatija, Croatia*
[3] *Croatian Veterinary Institute, Laboratory for Fish Pathology, Savska Cesta 143, 10000 Zagreb, Croatia*
[*] *e-mail: pleadin@veinst.hr*

Abstract

Fish meat is considered a foodstuff of high nutritional value since it contains a significant proportion of proteins, including essential amino acids, has a desirable composition of lipids and contains numerous valuable micronutrients. The nutritional composition of fish varies greatly depending on the age and sex of the fish, the environment and the growing season. In this research, the nutritional quality of sea bass and sea bream (n = 120) grown in the Adriatic Sea was examined by season over a two-year period. The basic and fatty acid composition, the amount of macro- and micro-minerals, vitamins A and E were analyzed, and the values of the nutritional quality index of the fat were determined. A significant ($p < 0.05$) variation in the proportion of total fat by season was found, at the same time proving that the cultivated species in terms of fatty acid composition are a rich source of omega-3 polyunsaturated long-chain fatty acids (n-3 LC PUFA). The values of the nutritional quality index of fat complied with the recommendations of international health organizations during the entire research period. Regarding the mineral composition, the highest amounts of potassium and phosphorus were found, followed by sodium, calcium and magnesium. Vitamin A and E content in both types of fish varied significantly by season, with vitamin E peaking in winter and vitamin A peaking in summer. Due to its highly valuable nutritional composition, marine fish should represent an integral component of the consumer's diet, through which usable and highly valuable macro- and micro-nutrients reach the body.

Keywords: farmed fish, sea bass, fennel, Adriatic, nutritional quality

Integrirani sustav uzgoja alternativnih vrsta školjkaša u uvjetima klimatskih promjena

prof. dr. sc. Jadranka Frece

Prehrambeno-biotehnološki fakultet, Sveučilište u Zagrebu, Pierottijeva ul. 6, Zagreb, Hrvatska
e-mail: jfrece@pbf.hr

Sažetak

Klimatske promjene značajna su dugoročna prijetnja održivosti uzgoja školjkaša u RH. Promjene okolišnih parametara, kao što su porast temperature mora, smanjenje dotoka slatke vode, porast saliniteta te acidifikacija mora, izrazito negativno utječe na uzgoj školjkaša, usporavajući i smanjujući njihov rast te povećavajući smrtnost. Na promjenu okolišnih parametara posebno je osjetljiv uzgoj kamenica, koje će u nekim područjima do kraja stoljeća postati nemoguće uzgajati. Porast temperature mora pospješit će i pojavu te širenje postojećih, ali i novih bolesti kod školjkaša u uzgoju, dok će porast prosječnih temperatura zraka značajno povećati rizik od kvarenja školjkaša tijekom njihova skladištenja i distribucije prema potrošačima te rukovanja sa školjkašima pri pripremi hrane, s posljedično negativnim efektima na zdravlje ljudi. Cilj projekta Integrirani sustav uzgoja alternativnih vrsta školjkaša u uvjetima klimatskih promjena (KK.05.1.1.02.0012) bio je učiniti segment marikulture vezan uz uzgoj školjkaša u RH otpornijim na klimatske promjene te dugoročno održivim, te predložiti konkretne mjere prilagodbe kojima će se spriječiti ili umanjiti opisani negativni učinci promjene klime na uzgoj školjkaša te s njima povezani negativni učinci na zdravlje ljudi te iskoristiti potencijalni pozitivni učinci klimatskih promjena kroz promjene u tehnologiji uzgoja školjkaša te diversifikacijom uzgoja, uvođenjem novih vrsta školjkaša u marikulturnu proizvodnju u RH. Projekt su proveli Prehrambeno-biotehnološki fakultet Sveučilišta u Zagrebu s partnerom – Sveučilištem Jurja Dobrile u Puli.

Projekt je odobren u sklopu poziva “Shema za jačanje primijenjenih istraživanja za mjere prilagodbe klimatskim promjenama” u okviru Operativnog programa Konkurentnost i kohezija 2014.-2020. Ukupna vrijednost projekta je 3.422.948,07 kuna, od čega bespovratna EU sredstva su iznosila 2.870.821,65 kuna. Projekt se proveo u razdoblju od 20. siječnja 2020. godine do 20. siječnja 2023. godine. Projektni rezultati istraživačkog tima PBF-a obuhvaćali su izolaciju, identifikaciju i karakterizaciju potpuno novog probiotičkog soja, izoliranog iz

češljače Aequipecten opercularis koja je odabrana kao potencijalna alternativna vrsta školjkaša u akvakulturi. Novi probiotički soj potpuno je istražen i zadovoljio je niz sigurnosnih, tehnoloških i funkcionalnih kriterija. Posebno se istaknula snažna antimikrobna aktivnost otkrivenog soja prema najčešćim patogenima. Primjena navedene bakterije u uzgoju školjkaša, posebice u uvjetima klimatskih promjena polučila je iznimne rezultate, jasno vidljive iz smanjenja mikroorganizama uzročnika kvarenja što otvara brojne mogućnosti primjene ovog soja ne samo u akvakulturi nego i u biokonzerviranju. Istraživački tim Sveučilišta u Puli postigao je značajne rezultate u praćenju uzgoja odabranog školjkaša u različitim periodima tijekom godine. Primjena novog probiotika rezultirala je pozitivnim učincima na prirast i kondicijski indeks školjkaša, a kada su se eksperimenti proveli u uvjetima klimatskih promjena rezultati su pokazali povoljne trendove koji uistinu otvaraju brojne mogućnosti i stvoren je prostor za nadogradnju i prijavu novih projekata u kojima bi se ispitala proizvodnja u većim mjerilima te ispitala otpornost kontinuiranog uzgoja u, nažalost neizbježnim, uvjetima klimatskih promjena.

Integrated system of breeding alternative species of shellfish in the conditions of climate change

PhD Jadranka Frece

Faculty of Food Technology and Biotechnology, University of Zagreb, Pierottijeva 6, 10000 Zagreb
e-mail: jfrece@pbf.hr

Abstract

Climate change is a significant long-term threat to the sustainability of shellfish cultivation in the Republic of Croatia. Changes in environmental parameters, such as an increase in sea temperature, a decrease in the inflow of fresh water, an increase in salinity and acidification of the sea, have an extremely negative effect on the cultivation of shellfish, slowing down and reducing their growth and increasing mortality. The cultivation of oysters is particularly sensitive to changes in environmental parameters, which will become impossible to cultivate in some areas by the end of the century. The rise in sea temperature will accelerate the occurrence and spread of existing and new diseases in shellfish cultivation, while the increase in average air temperatures will significantly increase the risk of spoilage of shellfish during their storage and distribution to consumers and handling of shellfish during food preparation, with a consequent negative effects on human health. The goal of the project *Integrated system of breeding alternative species of shellfish in the conditions of climate change* (KK.05.1.1.02.0012) was to make the segment of mariculture related to shellfish cultivation in the Republic of Croatia more resistant to climate change and sustainable in the long term, and to propose concrete adaptation measures that will prevent or reduce the described negative effects of climate change on shellfish farming and the associated negative effects on human health, and use the potential positive effects of climate change through changes in shellfish cultivation technology and by diversifying cultivation, introducing new species of shellfish into mariculture production in the Republic of Croatia. The project was carried out by the Faculty of Food Technology and Biotechnology, University of Zagreb with a partner - Juraj Dobrila University of Pula.

The project was approved as part of the call Scheme for strengthening applied research for climate change adaptation measures within the Operational Programme Competitiveness and cohesion 2014-2020. The total value of the project is HRK 3,422,948.07, of which

EU grants amounted to HRK 2,870,821.65. The project was implemented in the period from January 20, 2020 to January 20, 2023. The project results of the PBF research team included the isolation, identification and characterization of a completely new probiotic strain, isolated from the scallop *Aequipecten opercularis,* which was selected as a potential alternative shellfish species in aquaculture. The new probiotic strain has been fully researched and has met a number of safety, technological and functional criteria. The strong antimicrobial activity of the discovered strain against the most common pathogens was especially highlighted. The use of the mentioned bacteria in the cultivation of shellfish, especially in conditions of climate change, has produced exceptional results, clearly visible in the reduction of spoilage-causing microorganisms, which opens up numerous possibilities for the use of this strain not only in aquaculture but also in biopreservation. The research team of the University of Pula has achieved significant results in monitoring the cultivation of selected shellfish in different periods throughout the year. The use of a new probiotic resulted in positive effects on the growth and fitness index of shellfish, and when the experiments were conducted under conditions of climate change, the results showed favorable trends that truly open up numerous possibilities and created space for upgrading and conducting new projects in which production would be tested on a larger scale and tested the resistance of continuous cultivation in the unfortunately inevitable conditions of climate change.

Potencijalni rizici za hrvatsko školjkarstvo uslijed invazije stranih vrsta u Jadranskom moru

Prof.dr.sc. Branko Glamuzina

Sveučilište u Dubrovniku, Odjel za primijenjenu ekologiju, Ćira Carića 4, 20000 Dubrovnik, Republika Hrvatska
e-mail: branko.glamuzina@unidu.hr

Sažetak

Recentna pojava stranih vrsta u Jadranskom moru ima potencijalno značajne rizike za budući razvoj školjkarstva, te je ovoj problematici potrebno posvetiti pažnju, posebice u povećanoj brojnosti predatorskih vrsta riba i rakova, ali i nekih školjkaša. Nagli porast brojnosti orade u Malostonskom zaljevu u razdoblju 2010-2015. godine uzrokovao je velike štete na uzgajalištima dagnji, iako se od strane znanstvenog i ribarskog sektora upozoravalo na povećanje njezine brojnosti u obalnom pojasu Neretvanskoga kanala i ušća Neretve. Od stranih vrsta koje zadnjih 20-tak godina imaju invazivni karakter, a mogu naštetiti školjkarstvu, posebno se ističu plavi rak, *Calinectes sapidus* i pacifička kamenica, *Crassostrea gigas*. Obje vrste su već zasnovale stabilnu populaciju u nekim područjima istočne jadranske obale, a plavi rak dokazano ima izrazito štetne učinke na autohtone ekosustave. Tako je plavi rak potpuno uništio populacije nekih pridnenih školjkaša (kućica, brbavica, dagnja) na ušću Neretve, a pacifička kamenica je na nizu lokaliteta u Istri zauzela staništa autohtonih vrsta. Po rezultatima nekih znanstvenih istraživanja u Grčkoj, plavi rak ima veliku preferenciju u prehrani prema dagnjama i manjim kamenicama. Iako je u zaljevu Bistrina već potvrđena pojava plavoga raka, njegova brojnost je niska u odnosu na područje oko ušća Neretve, ali je opasnost od migracija ličinka ili odraslih jedinka velika. S obzirom na način kretanja i brzinu plivanja, može se očekivati njegova pojava i predatorstvo na plutajućim instalacijama s dagnjama i kamenicama. Povećanje brojnosti pacifičke kamenice može dovesti do prijenosa uzročnika niza bolesti i parazita na plosnatu kamenicu ili, uslijed povećanog novačenja, do kompeticije za hranu i stanište. Također, može doći do zamjene mlađi jedne za drugu vrstu i posljedične probleme u prodaji. Procjena rizika ovih vrsta AS-ISK programom ukazala je da ove dvije vrste imaju velike potencijale za štete u ekosustavima, ribarstvu i akvakulturi, te je u kratkoročnom razdoblju potrebno poduzeti mjere kontrole njihovih populacija, kako bi se izbjegle daljnje štete.

Ključne riječi: rizici, hrvatsko školjkarstvo, invazivne vrste, plavi rak

Potential risks for Croatian shellfish culture due to the invasion of non-native species in the Adriatic Sea

Prof Branko Glamuzina

University of Dubrovnik, Department of Applied Ecology, Ćira Carića 4, 20000 Dubrovnik, Republic of Croatia
e-mail: branko.glamuzina@unidu.hr

Abstract

The recent appearance of non-native species in the Adriatic Sea has potentially significant risks for the future development of shellfish farming, and attention should be paid to this issue, especially in the increased number of predatory species of fish and crustaceans, as well as some shellfish. There was a sharp increase in the number of gilthead seabreams in Malostonski Bay in the period 2010-2015, which caused great damage to mussel farms, even though the scientific and fishing sectors warned of an increase in its abundance in the coastal zone of the Neretvanski channel and the estuary of the Neretva River. Of the non-native species that have become invasive in the last 20 years and can harm shellfish farming, the blue crab, *Calinectes sapidus*, and the Pacific oyster, *Crassostrea gigas*, stand out. Both species are already domesticated in some areas of the eastern Adriatic coast, and the blue crab has been proven to have extremely harmful effects on native ecosystems. Thus, the blue crab completely destroyed the populations of benthic bivalve molluscs (clams, mussels) at the Neretva Estuary, and the Pacific oyster occupied the habitats of native species in a number of localities in Istria. According to the results of some scientific research in Greece, the blue crab has a great preference in its diet for mussels and smaller oysters. Although the occurrence of blue crabs has already been confirmed in Bistrina Bay, its number is low compared to the area around the mouth of the Neretva, but the risk of migration of larvae or adults is high. Given the way it moves and the speed of swimming, its appearance and predation on floating installations with mussels and oysters should be forecasted. An increase of Pacific oyster abundance can lead to the transfer of pathogens of various diseases and parasites to native flat oysters or, due to increased recruitment, to competition for food and habitat. Also, replacement of spat of one species for another may occur causing problems in the sale. The risk assessment of these species by the Risk Assessment Program AS-ISK has shown that these two species have the greatest potential for damage to ecosystems, fisheries, and aquaculture, and that it is necessary in the short term to take measures to control their populations to prevent further damage.

Keywords: risks, Croatian shellfish farming, invasive species, blue crab

Korištenje microgAMBI indeksa za brzu procjenu ekološkog stanja u uvjetima akvakulture

dr.sc. Anamarija Kolda[1], izv. prof. dr. sc. Ana Gavrilović[2], dr.sc. Jurica Jug-Dujaković[3], dr.sc. Angel Borja[4], izv. prof. dr. sc. Zrinka Ljubešić[5], prof.dr.rer.nat. Mansour El-Matbouli[6], dr.sc. Atle Lillehaug[7], dr.sc. Semir Lončarević[7], dr.sc. Lorena Perić[1], doc. dr.sc. Kristina Pikelj[8], dr. sc. Brigita Hengl, dr. med. vet.[9], dr.sc. Dražen Knežević, dr.med.vet.[9], izv. prof. dr.sc. Darija Vukić Lušić[10], dr.sc. Damir Kapetanović dr. med. vet.[1]*

[1] *Ruđer Bošković Institute, Division for Marine and Environmental Research, Zagreb, Croatia*
[2] *University of Zagreb, Faculty of Agriculture, Department of Fisheries, Apiculture, Wildlife Management and Special Zoology, Zagreb, Croatia*
[3] *Sustainable Aquaculture Systems, Inc., Frenchtown, New Jersey, USA*
[4] *AZTI - Marine Research, Basque Research and Technology Alliance (BRTA); Herrera Kaia, Portualdea z/g – 20110 Pasaia, Spain*
[5] *University of Zagreb, Faculty of Science, Department of Biology, Zagreb, Croatia*
[6] *Department For Farm Animals and Veterinary Public Health, Clinical Division of Fish Medicine, Wien, Austria*
[7] *Norwegian Veterinary Institute, Department of Fish Health and Biosecurity, Oslo, Norway*
[8] *University of Zagreb, Faculty of Science, Department of Geology, Zagreb, Croatia*
[9] *Croatian Agency for Agriculture and Food, Osijek, Croatia*
[10] *Department of Environmental Health, Faculty of Medicine, University of Rijeka, Rijeka, Croatia*
[*] *e-mail: Anamarija.Kolda@irb.hr*

Sažetak

Industrija akvakulture trenutno implementira strategiju Plave transformacije kako bi se poboljšala održivost rastuće proizvodnje. Mikrobi imaju ogroman utjecaj na održivost i zdravlje u akvakulturi. Posljedično, u tijeku su globalni napori za implementaciju eDNA metabarkodiranja mikroba za rutinsko praćenje različitih okoliša. Za procjenu ekološkog stanja (ES), prema sastavu mikrobne zajednice, kreiran je microgAMBI (AZTI-jev Marine Biotic Index, baziran na bakterijskom genomu). Uzorkovanje morske vode i sedimenta obavljeno je 2018. godine u ožujku, lipnju, rujnu i studenom, na uzgajalištu brancina u Malostonskom zaljevu (Hrvatska) pored otoka Maslinovac i kontrolnoj točki kod otoka Pučenjak. Ukupna DNA je ekstrahirana i 16S rRNA gen (V1-V3 regija) je sekvenciran korištenjem tehnologije sekvenciranja nove generacije (Illumina, UK). Na temelju dobivene taksonomske liste, napravljen je mikrogAMBI izračun te je svakom uzorku dodijeljeno ES. Većina uzoraka postigla je umjereno ES, pri čemu je ljetni uzorak morske vode s uzgajališta imao vrlo loše ES, dok je zimski kontrolni uzorak sedimenta imao je dobro ekološko stanje. Sediment u uzgajalištu bio je lošeg ES u toplijim godišnjim dobima, kao

i kontrolni sediment ljeti. Zaključno, microgAMBI je pokazao potencijal u učinkovitoj procjeni ES okoliša u uzgajalištu i okolici, pružajući korisne informacije za menadžere u akvakulturi i kreatore politike.

Ključne riječi: metabarkodiranje, microgAMBI, ekološko stanje, mikrobna ekologija, akvakultura

Use of microgAMBI index for fast ecological assessment of aquaculture environment

Anamarija Kolda, PhD[1], Ana Gavrilović, PhD, Associate Professor[2], Jurica Jug-Dujaković, PhD[3], Angel Borja, PhD[4], Zrinka Ljubešić, PhD, Associate Professor[5], Mansour El-Matbouli, Prof.dr.rer.nat.[6], Atle Lillehaug, PhD, DVM[7], Semir Lončarević PhD, DVM[7], Lorena Perić, PhD, Senior Research Associate[1], Kristina Pikelj, PhD, Assistant Professor[8], Brigita Hengl PhD, DVM[9], Dražen Knežević PhD, DVM[9], Darija Vukić Lušić, Associate Professor[10], Damir Kapetanović PhD, DVM, Senior Research Associate[1]*

[1] *Ruđer Bošković Institute, Division for Marine and Environmental Research, Zagreb, Croatia*
[2] *University of Zagreb, Faculty of Agriculture, Department of Fisheries, Apiculture, Wildlife Management and Special Zoology, Zagreb, Croatia*
[3] *Sustainable Aquaculture Systems, Inc., Frenchtown, New Jersey, USA*
[4] *AZTI - Marine Research, Basque Research and Technology Alliance (BRTA); Herrera Kaia, Portualdea z/g – 20110 Pasaia, Spain*
[5] *University of Zagreb, Faculty of Science, Department of Biology, Zagreb, Croatia*
[6] *Department For Farm Animals and Veterinary Public Health, Clinical Division of Fish Medicine, Wien, Austria*
[7] *Norwegian Veterinary Institute, Department of Fish Health and Biosecurity, Oslo, Norway*
[8] *University of Zagreb, Faculty of Science, Department of Geology, Zagreb, Croatia*
[9] *Croatian Agency for Agriculture and Food, Osijek, Croatia*
[10] *Department of Environmental Health, Faculty of Medicine, University of Rijeka, Rijeka, Croatia*
[*] *e-mail: Anamarija.Kolda@irb.hr*

Abstract

Aquaculture industry is currently implementing Blue Transformation strategy to enhance sustainability of the growing production. Microbes have tremendous impact on sustainability and health in aquaculture industry. Consequently, there is a global effort for implementation of eDNA metabarcoding of microbes for routine monitoring of various environments. To assess the ecological status (ES), according to microbial assemblage composition, microgAMBI (microbial genomic-based AZTI's Marine Biotic Index) was created. Sampling of seawater and sediment was conducted in 2018, at a small-scale seabass farm in Mali Ston Bay, Croatia near island Maslinovac and a respective control site (near island Pučenjak), in March, June, September and November. Total DNA was extracted and 16S rRNA gene (V1-V3 region) was sequenced using high-throughput sequencing technology (Illumina, UK). Based on the obtained taxonomic list, microgAMBI calculation was performed and ES of the sampling sites was assigned. Most of the samples achieved "moderate" ES, with summer farm seawater sample having "bad" ES and winter control sediment sample

having “good” status. Sediment in the farm was of “poor” ecological status in warmer seasons, as did the control sediment in the summer.

Overall, microgAMBI demonstrated potential in effective assessment of aquaculture and surrounding environment, providing useful information for aquaculture managers and policy makers.

Keywords: metabarcoding, microgAMBI, ecological status, microbial ecology, aquaculture

Istraživanje okolišnih uvjeta unutar dva važna područja uzgoja školjkaša na istočnoj obali Jadrana

Perić Lorena[1], Kapetanović Damir[1], Orlić Karla[1], Bolotin Jakša[2], Kožul Valter[2], Nerlović Vedrana[3], Bobanović-Ćolić Svjetlana[2], Barac Fran[1], Burić Petra[4], Marinac-Pupavac Sandra[5], Linšak Željko[5], Antunović Sanda[5] and Žurga Paula[5]*

[1] Institut Ruđer Bošković, Bijenička cesta 54, 10000 Zagreb, Hrvatska
[2] Institut za more i priobalje, Sveučilište u Dubrovniku, Hrvatska
[3] Sveučilišni odjel za Studije mora, Sveučilište u Splitu, Hrvatska
[4] Fakultet prirodnih znanosti, Sveučilište Jurja Dobrile u Puli, Hrvatska
[5] Nastavni zavod za javno zdravstvo Primorsko-goranske županije, Hrvatska
[*] e-mail: Lorena.Peric@irb.hr

Sažetak

Akvakultura školjkaša u istočnom Jadranu temelji se isključivo na tradicionalnom uzgoju mediteranske dagnje i europske plosnate kamenice. Školjkaši su tijekom životnog ciklusa u bliskom doticaju sa okolišem. Stoga je razumijevanje negativnog učinka mogućeg donosa antropogenih stresora s kopna na cjelokupnu kvalitetu uzgajanih organizama od iznimne važnosti za uspješnost njihove proizvodnje. Ovo istraživanje provedeno je na uzgajalištima u Limskom i Malostonskom zaljevu. Cilj istraživanja bio je procjena prostorno-vremenskih obrazaca okolišnih fizikalno-kemijskih parametara, mikrobiološke kvalitete i razine uobičajenih kemijskih zagađivala u tkivima uzgajanih školjkaša i sedimentu.

Fizikalno kemijski parametri mora kretali su se u okviru uobičajenih sezonalnih vrijednosti. Mikrobiološka kvaliteta te razine metala i policikličkih aromatskih ugljikovodika u tkivima i sedimentu pokazale su sezonske i prostorno uvjetovane razlike. Vrijednosti koncentracija polikloriranih bifenila i pesticida bile su ispod granica detekcije.

Rezultati pokazuju specifičnosti uzgojnih područja koji se mogu objasniti razlikama u obogaćenju hranjivim tvarima i hidrološkim uvjetima između Limskog i Malostonskog zaljeva. Budući da se zbog globalnog zatopljenja predviđaju sve veći pritisci na obalni morski okoliš, svijest o potrebi očuvanja uzgojnih područja bit će od ključne važnosti za daljnju održivost akvakulture školjkaša na području istočnog Jadrana.

Ključne riječi: školjkaši, akvakultura, istočni Jadran, antropogeni stresori

A survey of environmental conditions at two distinct eastern Adriatic bivalve aquaculture sites

Perić Lorena[1], Kapetanović Damir[1], Orlić Karla[1], Bolotin Jakša[2], Kožul Valter[2], Nerlović Vedrana[3], Bobanović-Ćolić Svjetlana[2], Barac Fran[1], Burić Petra[4], Marinac-Pupavac Sandra[5], Linšak Željko[5], Antunović Sanda[5] and Žurga Paula[5]

[1] Ruđer Bošković Institute, Bijenička cesta 54, 10000 Zagreb, Croatia
[2] Institute for Marine and Coastal Research, University of Dubrovnik, Croatia
[3] University Department of Marine Studies, University of Split, Croatia
[4] Faculty of Natural Sciences, University of Pula, Croatia
[5] Teaching Institute of Public Heath of Primorsko-Goranska County, Rijeka, Croatia
[*] e-mail: Lorena.Peric@irb.hr

Abstract

Bivalve aquaculture in the eastern Adriatic relies exclusively on traditional farming of Mediterranean mussel and European flat oyster. Since bivalves are intimately linked to surrounding environment, understanding of whether the anthropogenic stressors that may be delivered from land-based sources may negatively affect the overall quality of farmed organisms is crucial for seafood production success. This study was carried out at farming sites in Lim Bay and Mali Ston Bay. The specific aims were to assess the spatio-temporal patterns of environmental parameters, microbiological quality and levels of common chemical pollutants for farmed mussel and oyster tissues as well as for sediment samples.

Seawater physico-chemical parameters displayed typical seasonal variations. Patterns of microbiological quality and sediment and tissue levels of chemicals were both seasonal and site-specific for metals and polycyclic aromatic hydrocarbons. Levels of polychlorinated biphenyls and pesticides in both sediment and tissues were below detection limits.

The results reflect specificities of each farming site arising from differences in nutrients enrichment and hydrological conditions at Lim Bay and Mali Ston Bay. Since further aggravation of environmental conditions driven by climate changes has been anticipated, the awareness on the necessity for farming habitats' preservation will be crucial for future sustainability of eastern Adriatic bivalve aquaculture.

Keywords: Bivalve, aquaculture, eastern Adriatic, anthropogenic stressors

Dinamika i raznolikost bakterijske zajednice *Vibrio* u akvakulturi školjkaša s naglaskom na antibiotsku rezistenciju

Orlić Karla[1], Kazazić Snježana[1], Kapetanović Damir[1], Vardić-Smrzlić Irena[1], Kolda Anamarija[1], Bolotin Jakša[2], Kožul Valter[2], Buha Tonka[3], Nerlović Vedrana[4], Bobanović-Ćolić Svjetlana[2], Perić Lorena[1]*

[1] *Institut Ruđer Bošković, Bijenička cesta 54, 10000 Zagreb, Hrvatska*
[2] *Institut za more i priobalje, Sveučilište u Dubrovniku, Hrvatska*
[3] *Interdisciplinary Centre of Marine and Environmental Research, Porto, Portugal; Prirodoslovno-matematički fakultet, Sveučilište u Zagrebu, Hrvatska*
[4] *Sveučilišni odjel za studija mora, Sveučilište u Splitu, Hrvatska*
[*] *e-mail: korlic@irb.hr*

Sažetak

S obzirom da se u Hrvatskoj proizvodni ciklus odvija u prirodnom okruženju, školjkaši su izrazito osjetljivi na promjene u okolišu. Tijekom hranjenja, nakupljaju velik broj čestica uključujući *Vibrio* bakterije, poznate uzročnike bolesti. Sve izraženija antibiotska rezistencija u morskom okolišu moguća je prijetnja održivosti proizvodnje školjkaša akvakulture. Zbog toga, cilj istraživanja je bio analizirati brojnost i raznolikost *Vibrio* bakterija i odrediti njihovu otpornost na antibiotike.

Istraživanje je bilo provedeno na lokacijama poznatim po akvakulturi školjkaša, u Limskom i Malostonskom zaljevu, te na dvije vrste u akvakulturi, europskoj plosnatoj kamenici i mediteranskoj dagnji. Rezultati su pokazali da je temperatura najdominantniji okolišni parametar koji je utjecao na brojnost i raznolikost *Vibrio* vrsta. Sveukupna *Vibrio* zajednica je bila brojnija na višim temperaturama iako su na različitim temperaturama bile zastupljene različite vrste. Nadalje, rezultati su pokazali da je više od 95% izoliranih *Vibrio* bakterija bilo otporno na jedan ili više antibiotika te da postoje različiti obrasci antibiotske rezistencije.

U ovom istraživanju je po prvi put zabilježena pojavnost antibiotske rezistencije u akvakulturi školjkaša u Hrvatskoj. Rezultati ukazuju da klimatske promjene mogu dovesti do pojačanog negativnog utjecaja na akvakulturu školjkaša u smislu pojačane osjetljivosti na kolonizaciju školjkaša patogenim *Vibrio* bakterijama s potencijalno više izraženom rezistencijom.

Ključne riječi: *Vibrio*, akvakultura, školjkaši, antibiotska rezistencija

Dynamics and diversity of *Vibrio* community in bivalve aquaculture with focus on antibiotic resistance

Orlić Karla[1], Kazazić Snježana[1], Kapetanović Damir[1], Vardić-Smrzlić Irena[1], Kolda Anamarija[1], Bolotin Jakša[2], Kožul Valter[2], Buha Tonka[3], Nerlović Vedrana[4], Bobanović-Ćolić Svjetlana[2], Perić Lorena[1]*

[1] *Ruđer Bošković Institute, Bijenička cesta 54, 10000 Zagreb, Croatia*
[2] *Institute for Marine and Coastal Research, University of Dubrovnik, Croatia*
[3] *Interdisciplinary Centre of Marine and Environmental Research, Porto, Portugal; Faculty of Science, University of Zagreb, Croatia*
[4] *University Department of Marine Studies, University of Split, Croatia*
[*] *e-mail: korlic@irb.hr*

Abstract

Since bivalve aquaculture in Croatia is carried out in natural environment, bivalves are highly sensitive to environmental changes. During feeding process, they accumulate large amounts of particles including bacteria from genus *Vibrio*, known as cause of disease outbreaks. Emerging threat of antibiotic resistance further complicates situation for aquaculture. Therefore, our aim was to analyze abundance and diversity of *Vibrio* bacteria and to determinate their antibiotic resistance.

Study was conducted on two locations known for bivalve aquaculture, Lim Bay and Mali Ston Bay and on two aquaculture species, European flat oyster and Mediterranean mussel. Results showed that temperature was most dominant environmental parameter that influenced both abundance and diversity of *Vibrio* species. Overall *Vibrio* bacteria community was more abundant on higher temperatures, though different *Vibrio* bacteria were more represented on different temperatures. Furthermore, results showed that more then 95% of all isolated *Vibrio* bacteria was resistant to one or more antibiotics and there were species-specific patterns of antibiotic resistance**.**

This is the first report of antibiotic resistance occurrence in bivalve aquaculture in Croatia that shows rising concern that climate can negatively affect bivalve aquaculture both with bigger susceptibility of farmed bivalves to colonization by *Vibrio* pathogens and possibly with more resistant *Vibrio* bacteria.

Keywords: *Vibrio*, aquaculture, Bivalve, antibiotic resistance

Onečišćenje morskog i obalnog ekosustava mikroplastikom – utjecaj na akvakulturu

Mihaljević Željko[1], dr. sc. DVM, Sršen Ivan[2], M.Sc.Mech.Eng., Pečar Osvin[2], mag. biol., Benić Miroslav[1], doc. dr. sc. DVM, Naletilić Šimun[1], DVM*

[1] Hrvatski veterinarski institut, Savska cesta 143, 10000 Zagreb
[2] Javna ustanova „National Park Mljet", Pristanište 2, 20226 Goveđari-Mljet
[*] e-mail: miha@veinst.hr

Sažetak

Brojne studije su dokumentirale prisutnost mikroplastike u morskim organizmima, uključujući ribe, školjkaše i rakove. Naše istraživanje onečišćenja mikroplastikom je provedeno u Polačama u Nacionalnom parku Mljet. Uzorci su prikupljeni na plaži i sedimentu dna mora 10 m od obale. Na površinu sedimenta postavljen je metalni kvadrat veličine 50 cm × 50 cm (0.25 m2) te je metalnom lopaticom uzet sediment u dubini 5 cm. Nakon sušenja, prosijavanja i vaganja umjetni materijal je zatim kategoriziran prema EU TG ML Master List (Joint Research Centre, Institute for Environment and Sustainability, a identifikacija vrste plastike je napravljena pomoću infracrvene spektroskopije s Fourierovom transformacijom (FT–IR). Na plaži su dominirali uglati fragmenti , filmovi, stiropor, filamenti i disk peleti. U sedimentu dna mora su dominirali filamenti, filmovi i uglati fragmenti. Najzastupljenija vrsta polimernog materijala u ukupnom uzorku su polietilen, polistiren i polipropilen. Najvjerojatnije porijeklo polietilenske mikroplastike je ambalaža, plastične vrećice i mreže, a polipropilenskih materijala užad i plastične čaše. Slijede polistirenski materijali (stiropor) koji je čest ribolovni i građevinski otpad. Utvrđene čestica mikroplastike od najlona najvjerojatnije potječu od odbačenih ribolovnih mreža i najlona. Mikroplastika od celuloznog acetata (filter i omot cigareta) i polietilen-tereftalata (boca za piće) najvjerojatnije su posljedica direktnog odbacivanja otpada na plažu, prije nego li donošenja vjetrom i valovima. U sedimentu dna mora dominiraju polietilenske plastične niti najvjerojatnije od užadi i odbačenih ribolovnih mreža. Dobiveni rezultati ukazuju na opasnost od apsorpcije mikroplastike u riba, rakova, školjkaša i drugih morskih organizama. Osim direktnog utjecaja mikroplastike na organizam nakon apsorpcije značajna je i indirektna opasnost na organizme vezane za dno zbog blokiranja izmjene plinova između pridnene vode i porne vode u sedimentu. U usporedbi s divljim morskim vrstama izloženost akvakulture

je značajnija jer je koncentracija mikroplastike u moru veća u obalnom područjima. U slatkovodnoj akvakulturi apsorpcija mikroplastike u organizam ovisi kontaminaciji MP u hrani za ribe i direktnoj kontaminaciji vodotoka. Posljedice ingestije MP na organizam životinje uključuju smanjeno uzimanje hrane, poremećaj reprodukcije, neurotoksičnost i smanjeni metabolizam. Najugroženiji su larvalni stadiji riba koji MP mogu zamijeniti za plankton. U njihovu crijevu progutana MP uzrokuje aktivaciju imunosnog sustava kemijskom stimulacijom i mehaničkim i proteolitičkim ozljeđivanjem trepetljikavog epitela. Zbog toga su u akvakulturi najosjetljivija mrijestilšta gdje se moraju primijeniti različite strategije prevencije kontaminacije mikroplastikom.

Ključne riječi: Mikroplastika, onečišćenje, more,sediment, akvakultura

Microplastic pollution of marine and coastal ecosystems – impact on aquaculture

Mihaljević Željko[1], dr. sc. DVM, Sršen Ivan[2], M.Sc.Mech.Eng., Pečar Osvin[2], mag. biol., Benić Miroslav[1], doc. dr. sc. DVM, Naletilić Šimun[1], DVM*

[1] Hrvatski veterinarski institut, Savska cesta 143, 10000 Zagreb
[2] Javna ustanova „National Park Mljet", Pristanište 2, 20226 Goveđari-Mljet
[*] e-mail: miha@veinst.hr

Abstract

Numerous studies have documented the presence of microplastics in marine organisms, including fish, shellfish and crustaceans. Our research on microplastic pollution was conducted in Polače in the Mljet National Park. Samples were collected on the beach and seabed sediment 10 m from the shore. A metal square measuring 50 cm × 50 cm (0.25 m^2) was placed on the surface of the sediment, and the sediment was taken to a depth of 5 cm with a metal spatula. After drying, sieving and weighing, the artificial material was then categorized according to the EU TG ML Master List (Joint Research Centre, Institute for Environment and Sustainability), and the identification of the type of plastic was made using Fourier transform infrared spectroscopy (FT-IR). Angular fragments, films, styrofoam, filaments and disc pellets dominated on the beach. The seabed sediment was dominated by filaments, films and angular fragments. The most represented type of polymer material in the total sample are polyethylene, polystyrene and polypropylene. The most likely origin of polyethylene microplastics is packaging, plastic bags and nets, and polypropylene materials are ropes and plastic cups. Next are polystyrene materials (styrofoam), which is a common fishing and construction waste. The identified nylon microplastic particles most likely originate from discarded fishing nets and nylon. Microplastics from cellulose acetate (filter and cigarette wrapper) and polyethylene terephthalate (drinking bottle) are most likely the result of direct dumping of waste on the beach, rather than being carried by wind and waves. The sediment of the seabed is dominated by polyethylene plastic threads, most likely from ropes and discarded fishing nets. The obtained results indicate the danger of absorption of microplastics in fish, crabs, shellfish and other marine organisms. In addition to the direct impact of microplastics on the organism after absorption, there is also an indirect danger to organisms attached to

the bottom due to the blocking of gas exchange between bottom water and pore water in the sediment. Compared to wild marine species, the exposure of aquaculture is more significant because the concentration of microplastics in the sea is higher in coastal areas. In freshwater aquaculture, the absorption of microplastics in the organism depends on MP contamination in fish feed and direct contamination of watercourses. The consequences of MP ingestion on the animal's body include reduced food intake, reproductive disorders, neurotoxicity and reduced metabolism. The most endangered are the larval stages of fish, which MP can mistake for plankton. In their intestine, ingested MP causes activation of the immune system by chemical stimulation and mechanical and proteolytic damage to the ciliated epithelium. For this reason, hatcheries are the most sensitive in aquaculture, where different strategies to prevent contamination with microplastics must be applied.

Keywords: Microplastics, pollution, sea, sediment, aquaculture

Dijagnostika virusnih bolesti riba u slatkovodnoj akvakulturi

dr vet. Dušan Lazić[1], dr Miloš Pelić[1], dr Vladimir Radosavljević[2], dr Nikolina Novakov[3]*

[1] Naučni institut za veterinarstvo Novi Sad, Repiblika Srbija
[2] Naučni institut za veterinarstvo Srbije, Beograd, Republika Srbija
[3] Poljoprivredni fakultet, Departman za veterinarsku medicine, Novi Sad, Republika Srbija
[*] e-mail: dusan.l@niv.ns.ac.rs

Sažetak

U cilju pouzdane dijagnostike virusnih bolesti riba odgajanih u slatkovodnoj akvakulturi, neophodno je upoznati se sa svim dostupnim anamnestičkim podacima, patološkim promenama i rezultatima identifikacije infektivnog agensa kako bi, ukrštanjem ovih nalaza utvrdili najverovatniji uzrok bolesti i osnovne faktore koji su uticali na njen nastanak. Na vreme uočiti i prepoznati simptome bolesti kod riba predstavlja jedan od prvih koraka ka postavljanju adekvatne dijagnoze bolesti odnosno uočavanja problema koji je doveo do određenih simptoma. Pri farmskim uslovima gde se zdravstveni status riba prati i drži pod kontrolom uz primenu svih profilaktičkih i preventivnih mera, u koliko se primete znaci bolesti riba, oni se pažljivo isprate, a nekoliko obolelih riba se pregleda i secira radi utvrđivanja kliničkih i patoanatomskih znakova bolesti. Ukoliko postoji sumnja da je infektivni agens uzročnik oboljenja uzimaju se uzorci i šalju na laboratrorijska ispitivanja. Metode dijagnostike i detekcije virusnih bolesi riba obuhvataju izolaciju virusa na kulturi tkiva, elektronsku mikroskopiju i upotrebu seroloških i molekularnih metoda. Izolacija virusnih patogena na kulturi tkiva i dalje ostaje preporučeni metod za dijagnostiku virusnih bolesti riba. Nakon izolacije određenih virusa, dalja laboratorijska procedura je usmerena ka identifikaciji virusa, koja se vrši pomoću različitih metoda, kao što su serum-neutralizacioni test, test fluorescentnih antitela, ELISA test i molekularne metode PCR tehnike. Neke od ovih metoda dijagnostike se takođe koriste i za detekciju virusnih antigena ili nukleinskih kiselina u inficiranim tkivima riba, što obezbeđuje mnogo bržu identifikaciju virusa i postavljanje tačne dijagnoze.

Ključne riječi: Kontrola bolesti riba, dijagnostika, izolacija, identifikacija virusa, zdravstveni status riba, slatkovodna akvakultura

Diagnostics of fish viral diseases in freshwater aquaculture

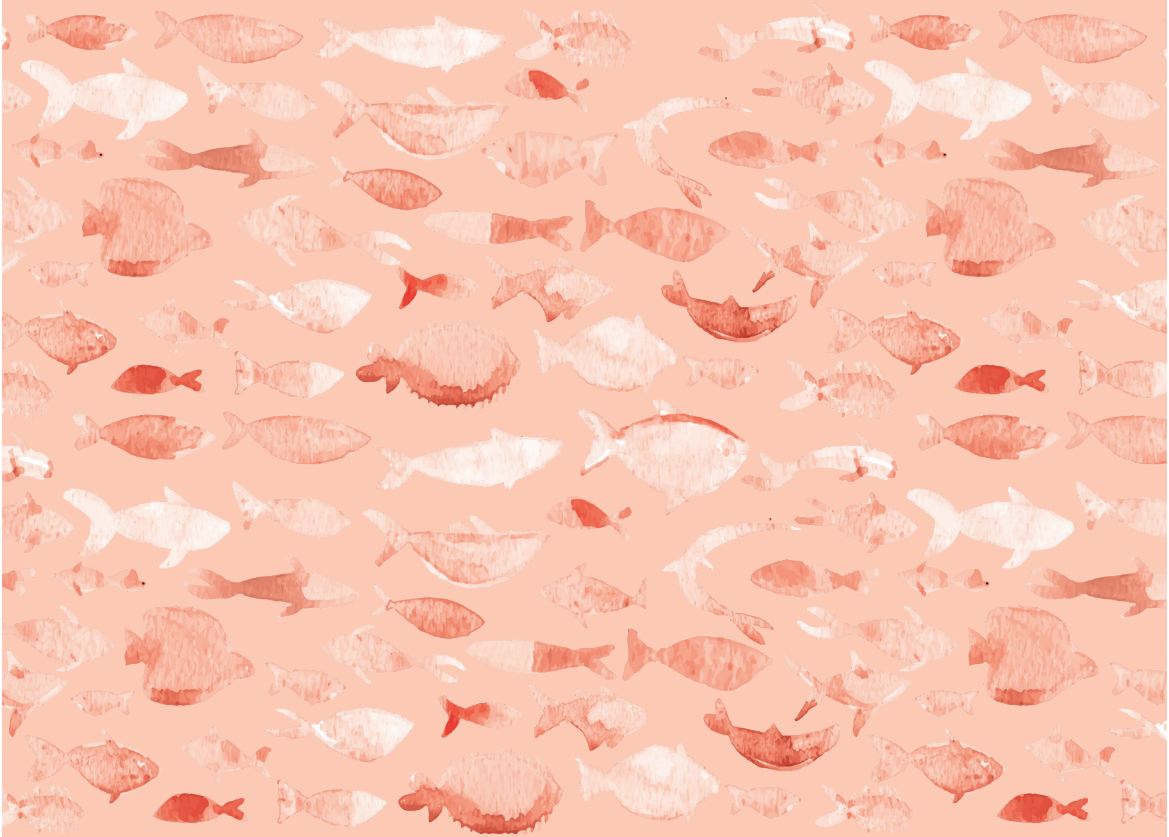
dr vet. Dušan Lazić[1], PhD Miloš Pelić[1], PhD Vladimir Radosavljević[2], PhD Nikolina Novakov[3]*

[1] Scientific Veterinary Institute Novi Sad, Serbia, [*]e-mail: dusan.l@niv.ns.ac.rs
[2] Scientific Veterinary Institute of Serbia, Belgrade, Serbia
[3] Department of Veterinary Medicine, Faculty of Agriculture, Novi Sad, Serbia
[*] e-mail: dusan.l@niv.ns.ac.rs

Abstract

In order to reliably diagnose viral diseases of fish raised in freshwater aquaculture, it is necessary to get acquainted with all available anamnestic data, pathological changes and the results of the identification of the infectious agent in order to determine the most probable cause of the disease and the basic factors that influenced its occurrence by crossing these findings. Spotting and recognizing disease symptoms in fish in time is one of the first steps towards making an adequate diagnosis of the disease, that is, noticing the problem that led to certain symptoms. In farm conditions where the health status of the fish is monitored and kept under control with the application of all prophylactic and preventive measures, if signs of fish disease are observed, they are carefully monitored, and several diseased fish are examined and dissected to determine clinical and pathoanatomical signs of the disease. If there is a suspicion that an infectious agent is the cause of the disease, samples are taken and sent for laboratory tests. Methods of diagnosis and detection of viral fish diseases include virus isolation on tissue culture, electron microscopy and the use of serological and molecular methods. Isolation of viral pathogens on tissue culture remains the recommended method for the diagnosis of viral diseases in fish. After the isolation of certain viruses, the further laboratory procedure is directed towards the identification of the virus, which is carried out using different methods, such as the serum-neutralization test, the fluorescent antibody test, the ELISA test and the molecular methods of the PCR technique. Some of these diagnostic methods are also used to detect viral antigens or nucleic acids in infected fish tissues, which ensures much faster virus identification and accurate diagnosis.

Keywords: Fish disease control, diagnostics, isolation, virus identification, fish health status, freshwater aquaculture



Poster sekcija

Poster session

Mast i sastav masnih kiselina u brancinu i oradi hranjenoj konvencionalnom i organskom hranom

Mia Brkljača, Ana Legac Bačić, Silvia Križanac, Renata Barić*

Cromaris d.d., Gaženička cesta 4b, Zadar
**e-mail: mia.brkljaca@cromaris.hr*

Sažetak

Cromaris od 2016. godine provodi koncept proizvodnje nutritivno izbalansirane ribe bogate omega-3 masnim kiselinama, vitaminima i visoko probavljivim proteinima. Riblja hrana se kontinuirano optimizirala prema stanju na tržištu sirovina: povećali smo udio ribljeg brašna od nusproizvoda i ulja lososa, te smo smanjili količine ribljeg ulja porijeklom iz ulova za 20-38%. U ovom radu cilj je bio tijekom 2022. utvrditi razlike u sastavu masnih kiselina u mesu brancina i orade hranjene organskom i konvencionalnom hranom. Hrana za brancina sastojala se od: 43-44,5% proteina i 20% masti, a hrana za oradu od 43-44% proteina i 17,0-17,8% masti. Omjer ribljeg i biljnog brašna u organskoj hrani za brancina i oradu bio je 2:1 a u konvencionalnoj 1:3. Sadržaj ukupne masti u bio brancinu (BB) bio je viši u odnosu na konvencionalni brancin (KB) za 1,7 postotni bod, a u bio oradi (BO) bio je niži u odnosu na konvencionalnu (KO) za 4,3 postotni bod. U BB u odnosu na KB omega 3 masne kiseline (g/100 g) su bile više za 42%, omjer omega 3/omega 6 viši za 82%, a EPA+DHA (g/100 g) viša za 57%. U BO u odnosu na KO omjer omega 3 / omega 6 bio je viši za 65% i EPA+DHA u sumi masnih kiselina je bila viša za 35%. KB i KO za oko 10 puta prelaze postavljenu vrijednost ukupne EPA i DHA u mesu za prehrambenu tvrdnju o bogatom sadržaju omega 3 masnih kiselina. Organska riba ima sadržaj PUFA povoljniji zbog visokog udjela ribljih sirovina zastupljenih u organskoj hrani. Konvencionalna i organska riba su vrijedan izvor omega 3 masnih kiselina koje pridonose ukupnom zdravlju potrošača.

Ključne riječi: brancin, orada, organska riba, omega 3, PUFA

Fats and fatty acids in sea bass and sea bream fed with conventional and organic feed

Mia Brkljača, Ana Legac Bačić, Silvia Križanac, Renata Barić*

Cromaris d.d., Gaženička cesta 4b, Zadar
**e-mail: mia.brkljaca@cromaris.hr*

Abstract

Since 2016 Cromaris has been implementing the production concept of nutritionally balanced fish rich in omega-3 fatty acids, vitamins, and highly digestible proteins. Fish feed has been optimized continuously according to the availability of raw materials on the market. We increased the portion of salmon oil and fish meal from by-products and decreased the amount of fish oil from catch by 20-38%. The aim of this study was to compare fatty acids composition in meat of organically and conventionally fed sea bass and sea bream during 2022. Feed for sea bass composed of 43-44.5% proteins and 20% fats, and feed for sea bream of 43-44% proteins and 17.0-17.8% fats. Ratio of fish and vegetable meal in organic sea bass and sea bream feed was 2:1, and in conventional 1:3. Total fats in bio sea bream (BB) was higher 1,7 percentage point than in conventional sea bass (KB), and in bio sea bream (BO) was lower 4,3 percentage points than in conventional one. In BB compared to KB omega-3 fatty acids (g/100 g) were higher by 42%, omega 3/omega 6 were higher by 82%, and EPA+DHA (g/100 g) were higher by 57%. In BO compared to KO omega 3/omega 6 was higher by 65% and EPA+DHA was higher by 35%. KB and KO had sum of EPA and DHA about 10 times above limit set for nutritional claim of high omega 3 fatty acids. PUFA content in organic fish was more favourable due to high portion of fish raw materials in organic feed. Both conventional and organic fish are notable sources of omega 3 fatty acids that contribute to general health of the consumer.

Keywords: sea bass, sea bream, organic fish, omega-3, PUFA

Promjena dimenzija fileta, udjela masti i iskorištenja fileta brancina *Dicentrarchus labrax* ovisno o sezoni i duljini gladovanja

Ana Bačić Legac, Marija Sičić Perović, Renata Barić, Viktorija Kiridžija*

Cromaris d.d., Gaženička cesta 4b, Zadar
** e-mail: ana.legac.bacic@cromaris.hr*

Sažetak

Cilj ovog istraživanja bio je prikazati promjene iskorištenja, udjela ukupne masti te dimenzije fileta, duljine, širine i visine, za isti raspon težine fileta, odnosno klasu fileta. Uspoređene su promjene prije i poslije ljetnog režima hranjenja, kao i promjene koje nastaju ovisno o dužini gladovanja prije izlova, jedne od najzastupljenijih mediteranskih vrsta bijele ribe brancina *Dicentrarchus labrax*.

Ovisno o sezoni primijećene su razlike u udjelu ukupne masti, iskorištenju i dimenzijama fileta za istu analiziranu težinu, odnosno klasu fileta. Nakon ljetnog perioda fileti iste analizirane težine kraći su širi i viši te je ustanovljeno da imaju bolje iskorištenje i veći udio masti.

Ustanovljeno je također da se gladovanjem mijenjaju dimenzije fileta, tako su fileti isti mase nakon dvadeset dana suspenzije dulji, uži i niži nego fileti analizirani na početku gladovanja. Nadalje sa gladovanjem se smanjuje udio ukupne masti i pada iskorištenje filetiranja. Sezonalost više doprinosi razlikama u udjelu ukupne masti i iskorištenju nego gladovanje prije izlova. Sezonalost i gladovanje prije izlova imaju podjednak utjecaj na promjenu dimenzija fileta za istu promatranu masu fileta.

Ključne riječi: udio masti, gladovanje, dimenzije fileta, senzualnost, brancin

Change in dimensions, fat content and yield of sea bass *Dicentrarchus labrax* fillets depending on season and length of starvation before harvesting

Ana Bačić Legac, Marija Sičić Perović, Renata Barić, Viktorija Kiridžija*

Cromaris d.d., Gaženička cesta 4b, Zadar
** e-mail: ana.legac.bacic@cromaris.hr*

Abstract

The aim of this study was to show changes in yield, total fat content and dimensions of fillets: length, width and height, for the same range of fillet weight. Changes in preand post-summer feeding regimes were compared, as well as changes that occurred depending on the length of the starvation before harvesting, one of the most common Mediterranean species of white fish, seabass Dicentrarchus labrax.

Depending on the season, differences in total fat content, yield and dimensions of the fillets were observed for the same analyzed weight, or fillet class. We established that after the summer, fillets of the same weight are shorter, wider, and taller and have better yield and higher fat content. We established also that the dimensions of the fillets change with the length of starvation before harvesting. The fillets of same weight, after twenty days of starvation, are longer, narrower, and lower than the fillets analysed at the beginning of the starvation. Furthermore, with length of starvation decreases total fat content and yield of filleting. Seasonality contributes more to differences in total fat content and yield, than starvation before harvesting. Seasonality and starvation prior to harvesting have an equal effect on changing the fillet dimensions for the same observed filet weight.

Keywords: fat content, starvation, fillet dimensions, seasonality, sea bass

Procjena maksimalnog dnevnog obroka podlanice (*Sparus aurata* L.) u kaveznom uzgoju

Božena Vitlov, Slavica Čolak, Renata Barić, Lav Bavčević

[1] *Cromaris d.d., Gaženička cesta 4b, Zadar*
[2] *Odjel za ekologiju, agronomiju i akvakulturu, Trg kneza Višeslava 9, Zadar*

Sažetak

Podlanica *Sparus aurata*, jedna je od vrsta riba koja se uzgaja u Sredozemlju. Pripada porodici *Sparidae* (ljuskavke), čija je proizvodnja tijekom posljednja dva desetljeća pokazala značajniji rast. Uspješnost uzgoja riba uvelike ovisi o kvaliteti hrane koja osigurava zdravlje i maksimalni prirast uzgajane vrste te osigurava optimalnih uvjeta za održavanje životnih funkcija. Osim toga visoka efikasnost iskorištenja hrane može smanjiti utjecaj uzgajališta na okoliš. Upravljanje hranidbom jedan je od najzahtjevnijih tehnoloških postupaka u kaveznom uzgajalištu riba, potrebne količine hrane ovisne su o biomasi ribe, prosječnoj veličini ribe, duljini dana te temperaturi uzgojnog medija. U idealnim prilikama, hranidba daje najbolje rezultate kada se riba hrani približno do sitosti. Hranidbom koja je dobro odmjerena uvelike se pridonosi postizanju optimalne konverzije hrane i prirasta riba, kao i na smanjenje utjecaja uzgoja na okoliš. Procjena maksimalnog obroka je jedan od temeljnih parametara u modelima za procjenu rasta i potrošnje hrane u akvakulturi, što je ujedno i cilj ovog rada tj. usporediti model za procjenu maksimalnog obroka sa postojećim modelima. Maksimalni obrok je procijenjen na temelju praćenja parametara rasta i potrošnje hrane kod generacije podlanice 2017. prosječne mase od 6-350 g. Model je uspoređen s modelom koji predlaže Seginer (2016.) na temelju rezultata istraživanja drugih autora. Validacija modela napravljena je na generaciji 2018.. Riba je hranjena svaki dan 2-8 x ovisno o veličini ribe i temperaturi mora. Hranjenje se provodilo na način da je ribi više puta dnevno ponuđena hrana. Jednom tjedno provodilo se cjelodnevno hranjenje do sita, uz pomoć kojeg se odredilo 80 % od ukupne količine koje je riba pojela do sitosti za ostale dane hranjenja. Prikupljeni podaci obrađeni su statistički i obličeni u formalni model za procjenu maksimalnog obroka u uzgojnim uvjetima. Procjene temeljene na modelu ovom radu kao i mjerenja u provedenom pokusu daju znatno veće vrijednosti od preporuke koju je dao Seginer (2016.) na temelju literaturnih navoda.

Ključne riječi: akvakultura, podlanica, hranidba riba, procjena maksimalnog obroka

Estimation of the maximum daily ration of seabream (*Sparus aurata* L.) in cage culture

Božena Vitlov, Slavica Čolak, Renata Barić, Lav Bavčević

[1] *Cromaris d.d., Gaženička cesta 4b, Zadar*
[2] *Odjel za ekologiju, agronomiju i akvakulturu, Trg kneza Višeslava 9, Zadar*

Abstract

Sea bream *Sparus aurata* is one of the species of fish that is cultivated in the Mediterranean. It belongs to the *Sparidae* family, whose production has shown significant growth over the last two decades. The success of fish farming largely depends on the quality of food, which ensures the health and maximum growth of the farmed species and provides optimal conditions for maintaining vital functions. In addition, the high efficiency of food utilization can reduce the impact of the farm on the environment. Feeding management is one of the most demanding technological procedures in cage fish farming, the required amount of food depends on the biomass of the fish, the average size of the fish, the photoperiod, and the temperature of the breeding medium. Under ideal circumstances, feeding produces the best results when the fish are fed close to satiety. Well-measured feeding greatly contributes to achieving optimal feed conversion and fish growth, as well as reducing the impact of farming on the environment. Estimating the maximum ration is one of the fundamental parameters in models for estimating growth and food consumption in aquaculture, which is also the goal of this work, i.e. to compare the model with existing models. The maximum ration was estimated based on the monitoring of growth parameters and food consumption in one generation of sea bream from 6-350 g. The model was compared with the model proposed by Seginer (2016.) based on the research results of other authors. Validation of the model was done on the generation of 2018. The fish were fed every day 2-8 times depending on the size. Feeding was carried out in such a way that the fish were offered food several times a day. Once a week, full-day feeding was carried out, with the help of which 80% of the total amount that the fish ate to satiety was determined for the rest of the feeding days. The collected data were statistically processed and converted into a formal model for estimating the maximum ration in growing conditions. Estimates based on the model in this paper as well as measurements in the conducted experiment give significantly higher values than the recommendation given by Seginer (2016.) based on literature references.

Keywords: aquaculture, sea bream, fish feeding, assessment of maximum ration

Alternativni izvori proteina za ekološki prihvatljiv uzgoj lubina u Jadranskom moru

dr.sc. Ivana Lepen Pleić[1], dr. sc Ivana Bušelić[1], dr. sc. Jerko Hrabar[1], Luka Žuvić[1], dr.sc. Igor Talijančić[1], dr.sc. Iva Žužul[1], dr.sc. Jelka Pleadin[2], dr.sc. Leon Grubišić[1], dr.sc. Tanja Šegvić-Bubić[1]

[1] Laboratorij za akvakulturu, Institut za oceanografiju i ribarstvo, Šetalište I. Meštrovića 63, 21000 Split, Hrvatska
[2] Hrvatski veterinarski institut, Laboratorij za analitičku kemiju, Zagreb, Hrvatska

Sažetak

Europska akvakultura je suočena sa izazovom uspostavljanja ravnoteže između zadovoljavanja rastućih zahtjeva za visokovrijednim ribljim vrstama i ublažavanja pritiska na sitnu plavu ribu, koja se pokušava postići uvođenjem održive hrane za ribe u uzgoju. Zamjenom dijela ribljeg brašna i ulja sa proteinima iz alternativnih izvora, kao što su kopnene životinje i biljke, nastoji se osigurati održivi rast bez ugrožavanja ekonomske vrijednosti i kvalitete konačnog ribljeg proizvoda. Unutar ove studije testiran je učinak eksperimentalnih formulacija hrane u kojoj su uobičajeno korišteni riblji i biljni derivati dijelom zamijenjeni nusproizvodima prerade peradi i/ili brašnom kukca, na rast i cjelokupnu kondiciju lubina, a sve sa ciljem razvitka održivije hrane i ekološki prihvatljivijeg protokola hranjenja.

Naši su rezultati pokazali da hrana temeljena na biljnim derivatima, ali obogaćena brašnom kukca samostalno i u kombinaciji s obrokom dobivenim iz nusproizvoda prerade peradi, ima veliki potencijal kao alternativna hrana za uzgojnog lubina, bez ugrožavanja rasta, homeostaze crijeva i ukupne kondicije te uz održavanje nutritivne vrijednosti fileta. Ovakve formulacije hrane su i ekonomski najodrživije opcije sa najniže procijenjenim troškovima proizvodnje. Ova je studija također pokazala važnost životinjskih proteina u prehrani lubina, budući je dodatak male količine brašna kukca i/ili peradi značajno poboljšao sve izmjerene parametre u odnosu na skupinu hranjenu hranom u kojoj isti nisu dodani. Budući su životinjski proteini nezamjenjivi za mesojedne vrste riba, važno je nastaviti potragu za optimalnim alternativama ribljem brašnu i ulju, kako bi se unaprijedio razvoj ekološki i ekonomski održive akvakulture.

Ključne riječi: održiva akvakultura, lubin, brašno kukca, nusproizvodi prerade peradi

Alternative protein sources for environmentally friendly farming of European sea bass in the Adriatic Sea

dr.sc. Ivana Lepen Pleić[1], dr. sc Ivana Bušelić[1], dr. sc. Jerko Hrabar[1], Luka Žuvić[1], dr.sc. Igor Talijančić[1], dr.sc. Iva Žužul[1], dr.sc. Jelka Pleadin[2], dr.sc. Leon Grubišić[1], dr.sc. Tanja Šegvić-Bubić[1]

[1] Laboratory of Aquaculture, Institute of Oceanography and Fisheries, Šetalište I. Meštrovića 63, 21000 Split, Croatia
[2] Croatian Veterinary Institute, Laboratory for Analytical Chemistry, Zagreb, Croatia

Abstract

Increasing demand for high value fish species and increasing pressure on forage fish challenge aquaculture to ensure sustainable growth by replacing fish derivatives in aquafeeds with novel ingredients such as plant and terrestrial animal proteins without compromising the economic value and quality of the final fish product. In order to develop sustainable feeds and feeding protocols for environmentally friendly Adriatic fish farming, experimental diets containing poultry by-product and/or insect meal as a partial substitute for commonly used fish or plant derivatives, were formulated and their effect on growth performance and overall fitness of farmed subadult European seabass were tested and compared.

Our results demonstrated that plant-based diets supplemented with insect meal singly or in combination with poultry by-product meal have great potential as an alternative feed for E. sea bass, without compromising growth performance, intestinal homeostasis and overall fitness, while maintaining the nutritional value of fillets for human consumption. These diets were also found to be the most economically sustainable options, as they had the lowest estimated production costs compared to diets with higher percentage of fish or plant derivatives. Finally, this study also demonstrated the importance of animal proteins in diets for E. sea bass, as the addition of small amount of insect meal and poultry by-product significantly improved all parameters measure compered to not supplemented plan-based diet. Since animal proteins are irreplaceable for carnivorous fish species, it is important to continue the search for optimal alternatives to advance the development of environmentally and economically sustainable aquaculture.

Keywords: European seabass, insect meal, poultry by-product meal, sustainable aquafeeds

Alohtone vrste školjkaša i akvakultura uz istočnu obalu Jadrana

Ines Rebac[1], mag.ing.agr., Verdana Nerlović[1], doc.dr.sc., Gorana Jelić Mrčelić[2], prof.dr.sc.*

[1] Sveučilište u Splitu, Sveučilišni odjel za studije mora, Ruđera Boškovića 37, 21000 Split, Hrvatska
[2] Sveučilište u Splitu, Pomorski fakultet Split, Ruđera Boškovića 37, 21000 Split, Hrvatska
[*] e-mail: irebac@unist.hr

Sažetak

Ovaj rad sažima ekološke učinke unošenja i širenja alohtonih vrsta školjkaša na ekosustave i akvakulturu uzduž istočne obale Jadrana. Prema posljednjem popisu, u Jadranu postoje 252 vrste školjkaša, od kojih je nekoliko alohtonih. U istočnom Jadranu zabilježene su neke vrste alohtonih školjkaša: *Magallana gigas*, *Ruditapes phillipinarum*, *Pinctada radiata* i *Anadara transversa*, a sve su slučajno unesene na područje istočnog Jadrana. *M. gigas* i *R. philipinarum* su uspostavile populacije uzduž istočne obale Jadrana, bez značajnijeg utjecaja na prirodne populacije i akvakulturu do danas. Obje su vrste važne za morsku akvakulturu drugdje. Uvođenje alohtonih vrsta školjkaša u morske ekosustave može imati značajan utjecaj na domaće ekosustave kao i na socioekonomske uvjete u određenom području. Hoće li se alohtona vrsta udomaćiti na novom području ovisi o tome u kojoj mjeri okolišni uvjeti zadovoljavaju potrebe iste u smislu staništa i dostupnosti hrane. Kako bi se pratili potencijalni utjecaji na akvakulturu uzduž istočne obale Jadrana i istražila moguća implementacija ovih vrsta u akvakulturi, važno je prikupljati podatke o rasprostranjenosti i ekološkom statusu navedenih alohtonih vrsta.

Ključne riječi: školjkaši, alohtone vrste, akvakultura, utjecaj na okoliš, Jadran

Non-native bivalve species and aquaculture along the eastern Adriatic coast

Ines Rebac[1], PhD student, Verdant Nerlović[1], Asistent Professor, Gorana Jelić Mrčelić[2], Full Professor*

[1] University of Split, Department of Marine Studies, Ruđera Boškovića 37, 21 000 Split, Croatia
[2] University of Split, Faculty of Maritime Studies, Ruđera Boškovića 37, 21000 Split, Croatia
[*] e-mail: irebac@unist.hr

Abstract

This paper summarizes the ecological impacts of the introduction and spread of non-native bivalve species on ecosystems and aquaculture along the eastern Adriatic coast. According to the latest checklist, there are 252 species of bivalves in the Adriatic, several of which are non-native. Some of the non-native bivales species have been recorded in the eastern Adriatic: *Magallana gigas, Ruditapes phillipinarum, Pinctada radiata* and *Anadara transversa*, and all of these four species have been accidentally introduced. *M. gigas* and *R. phillipinarum* have become established along the eastern Adriatic coast, without any significant impact on natural populations and aquaculture to date. Both species are important species for marine aquaculture elsewhere. The introduction of non-native bivalve species into marine ecosystems can have significant impacts on native ecosystems as well as on socioeconomic conditions in a given area. Whether non-native species can become established in a new area depends on the extent to which environmental conditions meet its needs in terms of habitat and food availability. It is very important to collect data on non-native species, their ecological status and distribution, to monitor the current situation for potential impacts on aquaculture and to investigate the possible implementation of these species in aquaculture along the eastern Adriatic coast.

Keywords: bivalves, non-native species, aquaculture, environmental impact, Adriatic Sea

Društvena dimenzija razvoja akvakulture: kako razvoj akvakulture utječe na lokalne zajednice na Jadranu

Mag. soc. Mislav Škacan

Odjel za sociologiju, Sveučilište u Zadru
e-mail: mskacan21@unizd.hr

Sažetak

Akvakultura i njezin razvoj značajno utječu na živote obalnih zajednica hrvatskog dijela Jadrana. Dosadašnja istraživanja akvakulture primarno se temelje na prirodnim, tehničkim i ekonomskim znanostima te je evidentan nedostatak istraživanja koja se izravno bave društvenom dimenzijom razvoja akvakulture. Cilj ovog rada, temeljenog na perspektivi sociološke teorije *društvene prihvatljivosti*, je istražiti kako lokalne zajednice prihvaćaju i na koji se način nose sa razvojem te prisutnošću akvakulture u svojoj blizini. Svrha ovakvog pristupa je istražiti kako ljudi koji žive na obali razmatraju probleme koje povezuju s akvakulturom, ali obuhvatiti i perspektivu onih iz samog sektora akvakulture (menadžeri/konzultanti iz akvakulture) kao i iz lokalne/nacionalne uprave (stručnjaci za javne politike i javni službenici). Oslanjajući se na sociološki pristup, ovo istraživanje istražuje mrežu odnosa u akvakulturi, uključenost lokalne zajednice u razvoj akvakulture, dostupnost ključnih informacija, raspodjelu troškova i koristi, tradicionalna prava i pristup moru te povezanost lokalnog stanovništva i mora. Ovakvim pristupom nastoji se istražiti kako pospješiti budući razvoj akvakulture. Predložit će se idejni dizajn odnosno nacrt istraživanja s ciljem daljnjeg unaprjeđenja i razvoja istog. 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, društvena prihvatljivost, morski prostor, Jadransko more

The social dimension of aquaculture development: how aquaculture development affects local communities on Adriatic

Mislav Škacan

Department of Sociology, University of Zadar
e-mail: mskacan21@unizd.hr

Abstract

Aquaculture and its development significantly impact the lives of the coastal communities in Croatian Adriatic Sea. Aquaculture research is primarily based within natural, technical and economic sciences and there is an evident lack of research dealing directly with the social dimension of aquaculture development. This paper, based on the sociological social acceptability perspective, aims to investigate how local communities accept and deal with the development as well as presence of aquaculture in their vicinity. The aim of this approach is to explore how people on the coast frame the problems which they connect with aquaculture but also to capture the perspective from those in aquaculture sector (aquaculture managers/consultants) and local/national government administration (policy experts). By relying on sociological approach, this research explores the network of relationships in aquaculture, involvement of local community in the aquaculture development, availability of key information, costs/benefits distributions, the traditional rights and access to the sea and the connection of local people and sea. With this approach, an attempt is made to investigate how the development of aquaculture can be even more successful. Proposed research design will be presented with the aim of further improvement. 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, social acceptability, marine space, Adriatic Sea

Environmental and aquaculture interactions – two decades of experience in Croatia

Iva Žužul PhD[1], Tanja Šegvić-Bubić PhD[1], Igor Talijančić PhD[1], Leon Grubišić PhD[1], Luka Žuvić PhD student[1], Ivana Lepen Pleić PhD[1], Ivana Bušelić PhD[1], Jerko Hrabar PhD[1]*

[1] Laboratory of Aquaculture, Institute of Oceanography and Fisheries, Šetalište I. Meštrovića 63, Split, Croatia
[*] e-mail: zuzul@izor.hr

Abstract

Today, modern scientific methods are increasingly being used to support aquaculture and marine environmental management to better understand the complex impacts of aquaculture on native populations. As selective schemes progress and the number of selection rounds increases, genome and phenotypic target traits tend to diverge between wild and farmed populations, while genetic variation in the latter decreases. In the last decade, the scientific community in Croatia has started to monitor the interactions between the most common species in mariculture, seabream and seabass, and the marine environment using genetic and genomic techniques (mtDNA, microsatellites, SNPs) and phenotypic fish traits (body, otolith and scale shape, condition index, coloration). This is particularly important for wild fish populations, as many farmers base their production on fingerling originating from French, Italian, and Greek hatcheries, and fish can escape during farming due to storms, fish manipulation, or net holes. In 2011 and 2022, hybrid and farmed gilthead seabream and sea bass were detected at moderate levels (13-15%) in farmed affected areas, indicating successful introgression of farmed fish into wild populations. Therefore, contingency plans should be designed and established to maximize the recapture of escaped fish following an escape event. The AquaPop-Croatian Science Foundation project created the first database of morphometric and multilocus data from farmed and wild sea bream, which can serve as a basis for developing strategies similar to those in Norway. In addition, long-term coexistence requires novel methods to prevent escapes, supported by genomic tools to control sex or maturation along with production of locally domesticated fish.

Keywords: mariculture, farm escapes, management

Histomorfologija crijeva lubina hranjenih novim formulacijama hrane

Jerko Hrabar[1], Ivana Bočina[2], Luka Žuvić[1], Iva Žužul Vrgoč[1], Ivana Lepen Pleić[1], Ivana Bušelić[1], Igor Talijančić[1], Tanja Šegvić Bubić, Leon Grubišić[1]*

[1] Institut za oceanografiju i ribarstvo, Laboratorij za akvakulturu, Šetalište Ivana Meštrovića 63, 21000 Split, Hrvatska
[2] Prirodoslovno-matematički fakultet, Sveučilište u Splitu, Ruđera Boškovića 33, 21000 Split, Hrvatska
[*] e-mail: hrabar@izor.hr

Sažetak

Cilj ovog rada bio je opisati histološku i ultrastrukturnu građu crijeva lubina hranjenih novim formulacijama hrane. Provedeno je šestomjesečno pokusno hranjenje tri skupine lubina koristeći *i*) komercijalnu (kontrolnu) hranu (CF); *ii*) kontrolnu hranu s visokim udjelom sastojaka biljnog podrijetla (CV); *iii*) CV hranu s dodatkom 10% proteina kukca i 30% proteina iz nusproizvoda peradarstva (VH10P30). Završetkom pokusa, dijelovi prednjeg (PC) i stražnjeg crijeva (SC) šest riba iz svakog tretmana su rutinski pripremljeni za histološku analizu (HE, AB/PAS). Dodatno, komadići crijeva tri ribe iz svakog tretmana su pripravljeni za ultrastrukturnu analizu. Kod riba hranjenih CF hranom prednje crijevo je imalo dobro očuvanu morfologiju bez degenerativnih ili upalnih promjena. Prednje crijevo riba hranjenih CV hranom imalo je nepravilno razgranate resice s izraženom vakuolizacijom enterocita, odvajanjem lamine epithelialis od lamine proprie te izraženim upalnim infiltratom. U riba hranjenih VH10P30 hranom crijevne resice bile su nepravilno razgranate s manje izraženom vakuolizacijom enterocita i povremeno izraženim odvajanjem lamine epithelialis i lamine proprie. U stražnjem crijevu su uočene manje izražene promjene i uglavnom su bile ograničene na oblik resica. Zaključno, životinjski proteini su važni u prehrani lubina budući da je dodatak proteina kukaca i nusproizvoda peradarstva značajno poboljšao morfologiju crijeva.

Ključne riječi: nusproizvod peradarstva, kukac, *Dicentrarchus labrax*, crijevo, histomorfologija

Intestinal histomorphology of European seabass fed novel feed formulations

Jerko Hrabar[1], Ivana Bočina[2], Luka Žuvić[1], Iva Žužul Vrgoč[1], Ivana Lepen Pleić[1], Ivana Bušelić[1], Igor Talijančić[1], Tanja Šegvić Bubić[1], Leon Grubišić[1]*

[1] Institute of Oceanography and Fisheries, Laboratory of Aquaculture, Šetalište Ivana Meštrovića 63, 21000 Split, Croatia
[2] Faculty of Science, University of Split, Ruđera Boškovića 33, 21000 Split, Croatia
[*] e-mail: hrabar@izor.hr

Abstract

The present work aimed to assess intestinal histomorphology and ultrastructure of seabass fed novel diet formulations. We performed a six-month feeding trial with three groups of seabass using *i*) commercial (control) diet (CF); *ii*) a control diet high in plant-derived ingredients (CV); *iii*) a CV diet supplemented with 10% insect and 30% poultry by-product protein (VH10P30). At the end of the feeding trial, pieces of the proximal (PI) and distal intestines (DI) from six fish per treatment were processed for histological analysis (HE, AB/PAS). Additionally, intestinal pieces from three fish per treatment were processed for ultrastructural studies. In the CF-fed fish, the proximal intestine showed well-preserved morphology with no degenerative or inflammatory changes. The proximal intestine of the CV-fed fish had irregularly branched villi with extensive enterocyte vacuolisation, detachment of *lamina epithelialis* from the *lamina propria* and pronounced inflammatory infiltrate. In VH10P30-fed fish, intestinal villi were irregularly branched with minor enterocyte vacuolisation and focally extensive detachment of *l. epithelialis* and mild to moderate inflammatory infiltrate. Less pronounced changes were observed in the distal intestine and were mostly limited to the appearance of villi. In conclusion, we confirmed the importance of animal proteins in the seabass diet, as the addition of insect and poultry by-product-derived proteins significantly improved intestinal morphology.

Keywords: poultry by-product meal, insect, *Dicentrarchus labrax*, intestine, histomorphology

Utječe li prehrana na bakterijsku zajednicu u crijevima mlađi lubina?

Ivana Bušelić[1], Ivana Lepen Pleić[1], Jerko Hrabar[1], Luka Žuvić[1], Igor Talijančić[1], Iva Žužul[1], Jelka Pleadin[2], Leon Grubišić[1], Tanja Šegvić-Bubić[1]*

[1] Laboratorij za akvakulturu, Institut za oceanografiju i ribarstvo, Šetalište I. Meštrovića 63, 21000 Split, Hrvatska
[2] Laboratorij za analitičku kemiju, Hrvatski veterinarski institut, Zagreb, Hrvatska
[*] e-mail: buselic@izor.hr

Sažetak

U posljednje vrijeme mikrobiom crijeva je u središtu istraživanja prehrane u akvakulturi, jer je potvrđeno da zajednica bakterija u crijevima može regulirati unos hranjivih tvari i promjene u metabolizmu riba. Takva funkcionalna fleksibilnost crijevne bakterijske zajednice vjerojatno povećava probavnu prilagodljivost riba i studije o mikrobiomu crijeva postaju nužne u istraživanju prehrane u akvakulturi. Unutar ove studije, testiran je učinak eksperimentalnih formulacija hrane na crijevni mikrobiom mlađi lubina (brancina) nakon 120-dnevnog pokusa hranjenja. Eksperimentalne hrane sadržavale su nusproizvode peradi i/ili brašno od insekata kao djelomičnu zamjenu za uobičajeno korištene sastavnice ribljeg ili biljnog podrijetla. Rezultati su pokazali otpornost crijevne mikrobiote mlađi lubina, neovisno o testiranoj prehrani. Ovi rezultati su u suprotnosti s našim istraživanjem subadultnih lubina, hranjenih istim eksperimentalnim formulacijama hrane, gdje je sekvenciranje 16S rRNA otkrilo da svaka tretirana skupina ima različite zajednice bakterija u crijevima. Zanimljivo je primijetiti da je ukupni učinak rasta mlađi bio lošiji na prehrani temeljenoj na biljnim izvorima u usporedbi s prehranom temeljenoj na ribljim izvorima unutar ovog istraživanja, dok je za subadulte potvrđeno suprotno. Postoji mogućnost da su promjene unutar crijevne mikrobiote subadulta povećale probavnu prilagodljivost i pomogle u boljoj učinkovitosti alternativne biljne prehrane dopunjene nusproizvodima peradi i/ili brašnom od insekata, dok je taj učinak izostao kod mlađi lubina.

Ključne riječi: brašno od insekata, brašno od nusproizvoda peradi, održiva hrana u akvakulturi, mikrobiom, 16S rRNA

Is intestinal microbial community of juvenile European sea bass affected by diet?

Ivana Bušelić[1], Ivana Lepen Pleić[1], Jerko Hrabar[1], Luka Žuvić[1], Igor Talijančić[1], Iva Žužul[1], Jelka Pleadin[2], Leon Grubišić[1], Tanja Šegvić-Bubić[1]*

[1] Laboratory of Aquaculture, Institute of Oceanography and Fisheries, Šetalište I. Meštrovića 63, 21000 Split, Croatia,
[2] Laboratory for Analytical Chemistry, Croatian Veterinary Institute, Zagreb, Croatia
[*] e-mail: buselic@izor.hr

Abstract

Recently, gut microbiome has been at the center of nutritional aquaculture research, as it has been confirmed to regulate nutrient uptake and changes in fish metabolism. Such functional flexibility of the intestinal microbiota likely increases the adaptability of fish digestion and studies of the gut microbiome are becoming a necessity for dietary research in aquaculture. Within this study, the effect of experimental diets on intestinal microbiome of juvenile European sea bass was assessed after 120-day feeding trial. Experimental diets contained poultry by-product and/or insect meal as a partial substitute for commonly used fish or plant derivatives. The results demonstrated a resilience of intestinal microbiota of juvenile E. sea bass, regardless of the tested diet. These results are in contrast to our study of subadult E. sea bass using the same experimental diets, where 16S rRNA sequencing revealed each treatment group had different gut microbial communities. It is interesting to note that the overall growth performance of juveniles was poorer on plant-based diets, compared to fish-based diets within this research, while the opposite was confirmed for subadults. There is a possibility that changes within the intestinal microbiota of subadults increased their digestive adaptability and aided in better performance of alternative plant-based diets supplemented with poultry by-product and/or insect meal, while this effect was missing in juvenile E. sea bass.

Keywords: insect meal, poultry by-product meal, sustainable aquafeeds, microbiome, 16S rRNA

Morfološke i molekularno-filogenetske značajke juvenilnih stadija vrsta iz porodice Scombridae

Luka Žuvić[1], Igor Talijančić[1], Tanja Šegvić-Bubić[1], Iva Žužul[1], Leon Grubišić[1], Ivana Lepen Pleić[1], Ivana Bušelić Garber[1], Jerko Hrabar[1]*

[1] Institut za oceanografiju i ribarstvo, Šetalište I. Meštrovića 63, Split, Hrvatska
[*] e-mail: zuvic@izor.hr

Sažetak

Trup (BLT) *Auxis rochei*, Luc (LTA) *Euthynnus alletteratus* i Atlantska plavoperajna tuna (BFT) *Thunnus thynnus* među najvažnijim su morskim predatorima i važne su ciljne vrste za komercijalni i rekreacijski ribolov. BFT je važna vrsta i za Hrvatsku akvakulturu, gdje je 85% komercijalnog ulova namijenjeno akvakulturi. Budući da je morfološka identifikacija juvenilnih Scombridae prilično izazovna, cilj istraživanja bio je identificirati najvažnije karakteristike za razlikovanje vrsta korištenjem geometrijske morfometrije i molekularnog pristupa. Juvenilne jedinke prikupljene su putem rekreacijskog ribolova u srednjem i južnom dijelu istočnog Jadrana tijekom 2019.-20. godine. Geometrijska morfometrija (GM) primijenjena je za analizu oblika tijela pomoću digitalnih fotografija riba, s konačnom konfiguracijom od 17 fiksnih biljega koji su naknadno korišteni za analizu varijacija među skupinama. Djelomični fragment kontrolne regije mtDNA umnožen je korištenjem početnica specifičnih za porodicu Scombridae na 10 jedinki po vrsti. Filogenetskom analizom otkrivene su tri različite klade koje odgovaraju prisutnosti ovih triju vrsta Scombridae. Rezultati GM analize su pokazali glavne razlike između vrsta u širini tijela i obliku glave, čime je omogućena visoka točnost klasificiranja jedinki u izvorna podrijetla. Zaključno, oba metodološka pristupa pokazala su se korisnima u identifikaciji vrsta i mogu se primijeniti u upravljanju ribarstvom, što je posebno važno za BFT kao kontroliranu ribolovnu vrstu.

Ključne riječi: Geometrijska morfometrija, filogenija, Scombridae, mtDNA

Geometric morphometric and phylogenetic differences in juvenile individuals of the Scombridae family

Luka Žuvić[1], Igor Talijančić[1], Tanja Šegvić-Bubić[1], Iva Žužul[1], Leon Grubišić[1], Ivana Lepen Pleić[1], Ivana Bušelić Garber[1], Jerko Hrabar[1]*

[1] Institute of Oceanography and Fisheries, Šetalište I. Meštrovića 63, Split, Croatia
[*] e-mail: zuvic@izor.hr

Abstract

Bullet tuna (BLT) *Auxis rochei*, Little tunny (LTA) *Euthynnus alletteratus*, and Atlantic bluefin tuna (BFT) *Thunnus thynnus* are among the most important marine predators and are important target species for commercial and recreational fisheries. BFT is also important for aquaculture in Croatia, where 85% of the commercial catch is destined for aquaculture. Since morphological identification of juvenile scombrids is often difficult, the aim of the study was to identify the most important characteristics for species separation using geometric morphometrics and molecular approaches. Juveniles were collected from recreational fisheries in the central and southern parts of the eastern Adriatic during 2019-20. Landmark-based geometric morphometrics (GM) was applied to analyse body shape using digital fish images, with the final configuration of 17 fixed landmarks subsequently used to analyze variation among groups. A partial fragment of the mtDNA control region was amplified using primers specific to the family Scombridae on 10 individuals/species. Phylogenetic reconstruction revealed the presence of three distinct clades corresponding to the presence of these three Scombridae species. The results of GM analysis showed that the main differences between the species are visible in body width and head shape, which allowed the individuals to be assigned to their origin with high accuracy. In conclusion, both methodological approaches proved useful in species identification and can be applied in fisheries management, which is particularly important for BFT as a controlled fishery species.

Keywords: Geometric morphometrics, phylogeny, Scombridae, mtDNA

Aeromonas veronii biovar *sobria* infekcija uzgojene kečige (*Acipenser ruthenus*)

Radosavljevic Vladimir[1], Radanović Oliver[1], Zdravković Nemanja[1], Novakov Nikolina[2], Pelić Miloš[3], Zolt Beckei[4], Nešić Ksenija[1]*

[1] Naučni institut za veterinarstvo Srbije, Janisa Janulisa 14, 11000 Beograd, Srbija
[2] Departman za veterinarsku medicinu, Poljoprivredni Fakultet, Univerzitet u Novom Sadu, Trg Dositeja Obradovića 8, 21000 Novi Sad, Srbija
[3] Naučni institut za veterinarstvo „Novi Sad", Rumenacki put 20, 21113 Novi Sad, Serbia
[4] Fakultet veterinarske medicine, Bulevar oslobođenja 18, Beograd, Srbija
[*] e-mail: vladimiradosavljevic@yahoo.co.uk

Sažetak

Nedavno je prijavljeno da je *Aeromonas veronii* važan patogen riba koji uzrokuje sepsu ulcerozni sindrom slatkovodnih riba, što dovodi do gubitaka u akvakulturi i ugrožava sigurnost hrane. U Srbiji se uzgajaju dvije vrste jesetri iz porodice Acipenseridae: ruska jesetra (*Acipenser gueldenstaedtii*) i kečiga (*Acipenser ruthenus*). Bakterijska hemoragijska septikemija utvrđena je u mlađi kečige (*Acipenser ruthenus*) uzgojenog u srpskom recirkulacijskom sustavu (RAS). Zaražene ribe pokazivale su krvarenja na koži trbušne strane glave, tijela i na dnu peraja, uz crvenilo anusa. Ribe su pokazivale nadutost abdomena s nakupljanjem ascitne tekućine, petehijalno krvarenje u jetri i povećanu, natečenu slezenu. Dobivene čiste bakterijske kolonije bile su sivo-bijele, glatke površine, neprozirne i blago konveksne, stvarajući β-hemolizu na krvnom agaru, a sastojale su se od gram-negativnih, pokretnih, kratkih štapićastih bakterija. *Aeromonas veronii* biovar *sobria* identificiran je na temelju morfoloških i biokemijskih značajki korištenjem konvencionalnih metoda i MALDI-TOF MS (Matrix Assisted Laser Desorption Ionization Time of Flight Mass Spectrometry).

Ključne riječi: *Aeromonas veronii* biovar *sobria,* kečiga (*Acipenser ruthenus*)

Aeromonas veronii biovar *sobria* infection in cultivated sterlet (*Acipenser ruthenus*)

Radosavljevic Vladimir[1], Radanović Oliver[1], Zdravković Nemanja[1], Novakov Nikolina[2], Pelić Miloš[3], Zolt Beckei[4], Nešić Ksenija[1]

[1] Institute of Veterinary Medicine of Serbia, Janisa Janulisa 14, 11000 Belgrade, Serbia
[2] Department of Veterinary Medicine, Faculty of Agriculture, University of Novi Sad, Trg Dositeja Obradovića 8, 21000 Novi Sad, Serbia
[3] Scientific Veterinary Institute "Novi Sad", Rumenacki put 20, 21113 Novi Sad, Serbia
[4] Faculty of Veterinary Medicine Belgrade, Bulevar oslobođenja 18, 11000 Belgrade, Serbia
[*] e-mail: vladimiradosavljevic@yahoo.co.uk

Abstract

Recently, *Aeromonas veronii* has been reported as an important fish pathogen causing freshwater fish sepsis and ulcer syndrome, resulting in losses to the aquaculture and threatening food safety. In Serbia, two sturgeon species of the Acipenseridae family are cultivated: Russian sturgeon (*Acipenser gueldenstaedtii*) and sterlet (*Acipenser ruthenus*). Bacterial haemorrhagic septicemia occurred in young sterlet *(Acipenser ruthenus)* cultivated in Serbian recirculating system (RAS). Affected fish showed haemorrhages on the skin of ventral side of head, body and at the base of fins, with reddening of the anus. Internally, fish showed abdominal distension with accumulation of ascitic fluid, petechial haemorrhage in the liver and enlarged, swollen spleen. Obtained pure bacterial colonies were grey-white, smooth-surfaced, opaque, and slightly convex, producing β-hemolysis on blood agar, consisiting of gram-negative, motile, short rod-shaped bacteria. The *Aeromonas veronii* biovar *sobria* was identified based on morphological and biochemical features by using conventional methods and MALDI-TOF MS (Matrix Assisted Laser Desorption Ionization Time of Flight Mass Spectrometry).

Keywords: *Aeromonas veronii* biovar *sobria,* sterlet (*Acipenser ruthenus*)

Ličinke *Anisakis* tipa I u argentinskom osliću (*Merluccius hubbsi,* Linnaeus 1758)

Radosavljevic Vladimir, Rokvić Nikola, Kureljušić Jasna, Pavlović Marija, Glišić Dimitrije, Maletić Jelena, Vasić Ana*

Naučni institut za veterinarstvo Srbije, Janisa Janulisa 14, 11000 Beograd, Srbija
** e-mail: vladimiradosavljevic@yahoo.co.uk*

Sažetak

Poznato je da je anisakijaza jedna od važnih zoonoza koje prenose ribe. Ličinke roda Anisakis prema svojim morfološkim značajkama mogu se identificirati kao *Anisakis* tip I ili tip II. Ličinke Anisakis L3 ranije su prijavljene na srpskim tržištima iz različitih vrsta riba. Uzorak uvezenog duboko smrznutog argentinskog oslića (*Merluccius hubbsi, Linnaeus* 1758), za kojeg se sumnjalo da je zaražen parazitima, nadležna je služba poslala u laboratorij. Parazitološki pregled uzorka od 10 riba na prisutnost ličinki *Anisakis* u unutarnjim organima obavljen je vizualno pod stereomikroskopom. Zatim su iznutrice i epaksijalni i hipoksijalni mišići uklonjeni i odvojeno digestirani u otopini pepsin/HCl. Uzorci su potom mikroskopski pregledani u Petrijevim zdjelicama kako bi se otkrile i prebrojale ličinke. U trbušnoj šupljini otkriveno je između 10 i 14 ličinki po ribi. Izolirane Anisakis spp. ličinke su isprane u 0,9% otopini NaCl i isprane u 70% alkoholu i ledenoj octenoj kiselini radi mikroskopskog promatranja i morfološke studije, koja je uključivala bilježenje prisutnosti zuba na prednjem kraju i ventrikula jednjaka u prvoj trećini i stražnjem kraju larva, koja varira između morfotipa I i II. Otkrivene ličinke su svjetlosnim mikroskopom identificirane na temelju morfoloških kriterija kao *Anisakis* ličinke trećeg stadija (L3) tip I.

Ključne riječi: Anisakis L3 tip I, argentinski oslić (*Merluccius hubbsi*, *Linnaeus* 1758)

Anisakis type I larvae in Argentine hake (*Merluccius hubbsi*, *Linnaeus* 1758)

Radosavljevic Vladimir[*], *Roković Nikola, Kureljušić Jasna, Pavlović Marija, Glišić Dimitrije, Maletić Jelena, Vasić Ana*

Institute of Veterinary Medicine of Serbia, Janisa Janulisa 14, 11000 Belgrade, Serbia
[*] *e-mail: vladimiradosavljevic@yahoo.co.uk*

Abstract

It is known that anisakiasis is one of the important fish-borne zoonotic diseases. Based on their morphological features, larvae of the genus *Anisakis* can be identified as *Anisakis* type I or type II. The *Anisakis* L3 larvae had been previously reported in Serbia from different fish species. The sample of imported deep-frozen Argentine hake (*Merluccius hubbsi*, *Linnaeus* 1758), which was suspected with parasite infection, was sent to the laboratory by the governing authority. A parasitological examination of sample consisting of 10 fish, for the presence of *Anisakis* larvae in the viscera was visually performed under a stereomicroscope. Then, the viscera and epaxial and hypaxial muscles were removed and separately digested in pepsin/HCl solution. Samples were then examined microscopically in Petri dishes to detect and count the larvae. Between 10 and 14 larvae per fish were detected in the abdominal cavity. Isolated *Anisakis spp*. larvae were washed in 0.9% NaCl solution and rinsed in 70% alcohol and glacial acetic acid for microscopic observation and morphological study, which included noting the presence of a boring tooth at the anterior end and oesophageal ventricle in the first third and posterior end of the larva, which varies between morphotypes I and II. The detected larvae were identified as based on distinct morphological criteria as *Anisakis* third-stage larvae (L3) type I via light microscopy.

Keywords: Anisakis L3 type I, Argentine hake (Merluccius hubbsi, Linnaeus 1758)

Usporedba reproduktivnog uspjeha vodenbuhe *Daphnia magna* Straus u različitim uzgojnim vodama

dr. sc. Mažuran Neda[1], prof. dr. sc. Kovačević Goran[2]*

[1] Salopekova 2b, HR-10000 Zagreb, Croatia
[2] Prirodoslovno-matematički fakultet, Sveučilište u Zagrebu, Biološki odsjek, Zoologijski zavod, Horvatovac 102A, HR-10000 Zagreb, Croatia
[*] e-mail: goran.kovacevic@biol.pmf.hr

Sažetak

Daphnia magna široko je korištena u laboratorijima za procjenu ekološkog rizika površinskih voda, industrijskih otpadnih voda, kemikalija i raznih efluenata i recipijenata, a također i u akvakulturi u uzgajalištima i mrijestilištima riba kao hrana za riblji mlađ. *D. magna* je vrlo osjetljiva na uvjete okoliša uključujući temperaturu, kemijski sastav vode, pH, osvjetljenje i hranu. U laboratorijskim kulturama nepovoljni uvjeti utječu na razmnožavanje i preživljavanje. Ovdje smo usporedili uspjeh razmnožavanja vodenbuhe *D. magna* u nekima od voda preporučenih u literaturi za uzgoj. Usporedili smo dvije prirodne vode (dekloriranu vodovodnu vodu i nezagađenu površinsku vodu) i dvije sintetičke vode: ISO vodu za razrjeđivanje i MS medije. Najbolji reproduktivni rezultati s obzirom na kumulativni broj neonata i veličinu legla dobiveni su u MS vodi koja sadržava vitamine, makro-nutrijente i elemente u tragovima ($p<0.005$). ISO voda za razrjeđivanje i vodovodna voda pokazale su slične reproduktivne rezultate (bez statističke značajnosti). Sve tri vode ispunjavale su OECD kriterije valjanosti od ≥ 60 živih neonata po roditelju u 21 dan. Najlošiji rezultati su dobiveni u površinskoj vodi vjerojatno zbog nepovoljnog omjera Ca/Mg i visoke vodljivosti. Ova studija potvrdila je da kemijski sastav vode ima izražen učinak na reproduktivni kapacitet vodenbuhe *D. magna*.

Ključne riječi: *Daphnia*, razmnožavanje, okolišni uvjeti

Comparison of reproduction success of *Daphnia magna* Straus in different culturing waters

dr. sc. Mažuran Neda[1], prof. dr. sc. Kovačević Goran[2]*

[1] *Salopekova 2b, HR-10000 Zagreb, Croatia*
[2] *Faculty of Science, University of Zagreb, Department of Biology, Division of Zoology, Horvatovac 102A, HR-10000 Zagreb, Croatia*
[*] *e-mail: goran.kovacevic@biol.pmf.hr*

Abstract

Daphnia magna is widely used in laboratories for ecological risk assessment of surface waters, industrial waste waters, chemicals and various effluents and receiving waters, and also in aquaculture in fish hatcheries and nurseries for fish fry nutrition. *D. magna* is very sensitive to environmental conditions which include temperature, water chemical composition, pH, illumination and food. In laboratory cultures, unfavourable conditions affect reproductive performance and survival. Here we compared the reproductive succcess of *D. magna* in some of the waters recommended in literature for cultivation. We compared two natural waters (dechlorinated tap water and an unpolluted surface water) and two synthetic waters: ISO dilution water and MS media. The best reproductive results in respect with cumulative number of neonates and brood size were obtained in MS water which contained vitamins, macro-nutrients and trace elements ($p<0.005$). ISO dilution water and tap water showed similar reproductive results (no significant differences). All three waters fulfilled the OECD validity criterion of a mean ≥ 60 living offspring per parent in 21 days. The poorest results were achieved in surface water probably due to unfavourable Ca/Mg ratio and high conductance. This study confirmed that the chemical composition of the cultivation water has a pronounced effect on *D. magna* reproductive capacity.

Keywords: *Daphnia*, reproduction, environmental conditions

Akvakultura od znanosti do škole

prof. dr. sc. Kovačević Goran[1], dr. sc. Sirovina Damir[1]*

[1] Prirodoslovno-matematički fakultet, Sveučilište u Zagrebu, Biološki odsjek, Zoologijski zavod, Horvatovac 102A, HR-10000 Zagreb, Croatia
[*] e-mail: goran.kovacevic@biol.pmf.hr

Sažetak

Na Biološkom odsjeku Prirodoslovno-matematičkog fakulteta u Zagrebu, desetljećima se uzgajaju ili kultiviraju različiti mali slatkovodni beskralješnjaci i alge: hidre (*Hydra viridissima* Pallas, 1766; *Hydra oligactis* Pallas, 1766), vodenbuhe (*Daphnia magna* Straus, 1820), virnjaci (*Polycelis felina* Dalyell, 1814; *Dugesia gonocephala* Duges, 1830), slobodnoživuće alge (*Chlorella vulgaris* Beij. [K&H, 1992]; *C. kessleri* Fott et Novak. [K&H, 1992]) i izolirane endosimbiotske alge (*Mychonastes homosphaera* (Skuja) Kalina et Punčochářová; *Desmodesmus subspicatus* (Chodat) Hegewald et Schmidt). Uobičajeni izrazi koji se koriste su „rast u kulturama", „uzgoj u različitim medijima", „održavanje organizama", ali to je zapravo vrlo blisko i slično akvakulturi. Navedeni organizmi prvenstveno se koriste za znanstveni rad i nastavu u akademskom okruženju. Kroz cijelo to vrijeme, pa i u vrijeme COVID pandemije, prisutan je interes škola za ove organizme u svrhu nastave, demonstracija, školskih istraživanja i natjecanja iz biologije. Kako su metode uglavnom jednostavne, ova je suradnja praktički bazirana na *akvakulturi*. Budući da ta suradnja nije organizirana i potiče je uglavnom nekoliko entuzijastičnih nastavnika iz škola i/ili fakulteta i budući da je interes učenika za područje prirodnih znanosti u opadanju, a akvakultura još nije dobro poznata u školama, čini nam se da bi bilo dobro uspostaviti organiziranu podršku učiteljima u ovom području.

Ključne riječi: akvakultura, škole, nastavnici, učenici

Aquaculture from science to school

prof. dr. sc. Kovačević Goran[1], dr. sc. Sirovina Damir[1]*

[1] Faculty of Science, University of Zagreb, Department of Biology, Division of Zoology, Horvatovac 102A, HR-10000 Zagreb, Croatia
[*] e-mail: goran.kovacevic@biol.pmf.hr

Abstract

For decades on the Faculty of Science, Department of Biology, Zagreb, different small freshwater invertebrates and algae have been reared or cultivated: hydras (*Hydra viridissima* Pallas, 1766; Hydra *oligactis* Pallas, 1766), water fleas (*Daphnia magna* Straus, 1820), planarians (*Polycelis felina* Dalyell, 1814; *Dugesia gonocephala* Duges, 1830), free-living algae (*Chlorella vulgaris* Beij. [K&H, 1992]; *C. kessleri* Fott et Novak. [K&H, 1992]) and isolated endosymbiotic algae (*Mychonastes homosphaera* (Skuja) Kalina et Punčochářová; *Desmodesmus subspicatus* (Chodat) Hegewald et Schmidt). Common expressions used are „growing in cultures", „rearing in different media", „maintaining of the organisms", but it is actually very close and similar to the terms of aquaculture. These are primarily used for scientific work and teaching in academic environment. During all of this time, even in COVID-times, the interest from schools for these organisms for the purpose of teaching, demonstrations, school research, biology competitions has been present. As methods are mostly simple, this cooperation continues practically on the basis of *aquaculture*. Since this is not organized and it is encouraged mainly by a few enthusiastic teachers from schools and/or faculty and since the interest in the natural sciences field among school students is decreasing, and aquaculture is not yet well known in schools, it seems to us that it would be good to establish organized support for teachers in this area.

Keywords: aquaculture, schools, teachers, students

Rast i razmnožavanje puža *Planorbarius corneus* (Linnaeus, 1758) u laboratorijskim uvjetima

dr. sc. Mažuran Neda[1], prof. dr. sc. Kovačević Goran[2]*

[1] Salopekova 2b, HR-10000 Zagreb, Croatia
[2] Prirodoslovno-matematički fakultet, Sveučilište u Zagrebu, Biološki odsjek, Zoologijski zavod, Horvatovac 102A, HR-10000 Zagreb, Croatia
[*] e-mail: goran.kovacevic@biol.pmf.hr

Sažetak

Testove toksičnosti sa životnim ciklusom mekušaca Organizacija za ekonomsku suradnju i razvoj (OECD) preporučila je 2010. godine zbog povećane zabrinutosti vezane za endokrine disruptore, kemijske spojeve koji oštećuju razmnožavanje riba i mekušaca u prirodnim populacijama i u uzgajalištima. Slatkovodni puževi, koje je lako uzgajati i održavati u laboratoriju uz niske troškove, su vjerojatno najpogodniji za razvijanje novih metoda dugotrajnih testova toksičnosti. Ovdje smo prikazali rezultate promatranja rasta i razmnožavanja puža *Planorbarius corneus* L. (Gastropoda, Pulmonata) tijekom nekoliko godina neprekidnog uzgoja u laboratoriju. Opisana su neka svojstva rasta i razmnožavanja koja je lako mjeriti i brojati te su prikazani kvantitativni rezultati rasta i razmnožavanja: heterogeni rast koji je varirao između 0.1 mm i 5.3 mm u individualnih puževa, dobivena proizvodnja od 0.6 mrijestova po pužu na dan i 11 jaja po pužu na dan. Uočena je statistički značajna negativna korelacija između početne veličine i rasta puževa. Također je uspoređena kvantiteta razmnožavanja 4 izolirana puža s onom puževa držanih u grupi. Kao rezultat, opažen je dvostruko smanjen rast i četverostruko smanjeno razmnožavanje u izoliranih životinja. Istraživanje laboratorijske kulture vrsta puževa, poput *P. corneus* može pružiti podatke za uzgoj i uvjete održavanja sa svrhom da ih se koristi kao test organizme u procjeni kvalitete voda.

Ključne riječi: mekušci, rast, razmnožavanje, *Planorbarius*

Growth and reproduction of *Planorbarius corneus* (Linnaeus, 1758) in laboratory conditions

dr. sc. Mažuran Neda[1], prof. dr. sc. Kovačević Goran[2]*

[1] *Salopekova 2b, HR-10000 Zagreb, Croatia*
[2] *Faculty of Science, University of Zagreb, Department of Biology, Division of Zoology, Horvatovac 102A, HR-10000 Zagreb, Croatia*
[*] *e-mail: goran.kovacevic@biol.pmf.hr*

Abstract

Life-cycle toxicity testings with molluscs were recommended by Organisation for Economic Co-operation and Development in 2010 because of increasing concern about endocrine-disrupting chemicals which damage reproduction in fish and molluscs in native populations and fisheries. Freshwater snails, which are easily reared and handled in laboratory at low cost are probably most suitable for developing new long-term toxicity test methods. Here we presented the results of observation on growth and reproduction of *Planorbarius corneus* L. (Gastropoda, Pulmonata) over the course of several years of continuous rearing in the laboratory. Some growth and reproduction features which are easy to measure and count are described and the quantitative results of growth and reproduction observations are presented: heterogenous growth varied between 0.1 mm and 5.3 mm in individual snails, production of 0.6 egg masses per snail/day and 11 eggs per snail/day was obtained. A statistically significant negative correlation between initial snail size and growth was noticed. Also, the reproductive output of 4 isolated snails was compared to that of permanently grouped snails. As a result, 2-fold decreased growth and 4-fold decreased reproductive output in the progeny of isolated animals was noticed. Studies on laboratory culture of snail species like *P. corneus* could provide data for breeding and maintenance conditions in order to use them as test species in water quality assessments.

Keywords: molluscs, growth, reproduction, *Planorbarius*

Control of the presence of insects in feed for animals in aquaculture

Dr Ksenija Nešić[1], dr Vladimir Radosavljević[1]*

[1] Scientific Institute of Veterinary Medicine of Serbia, Smolućska 11, 11070 Belgrade
[*] e-mail: ksenija.nesic@nivs.rs

Abstract

Insects belong to the category of feedingstuffs of animal origin and are subject to the regulations for processed animal proteins, so the official control methods are classical light microscopy and PCR. However, since seven species of insects are currently approved for use in animal nutrition (first in aquaculture in 2017), it is necessary to use a method that would provide apropriate information and enable distinction between permitted and undesirable species. There are a few validated PCR protocols, but not all permitted species are analytically covered, while there are still more than a million insect species to differentiate and exclude from the food chain. The possibility of a multiplex PCR methods can be a good option. Alternatively, next-generation sequencing (NGS) based on arthropod metabarcoding are useful considerations. A big challenge will be to identify universal primers that target DNA fragments of the appropriate size (≤ 150 bp), and at the same time cover all major groups of insects, at least *Diptera, Orthoptera, Lepidoptera* and *Coleoptera*, considering that they include the most important cultivated species. Apart from DNA-based methods, some other laboratory tests, such as immunochemical analyses, near-infrared spectroscopy or mass spectrometry, could be used as complementary procedures when insect fragments are microscopically determined within a non-specific screening approach.

Keywords: feed control, insects, laboratory methods

Pojava antimikrobne rezistencije kod bakterija izoliranih iz ribogojilišta sa i bez uporabe antibiotika

Božidar Kurtović[1], Damir Kapetanović[1], Ana Gavrilović[2], Irena Vardić Smrzlić[1], Anamarija Kolda[1], Fran Barac[1], Jakov Žunić[3], Tin Klanjšček[1]

[1] Institut Ruđer Bošković, 10000 Zagreb, Hrvatska; Bozidar.Kurtovic@irb.hr; kada@irb.hr; ivardic@irb.hr; Anamarija.Kolda@irb.hr; fran.barac.3@gmail.com; Tin.Klanjscek@irb.hr
[2] Sveučilište u zagrebu Agronomski fakultet, 10000 Zagreb, Hrvatska; agavrilovic@agr.hr
[3] Ministarstvo poljoprivrede Republike Hrvatske, 51000 Rijeka, Hrvatska, jakov.zunic@mps.hr

Sažetak

Prisutnost rezistentnih bakterija u morskom okolišu svjetski je problem. Liječenje bakterijskih bolesti u akvakulturi uobičajeno se provodi primjenom antibiotika. Istovremeno, kupci sve više traže ribu i riblje proizvode proizvedene po visokim ekološkim standardima u uzgoju bez uporabe antibiotika.

Cilj ovog istraživanja bio je utvrditi pojavu rezistencije na antibiotike kod bakterija izoliranih iz dva ribogojilišta koja primjenjuju tehnologije s i bez primjene antibiotika. Bakterije su izolirane iz zdravih lubina (*Dicentrarchus labrax*), morske vode i sedimenta.

Rezultati su pokazali višu razinu antimikrobne rezistencije kod bakterijskih izolata s farme na kojoj se primjenjuju antibiotici. Nasuprot tome, prisutnost rezistentnih bakterija na drugoj farmi nije bila u skladu s tehnologijom uzgoja bez antibiotika. Budući da se radi o uzgajalištu bez uporabe antibiotika, ostvareni rezultati ukazuju da bi prisutnost rezistentnih bakterija mogla utjecati na uzgoj lubina i kvalitetu ribljih proizvoda.

Naši rezultati naglašavaju važnost specifičnog pristupa u proučavanju otpornosti bakterija na antibiotike pri različitim tehnologijama uzgoja i u različitim morskim staništima. Također je evidentno da bi učinke iz okoliša na otpornost bakterija u uzgojima bez uporabe antibiotika trebalo dodatno istražiti te da bi trebalo poboljšati preventivne mjere u akvakulturi kako bi se smanjila uporaba antibiotika.

Ključne riječi: Jadransko more, uzgoj lubina, morska voda, sediment, otpornost na antibiotike

Occurrence of antimicrobial resistance in bacteria isolated from fish farms with and without antibiotic use

Božidar Kurtović[1], Damir Kapetanović[1], Ana Gavrilović[2], Irena Vardić Smrzlić[1], Anamarija Kolda[1], Fran Barac[1], Jakov Žunić[3], Tin Klanjšček[1]

[1] Ruđer Bošković Institute, 10000 Zagreb, Croatia; Bozidar.Kurtovic@irb.hr; kada@irb.hr; ivardic@irb.hr; Anamarija.Kolda@irb.hr; fran.barac.3@gmail.com; Tin.Klanjscek@irb.hr
[2] University of Zagreb Faculty of Agriculture, 10000 Zagreb, Croatia; agavrilovic@agr.hr
[3] Ministry of Agriculture Republic of Croatia, 51000 Rijeka, Croatia, jakov.zunic@mps.hr

Abstract

The presence of resistant bacteria in the marine environment is a worldwide problem. Under aquaculture conditions, antibiotics are regularly administered to treat bacterial diseases. Simultaneously, customers are increasingly asking for fish and fish products produced according to high ecological standards in aquacultures without the use of antibiotics.

The aim of this study was to determine the occurrence of antibiotic resistance in bacteria isolated from two fish farms using technologies with and without antibiotic use. Bacteria were isolated from healthy European seabass (*Dicentrarchus labrax*), seawater, and sediment.

The results showed a higher level of antimicrobial resistance in bacterial isolates in the farm with the use of antibiotics. In contrast, the presence of resistant bacteria on another farm was not consistent with the antibiotic-free culture technology. Since this was a farm without antibiotic use, these results could imply that the presence of resistant bacteria could affect seabass aquaculture and fish product quality.

Our results highlight the importance of a bacteria-specific approach in studying antibiotic resistance in different aquaculture technologies and different marine habitats. It is also evident that the observed environmental effects on bacterial resistance in cultures without the use of antibiotics should be further investigated and that preventive measures in aquaculture should be improved to reduce the use of antibiotics.

Keywords: Adriatic Sea, European seabass aquaculture, seawater, sediment, antibiotic resistance

Hiperprodukcija Velike vodenbuhe (*Daphnia magna*) u slatkovodnom mikrokozmosu

prof. dr. sc. Kovačević Goran[1], dr. sc. Sirovina Damir[1], Tramontana Petra[2], mag. educ. biol. et chem., Petrinec Daniela[3], mag. educ. biol. et chem, dr. sc. Želježić Davor[4]*

[1] Sveučilište u Zagrebu, Prirodoslovno-matematički fakultet, Biološki odsjek, Zoologijski zavod, Horvatovac 102A, HR-10000 Zagreb, Hrvatska
[2] Sveučilište u Zagrebu, Medicinski fakultet, Zavod za Histologiju i Embriologiju, Šalata 3, HR-10000 Zagreb, Hrvatska
[3] IV. gimnazija, Žarka Dolinara 9, HR-10000 Zagreb, Hrvatska
[4] Institut za medicinska istraživanja i medicinu rada, Ksaverska cesta 2, HR-10001 Zagreb, Hrvatska
[*] e-mail: damir.sirovina@biol.pmf.hr

Sažetak

Mikrokozmos predstavlja pojednostavljeni ekosustav u kontroliranim uvjetima koji se koristi za simulaciju, predviđanje uloga i ponašanja organizama unutar prirodnih ekosustava. U ovom istraživanju koristili smo mikrokozmos kako bismo odredili i razjasnili interakcije predatora i plijena u različitim okolišnim uvjetima. Za postavljanje pokusa korištene su staklene posude volumena 60 mL napunjene s 50 mL aerirane vode. Promatrani su sljedeći organizmi: *Daphnia magna* kao plijen, *Dugesia gonocephala*, *Polycelis felina*, *Hydra viridissima* kao predatori i izolirane endosimbiotske alge, kroz 24 h pri dva eksperimentalna uvjeta (25 °C, fotoperiod 8 sati dan/16 sati noć i pri 13.5 °C u mraku). Korištene su site i gladne jedinke predatora. Tijekom pokusa uočena je *hiperprodukcija* jedinki *D. magna*, ali se ne isključuje mogućnost da je uočena pojava posljedica ubrzanog presvlačenja. Pojava je bila najizraženija nakon 24 h, uglavnom u prisustvu gladnih predatora. Nadalje, prisustvo izolirane endosimbiotske alge također je rezultiralo pojavom *hiperprodukcije* što implicira da alge mogu utjecati na dinamiku slatkovodnog mikrokozmosa. Uočeno je i da su novonastale jedinke *D. magna* ponekad manje u odnosu na jedinke unesene u eksperimentalni postav. Uočene pojave mogu biti posljedica bržeg sazrijevanja jedinki *D. magna* u postavljenim eksperimentalnim uvjetima. Sve uočeno/navedeno bi moglo omogućiti učinkovitiju zaštitu vodenbuhe *D. magna* od predatora koji preferiraju veće jedinke plijena (vodenbuhe).

Ključne riječi: slatkovodni mikrokozmos, predatori, plijen, alge

Hyperproduction of Daphnia magna in freshwater microcosm

prof. dr. sc. Kovačević Goran[1], dr. sc. Sirovina Damir[1], Tramontana Petra[2], mag. educ. biol. et chem., Petrinec Daniela[3], mag. educ. biol. et chem, dr. sc. Želježić Davor[4]*

[1] *Faculty of Science, University of Zagreb, Department of Biology, Division of Zoology, Horvatovac 102A, HR-10000 Zagreb, Croatia*
[2] *School of Medicine University of Zagreb, Šalata 3, HR-10000 Zagreb, Croatia*
[3] *IV. gimnazija, Žarka Dolinara 9, HR-10000 Zagreb, Croatia*
[4] *Institute for Medical Research and Occupational Health, Ksaverska cesta 2, HR-10001 Zagreb, Croatia*
[*] *e-mail: damir.sirovina@biol.pmf.hr*

Abstract

Microcosm represents a simplified ecosystem in controlled conditions, which is used to simulate and predict the behavior and roles of organisms within natural ecosystems. We applied that approach in the present research to determine and improve understanding of the predator-prey interactions in different environments. The experimental set-up was carried out in 60 mL glass vessels with 50 mL of aerated water. Observed organisms: *Daphnia magna* as prey, *Dugesia gonocephala*, *Polycelis felina*, *Hydra viridissima* as predators, and isolated endosymbiotic algae, in two environmental conditions for 24 h (25 °C, photoperiod 8 hours day/16 hours night and 13.5 °C in the dark). Hungry and fed predatory animals were used. During the experiment *hyperproduction* of *D. magna* was observed, but it cannot be ruled out that it was reflection of a rapid molting. The effect was most pronounced after 24 h, dominantly in the presence of hungry predators. Besides, the presence of isolated endosymbiotic algae resulted in *hyperproduction* effect either, indicating that algae could affect the dynamics in freshwater microcosm. Occasionally, the subsequently produced *Daphnia* individuals were smaller than the individuals introduced into the system. The observed phenomena could be the result of faster maturation of *Daphnia magna* individuals under the set experimental conditions. This could provide more efficient protection to *Daphnia* to avoid predator pressure/attacks by predators that prefer larger water fleas.

Keywords: freshwater microcosm, predators, prey, algae

Indeks kondicije, gonadosomatski indeks i indeks mišića aduktora Jakovljeve kapice *Pecten jacobaeus* (Linneaus, 1758) iz ušća rijeke Krke

Šebalj Valentina[1], izv. prof. dr. sc. Župan Ivan[2], izv. prof. dr. sc. Šarić Tomislav[2]

[1] Doktorand; vsebalj@gmail.com
[2] Sveučilište u Zadru, Odjel za ekologiju, agronomiju i akvakulturu, Trg Kneza Višeslava 9, 23000 Zadar; zupan@unizd.hr; tosaric@unizd.hr

Sažetak

Akvakultura je proteklih desetljeća jedan od najbrže rastućih sektora u proizvodnji hrane u svijetu, te sve više dominira u opskrbi tržišta proizvodima ribarstva. Danas je velika većina proizvoda školjkaša na tržištu porijeklom iz uzgoja, ali je ta ponuda ograničena na mali broj vrsta [1]. U Hrvatskoj je uzgoj školjkaša uglavnom ograničen na uzgoj dagnji i kamenica te se stoga javlja sve veća potreba za uvođenjem novih vrsta u uzgoj. Jakovljeva kapica *Pecten jacobaeus* (Linnaeus, 1758) najveći je školjkaš iz porodice Pectinidae koji je rasprostranjen u Sredozemnom i Jadranskom moru. Tražena je komercijalna vrsta, a najpoželjniji dio njena mesa je veliki mišić aduktor [2]. U prošlosti se naveliko izlovljavala kroz ribolov u cijelom Mediteranu, a sada se smatra da je njena populacija dovoljno velika za komercijalni ribolov samo na području sjevernog Jadrana [3]. Zbog znatne veličine, brzog rasta i vrijednosti koju postiže na tržištu, zanimljiva je vrsta za uvođenje u akvakulturu.

U ovom radu istraživali smo indeks kondicije (IK), gonadosomatski indeks (GSI) i indeks mišića aduktora (IMA) kod jakovljeve kapice iz ušća rijeke Krke, sa ciljem da se utvrdi najpovoljnije razdoblje za prikupljanje mlađi kolektorima iz prirode kao i za prikupljanje i kondicioniranje matičnog jata i poticanje mrijesta u laboratorijskim uvjetima, radi utvrđivanja potencijala jakovljeve kapice za uvođenje u komercijalni uzgoj. Mjerenje IK koristi se kako bi se procijenila nutritivna vrijednost školjkaša, a uglavnom se izražava kao udio mesa u odnosu na ukupnu masu ljušture. Gonadosomatski indeks (GSI) koristi se da se procjeni reproduktivni status školjkaša [4], te se izražava uglavnom kao udio gonada u odnosu na masu cjelokupnog mekog tkiva ili na masu ljušture. Indeks mišića aduktora (IMA) ukazuje na stanje hranjivih zaliha u mišiću aduktoru, glavnom organu za pohranu kod kapica [2].

Ovi indeksi mogu varirati ovisno o veličini jedinke, reproduktivnom ciklusu, sezoni, kao i o lokalnim okolišnim uvjetima, poput temperature mora i dostupnosti hrane [2, 4].

U razdoblju od prosinca 2021. do prosinca 2022. godine prikupljeno je otprilike 20 uzoraka mjesečno, koji su potom obrađeni i analizirani u laboratoriju. Parametri koji su mjereni su dimenzije (mm) i masa ljušture (g), te masa mekog tkiva (g), u mokrom i suhom stanju. Na osnovu dobivenih mjerenja izračunati su IK, GSI i IMA za svaki mjesec koristeći sljedeće metode:

- IK = (ukupna suha masa mekog tkiva (g)/ masa ljušture (g)) x 100 [5]
- GSI = (suha težina gonada (G) *100)/ masa ljušture (g) [6]
- IMA = suha masa mišića aduktora (g)/ ukupna suha masa mekog tkiva (g) x 100 [5]

Naši rezultati ukazuju da je IK jakovljeve kapice iz ušća rijeke Krke najviši u rano proljeće neposredno prije mrijesta, a nakon kojeg slijedi nagli pad u vrijednostima. Visoke vrijednosti zabilježene su opet u razdoblju od srpnja do listopada, nakon čega opet slijedi pad te su najniže vrijednosti zabilježene tijekom zimskih mjeseci. Najviše vrijednosti GSI zabilježene su u kasnu zimu/ rano proljeće, što ukazuje da je glavno razdoblje mrijesta u proljeće. Povišene vrijednosti GSI zabilježene su i u rujnu te u ranu zimu, što ukazuje na dva dodatna moguća razdoblja mrijesta, dok su najniže vrijednosti zabilježene tijekom ljetnih mjeseci. Zabilježen je i obrnuto proporcionalni odnos GSI u odnosu na IMA, sa najvišim vrijednostima IMA u ljetnim mjesecima, a najmanjim u rano proljeće. Na temelju dobivenih rezultata zaključujemo da je najpovoljnije razdoblje za postavljanje kolektora za prikupljanje mlađi iz prirode, kao i za prikupljanje i kondicioniranje matičnog jata u laboratorijskim uvjetima, u proljetnom razdoblju. S obzirom da je za plasman na tržište važna veličina i kvaliteta mišića aduktora, kvaliteta proizvoda bi u skladu s time bila najpovoljnija u ljetnom razdoblju kada IMA postiže najviše vrijednosti.

Ključne riječi: akvakultura, *Pecten jacobaeus*, indeks kondicije, gonadosomatski indeks, indeks mišića aduktora

Condition index, gonadosomatic index and adductor muscle index of scallop *Pecten jacobaeus* (Linneaus, 1758) from the Krka river estuary

Šebalj Valentina[1], Župan Ivan, Ph.D., Associate Professor[2], Šarić Tomislav, Ph.D., Associate Professor[2]

[1] Ph.D. student; vsebalj@gmail.com
[2] University of Zadar, Department of Ecology, Agriculture and Aquaculture, Trg Kneza Višeslava 9, 23000 Zadar; zupan@unizd.hr; tosaric@unizd.hr

Abstract

In recent decades, aquaculture has been one of the fastest growing sectors in food production in the world and it is increasingly replacing commercial fishing in supplying the market with fisheries products. Today, the vast majority of shellfish products on the market comes from farming, but this offer is limited to a small number of species [1]. In Croatia, shellfish farming is mainly limited to the cultivation of mussels and oysters, and therefore there is an increasing need to introduce new species to aquaculture. The Mediterranean scallop *Pecten jacobaeus* (Linnaeus, 1758) is the largest bivalve of the Pectinidae family that lives in the Mediterranean and Adriatic Sea. This commercial species is in high demand, especially for its large adductor muscle which is the most desirable part of its meat. In the past, it was heavily exploited through fishing throughout the Mediterranean, but now its population is considered to be large enough for commercial fishing only in the northern Adriatic [3]. Due to its considerable size, fast growth and its market value, it is an interesting species for the introduction to aquaculture.

In this research, we investigated condition index (CI), gonadosomatic index (GSI) and adductor muscle index (AMI) of *Pecten jacobaeus* from the Krka River estuary with the aim of determining the most favorable period for the wild spat collection with artificial collectors as well as for collection and conditioning of broodstock and initiating spawning under laboratory conditions, in order to determine the potential of *P. jacobaeus* for the introduction to aquaculture. The CI measurement is used to estimate the nutritional value of shellfish and is generally expressed as the proportion of meat relative to the total weight of the shell. The gonadosomatic index (GSI) is used to assess the reproductive

status of bivalves [4] and is expressed mainly as the proportion of gonads in relation to the mass of the total soft tissue or to the mass of the shell. The adductor muscle index (AMI) indicates the state of nutrient stores in the adductor muscle, the main storage organ in scallops [2]. These indices can vary depending on the size of the individual, reproductive cycle, season, as well as local environmental conditions, such as sea temperature and food availability [2, 4].

In the period from December 2021 to December 2022, approximately 20 samples were collected per month, which were then processed and analyzed in the laboratory. The parameters that were measured were the dimensions (mm) and mass of the shell (g) and the mass of soft tissue (g), wet and dry weight. Based on the obtained measurements, CI, GSI and AMI were calculated for each month using following methods:

- CI = (soft tissue dry weight (g)/shell dry weight (g)) x 100 [5]
- GSI = (gonad dry weight (G) *100)/ shell weight (g) [6]
- AMI = muscle adductor dry weight (g)/ total tissue dry weight (g) x 100 [5]

Our results indicate that the CI of *P. jacobaeus* from the Krka River estuary is highest in early spring, just before spawning occurs, and it is then followed by a rapid decline. High CI values were recorded again in the period from July to October, followed again by a decline, with the lowest values recorded during the winter months. The highest GSI values were recorded in late winter/early spring, which indicates that the main spawning period is during spring season. Elevated GSI values were also recorded in September and also in early winter, which indicates two possible additional spawning periods, while the lowest values were recorded during the summer months. An inversely proportional relationship between GSI and IMA was also recorded, with the highest AMI values in the summer months, and the lowest in early spring. Based on the obtained results, we conclude that the most favorable period for setting up collectors for wild spat collection, as well as for collecting and conditioning of broodstock under laboratory conditions is during spring season. Given that the size and quality of the adductor muscle is important for placement of products on the market, the products quality would accordingly be the most favorable in the summer period when the AMI reaches its highest values.

Keywords: aquaculture, *Pecten jacobaeus*, condition index, gonadosomatic index, adductor muscle index

Unapređenje kvaliteta i bezbednosti ribe – pristup jednog zdravlja

Dragana Ljubojević Pelić[1], Miloš Pelić[1], Nikolina Novakov[2], Jasna Kureljušić[3], Ana Gavrilović[4], Jurica Jug-Dujaković[5], Milica Živkov Baloš[1]*

[1] Naučni Institut za veterinarstvo "Novi Sad", Zavod za bezbednost hrane, Novi Sad, Republika Srbija
[2] Univerzitet u Novom Sadu, Poljoprivredni fakultet, Departman za veterinarsku medicinu, Novi Sad, Republika Srbija
[3] Naučni institut za veterinarstvo Srbije, Beograd, Republika Srbija
[4] Univerzitet u Zagrebu, Poljoprivredni fakultet, Zagreb, Republika Hrvatska
[5] Sustainable Aquaculture Systems Inc., Frenchtown, New Jersey, USA
[*] e-mail: dragana@niv.ns.ac.rs

Sažetak

Akvakultura je grana privrede koja je doživela orgroman globalni rast u poslednjih nekoliko decenija. Na dalji razvoj akvakulture će svakako uticati tržište, mišljenje potrošača, a posebno njihova zabrinutost vezana za bezbednost proizvedene ribe, ali i za uticaj proizvodnje ribe na životnu sredinu. Riba se smatra neizostavnom namirnicom u zdravoj ishrani, ali treba imati u vidu da mnogobrojni hazardi, kao što su mikrobiološki, hemijski i drugi mogu dospeti u ribu u toku celog procesa proizvodnje. Imajuću sve u vidu veoma je važno poznavanje i razumevanje distribucije i uloge ovih hazarda duž celog procesa proizvodnje, a prvenstveno je važno njihovo sagledavanje sa aspekta jednog zdravlja. Za nesmetani razvoj akvakulture je od ogromnog značaja primena dobre ribarske prakse i strogo pridržavanje i primena postojećih zakonskih propisa. Da bi se obezbedio kvalitet i pre svega osigurala bezbednost proizvedene ribe neophodno je uvođenje sistema menadžmenta kvaliteta. Ogroman značaj takođe ima primena biosigurnosnih mera u primarnoj proizvodnji. Multidisciplinarni pristup, kao i udruživanje različitih sektora po prinicipima Jednog zdravlja može dovesti do povećanja efikasnosti proizvodnje u akvakulturi sa minimalnim negativnim efektom na životnu sredinu. Ovakav pristup je neophodan za održivi razvoja slatkovodne akvakulture, a glavni cilj je da se osigura proizvodnja bezbedne hrane što je preduslov za nesmetanu trgovinu ribom.

Ključne riječi: slatkovodno ribarstvo, kvalitet ribe, bezbednost, dobra proizvođačka praksa

Improvement of quality and safety of freshwater fish – one health approach

Dragana Ljubojević Pelić[1], Miloš Pelić[1], Nikolina Novakov[2], Jasna Kureljušić[3], Ana Gavrilović[4], Jurica Jug-Dujaković[5], Milica Živkov Baloš[1]*

[1] Scientific Veterinary Institute Novi Sad, Department of Food Safety, Novi Sad, Republic of Serbia
[2] University of Novi Sad, Faculty of Agriculture, Department of Veterinary Medicine
[3] Scientific Institute of Veterinary Medicine of Serbia, Belgrade, Serbia
[4] University of Zagreb, Faculty of Agriculture, Zagreb, Croatia
[5] Sustainable Aquaculture Systems Inc., Frenchtown, New Jersey, USA
[*] e-mail: dragana@niv.ns.ac.rs

Abstract

Aquaculture is an economic sector that has experienced tremendous global growth in the last few decades. The further development of aquaculture will certainly be influenced by the market, the opinion of consumers, and especially by their concern regarding the safety of the produced fish, but also the impact of fish production on the environment. Fish is considered an important food in a healthy diet, but it should be borne in mind that numerous hazards, such as microbiological, chemical and others, can get into the fish during the entire production process. Having all above mentioned in mind, it is very important to know and understand the distribution and role of these hazards along the entire production process, and it is primarily important to consider them from the aspect of one's health. For the regular development of aquaculture, the application of good fishing practices and the strict adherence and application of existing regulations are of great importance. In order to ensure the quality and the most important the safety of the produced fish, it is necessary to introduce a quality management system. The application of biosecurity measures in primary production is also of great importance. A multidisciplinary approach, as well as the cooperation of different sectors according to the principles of One Health, can lead to an increase in the efficiency of production in aquaculture with a minimal negative effect on the environment. This approach is necessary for the sustainable development of freshwater aquaculture, and the main goal is to ensure the production of safe food, which is a prerequisite for an unhindered fish trade.

Keywords: freshwater fisheries, fish quality, safety, good production practice

Utjecaj hidroakumulacija na status i uspješnost alohtonih vrsta riba u slivu rijeke Neretve i utjecaj na ribarstvo

doc.dr.sc. Irena Rozić, prof.dr.sc. Jerko Pavličević

Agronomski i prehrambeno tehnološki fakultet Sveučilište u Mostaru

Sažetak

Prije formiranja vodnih akumulacija fauna riba rijeke Neretve bila je, kako po brojnosti tako i po raznovrsnosti vrsta, znatno drugačija u odnosu na današnje stanja faune u jezerima, ostatku rijeke i pritokama. Invazije alohtonih vrsta u vodenim ekosustavima predstavljaju danas jednu od najvećih prijetnja biorazolikosti u svijetu. Većina introdukcija je posljedica antropogenih promjena izvornih značajka sliva Neretve, posebice izgradnje brana i formiranje akumulacijskih jezera i melioracija močvarnih ekosustava. Većina, od 31 do danas zabilježene alohtone vrste u slivu Neretve, nije ustanovila stabilne mrijesne populacije, te se neke više i ne pojavljuju u ulovima. Međutim, za niz vrsta se može potvrditi da su ustanovile mrijesne populacije u nizu neretvanskih ekosustava, te danas predstavljaju ili važan ribarstveni resurs poput šarana, linjaka i smuđa ili čine značajne štete u svim neretvanskim ekosustavima poput babuške, sunčanice, štuke ili pastrvskog grgeča. Većina od jedanaest vrsta ima tipičan invazivni karakter koji obilježava mrijest u prijemnim ekosustavima. Međutim, u pogledu šteta u prijemnim ekosustavima i koristi u socio-ekonomskom pogledu ovih vrsta se značajno razlikuju. Cilj rada je ukazati na promjene koje su se dogodile u fauni riba od formiranja prve hidroakumulacije na rijeci Neretvi do danas, prikazati status alohtonih vrste, te posljedice, odnosno koristi i štete pojedinih alohtonih vrsta riba, na lokalne ekosustave .

Ključne riječi: alohtone vrste riba, sliv rijeke Neretve, hidroakumulacije, invazivne vrste

The effect of hydroaccumulations on the status and success of non-native fish species in the Neretva river basin and the influence on fisheries

Assoc. Ph.D.Sc. Irena Rozić, Prof. Ph.D. Jerko Pavlicevic

Faculty of Agronomy and Food Technology, University of Mostar

Abstract

Prior to the formation of water reservoirs, fish fauna differed significantly in abundance and diversity of species from the current state of fauna in lakes, the rest of the river, and its tributaries. Invasions of non-native species in aquatic ecosystems represent one of the biggest threats to biodiversity in the world today. Most of the introductions are the result of anthropogenic changes in the original features of the Neretva basin, especially the construction of dams and the formation of water reservoirs and the amelioration of wetland ecosystems. Most of the 31 non-native species recorded to date in the Neretva basin have not established stable spawning populations, and some don't even appear in catches anymore. However, for a significant number of fish species, it can be confirmed that they have established spawning populations in a number of Neretva ecosystems, and today they either represent an important fishing resource such as carp, tench and perch or cause significant damage in all Neretva ecosystems such as prussian carp, pumpkinseed, pike or largemouth bass. Most of the eleven species have a typical invasive character that marks spawning in receiving ecosystems. However, these species differ significantly in terms of the damage they cause and the socio-economic benefits they have in their host ecosystems. The aim of this paper is to point out the changes that have occurred in the fish fauna since the formation of the first hydroaccumulation on the Neretva River until today, and the consequences, i.e. the benefits and harms of individual non-native fish species, on local ecosystems.

Keywords: non-native fish species, Neretva river basin, water reservoirs, invasive species

Prijedlozi za zaštitu stoka Europske jegulje, *Anguilla anguilla* (Linnaeus, 1758) u delti rijeke Neretve

izv. prof. dr. sc. Ana Gavrilović, Oliver Barić, Tena Radočaj, Ivan Špelić, izv. prof. dr. sc. Daniel Matulić, prof. dr. sc. Marina Piria, prof. dr. sc. Tea Tomljanović

Sveučilište u Zagrebu Agronomski fakultet, Svetošimunska cesta 25, 10000 Zagreb, Hrvatska

Sažetak

Obična ili europska jegulja, *Anguilla anguilla* (Linnaeus, 1758) tradicionalno se na području delte Neretve izlovljava stoljećima. Tradicionalna jela – brudet (brodet, brujet) od jegulje ili jegulje i žaba te jegulja na ražnju osnova su gastronomske ponude i prepoznatljivosti ovog područja. Međutim, kao i na ostalim područjima Europe, posljednjih desetljeća uočeno je znatno smanjenje novačenja ove vrste. Razlozi za to su višestruki i uključuju nestanak slatkovodnih staništa, prelov, bolesti, klimatske promjene, izgradnju brana i prepreka koje sprječavaju uzvodnu migraciju, onečišćenje vodotoka te druge antropogene utjecaje. U cilju zaštite i boljeg poznavanja stanja populacije ove vrste, donesene su regulative i preporuke na europskoj i međunarodnoj razini. Pored kontinuiranog monitoringa te nedavno uvedenog šestomjesečnog razdoblja lovostaja na razini EU, brojne zemlje su uz planove upravljanja u svrhu zaštite stoka uvele i minimalnu lovnu veličinu. U Hrvatskoj se redoviti monitoring još uvijek ne provodi te još ne postoji plan upravljanja. Uspostavljanje ovakvog plana traži prethodno detaljno poznavanje karakteristika prisutnih populacija pa je, s ciljem dobivanja polazne osnove za plan upravljanja, provedeno detaljno istraživanje jegulje tijekom zajedničkog terenskog rada s ribarima u sklopu projekta "Ribarsko-znanstvena mreža Grada Ploča" u okviru Mjere I.3. "Partnerstvo između znanstvenika i ribara za razdoblje 2017.-2020.". U skladu s dobivenim rezultatima utvrđena je potreba revizije postojeće legislative koja se odnosi na ribolovne alate te je predložena minimalna lovna veličina.

Ključne riječi: plan upravljanja, minimalna lovna veličina, ribolovni alati, legislativa

Suggestions for the protection of the European eel, *Anguilla anguilla* (Linnaeus, 1758) stock in the Neretva River delta

izv. prof. dr. sc. Ana Gavrilović, Oliver Barić, Tena Radočaj, Ivan Špelić, izv. prof. dr. sc. Daniel Matulić, prof. dr. sc. Marina Piria, prof. dr. sc. Tea Tomljanović

Sveučilište u Zagrebu Agronomski fakultet, Svetošimunska cesta 25, 10000 Zagreb, Hrvatska

Abstract

Common or European eel, *Anguilla anguilla* (Linnaeus, 1758) has been traditionally fished in the Neretva delta for centuries, while traditional dishes - *brudet (brodet, brujet)* made of eel or eel and frogs, and eel on a spit are the basis of the gastronomic offer and recognition of this area. However, as in other areas of Europe, a significant reduction in recruitment of this species has been observed in recent decades. The reasons for this are multiple and include the disappearance of freshwater habitats, overfishing, diseases, climate change, construction of dams and barriers that prevent upstream migration, pollution of water courses and other anthropogenic influences. To protect and better understand the state of the population of this species, regulations and recommendations have been adopted at the European and international level. In addition to continuous monitoring and the recently introduced six-month fishing closure at the EU level, numerous countries have introduced minimum landing size in addition to management plans for the purpose of protecting livestock. In Croatia, regular monitoring is still not carried out and there is no management plan. The establishment of such a plan requires prior detailed knowledge of the characteristics of the present populations, so with the aim of obtaining a starting point for the management plan, a detailed study of eels was carried out during joint field work with fishermen as part of the project "Fisheries and Science Network of the City of Ploče" under Measure I.3. "Partnership between scientists and fishermen for the period 2017-2020". Based on the obtained results, the need to revise the existing legislation related to fishing gears was determined, and the minimum hunting size was proposed.

Keywords: managament plan, minimal landing size, fishing gears, legislation

Očuvanje i akvakultura mekousne (*Salmo obtusirostris*)

prof. dr. sc. Milorad Mrakovčić, dipl. ing. biol.[1], Matija Kresonja, mag. prot. nat. et amb.[1], Juraj Petravić, mag. ing. agr [2]*

[1] OIKON doo – Institut za primijenjenu ekologiju, Trg Senjskih uskoka 1-2, 10000 Zagreb, Croatia
[2] JU AQUATIKA – Slatkovodni akvarij Karlovac, Branka Čavlovića Čavleka 1A, 47000 Karlovac, Croatia
[*] e-mail: jpetravic@aquariumkarlovac.com; jurajpetravic@gmail.com

Sažetak

Mekousna pastrva ima diskontinuirano rasprostranjenje. Historijski je opisana kroz četiri podvrste. Prirodno je bila rasprostranjena u rijekama Krki, Jadru, Vrljici i Neretvi u Hrvatskoj, u slijevu Neretve i njenim pritocima u Bosni i Hercegovini te u rijeci Zeti u Crnoj Gori. Premda ova vrsta ima ogromnu ekonomsku važnost, ukupna površina prostora gdje vrsta živi je manja od 500 km2, a na brojnim mjestima primjećuje se smanjenje populacija mlađa a posebno odraslih jedinki. U prošlosti je mekousna bila uobičajena vrsta u svim rijekama koje je nastanjivala (Heckel, 1851; Steindachner, 1882; Karaman, 1926), dok su u posljednjih nekoliko desetljeća pojedine podvrste značajno smanjene, a u dvije i potpuno izumrle. Dodatak II Direktive o staništima na insistiranje Hrvatske dopunjen je mekousnom, što ima za posljedicu obvezu izdvajanja i zaštite područja koja obuhvaćaju 20-60 % nacionalne populacije. U POVS-ovima HR2000931 Jadro, HR2000933 Vrljika i HR5000031 Delta Neretve mekousna je ciljna vrsta za očuvanje. Premda zaštićena zakonom ili u Naturi 2000 populacije vidljivo nestaju u zonama obitavanja. Biologija i ekologija mekusne slabo je proučena, unatoč njene lokalne ekonomske važnosti, a u rijekama u kojima su uvjeti još uvijek dobri, njezine su populacije daleko veće od očekivanih. Pred desetaka godina otkriveno je da je mekousna dobar kandidat za akvakulturu. Ovdje pružamo temeljne znanstvene i korisne informacije o biologiji vrste koja su provedeni u uzgoju na nasumično lovljenim divljim maticama. Postignuto je osnovno znanje o reprodukciji, genetici, prehrani larvi i rastu i uzgoju te zdravlju mlađi moglo bi pridonijeti održanju ove vrste

Ključne riječi: slatkovodne ribe, jadranski sliv, endemi

Conservation and aquaculture of Softmouth trout (*Salmo obtusirostris*)

prof. dr. sc. Milorad Mrakovčić, dipl. ing. biol.[1], Matija Kresonja, mag. prot. nat. et amb.[1], Juraj Petravić, mag. ing. agr [2]*

[1] OIKON doo - Institute for Applied Ecology, Trg Senjskih uskoka 1-2, 10000 Zagreb, Croatia
[2] JU AQUATIKA- freshwater aquarium Karlovac, Branka Čavlovića Čavleka 1A, 47000 Karlovac, Croatia
[*] e-mail: jpetravic@aquariumkarlovac.com; jurajpetravic@gmail.com

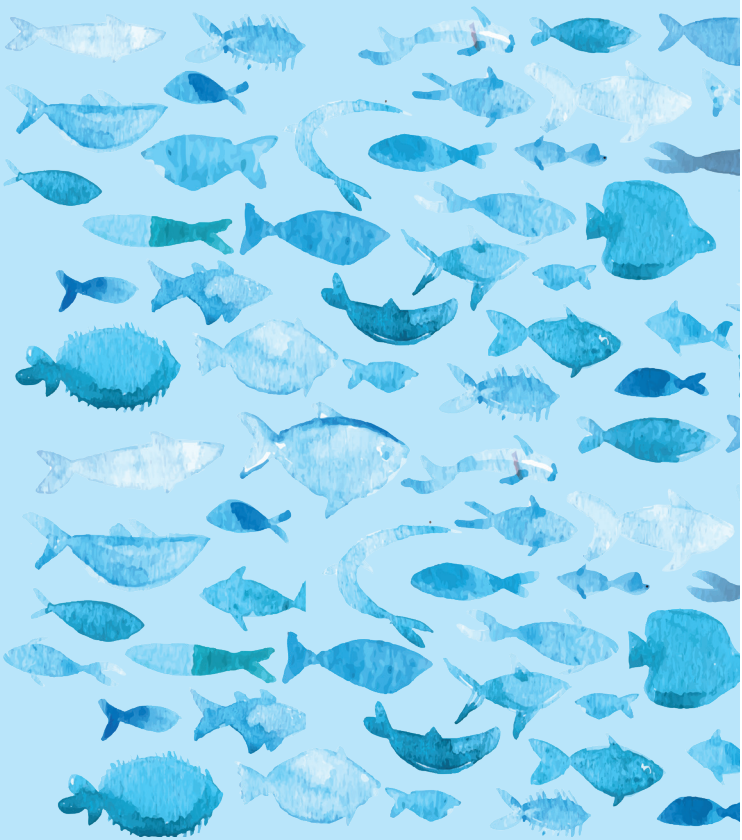
Abstract

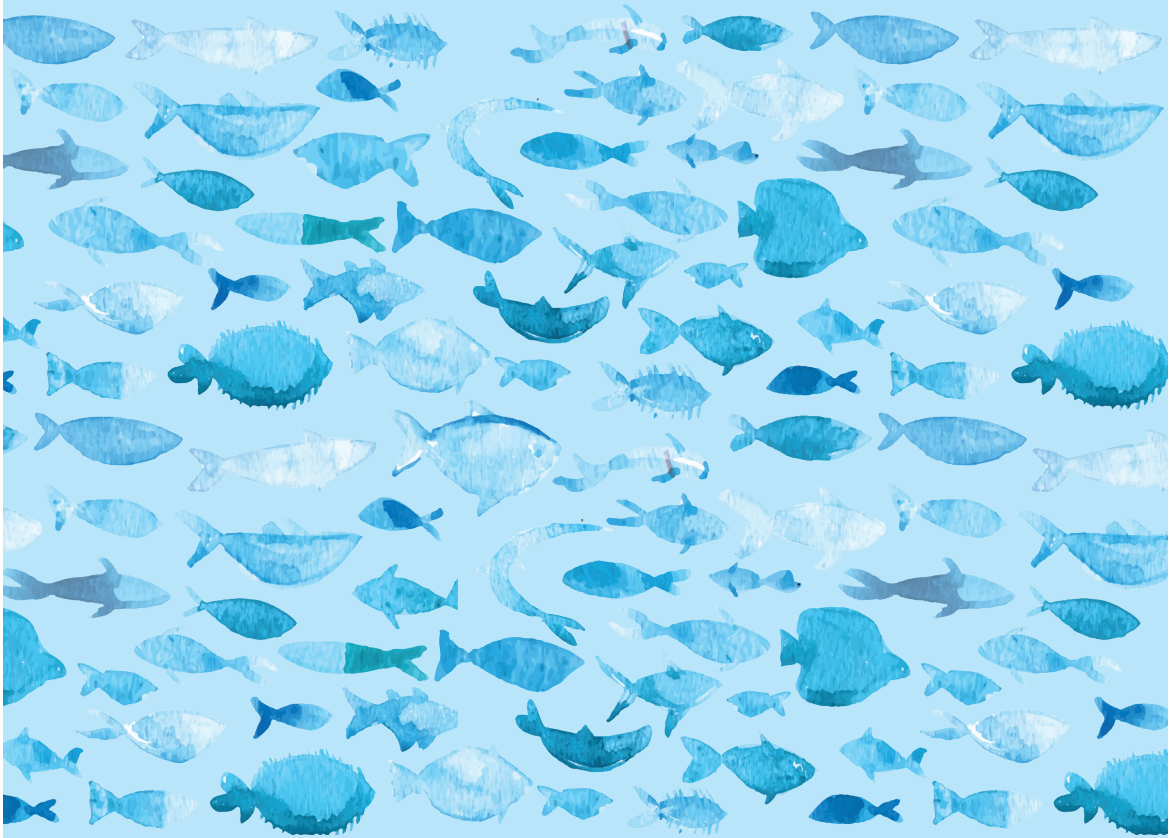
Softmouth trout has a discontinuous distribution. Historically described through four subspecies. Its natural distribution was in the rivers Krka, Jadro, Vrljika and Neretva in Croatia, in the Neretva basin and its tributaries in Bosnia and Herzegovina and in the River Zeta in Montenegro. Although this species has enormous economic importance, the total area of the area where the species lives is less than 500 km2, and in many places, there is a decrease in populations of younger and especially adult individuals. In the past, softmouth trout was a common species in all the rivers it inhabited (Heckel, 1851; Steindachner, 1882; Karaman, 1926). In the last few decades, some subspecies declined drastically, and in two, they have become extinct. The main problems affecting this species are river fragmentation, oscillations in the flow regime, dam hydropower reservoirs and changes in water temperature, downstream sediment deposition, the introduction of alien and translocated Danube basin species into reservoirs, etc. Constant habitat destruction and reduction of the quality of habitats, excessive exploitation and poaching, trout farms in watercourses inhabited by softmouth trout, and the introduction of alien trout species, with hybridisation remain serious issues. Appendix II of the Habitats Directive in Croatia is supplemented with a softmouth trout, resulting in the obligation to allocate protection areas covering 20-60% of the national population size. In POVSS HR2000931 Jadro, HR2000933 Vrljika and HR5000031 Neretva Delta *Salmo obtusirostris* is a target species. Although protected by law in Natura 2000 sites populations are visibly disappearing. The biology and ecology of the softmouth trout have been poorly studied, despite its importance as an economically important species, and in rivers where the conditions are still good, its populations are far higher than expected. A few years ago, it was discovered that softmouth trout is a good candidate for aquaculture. We provide here core scientific and useful information on the biology of the species. Basic knowledge of reproduction, breeding genetics, nutrition of larvae and growth could definitely contribute to the conservation of this species

Keywords: fish, conservation, biology ,salmonids

Bilješke

Notes





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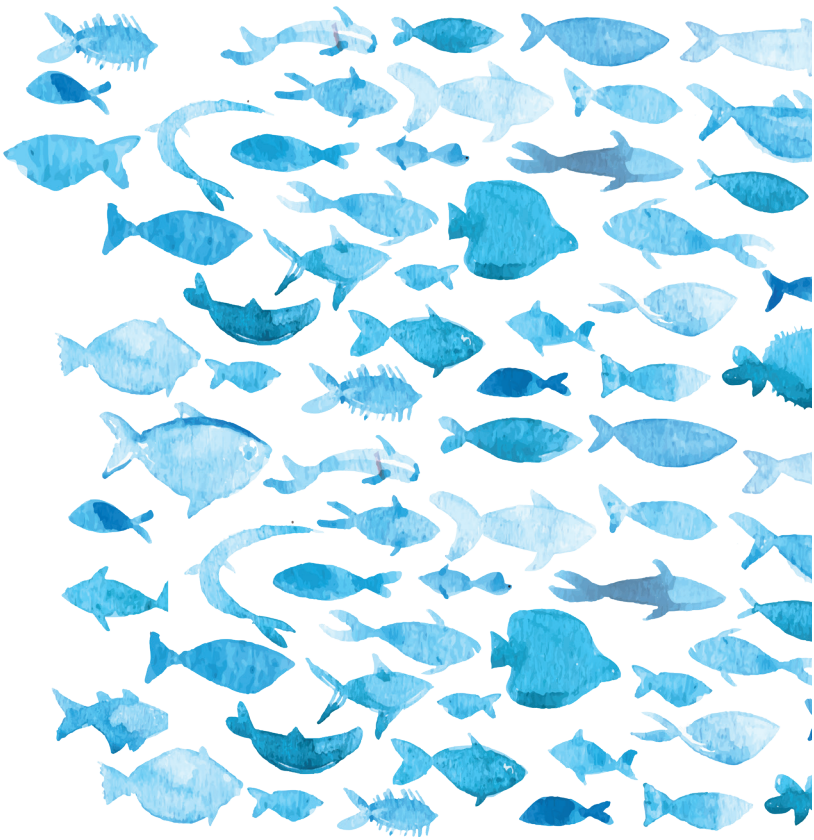

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