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SIXTH INTERNATIONAL CARP CONFERENCE

Szarvas, 31 August–1 September 2023

HUNGARIAN UNIVERSITY OF AGRICULTURE AND LIFE SCIENCES
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MA-HAL

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PREPARATION OF THIS DOCUMENT

International carp conferences organized by leading carp farmer's associations are one of the most important events dedicated to positioning and enhancing European carp aquaculture. The previous international carp conferences were held in Poland (2011–2013), Czechia (2015), Croatia (2017) and Germany (2019). Each conference published a closing document (e.g. a recommendation, resolution, or declaration). Although the structure and content of the closing documents show a great variety, three major sections can be identified: 1) a presentation of the positive impacts of pond fish culture; 2) an overview of obstacles and threats that constrain the development of pond fish culture; and 3) a call for action to strengthen the pond culture aquaculture sub-sector.

The Sixth International Carp Conference was organized jointly by the Hungarian Aquaculture and Fisheries Inter-branch Organisation (MA-HAL) and the Research Center for Fisheries and Aquaculture of the Hungarian University of Agriculture and Life Sciences (MATE AKI HAKI) and held in Szarvas, Hungary on 31 August and 1 September 2023.

The key topics of the conference were introduced through keynote presentations and panel discussions. The conference also contained a poster session where scientific results connected to carp aquaculture were presented. The participants also prepared and agreed on an outcome document: the Szarvas Declaration.

This EIFAAC occasional paper contains the proceedings of the conference, including abstracts of keynote presentations, outcomes of five panel discussions, some poster abstracts, and the Szarvas Declaration.

This document was prepared and edited by Béla Halasi-Kovács, Zsuzsanna Brlás-Molnár, Gergő Gyalog, Emese Békefi, Gyula Kovács (MATE AKI HAKI), László Váradi (NACEE), and Raymon van Anrooy (FAO/EIFAAC).

The document attempts to capture the issues raised by each presenter and panel session faithfully. The summaries and abstracts of the presentations and posters have been reproduced as submitted with some light editing. The editors apologize for any misrepresentation that may have arisen in their abstracts. All photographs and figures in the document were kindly provided by the authors and editors.

The contribution by the members of the international- and local organising committees to the success of the conference is acknowledged. The members of the international organising committee came from the main carp producer countries in Europe: Austria, Croatia, Czechia, Germany, Hungary, Poland, and Romania. Please find the list of members in Annex 3. The Conference received support from a range of Hungarian and regional institutions and companies. A list of contributors and sponsors is provided in Annex 4.

The high-quality presentations at the conference, abstracts submitted, and the work of the sessions' chairpersons, are greatly appreciated. The important contributions by the FAO Regional Office for Europe and Central Asia (REU) and the EIFAAC Secretariat to the conference and the preparation of this document are recognized.

ABSTRACT

The Sixth International Carp Conference was organized jointly by the Hungarian Aquaculture and Fisheries Inter-branch Organisation (MA-HAL) and the Research Center for Fisheries and Aquaculture of the Hungarian University of Agriculture and Life Sciences (MATE AKI HAKI) in Szarvas, Hungary, on 31 August and 1 September 2023. The conference was attended by 114 participants from 14 countries and represented a wide range of carp value chain stakeholders.

In Europe, the recognition of the importance of carp production and pond farming for food security and rural income generation has increased. However, this aquaculture sub-sector still faces several challenges. Its visibility and recognition are not in proportion to the environmental–, social– and economic values that pond farming creates and sustains. The motto of the conference was therefore *"Get the carp to its right place in aquaculture"*. The conference aimed to strengthen the "carp segment" within European aquaculture, improve the image of carp pond aquaculture as common European heritage, and to explore the opportunities for carp within "blue aquaculture". The conference also aimed to inform carp producers about the latest scientific findings and European policies.

The Sixth International Carp Conference approved the *"Szarvas Declaration"*, which was prepared to become the backbone of a strategy for the carp aquaculture sector development both on national and European level. The declaration recognizes the contribution of carp pond aquaculture to sustainable and healthy food production, its role in maintaining and protecting complex socio-economic and environmental values, and that carp farming is a unique segment within European aquaculture.

The Conference participants agreed that carp pond farming systems provide complex ecosystem services and contribute to enhance the biodiversity connected simplify wetlands. To increase carp production in Europe policy and decision makers are urged to simply administrative procedures, provide access to water and suitable locations for aquaculture, and arrange for compensation of damage caused to sustainable fish farming by cormorants and otters. Innovation is necessary for the sub-sector to maintain its economic viability and to attract youth to a career in aquaculture. Stronger collaboration between stakeholders along the carp value chain and between research and product is needed, as well as better communication on the role of carp aquaculture production at European level and globally.

CONTENTS

ABBREVIATIONS

EIFAAC	European Inland Fisheries and Aquaculture Advisory Commission
HUNATIP	Hungarian Aquaculture Technology and Innovation Platform
MA-HAL	Hungarian Aquaculture and Fisheries Inter-branch Organisation
MATE AKI HAKI	Research Center for Fisheries and Aquaculture of the Hungarian University of Agriculture and Life Sciences
NACEE	Network of Aquaculture Centres in Central and Eastern Europe

1. INTRODUCTION

Carps are the leading farmed fish species worldwide. Carp farming is a historically important component of the fisheries and aquaculture sector. Common carp aquaculture dates back thousands of years in Asia and Europe. Carp is a geographically widespread fish, which is cultured in 97 countries. The production carps, barbels and other cyprinids, accounts for a quarter of global aquaculture production with some 31 million tonnes annually and an off-farm value of more than USD 62 billion (FAO, 2022). Asia is the main region where carp is cultured, followed by central and eastern Europe.

In Europe, the recognition of the importance of carp production and pond farming for food security and rural income generation has increased. However, this aquaculture sub-sector still faces several challenges. Its visibility and recognition are not in proportion to the environmental, –social– and economic values that pond farming creates and sustains. The motto of the Sixth International Carp Conference was therefore "*Get the carp to its right place in aquaculture*".

The conference aimed to strengthen the "carp segment" within European aquaculture, improve the image of carp pond aquaculture as common European heritage, and to explore the opportunities for carp within "blue aquaculture". The conference also aimed to inform carp producers about the latest scientific findings and European policies.

The first International Carp Conference was organised in 2011 by the Polish Fish Producers' Association. Since then, its international organising committee decided to hold the event every two years. The subsequent international carp conferences were held in Poland (2013), Czechia (2015), Croatia (2017) and Germany (2019). The decision to organise the Sixth conference in Hungary was taken at the 2019 conference in Ansbach, Germany, but due to the COVID-19 pandemic, it was postponed until 2023.

The Sixth International Carp Conference was organized jointly by the Hungarian Aquaculture and Fisheries Inter-branch Organisation (MA-HAL) and the Research Center for Fisheries and Aquaculture of the Hungarian University of Agriculture and Life Sciences (MATE AKIHAKI) in Szarvas, Hungary on 31 August and 1 September 2023. It was attended by 114 stakeholders from 14 countries, including: fish farmers, farmers associations, feed industry, scientists, aquaculture managers, fish processors, non-governmental organizations and regional and international organizations. The conference agenda and list of participants can be found respectively in Annexes A and B.

References

FAO. 2022. *The state of world fisheries and aquaculture 2022. Towards blue transformation.* Rome, FAO. https://doi.org/10.4060/cc0461en

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2. SUMMARY OF THE CONFERENCE

2.1 Opening

The conference participants were welcomed by Prof. Dr. Csaba Gyuricza, Rector of the Hungarian University of Agriculture and Life Sciences (MATE), Mr. Gábor Csörgics, Head of Department of Aquaculture and Fisheries Management of the Hungarian Ministry of Agriculture, Dr. István Németh, President of the Hungarian Aquaculture and Fisheries Inter-Branch Organization (MA-HAL), and Dr. Béla Halasi-Kovács, director of the Research Center for Fisheries and Aquaculture of the Hungarian University of Agriculture and Life Sciences (MATE AKI HAKI).

2.2 Keynote presentations

Status and trends in the carp supply chain in Asia

Zaijie Dong[1,2,3]

1. Freshwater Fisheries Research Center, Chinese Academy of Fishery Sciences; Key Laboratory of Freshwater Fisheries and Germplasm Resources Utilization, Ministry of Agriculture and Rural Affairs, Wuxi, China

2. Chinese Modern Agroindustry Technology Research System, Wuxi, China

3. Jiangsu Genetics Society, Nanjing, China

Carps are the most cultured and important aquatic species around the world in terms of quantity and total value. They account for 25 percent of global aquaculture production and significantly contribute to fulfilling the demand for animal protein. Asia dominates in the global aquaculture production, contributing over 92 percent to the total output (FAO, 2022). China leads the way, representing about 90 percent of aquaculture production in Asia. Carp production was 27.58 million tonnes in 2020 in Asia, and 20.26 million tonnes in 2022 in China (BoF, 2023). Carp aquaculture in Asian countries exhibits a high level of diversity in cultured species and production types and has undergone a rapid evolution. Carp aquaculture is facing challenges in the supply chain in terms of seed supply, food fish supply and processing products supply, such as seed quality, culture costs, environmental challenges and limited economic benefits. For the sustainable development of the carp industry, the seed, culture, processing and marketing should be further promoted. The first successfully induced breeding of fish realized in Chinese major carps (1958–1961) was extended to other species which contribute to the seed supply of carp species. Genetic breeding projects to improve carp seed quality by traditional and modern breeding methods were carried out in some Asian countries. Multiple traits selection and genomic manipulation should be encouraged for the genetic improvement of carps (Dong, 2023; Dong *et al.,* 2015). Carp aquaculture should aim at ecological, green and profitable culture models through technical innovation. To resolve the low-price problem of carps in the market, value addition and promotion of carps needs to be considered through processing, products development and culture of higher value varieties.

References

FAO. 2022. *The state of world fisheries and aquaculture 2022. Towards blue transformation*. Rome, FAO. https://doi.org/10.4060/cc0461en.

Bureau of Fisheries, Ministry of Agriculture & Rural Affairs, National Fisheries Technology Extension Center, China Society of Fisheries. 2023. *China fishery statistical yearbook 2023*. Beijing: China Agriculture Press.

Dong Zaijie, L. M. 2023. Main methods, genetic analysis and prospect of common carp (*Cyprinus carpio*) breeding in China. *Journal of Fisheries of China*, 47(1): 019604. DOI: 10.11964/jfc.20221113785.

Dong Zaijie, N. N. H. & Zhu Wenbin. 2015. Genetic evaluation of a selective breeding program for common carp *Cyprinus carpio* conducted from 2004 to 2014. *BMC Genetics, 16*:94. DOI 10.1186/s12863-015-0256-2.

Carp culture in Europe: history and recent trends

Eugen Cătălin Platon
Romfish Fish Farmers' Association, Iaşi, 700224– Romania

The increased importance of aquaculture in the last decades as an important source of high-quality protein developed in the public discourse a misconception that this is a brand-new activity seeking societal recognition.

As aquaculture was not invented, nor revealed or imposed by a regulation, but was a result of a very long process of societal development, which addressed a genuine need for food security, it is very hard to determine when exactly the people decided to farm fish close to their home, instead of preserve fish caught. Whenever the demand for aquatic ("*seafood" in original*) food-eating peoples exceed the abilities of their indigenous aquatic ecosystems to provide for them, these cultures, throughout the world, developed aquaculture (Costa-Pierce, 2010). There is historical information on tilapia culture in Egypt, on carp culture in China, and Sergius Orata's oysters in Venetian lagoons.

In Europe, books like *Rerum rusticarum libri III* (On agriculture) by Marcus Terentius Varro (36 BC) describe in Chapter XVII freshwater and saltwater fish ponds and *De re Rustica* (On agriculture) by Lucius Junius Moderatus of Cadiz, known as Columella (cca 50 AD), including in Chapter VIII: De villaticis pastionibus: Aviarus et piscator (Animal farming: Birds and Fish) were used as handbooks centuries after they were written. One of the most characteristic species for European freshwater aquaculture was the Common carp. The transition from catch to farming was long.

Common carp was present in the wild in Eastern and Central Europe and around the Black Sea basin. Although the Roman culture favoured sea fish over freshwater fish, which was considered a poor meal, some texts written in the first millennia show that Common carp (Balon, 1995) was consumed also by high-end consumers, such as kings and nobles. Firstly, Cassiodorus (490–585), praetorian prefect of King Theodoric (454–526), wrote to the *canonicarius* (revenue officer) of Venice "A well-furnished royal table is a credit to the State. A private person may eat only the produce of his own district; but it is the glory of a King to collect at his table the delicacies of all lands. Let the Danube send us her carp […]." (Cassiodorus, 1886). A few centuries later Emperor Charles the Great (747–814), in one of his latest Codices (Charlemagne, 812) stated the following rules: "*21. Every steward is to keep fishponds on our estates where they have existed in the past, and if possible, he is to enlarge them. They are also to be established in places where they have not so far existed but where they are now practicable*" and "*65. That the fish from our fishponds shall be sold, and others put in their place, so that there is always a supply of fish; however, when we do not visit the estates, they are to be sold, and our stewards are to get a profit from them for our benefit*" and one of the species involved in this was Common carp (Pillay, 1967).

Why Common carp was chosen to support inland communities' needs for a regular protein source, for exquisite dishes or for the "fish days" throughout the religious calendar, is not hard to determine. Carp is a very adaptable, highly prolific, fast-growing and tasteful species suitable for the Central and Eastern European region. Roger North, an English lawyer published in 1714 *A Treatise on Fish and Fish-Ponds* (North, 1794) and confirmed Common carp "is the most valuable of all kinds of fish for stocking ponds, because of its quick growth and great increase".

Carp pond development is often attributed to the expansion of Christianity across Europe, as documents were found in monasteries, such as the 1115 description of carp ponds near Kladruby, in the Bohemian Třeboň basin. As a matter of fact, during the 13th to 16th centuries carp ponds developed mainly in Central and Eastern Europe, but expanded also in Western Europe and Northern Europe (Hoffmann, 1994), not only for supplying the monasteries, but also as a sign of welfare for local communities or families, as a complementary activity for watermills (Giurescu, 1964), and as leisure asset for upper classes. One essential step in carp farming was the establishment in 1353 of the Universitas Carolina, in Prague, by Carl the IVth Venceslaus, which upraised education in different subjects. As a result, Bohemian hydrotechnical construction specialists were famous and looked for. Some of these constructors, like Josef Štěpánek Netolický (1460–1539) and his follower, designed and built South Bohemians Třeboň ponds. Another important milestone in the development of carp culture was the publication of several important books such as *De piscinis et piscium qui in eis aluntur naturis libri quinque* (About ponds and fish husbandry) written by Janus Dubravius, bishop of Olomouc (Moravia) in 1559. Dubravius updated the old Roman knowledge, focusing mainly on carp, by enriching the text with practical information based on the experience of carp farmers, such as polyculture of species, feeding, alternate use of ponds for fish production and grazing. The second important book was *O sprawie, sypaniu, wymierzaniu i rybieniu stawów* (On the repair, grading, measuring and stocking of ponds) written by Olbrycht Strumienski, a Polish hydraulic engineer 1573, describing the techniques of building and managing fishponds in Moravia, Bohemia and Silesia (Guziur, 2005). It is worth mentioning that pond fish farming was well developed at that time, which is demonstrated by the number of ponds all over Europe, with carp as the main cultured species. Georg Reicherstorffer, a special envoy of King Ferdinand of Habsburg, king of Bohemia and Hungary at that time, at the Moldavian Court in 1528, in his book *Moldaviae quae olim Daciae pars* (Describing Moldova[1] which was a part of Dacia), Chorographia, Vienna, first edition 1541 revealed that "Moldova is so rich in ponds and lakes in a manner that one could not ask more from nature for the daily needs." (Holban, 1968). In the middle of the 15th century, in Bohemia and Moravia, there were 20 000 ponds on 75 000 hectares producing "intensively" 100 kg of fish per hectare. Four hundred years later, in 1868, Tomasz Dubisch, master fisherman at a complex of ponds of Iłownica re-introduced a forgotten carp breeding method using specialised ponds to raise the production of the ponds to 300 kg/ha. Archaeological studies performed in Transylvania, Moldova and Galicia (Eastern Europe) showed similarities in construction patterns in all three regions and also identified Neolithic settlements around the ponds (Roska, 1937).

Carp ponds became important not only for their nutritive and economic outcomes, but also because diversification in polyculture was possible in the 16th century: "The best fish in my opinion is Carpe, Breame, Tench, and Perch" (Taverner, 1600). Roger North highlighted also the Epicurean side of pond farming, such as leisure activities. In the same period a German economist Johannes Coler (1566–1639) wrote a comprehensive treaty (Hoffmann, 2010) describing, *inter alia*, a remedy for infertile agricultural soils: pond muck. Environmental pressures to carp pond farming, such as predators (Beike, 2014) or water quantity or quality shortages due to other activities, such as hemp, flax or linden washing (Giurescu, 1964) or building ponds above the stream's capacity of supplying the needed flow, were also present.

Between the late 18th and late 19th centuries, although the number of publications on carp farming increased, many ponds were abandoned and carp production was hindered, because of the following main causes: the culture of crops and other animals' husbandry were considered much more profitable, the industrial revolution replaced water power with steam power, controlled reproduction of trout, and the spreading of the misconception that the malaria spread was linked with carp ponds (Pellegrin, 1941).

After WWII fish farming and aquaculture showed a continuous development all around the world surpassing, by 2014, the capture fisheries production. According to FAO data (FAO, 2022), the main aquaculture production system globally, is raising finfish and other species in constructed earthen ponds, with Common carp being the fourth most cultivated finfish species (7.3 percent in 2020) and the whole group of carps accounting for over 47 percent of the total finfish production and more than 22 percent of the total aquaculture production.

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[1] At that time Moldova stretched from the Eastern Carpathians to the Dniester and the Black Sea.

Conclusions

1. Common carp farming is not an industry, but a part of the world's cultural heritage and an occupation enshrined in Europe's societal evolution.
2. The vast majority of carp farms that are included in Natura 2000 networks confirms that carp farming fits into environmental objectives.
3. Common carp farming is well documented in the European historical literature, but unfortunately very few carp farming books are translated into worldwide spoken languages.
4. Presently carp farming in Europe is stagnating and faces many challenges, which must be addressed.
5. Common carp farming is easily compatible with almost all the United Nations Sustainable Development Goals (SDGs), can contribute to all major European Union (EU) strategies and policies. This has to be documented and acknowledged.

References

Albin, E. & Essay. 1994. *The History of Esculent Fish, with plates, drawn and engraved on the Breeding of Fish and the Construction of Ponds*. London.

Balon, E. K. 1995. Origin and domestication of the wild carp, Cyprinus carpio: from Roman gourmets to the swimming flowers. *Aquaculture, 129* (1-4), 3-48. doi:10.1016/0044-8486(94)00227-F

Beike, M. 2014. *Phalacrocorax carbo sinensis in Europe–indigenous or introduced?* (P. Karell, ed.) Ornis Fennica, 48-56.

Charlemagne. 812. *Capitulare de villis vel/et curtis imperii/imperialibus est ordo territoriorum regalium auctoritate Caroli Magni et auctore Ansegis monachi Benedictini verisimiliter anno 812 Aquisgrani scriptus*. Aachen.

Costa-Pierce, B. A. 2010. Sustainable ecological aquaculture systems: the need for a new social contract for aquaculture development. *Marine Technology Soc. Jor.* (44(3)), 1-25.

FAO. 2022. *The State of World Fisheries and Aquaculture 2022. Towards Blue Transformation*. Rome. doi:https://doi.org/10.4060/cc0461en

Giurescu, C. 1964. *Istoria pescuitului si a pisciculturii în România* (The History of capture fisheries and fish farming in Romania) (Vol. 1). Bucuresti: Editura Academiei.

Guziur, J. 2005. History of Pond Fisheries in Poland. In J. Lehr (ed.), *Water Encyclopedia* (p. 956). New Jersey: John Wiley&Sons.

Hodgkin, T. & eds. 2006. *The Letters of Cassiodorus being a condensed translation of the variae epistolae of Magnus Aurelius Cassiodorus Senator.* (T. Hodgkin, ed., & T. Hodgkin, Trans.) London: Oxford University.

Hoffmann, R. 1994. Remains and verbal evidence of Carp (*Cyprinus carpio*) in Medieval Europa. In: W. van Neer (ed.). Fish exploitation in the past. In W. v. Neer (ed.), *Proceedings of the 7th Meeting of the ICAS Fish Remains Working Group*. 274, pp. 139-150. Tervuren: Ann. Mus. Royal l'Afrique Centrale, Sci. Zool.

Hoffmann, R. W. 2010. Making Land and Water Meet: The Cycling of Nutrients between Fields and Ponds in Pre-Modern Europe. *Agricultural History*, 84(3), 352-380. Retrieved from www.jstor.org/stable/i27868993

Holban, M. E. ed. 1968. *Calatori straini despre Tarile Române* (Foreign travelers about the Romanian historical regions) (Vol. 1). Bucuresti: Editura Stiintifica.

Pellegrin, J. 1941, Mars-Avril). La Pisciculture en étangs. *Revue de botanique appliquée et d'agriculture coloniale*, 21e année (235-236), pp. 81-92. doi:10.3406/jatba.1941.1622

Pillay, T. ed. 1967. Regional and country reports India. Latin America. Far East. Near East. Europe. Africa. N. America. *Proceedings of the FAO world symposium on warm- water pond fish culture*. 2, p. 174. Rome: FAO.

Taverner Gentleman, J. & Ponsonby, W. 1600. *Certain experiments concerning fish and fruit: practised*. London.

Carp in the global aquaculture scene

Béla Halasi-Kovács
MATE Research Center for Fisheries and Aquaculture (MATE AKI HAKI), Szarvas, Hungary

Freshwater finfish aquaculture dominates the global aquaculture production with a share of 85 percent. The low food chain, herbivorous and omnivorous fish species contribute to 67 percent to global aquaculture production (FAO, 2018). Cyprinid species add up to 48 percent of the global freshwater aquaculture production, of which Common carp is the third most abundant species with 4.2 million tonnes of production. At the same time, the share of Cyprinid production in the European Union (EU) aquaculture production is just 7 percent, while all together only 21 percent of the aquaculture production in this region comes from freshwaters (FAO, 2022). Moreover, the vast majority of aquaculture production in the EU consists of predatory fish species, positioned high on the trophic chain, which relies on fishmeal protein, mostly originating from marine fisheries.

While global aquaculture output has been growing at 6.5 percent per year, the EU aquaculture production is growing at just under 2 percent. Another fact is that the EU is only able to meet 15 percent of its own fish market needs, to which aquaculture production only contributes 7.5 percent. Eighty-five percent of fish and fisheries products imported in the EU are imported from third countries. This poses a major challenge from both a sustainability and food security point of view.

Two main families, Salmonids and Cyprinids dominate the freshwater aquaculture sector in the EU. Their production represents 83 percent of the EU freshwater aquaculture production. The rearing of these two species groups shows a remarkable regional distribution. Nowadays carp farming is mostly located in the Central Eastern European (CEE) region (EUMOFA, 2021). The traditional carp farming in fishponds is our common European heritage with a millennia-old history, strongly connected to the Christian religion, but also to local community development. Data shows that the volume of carp production dramatically decreased in western European countries with the loss of traditional pond aquaculture, while it has maintained its significance in most of the CEE countries (FAO, 2022).

Although carp production uses both intensive and extensive (semi-intensive) systems (Tacon, 2001, Woynarovich *et al.,* 2010) most carp farming is done in a traditional, extensive production system. It is based on natural nutrient cycle, typical of natural wetland ecosystems. It operates as an open ecological system, where natural and technological processes support each other (AAC, 2021). Thanks to the extensive and seasonal production method, pond aquaculture has high economic resilience, proven by the production data during the COVID-19 pandemic period (AKI 2020, 2021, 2022). The species –Common carp, Chinese carps, and small Cyprinid species– produced in this system are low food chain species, so production is independent of fish meal availability. The low energy demand and the short food supply chain also contributes to low operational expenditures (OPEX) of pond aquaculture, increasing the economic resilience of the sector. The EU pond aquaculture sector produces yearly 80 000 tonnes of carp –that is 26 percent of the total EU freshwater aquaculture production– in volume and 260 million euros in value (EUMOFA, 2021). Pond aquaculture operates in rural areas and provides jobs to 13 000 people in these often less developed areas.

Beyond the direct economic values, the traditional pond aquaculture has diverse and complex environmental benefits. Maybe the most important value of pond aquaculture is that it maintains 250 000 ha of man-made wetlands in the EU. Pond farms highly contribute to preserving biodiversity maintaining the populations of more than 400 bird species –most of them with NATURA 2000 importance– a substantial part of the otter population in Europe, and numerous wetland related plant and animal species with European significance (FDFS, 2020). Pond farming requires low levels of inputs and is strongly integrated into the natural environment resulting in low impact on the environment (Koushik *et al*., 2020). Ponds are also contributing to climate resilience through carbon sequestration, and retention of water (Knösche *et al.,* 2004). Pond farming assists in better water management. Pond aquaculture provides for a complex web of ecosystem services connected to human food production systems (Willot *et al*., 2019; Palásti *et al.,* 2020) (Table 1).

Research demonstrates that the role of freshwater aquaculture in the future must be further increased to ensure a sustainable and healthy supply of fish products. Despite the increasing scientific evidence on its complex social, economic and environmental benefits, as well as increasing international recognition of carp production in Europe, the sector still faces many challenges both from economic and environmental points of view (Table 2).

TABLE 1
The main regulating, maintaining and provisioning, cultural ecosystem services of fishponds

Regulating and maintaining services of fishponds	Provisioning and cultural services of fishponds
CO_2 absorption/Global climate regulation	Reed production
Microclimate regulation	Livestock and crop production near the ponds (e.g.) utilization of dams and other open areas)
Air quality regulation	Recreational opportunities/Ecotourism
Water quality regulation	Aesthetics
Water storage	Environmental education
Excess water retention	Cultural heritage/Source of inspiration
Groundwater recharge	Opportunity for research

Source: Palásti *et al*., 2020. *Expert Knowledge and Perceptions about the Ecosystem Services and Natural Values of Hungarian Fishpond Systems.* Water, 12. 2144.

TABLE 2
Values and challenges of European Union (EU) pond aquaculture

	Values of carp aquaculture	Challenges of carp pond aquaculture
Socio-economic aspects	• 80 000 tonnes of carp production in the EU per year. • 260 million € production value. • 13 000 employees in rural areas. • Low food chain species production. • Production independent from fish meal. • Short food supply chain. • High economic resilience due to the extensive and seasonal production methods.	• High labour intensity. • Low productivity, seasonal and uncertain product supply. • Low levels of processing and a weak supply chain. • Significant land requirements. • High investment costs. • Low profitability.
Environmental aspects	• Pond aquaculture maintains 250 000 ha of man-made wetlands in the EU. • Contributes to preserve biodiversity. • More than 400 bird species, most of them with NATURA 2000 importance are found in pond systems. • A substantial part of the otter population in Europe is benefiting from ponds. • Numerous wetland related plant and animal species with European significance are found near ponds. • Retention of water. • Carbon sequestration. • Retention of soluble and floating compartments of supply water. • Complex ecosystem services.	• Impact of wildlife predation on production. • Decreasing renewable water resources. • Decrease of predictability of water regime. • Declining water quality. • Increasing algae blooms in water. • Emerging new pathogens. • Decrease of non-specific immune status. • Emerging and spread of new invasive competitor species.
Policy aspects	• A remarkable part of fishponds belongs to nature protected areas (national parks, NATURA 2000 areas) and contribute to their nature conservational values. • Fishponds contribute to the better water management.	• No support provided for creation and maintenance of complex natural-environmental values of constructed wetlands (fishponds). • Lack of a coordinated Great cormorant management plan on a European scale. • Unnecessary administrative burden for aquaculture development, due to over regulation. • Low value of EU contributions to research, development and innovation (RDI) on freshwater aquaculture development.

Source: Author's own elaboration.

Recently more and more scientific information has become available on the positive interaction between finfish aquaculture and the environment, as well as on its role in climate change mitigation. However, the EU's support to freshwater aquaculture is limited (EC, 2022). It is also regrettable that the Commission focuses exclusively on the development of algae aquaculture and does not take into account traditional low trophic finfish aquaculture in pond aquaculture. It is important to learn lessons from traditional pond aquaculture for the development of circular bio-based farming. Lower trophic freshwater aquaculture should be an important component of a freshwater blue bioeconomy, not only as an efficient and sustainable biomass-producing sector, but also for its potential to minimize waste and its ecosystem services.

Therefore, more emphasis should be put on the development of freshwater aquaculture in the EU. This could be achieved through focused research and innovation into sustainable, competitive and resilient production, and implementing a consistent policy in support of the blue bioeconomy. However, currently neither the research policy and in the aquaculture strategic guidelines nor the European aquaculture support schemes give much attention to this sub-sector. The main directions for research and innovation in freshwater aquaculture can be summarized as follows:

1. Development of new systems, focusing on freshwater low trophic species, such as microalgae, plants, molluscs, crustaceans, herbivorous and omnivorous fish species.
2. Sustainable intensification of pond aquaculture through the introduction of different combined intensive-extensive systems.
3. Lessons learnt from traditional pond aquaculture for the development of circular biobased farming.
4. Enhance a circular approach both in the aquaculture sector and with other freshwater related sectors.
5. Elaboration of a framework for organic aquaculture production in ponds, development of guidelines and legislation, taking into account the Farm to Fork (F2F) Strategy recommendation for a significant increase in organic aquaculture production.
6. Knowledge and technology transfer strengthening and cooperation among producers, their associations and scientists, to improve the international representation of the sector, in order to get the specific values of freshwater pond fish culture better acknowledged and considered as an essential part of development programmes in Europe and worldwide.

References

AKI. 2020. *Harvesting report. Statistical reports: XXV.* vol., AKI. Budapest (in Hungarian)

AKI. 2021. *Harvesting report. Statistical reports: XXVI.* vol., AKI. Budapest (in Hungarian)

AKI. 2022. *Harvesting report. Statistical reports: XXVII*. vol., AKI. Budapest (in Hungarian)

AAC. 2021. The provision of ecosystem services by European aquaculture.

EUMOFA. 2021. *Freshwater aquaculture in the EU*.

European Commission DG RTD. 2022. Portfolio Analysis Horizon 2020 Aquaculture Projects. *Expert report*.

FAO. 2018. *Fishstat, 2018*.

FAO. 2022. *The State of World Fisheries and Aquaculture 2022. Towards Blue Transformation.* Rome, FAO. https://doi.org/10.4060/cc0461en.

Foundation for Development of Fisheries Sciences, (FDFS), NAIK Research Institute for Fisheries and Aquaculture (eds). 2020. Role of freshwater pond aquaculture in the maintenance of natural values of wetland habitats. *Szarvas*. Pp.21.

Knösche, R., Schreckenbach, K., Pfeifer, M. & Weissenbach, H. 2004. Balances of phosphorus and nitrogen in carp ponds. *Fisheries Management and Ecology*.
https://doi.org/10.1046/j.1365-2400.2000.00198.x.

Koushik R, Vrba J, Koushik S and Mraz J. 2020. Nutrient footprint and ecosystem services of carp production in European fishponds in contrast to EU crop and livestock sectors *Journal of Cleaner Production 270 (2020) 122268*. DOI:10.1016/j.jclepro.2020.122268.

Palásti, P., Kiss, M., Gulyás, Á. & Kerepeczki, É. 2020. *Expert Knowledge and Perceptions about the Ecosystem Services and Natural Values of Hungarian Fishpond Systems.* Water, 12. 2144.

Tacon, A.G.J. 2001. Increasing the contribution of aquaculture for food security and poverty alleviation, pp.67-77. *In:* R.P. Subasinghe, P. Bueno, M.J. Phillips, C. Hough & S.E. McGladdery (eds.) Aquaculture in the Third Millennium*. Technical Proceedings of the Conference on Aquaculture in the Third Millennium*, Bangkok, Thailand, 20-25 February 2000

Willot, P.A., Aubin, J., Salles, J-M., Wilfart, A. 2019. *Ecosystem service framework and typology for an ecosystem approach to aquaculture.* Aquaculture, Elsevier, 2019, 512, pp.734260. ff10.1016/j.aquaculture.2019.734260ff. ffhalshs-02172389f.

Woynarovich, A., Moth-Poulsen, T., Péteri, A. 2010. *Carp polyculture in Central and Eastern Europe, the Caucasus and Central Asia.* FAO Fisheries and Aquaculture Technical Paper. No. 554.

The role of EIFAAC in European carp aquaculture

Ana Gavrilović[1] and Raymon VanAnrooy[2]
[1]University of Zagreb, Faculty of Agriculture, Department of Fisheries, Apiculture, Wildlife Management and Special Zoology, Svetošimunska 25, 10000 Zagreb, Croatia,
[2]EIFAAC Secretary, Fisheries and Aquaculture Division (NFI), Food and Agriculture Organization of the United Nations (FAO), Viale delle Terme di Caracalla, 00153 Rome, Italy

The mission of the European Inland Fisheries and Aquaculture Advisory Commission (EIFAAC) is to promote long-term sustainable development, utilization, conservation, restoration and responsible management of European inland fisheries and aquaculture, consistent with the objectives and principles of the FAO Code of Conduct for Responsible Fisheries and with other relevant international instruments, and to support sustainable economic, social, and recreational activities towards these goals through: (1) providing advices, scientific information and regional coordination; (2) encouraging enhanced stakeholder participation and communication; and (3) delivering of effective research.

EIFAAC was established as an advisory regional fishery body (RFB) in 1957 by the FAO Council under Article VI-1 of the FAO Constitution. Its initial name was the European Inland Fisheries Advisory Commission (EIFAAC). In 2008 the Twenty Fifth Session of EIFAC, held in Antalya, Türkiye, proposed to change the name of EIFAC, introducing aquaculture in order to recognize its importance to the countries in Europe and to properly reflect the activities of EIFAC. This proposal was accepted by Council of FAO in its 140th Session in 2010, adopted by Resolution 3/140, which approved the name change and revised Statutes of the Commission. Inland aquaculture, including breeding of Common carp as the main species of the fish pond culture in Europe, was specifically emphasized by EIFAAC.

EIFAAC has been coordinating and carrying out research, and preparing guidelines, best-practices, policy recommendations and manuals on inland fisheries and aquaculture subjects as a support to its members. All these activities are contributing to the implementation of the UN Sustainable Development Goals and European Union (EU) Policies, Strategies and Directives that include: EU Common Fisheries Policy, Farm to Fork strategy, Blue economy approach, EU Biodiversity Strategy for 2030, EU Aquaculture Guidelines 2021–2030, DG Mare Strategic Plan 2020–2024, and EU Directives (Habitats, Water framework and Birds).

The technical and scientific work of EIFAAC is undertaken through projects and working groups composed of specialists from members (today 37 European countries and EU DG Mare). EIFAAC also provides technical advice on request, and links those who seek technical expertise with those who can provide it. One example of activities directly related to Common carp farming is FAOs publication „Better Management Practices for Carp Production in Central and Eastern Europe, Caucasus and Central Asia“ (Woynarovich *et al.,* 2011). This publication describes and explains the key biological, technical, economic, social and environmental aspects of BMPs for carp production. It also provides BMPs for advanced fry and grow-out production of carps in general, and of Common carp in particular. Another publication, related to all fish species, including Common carp, was „Welfare of Fishes in Aquaculture" (Segner *et al*., 2019).

Ongoing EIFAAC projects of relevance to carp aquaculture are: Developing Advice on Sustainable Management Actions on Cormorant Populations"; Management and Threat of Aquatic Invasive Species in Europe (FINS)"; The problems and challenges of climate change and its impact on inland aquatic resources and fisheries of Europe" and Fish stocking guidelines, including general principles, best practices, economic aspects, interaction with natural stocks and safeguarding biodiversity".

EIFAAC regards the International Carp Conferences important for sharing scientific and practical information. In view of the large number of members and their diversity in aquaculture production systems, it is of interest to EIFAAC carry out a comprehensive review of current carp production, technologies and management throughout Europe. Such a review will facilitate knowledge and information sharing on aquaculture innovations (Franěk *et al.,* 2019; Gavrilovic *et al*., 2019; 2022), address information needs of policy and decision makers, support small-scale producers in the uptake on new technologies, and contribute to increasing sustainable and climate resilient aquaculture production.

References

Franěk, R., Marinović, Z., Lujić, J., Urbányi, B., Fučíková, M., Kašpar, V., Pšenička, M. & Horváth, A. 2019. Cryopreservation and transplantation of common carp spermatogonia. *PLoS One. 2019*; 14(4): e020548. doi: 10.1371/journal.pone.0205481

Gavrilović, A. & Jug-Dujaković, J. 2022. Different ways of introducing a closed recirculation system in aquaculture production. *EIFAAC Symposium 2022, Inland Fisheries and Aquaculture–Advances in Technology, Stock Assessment and Citizen Science in an Era of Climate Change, 20th and 21st June 2022,* Killarney, Ireland, 68-69.

Gavrilović, A., Piria, M. & Jug Dujaković, J. 2019. Possible Technological Improvements of European Carp Production. *European Inland Fisheries and Aquaculture Advisory Commission (EIFAAC) conference, book of abstract, 8–11 September 2019*, Dresden, Germany, 38.

Segner, H., Reiser, S., Ruane, N., Rösch, R., Steinhagen, D. & Vehanen, T. 2019. *Welfare of fishes in aquaculture*. FAO Fisheries and Aquaculture Circular No. C1189. Budapest, FAO. https://openknowledge.fao.org/handle/20.500.14283/ca5621en

Woynárovich, A., Bueno, P.B., Altan, Ö., Jeney, Zs., Reantaso, M., Xinhua, Y. & Van Anrooy, R. 2011. *Better Management Practices for Carp Production in Central and Eastern Europe, the Caucasus and Central Asia.* FAO Fisheries and Aquaculture Technical Paper. No 566. Ankara, FAO. 153 pp. https://openknowledge.fao.org/handle/20.500.14283/i2409e

The aspects of sustainable extensive pond aquaculture from a farm manager's point of view

Nándor Puskás[1] and Béla Halasi-Kovács[2]
[1]*Biharugra Fish Farm, Biharugra, Hungary*
[2]*MATE Research Center for Fisheries and Aquaculture (MATE AKI HAKI), Szarvas, Hungary*

The origin of traditional pond aquaculture goes back thousands of years (Francis, 1863; Herman, 1887; Jakab *et al*., 2018). The main technological elements were worked out at the end of the XIX century, and did not change fundamentally since then (Herman, 1888; Antalfi and Tölg, 1971). Pond aquaculture is based on the natural nutrient cycle typical of natural wetland ecosystems. It operates as an open ecological system, where natural and technological processes support each other (AAC, 2021). Thanks to the nature-based production system, pond aquaculture provides one of the most complex and rich ecosystem services and additional social- and environmental benefits beyond its economic values (Halasi-Kovács, 2022). Based on scientific evidence this traditional farming system can be considered as a sustainable way of food production.

The concept of sustainability is being used increasingly in relation to the assessment of different kinds of management and farming activities, despite that in many cases the concept is not well defined and parameterized yet. In most cases, sustainability is approached only from a narrow environmental perspective, whereas it should be understood in a sector-specific way.

The European Union (EU) taxonomy regulation is a cornerstone of the EU's sustainable finance framework and an important market transparency tool. It helps direct investments to the economic activities most needed for the transition, in line with the European Green Deal objectives (EU, 2023). This is also important in order to determine the priority and structure of the development of subsidies related criteria; this should avoid the current lobbying-based priority system for subsidies. Although aquaculture is not the part of the Taxonomy regulation, a sustainability criteria system was developed in 2022, which can become a good basis for the future enhanced framework. The suggested criteria for sustainable aquaculture are based on three sustainability pillars: environmental, economic and social (Plesner *et al*., 2022). The Hungarian pond aquaculture should be also evaluated based on the above three pillars.

Environmental sustainability of aquaculture production in fishponds can be analysed through ecosystem service studies –more precisely their regulation and maintenance service– which connect both water management, nature conservational and environmental aspects. Since the change of the Hungarian regime in 1990, pond aquaculture has played a major role in agricultural water use with a share of 70–75 percent. Today, in Hungary, the use of water in fishponds accounts for ca. 400 million m^3, while the amount of water used for irrigation is only 120 million m^3. A question has arisen: is pond aquaculture a water-wasting or water-saving industry? Research on ecosystem services of pond aquaculture show that fishpond management provides important regulation and maintenance services connecting to water management, such as the hydrological cycle and water flow maintenance, excess water retention, flood and storm protection, and ground water control. Fish ponds also play an important role in buffering and attenuation of mass flows, nutrient retention (Willot *et al.,* 2019; Palásti *et al*., 2020). Fishponds contribute to rational and sustainable water management practices in the areas affected by the negative consequences of climate change. Fishponds have become a priority for water management and their importance will continue to grow in the future.

Nature conservation benefits provided by Hungarian pond aquaculture are also well documented (Halasi-Kovács, 2008; Halasi-Kovács *et al*., 2012; Kerepeczki *et al.,* 2011; Palásti *et al*., 2020). Thanks to the pond farming system a special fishpond ecosystem is created. Although it is an artificial system, its nutrient cycle process is identical to natural semi static wetlands. One of the main characteristics of the fishpond ecosystem is the artificially increased nutrient level. The increased nutrient input increases the population sizes of all elements of this system. Fishponds in Hungary contribute to maintaining a diverse and valuable wildlife connected to wetland areas. The existing natural values of the fishpond ecosystem are strongly connected to the farm operation; without appropriate farming these areas have no nature conservational values. Fishponds in Hungary have crucial importance in the maintenance of wetland habitats and their biodiversity. Fish farmers and conservationists have the same interest: the long-term conservation of fishponds.

From an environmental point of view the Hungarian fishpond farm technology can be considered a particularly environmentally friendly system. Compared to other agricultural sectors, pond aquaculture has a low environmental footprint (Koushik *et al*., 2020).

The extensive pond aquaculture production systems are based on natural nutrient cycles typical of natural ecosystems; these operate as an open ecological system, where natural and technological processes are built on each other inseparably; the managerial interventions only enhance the natural processes to increase the productivity of target species. The main inputs are the soil of the pond bed, sunlight, surface water, supplementary feed (cereals) up to 50 percent of the gross yield, organic farm manure and labour (Figure 1–2).

Thanks to its extensive production, Hungarian pond aquaculture is a unique segment of European aquaculture, which can be described with low input costs for energy, feed, and transport of inputs. Hungarian pond aquaculture has a not very well developed, but short supply chain. An interesting feature of this extensive farm system is that instead of a profit maximizing strategy it follows a cost minimizing strategy without significant economies scale (Gyalog, 2018). Pond aquaculture is an economically efficient and forward-looking way of farming. The resilience of pond aquaculture during the COVID-19 pandemic and the energy crisis can be explained as follows. Due to the extensive, seasonal and outdoor production, the local inputs, independence of imports, low energy costs, simple output structure and logistics, as well as a short supply chain, pond aquaculture has an embedded great resilience against crises.

Looking at the sustainability from a social impact point of view, pond aquaculture has a vital role in the maintenance and development of rural life and the economy. Pond farming is undoubtedly a labour-intensive system making the sector an important employer in rural areas and giving opportunities to the youth. Since pond farming is a traditional way of production, fish farms are natural centres for the preservation of cultural heritage.

Figure 1. Structure of operational expenditures in Hungarian pond aquaculture

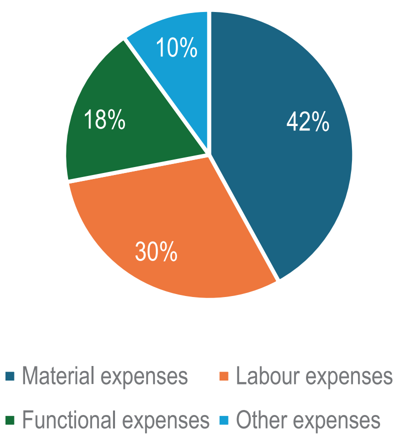
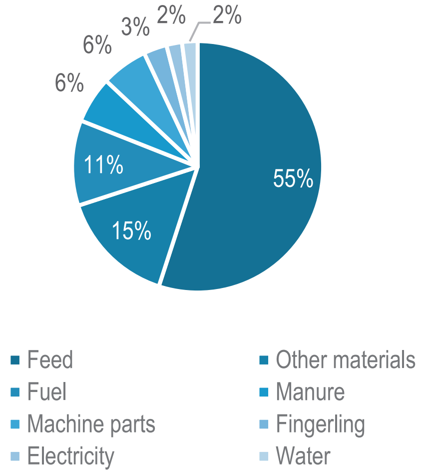


Figure 2. Percentages of item costs categorized under material costs in Hungarian pond aquaculture



Source: Author's own elaboration.

The Hungarian pond aquaculture sector faces various challenges and risks, which threaten the sustainability of the sector. The challenges and the possible responses, tasks and strategies can be listed as follows:

TABLE 1
Challenges to Hungarian pond farming and possible responses

Challenges	Responses
• Increasing extreme agrometeorological events (water scarcity, flood damage, high water temperature, low oxygen etc.). • Increasing bird predation. • Lack of organic farm manure. • Increasing energy price. • Increasing feed price. • Inadequate and too complicated subsidy systems. • Inadequate and unfeasible rules and directives. • Adverse change in the water supply management system. • Market problems and disturbances. • Lack of human resources.	• Water reservation, water infrastructure development. • A well-functioning and incentive subsidy system. • Development in renewable energy sources, improving energy efficiency. • Introduction of smart nutrient management for more efficient use of nutrients. • Development in feed technology. • Own feed production area, infrastructure development of reservoir. • Technical innovation – state-of-the-art technology. • Introduction of intensive fingerling rearing in ponds. • Dissemination of good pond management practices, • Have pond farming accepted by the European Commission as organic farming. • Provide subsidies proportional to the maintenance of agro-ecological values of fishponds. • Elimination of discriminatory measures connected to subsidies. • "Building a bridge" between aquaculture and rural development, especially in subsidy system. • Maintain the current water supply management system. • Product diversification to benefit from more competitive prices. • Better human resource management. • Knowledge dissemination, especially to the youth.

Source: Author's own elaboration.

Extensive pond aquaculture in Hungary is sustainable from environmental, economic and social points of view, and therefore worthy of support. Carp is the key to preserving the complex set of values created by our fish production, so it should be regarded as the fish of the future in terms of sustainability. However, meeting the challenges carp pond aquaculture faces in a fast-changing world requires effective solutions and rational responses.

References

Antalfi, A. & Tölg, I. 1971. Halgazdasági ABC. *Mezőgazdasági Kiadó.* Budapest. 218p.

European Union. 2023. *EU taxonomy for sustainable activities*. [online] https://finance.ec.europa.eu/sustainable-finance/tools-and-standards/eu-taxonomy-sustainable-activities_en (accessed 26 May 2024)

Francis, F. 1863. Fish-Culture: *A Practical Guide to the Modern System of Breeding and Rearing Fish*. London. Routledge, Warne, and Routledge.18+267pp.

Gyalog, G. 2019. *A hazai halastavi termelés modell alapú vizsgálata.* PhD Thesis. Kaposvári Egyetem Gazdaságtudományi Kar Módszertani Intézet. 144pp. DOI: 10.17166/KE2019.007.

Halasi-Kovács, B. 2008. *Conservational significance of the Hortobagy Fishfarm, the natural values of the fishponds*. Manuscript. Pp. 1-20. (in Hungarian)

Halasi-Kovács, B. 2022. *Role of freshwater pond aquaculture in maintaining the natural values of wetland habitats*. HFA – MATE-HAKI. 28pp.

Halasi-Kovács, B., Puskás, N. & Szűcs, I. 2012. The characteristics of the Hungarian pond aquaculture, its complex ecological and socio-economic importance, and evaluation of the threatening factors of the sustainable aquaculture production. *Fisheries development,* 34: 78-95. (in Hungarian)

Herman, O. 1887. *A magyar halászat könyve I-II.* Királyi Magyar Természettudományi Társulat. Budapest. 860pp.

Herman, O. 1888. *A Halgazdaság rövid foglalatja.* Királyi Magyar Természettudományi Társulat. Budapest. 200pp.

Jakab, G., Sümegi, P. & Benkő, E. 2018. Tógazdálkodás emlékei a középkori Magyarországon. *In Alkalmazkodó vízgazdálkodás: lehetőségek és kockázatok. Víztudományi Nemzetközi Konferencia Proceedings.* Pp. 71-76. ISBN 978-963-269-736-9.

Kerepeczki, É., Gyalog, G., Halasi-Kovács, B., Gál, D. & Pekár, F. 2011. Extenzív halastavak ökológiai értékei és funkciói. *Halászatfejlesztés, 33*: 47–54.

Koushik R, Vrba J, Koushik S and Mraz J. 2020. Nutrient footprint and ecosystem services of carp production in European fishponds in contrast to EU crop and livestock sectors *Journal of Cleaner Production 270 (2020) 122268*. DOI:10.1016/j.jclepro.2020.122268.

Palásti, P., Kiss, M., Gulyás, Á. & Kerepeczki, É. 2020. Expert Knowledge and Perceptions about the Ecosystem Services and Natural Values of Hungarian Fishpond Systems. *Water, 12*. 2144.

Plesner, L.J., Beckett, R., Fransen, M., Homme, T.E., Martins, C., Maynard, L., Mihalffy, Sz., Šimunović, I. & Stenwig, H. 2022. *Technical Screening Criteria for sustainable finfish aquaculture: input to the EU marketing standards, towards a sustainable food system and the EU taxonomy. Federation of European Aquaculture Producers*. Manuscript. 20pp.

Willot, P.-A., J. Aubin, J.-M., Salles & Wilfart, A. 2019. Ecosystem service framework and typology for an ecosystem approach to aquaculture. *Aquacultures 512*, 734260. https://doi.org/10.1016/j.aquaculture.2019.734260.

2.3 Thematic sessions

This section provides a summary of the thematic sessions, in which the participants discussed about a range of topics.

Session I: Strengthening the role of Europe in global carp aquaculture

Common carp is one of the most important freshwater fish species in the world, which provides animal protein and employment in rural areas for millions of people, mainly in developing countries and especially in Asia. Common carp is also an important game fish in recreational– and sports fisheries in many countries where this species is not a popular food fish. Outside of Asia, Central and Eastern Europe is the region where carp species, mainly Common carp play an important role in aquaculture production. Common carp is considered as European heritage, and its consumption is linked to Christian religion. Common carp is one of the most researched freshwater fish species in the world and a wide range of rearing technologies and systems have been developed and applied worldwide. Even if the volume of European Common carp production is a fraction of the global production, valuable knowledge and experience have been generated on breeding and rearing of Common carp. It should be noted however, that research on environmental interactions (e.g. value of ecosystem services, carbon footprint, mitigation of the effect of climate change) should be strengthened.

Europe has valuable resources to remain a major carp producing region. Communication within the sector and with other food systems is one of the basic conditions for the sustainable utilization of resources, especially water and land resources. Collaboration and communication have a crucial role to play in pond fish culture since carp production systems –unlike other aquaculture systems– have a close and essential interaction with nature. It is increasingly recognized that without effective communication between stakeholders (producers, processors, traders, academia, government) along the value chain, and constructive dialogue with representatives of other food systems, the society and NGOs, the long-term viability of the European carp sector may become questionable. European aquaculture associations and organisations (e.g. FEAP, EATiP, NACEE) are important facilitators of communication within the sector and also for collaboration with international organisations (e.g. EU, FAO). Efficient communication is a good basis for target-oriented and mutually beneficial cooperation between stakeholders that can contribute to the strengthening of the European carp production sector.

Even if the traditional character and local supply is still dominant in most of the carp production systems all over the world and carp plays an insignificant role in the international trade of aquaculture products, this situation may change in the future. This is indicated by export of processed carp to Europe from other regions. There is a need for communication and cooperation at the European level.

One of the roles of Europe in strengthening carp aquaculture on a global level is knowledge and technology transfer through inter-regional collaboration, focusing on the following areas:

1. efficient use of freshwater resources mainly through sustainable intensification;
2. transition to a circular economy;
3. protection and restoration of biodiversity and ecosystems; and
4. climate change mitigation and adaptation.

The usefulness of European assistance to Common carp aquaculture development programes has been demonstrated by various successful projects in which training, expert consultancy and genetic materials were supplied. There have been several bilateral institutional collaborations and business initiatives between Eastern European countries (mainly Hungary) with China, Lao PDR and Vietnam. Strengthening the role of Europe in global carp aquaculture would contribute to the improvement of livelihoods and food security for millions of people in developing countries in the spirit of fulfilling the UN Sustainable Development Goals.

Session II: Environmental benefits provided by pond aquaculture; pond aquaculture as European heritage, discussion on possibilities to aware of traditional pond aquaculture (GIAHS, Intangible Cultural Heritage)

There are clear historic evidences that pond aquaculture of indigenous Common carp is a traditional activity in rural regions of Europe, closely linked to the European history and Christian religion. Among the food-producing sectors, pond fish production is the one that has best preserved its traditional character. Pond fish production naturally includes elements that are important for sustainable food production, such as the bio-based economy and circular economy. Pond fish production contributes to achieve several goals of European Green Deal and the targets of the EU Farm to Fork strategy and the EU Biodiversity strategy. In addition to contributing to healthy food supply and rural livelihood, traditional pond aquaculture provides for complex environmental services.

From an ecological point of view, fishponds rely on the natural conditions of wetland habitats. Their management aims to strengthen these processes artificially for the purpose of increasing production. Fishponds operate as open ecological systems where natural and technological processes are in synergy and cannot be separated. This also means that fishpond production is relying on the reuse of natural resources through nutrient cycling in identical ways as in natural wetlands. Fishpond ecosystems are comparable to natural aquatic ecosystems in complexity.

The fish pond production technology maintains about 250 000 ha of nature-like wetlands in the European Union (EU). The high value of fishponds is demonstrated by the fact that the proportion of NATURA 2000 sites with fishponds are higher than areas under agricultural cultivation. Furthermore, fish farming ponds have been highlighted multiple times as regional biodiversity hotspots, providing nesting, feeding and resting habitats for some of the endangered species related to wetlands. More than 400 bird species are connected these wetland habitats, which have NATURA 2000 importance. Fishponds also provide remarkable habitats for other vertebrate and invertebrate animal species, as well as plant species with high nature conservational importance.

The wildlife predation on fish in fishponds influences the outcome of production and the income of fish farmers. Birds are the most abundant group predating on fish in fishponds, which, therefore, have the biggest influence. The impact of predation by bird species is not constant. It is determined by their number, the duration of their stay in the ponds, the amount of fish and feed they consume, and the species and size of the fish they consume. The economic impact caused by fish-eating birds is multiple. The first is the direct effect of their fish consumption, while the second is the loss of yield resulting from it. Among the species that have direct economic influence, the damage caused by the Great cormorant and Pygmy cormorant is high. In recent years, also the populations of the Eurasian otter *(Lutra lutra)* and other vertebrates living around fishponds have been gradually increasing. The economic damage caused by the otter is becoming significant. In addition to direct losses, the indirect impact of predators on the protected natural values provided by fishponds is also significant. No method exists for estimating the economic impact of indirect damage, such as disease spread due to predator injured fish that are prone to infections. Nature conservation restrictions (e.g. restrictions on filling, drainage or harvesting, spatial and temporal restrictions on technology) that cause additional costs or loss of income during production have an economic impact on farmers' incomes.

As a result of the water regulations, which were introduced in the second half of the 19th century, the extent of wetlands has significantly decreased. Fishponds have multiple roles in water management. These roles are based on their ability to retain and regulate surface waters. However, in addition to the quantitative aspects, several characteristics of fishpond systems need attention. One is that the nature of fishpond water use is fundamentally different from other industrial water uses, including agricultural water usage. The most important feature is that the pond aquaculture technology is based on renewing natural resources. It does not deplete natural resources, only utilizes them, especially surface water, while the quality of some parameters is improved as a result of the technology. On the other hand, pond aquaculture can be well integrated into the sustainable water management practices.

Fishponds can play a significant role in optimizing environmental conditions and reducing the negative effects of extreme climatic events (e.g. drought, rapid temperature fluctuations, etc.). The benefits of these processes can be identified as “Regulating and maintaining services”, which is the most diverse group of “ecosystem services”. Both natural and semi-natural wetlands are particularly important for carbon sequestration. Fishponds also provide a wide range of other services, such as water provisioning, management and purification, and flood defence, besides offering value for recreational and tourism purposes. In the case of cultural ecosystem services, they can provide aesthetics, cultural heritage and inspirational sources, opportunities for scientific research, opportunities for environmental education, and recreation.

These values of pond fish production are increasingly recognized; however, the costs of ecosystem services are still largely borne by fish farmers. Further efforts are needed to fully recognize the ecosystem services of fishponds, which should include potential financial support for maintaining these services.

The full recognition of specific values of freshwater fishponds could be helped if pond carp production was added to the official lists of recognized traditional values. The organisers of the Sixth International Carp Conference received interesting and encouraging information from colleagues in Austria and Germany on initiatives to recognize the value of traditional carp pond culture by various international schemes such as the FAO Globally Important Agriculture Heritage Systems (GIAHS) or the UNESCO Intangible Cultural Heritage (ICH). These opportunities are worth to be discussed as possible useful measures to get a better recognition of the specific values of European pond aquaculture.

Besides better recognition of pond carp culture by proposing traditional pond carp farming for international lists (e.g. GIAHS), further efforts are also needed to generate scientific evidence of the environmental benefits of pond aquaculture. Valuable initial studies have been carried out and published. However, further efforts are needed to quantify the value of various non-productive services of fishponds. Joint work with international teams (also from other regions of the world where pond aquaculture is important) and experts from other sectors (e.g. forestry) would be beneficial to collect, analyse and present convincing data on the value of the environmental benefits provided by pond aquaculture.

Session III: Development of carp rearing systems and technologies through innovation along its value chain

Carp-based Pond aquaculture is often considered as a declining segment of European aquaculture that faces competitiveness challenges. Emerging social, market and environmental stressors provide a strong stimulus for farmers and post-harvest stakeholders to innovate. Most important challenges to current carp farming practiced in large extensive pond areas include lack of workforce; emerging threats associated with climate change (e.g., increasing frequency of water stress periods and disease occurrence); fish predation by wildlife; and altering consumer preferences in traditional carp markets.

The existing carp production infrastructure and the associated wetland ecosystem functions need to be considered when sectoral visions are formulated and principles of innovations are laid down. In the European Union (EU) ponds used for carp farming cover an area of 360 000 ha. Many ponds are located in protected areas, where they provide a wide range of ecosystem services, including water and nutrient retention, flood protection, nature conservation, biodiversity maintenance, and landscape formation. Development of farming technologies must be made in such a way that pond water level management is ensured and aquatic ecosystems functions are maintained. Societal expectations for farming on a low trophic level and applying circular economy principles need also to be taken into account.

Against this background, the main directions for developing European carp aquaculture appear to be the sustainable intensification of pond aquaculture on one hand and circularization of water and nutrient streams on the other. Combining intensive-extensive systems, such as the pond-in-pond system (sometimes called in-pond-raceway system), cage-in-pond system, and RAS-pond system, are good techniques for improving productivity while minimizing emissions and reusing waste streams. These systemic solutions have been applied on research and pilot-scale level for decades, but industrial uptake on a larger scale is still yet to be implemented. Engineering support for optimal sizing of intensive (fed sub-systems) units in relation to extensive units (extractive sub-system), adequate selection of species for the intensive system, and practical solutions for overcoming difficulties in daily management would facilitate the spread of the systems.

Carps can potentially be used in Freshwater Integrated Multi Trophic Aquaculture (FIMTA) systems, which are based on the systematic linking of fed aquaculture units, organic extractive aquaculture units and inorganic extractive units in which aquatic plants are cultured. Plants produced in FIMTA systems can serve either as energy sources or as substrates in insect farming.

The integration of "Industry 4.0" technologies into carp farming is essential for creating competitiveness in the coming decades. The application of sensors for water quality management and data-driven nutrient management have the potential to reduce environmental effects and to increase cost-effectiveness.

Looking at the post-harvest segment, there is a need to invest in carp value addition and marketing to supplement shrinking traditional markets. In recent years successfully applied innovations include the penetration into new export markets (e.g. United Kingdom of Great Britain and Northern Ireland); allocating a larger share of the production to angler's markets; labelling with geographical indication of products to differentiate regional products from imported products; partial harvesting and marketing of carps during late spring and summer. Multifunctional pond fish farming is also important for increasing and diversifying income and generating additional employment opportunities.

Session IV: Future opportunities in carp genetics and breeding

The breeding and domestication of Common carp started much earlier than most other aquaculture fish species. However, in terms of modern breeding it currently lags behind the technologies used in Salmonid and Cichlid fish species breeding. Nevertheless, with the growing demand for protein-rich food and for sustainable aquaculture practices, the field of Common carp genetics and breeding could have the potential for making substantial advancements in the coming years. In this session the future opportunities in carp genetics and breeding were explored, highlighting key areas of research, technological innovations, and their implications for the aquaculture industry.

Genomic selection and molecular techniques

Advancements in genomic techniques have revolutionized the field of genetics and breeding. In carp, the application of genomic selection holds great promise for accelerating the breeding process. Through the identification of genetic markers associated with desirable traits, such as growth, disease resistance, and flesh (fillet) quality, breeders can make informed decisions about which individuals to select as parents, leading to faster and more efficient genetic improvement.

Disease resistance and health management

Disease outbreaks pose significant challenges to carp aquaculture nowadays. Opportunities lie in enhancing disease resistance through selective breeding. Identifying genetic markers associated with resistance to common diseases could lead to the development of disease-resistant strains. Additionally, advancements in understanding the fish microbiome might open avenues for improving disease management through probiotics and other microbiota-based strategies.

Climate adaptation and environmental sustainability

As climate change impacts aquatic ecosystems, carp genetics and breeding could play a role in ensuring the resilience of farmed carp populations. Research focused on identifying genes related to higher water temperature tolerance, oxygen utilization, and stress resistance will be crucial. Carp gene banks could play an important role in the identification process of important genes among the traditional carp landraces and wild types. Developing strains that are better adapted to changing environmental conditions could mitigate risks associated with extreme weather events and contribute to the long-term sustainability of carp aquaculture.

Freshwater Integrated Multi-Trophic Aquaculture (FIMTA) systems and ecosystem integration

Future carp breeding programs could align with the principles of multi-trophic aquaculture, where the waste from one species serves as nutrients for another. Carp strains with efficient nutrient conversion rates and low environmental impact could be developed for culturing them together with other species, creating a more ecologically balanced and efficient farming system.

Data-driven decision making and Artificial intelligence (AI)

The integration of data analytics and artificial intelligence (AI) into carp breeding programs holds significant potential. By analysing large datasets encompassing genetic, environmental, and phenotypic information, AI algorithms could aid in predicting the performance of potential breeding candidates. This data-driven approach could enhance the accuracy of trait selection and accelerate genetic improvement.

Summary of the panel discussion

The future of carp genetics and breeding is full of opportunities that span from advancements in molecular techniques to adapting to changing environmental conditions and consumer preferences.

Common carp live gene banks could provide a strong base for breeding programmes contributing to the establishment of a genetically wide founder population with numerous breeding individuals from different strains.

However, it is still challenging to design successful carp breeding programmes for extensive pond aquaculture where the environmental and culture conditions vary greatly. It seems to be more effective to design novel selective breeding programs supported by molecular techniques to intensify carp production in which the culture and technological conditions are more standardized.

A recurring issue in carp breeding programmes is the finance required for establishment and maintenance of breeding programmes. Many European Union (EU) and national research, development and innovation projects are too short (2 to 4 years projects) to implement a successful breeding programme, which would require at least 8 to 10 years.

In most of Central and Eastern European countries the volume of carp production is not sufficient to justify financing a national carp breeding programme. However, the regional carp farming sector could be economically sufficiently powerful to initiate a regional carp breeding programme.

Collaboration and communication should be stregthened among production (producers associations, networks) and research entities (and maybe agricultural governing entities) to determine possible directions and financial requirements for the breeding cooperation.

FAO and EIFAAC in their role of facilitators of the international dialogue for the promotion of global food security and sustainable management of natural resources, could support their members in various ways with strengthening cooperation between countries for the establishment and implementation of successful carp breeding programmes.

Two possible options could be to:

1. Facilitate the establishment of a regional platform bringing together sector stakeholders (policy makers, scientists, producers etc.) with the aim to:
   - identify and agree on the needs for regional cooperation;
   - develop a roadmap to guide the regional cooperation and achievements of set goals; and
   - monitoring, over time, the progress of the platform members in achieving the goals.

2. Develop, upon request by countries, a regional Technical Cooperation Programme (TCP) project for the development of a regional cooperation strategy.

The first option might not be suitable as funds availability can limit the long term sustainability. In the case of a TCP, funding opportunities could be explored with the FAO Regional office for Europe and Central Asia.

Session V: Recent and future challenges on carp health and welfare

The European carp culture is dominated by extensive pond aquaculture. Feeding is based on natural food and only cereals. The main carp health, and fish welfare issues and solutions are based on the current culture system. It is essential to produce healthy freshwater aquatic products for the market. Extensive carp production in natural pond conditions is a “low-risk” production activity affected mainly by parasitic and a few significant virus diseases. Although methods of treatment against parasitic infestations are known, only a few treatment methods are available. Due to the openness of this culture system, there will be a continuous threat of introducing new and exotic forms of diseases, through incoming water sources and birds. The development of new treatments and prevention methods (e.g. vaccine development, breeding programmes targeting disease resistance) needs a concentrated effort and investment. There is a risk that the carp aquaculture will not be able to unite enough force and funding for such projects. China may have a role to play, as it is the largest carp producer in the world, and the country makes large scientific efforts to elaborate such methods. Close cooperation with Chinese carp producers in the field of carp health and welfare is essential.

Viruses affect the health of the animals and can cause mass mortalities in aquaculture. The koi herpesvirus (KHV), the spring viremia of carp virus (SVCV) and the carp oedema virus (CEV) are causative agents of serious diseases in carp production. It is presumed that the KHV was already present in European waters in the past and might have played an important role in the gill necrosis disease. However, the virus was never detected in samples due to the lack of technology. This could be the reason why some carp populations are more resistant to KHV. Nevertheless, the virus can cause high mortality. SVCV may also cause high mortality in carp farming. Promising vaccine candidates are under development for SVCV and KHV. The CEV is spreading in natural waters used for aquaculture and in the pet fish industry. The virus can cause high mortality in native populations, but some animals might survive, and they will be carriers of the virus. If the viral host is in the system, new outbreaks will be likely annually. So far, no vertical transmission of the virus has been confirmed. Strict hygiene and biosecurity rules should be applied on the farms. The newly arrived animals should be placed in quarantine and viral monitoring is necessary during the quarantine time. Vaccination is going to be the best solution against the diseases. However, the following questions may arise. What is the cost-benefit ratio? What is the right time and place of the vaccination in the production technology?

Parasitic diseases are well-known in aquaculture. Protozoan parasites, like ciliates or Metazoan parasites, like *Myxobolus* species could cause production losses, or could lead to secondary infection. The helminthiasis, as *Dactylogyrus* sp., *Gyrodactylus* sp. or other cestode species play an important role in the health status of the animals. Crustacean parasites should also be dealt with in the health management of carps. Chemicals used previously against the parasites (*Argulus* sp., *Ergasillus* sp., *Lernaea* sp., etc.) are all banned in the European Union (EU) and alternative and effective medication or treatment is not available yet. Research should focus on finding new treatment methods and pharmaceutics against the common diseases.

Climate change also has an impact on carp production. Farmers should expect higher water temperatures during the winter period. Due to the warm weather animals are looking for feed and if they do not find any in the ponds, they will use their own energy storages. This will weaken the carps and could result in immune system dysfunction in the spring. Carp farmers should keep this in mind, and they should feed the animals during winter as necessary. Otherwise, the animals will have more health issues in the warming waters, as parasites and other pathogens impact easier on fish with low immune status.

3. THE SZARVAS DECLARATION

3.1 Declarations and Resolutions of the previous International Carp Conferences

Since 2011, five International Carp Conferences have been organized: Kazimierz Dolny, Poland (2011); Wroclaw, Poland (2013); Vodnany, Czechia (2015); Zagreb, Croatia (2017); and Ansbach, Germany (2019).[2] Each conference published a closing document (e.g. a Letter of Recommendation, Resolution, or Declaration). Although the structure and content of the closing documents show a great variety, three major sections can be identified:

1. presentation of the specificities/positive impacts of pond fish culture;
2. presentation of the obstacles and threats that constrain the development of pond fish culture; and
3. a call for actions to strengthen the sector and promote growth.

Since the dominant technology of Common carp production in Europe is extensive and semi-intensive pond rearing, findings and recommendations are equally relevant to Common carp cultivation and fish rearing in general in earthen fishponds where extensive and semi-intensive rearing technologies are applied. Major findings and recommendations of the closing documents of the previous five International Carp Conferences include the following:

Characteristics and positive impacts of pond fish culture:

- provide high-quality fresh fish locally;
- contribute to rural livelihoods;
- maintain and enhance biodiversity, provide ecosystem services;
- improve water management;
- preserve and enhance social and cultural values;
- maintain indigenous fish stocks; and
- contribute to the "Blue economy.

Obstacles and threats to the development of pond fish culture:

- losses caused by predators without compensation;
- administrative burdens;
- restrictive legislation (water management/environment/fish health); and
- weak representation of the sector in important decision making fora.

Calls for action to strengthen the sector and promote growth:

To decision makers (mainly at European Union (EU) level):

- simplify regulations;
- apply appropriate and supportive legislation;
- provide compensation for losses;
- provide financial support for ecosystem services; and
- supply financial support for promotion.

To farmers and stakeholders:

- improve cooperation between producers and their associations;
- improve cooperation with research institutions (for innovation and to assist science-based legislation);
- strengthen collaboration with international organisations (e.g. AAC, FEAP, EATiP, NACEE, EIFAAC);
- strengthen involvement in global carp culture development programmes (e.g. FAO);
- intensify innovation (sustainable intensification) to increase growth and improve resiliency;

[2] Before the series of International Carp Conferences started some other conferences on carp were organized in Szczyrk, Poland (2007) and in Berlin, Germany (2010).

- value added product development;
- elaborate methods to quantify the value of ecosystem services;
- improve data collection, analysis and dissemination; and
- explore new funding opportunities.

3.2 Conclusions of the previous declarations and resolutions of the International Carp Conferences

The messages of the International Carp Conferences to decision makers and sector stakeholders contributed to better acknowledgement of the values of freshwater pond fish production with specific attention to the cultivation of Common carp, which is considered a European heritage. It should be considered that the European carp production sector shows some diversity based on resources, and cultural- and socio-economic conditions. This should be considered in the elaboration of strategies and specific development programmes. Since 2011, when the first International Carp Conference was organised in Poland, various development trends have been observed. The application of traditional production pond rearing technologies remained dominant in most of the carp producing countries. However, innovative systems and technologies appeared and strengthened the European carp sector, such as intensive systems, multi-functional pond fish farming, the combination of intensive– and extensive (pond) systems. Carp is still a traditional product, and its consumption is linked to Christian religious holidays in Europe.

There have been moderate results in the development of value-added products. Further efforts are needed to elaborate methods to quantify the value of ecosystem services that could form the basis of financial support for services. There are also opportunities in innovation to increase sustainable growth, economic viability and resilience. It remains an important task to strengthen cooperation between producers and their associations and to improve the international representation of the sector in order to get the specific values of freshwater pond fish culture better acknowledged in Europe and worldwide.

Considering the above and taking into account the new challenges which emerged in the last four years (anti-pandemic measures, draughts and heavy rains, wars, economic and financial turmoil) the participants of the Sixth International Carp Conference held in Szarvas, Hungary, unanimously adopted the “Szarvas Declaration 2023”.

BOX 1

The Szarvas Declaration 2023

Pond carp farming is a unique aspect of European freshwater aquaculture. In addition to the production of sustainable and healthy food, pond carp farming creates, maintains and protects complex socio-economic and environmental values. It is in perfect harmony with circular Blue Bioeconomy and One Health concepts and contributes to achieving the goals of the European Green Deal, the Blue Transformation of the FAO and the UN Sustainable Development Goals.

Recognizing the science-based evidence of these complex multiple benefits of pond aquaculture, producers are committed to preserving these values, maintaining the millennia-old traditions of pond aquaculture based on Common carp rearing.

Noting global trends in production and the high demand for sustainability, circularity, resilience and the necessity of short food supply chains, European carp producers are committed to strengthening their efforts to take a greater part in the production of sustainable and healthy freshwater aquatic food in Europe.

Responding to economic and environmental challenges, producers strive to develop their production systems based on scientific research, taking into account realistic options and differences in the environmental and social conditions of each region as well as the specificities of technologies used.

Agreeing that stronger cooperation among producers and stakeholders along the carp value chain is necessary with special emphasis on increased lobbying and representation at a European level, including more focused and professional communication initiatives.

Strengthening the role of Europe in global carp aquaculture and maintaining its traditions and values

Emphasising that urgent targeted actions are needed to ensure that freshwater finfish farming continues to provide inclusive, effective and sustainable pathways of production and reduce dependence on imports, secure livelihoods, underpin food security and highlighting the real need of the sector to be addressed in a coherent and consistent manner across EU policies and within national as well as regional strategies and action plans.

The long-term objectives regarding EU aquaculture should be its recognition as a principal area in the Treaty on the Functioning of the European Union (TFEU) and consequently, the development of a standalone Common Aquaculture Policy, including forms of tailored support which could increase sustainable production. In any such policy the Commission must pay greater attention to better exploiting the potential of traditional low trophic freshwater finfish aquaculture to achieve EU blue bioeconomy goals.

The short and medium-term objectives regarding national strategies should be the simplification of administrative procedures and bureaucracy and streamlining access to water and space for aquaculture, in particular with regard to the construction of new fishponds, water management and environmental and nature conservation restrictions during operation, alongside consideration of the application for subsidies.

Regulation of predator control within the farm's boundaries should be both simplified and supported, in recognition of the problem of pond farming systems being abandoned (due to predation) and the consequent degradation of habitat that ensues. Evaluation and appropriate compensation of the factors threatening the environmental and economic sustainability of pond production system should be considered, with special regard to the development of a European management plan for cormorants and otters and compensation for the damage caused by them.

Sustainable development of pond fish farming cannot endure without economic viability. This activity should be attractive for both young farmers and investors, increasing carp production and diversifying products and ensuring a stable market supply at affordable prices.

The maintenance of natural values generated by pond aquaculture must be acknowledged and appropriate financial support must be provided through alignment of such structural funds as the European Rural Development Fund (ERDF) and the European Maritime Fisheries and Aquaculture Fund (EMFAF), as these activities are strongly connected to EU rural development goals and aspirations for freshwater aquaculture production.

As representatives of the European communities of carp pond farming, an occupation which has developed through millennia and has been passed from one generation to another, evolving as a response to the needs of local communities whilst creating within them a sense of identity and continuity, from ancestors to descendants, we identify and recognise this activity as part of the Europe's intangible cultural heritage. We agree to cooperate in the enrolment of pond farming activity as part of the FAO Globally Important Agricultural Heritage Systems (GIAAHS) and the UNESCO Intangible Cultural Heritage System.

Carp aquaculture research and innovation should target better understanding of the challenges and opportunities of fishpond management particularly concerning climate change; the investigation of the role of fishponds in preserving natural values; good quality seed supply based on coordinated science driven breeding programme; more efficient nutrient management of ponds; as well as the development of sustainable intensification; and the strengthening of the circular economy. Further efforts are needed to facilitate knowledge transfer as well as the application of research and innovation results in practice.

Strengthening the integration of pond farming with other terrestrial food systems, which beyond the joint use of nutrients and raw materials, is based on the need to strengthen circular farming and the recognition of the potential for interdependence and joint action in resource sharing, rural development, market organisation, joint innovation, development of European food policy strategies and joint actions for sustainable food systems.

Source: Author's own elaboration.

4. POSTER SESSION

Improving risk management and climate-change resilience of carp aquaculture

Jurica Jug-Dijaković[1] and Ana Gavrilović[2]
*[*1] MJD Consulting, Put bana Josipa Jelačića 6, Stari Grad, Hrvatska,*
[2]University of Zagreb, Faculty of Agriculture, Department of Fisheries, Apiculture, Wildlife Management and Special Zoology, Svetošimunska 25, 10000 Zagreb, Croatia

The carp is an excellent fish for food and a popular fish in recreational and sport fishing, which in addition to its affordability ensures its steady presence in the markets of Central and Eastern European countries. Carp is a relatively hardy fish species and can tolerate wide ranges of temperature, oxygen levels, water pH, and suspended solids. Providing optimal ranges of these environmental conditions is the basis for successful production. Rapid temperature changes, non-ionized ammonia, algal blooms, bird predation and disease are major welfare issues in carp farming. To date, the only economically profitable way of carp breeding is pond polyculture or natural carp breeding in reservoirs. The pond ecosystem is a dynamic complex of communities of bacteria, plants and animals and non-living environment. Management techniques include manipulation of the pond ecology to ensure optimal production of natural fish food while maintaining water quality parameters within tolerance limits for the farmed species and fish breading through stock manipulation, feed supplementation, and health care (Kumar, 1992). Pond ecosystems get energy from the sun. As with other ecosystems, plants (algae, and water weeds) are the primary producers, which convert carbon dioxide and water to organic compounds and oxygen.

The feed used in carp farming in ponds is still mainly a supplement to natural feed. This animal feed can be grains, by-products and compound feed produced on the farm or commercially. The common characteristic of these supplements is that none of them alone can provide biologically complete nutrition for carp, and consumption of natural food in certain proportions is still needed. There are essential proteins, minerals and vitamins missing, and these must be supplemented by natural fish food.

While there are many variables and few things consistent with so many different ponds, the principles of managing pond waters are solid and predictable. Drainable ponds and hard bottom ponds depend on frequent water exchange. In undrainable ponds where the frequent change of water is a remote possibility, the physicochemical properties of pond water governing the biological production cycle reflect the properties of bottom soil. The organic and mineral constituents of the soil play their part in releasing the required nutrients into water for pond productivity through chemical and biological processes. Pond bottom soil also provides suitable substrates and the necessary environment for the microbial decomposers - the living fertilizer producers of the pond. The texture of pond soil, i.e., the mechanical composition of the soil comprising sand, silt and clay and organic matter content, basically influences the economy of both inherent and added nutrients. In fishponds, there is an intensive (0.5–1.0 cm/year) development of mud rich in nutrients and organic materials. From time to time, the mud should be dried and removed from the pond (Woynarovich *et al*., 2010).

Basic knowledge about the functioning of the ecological system in earthen breeding ponds is very well known, and the production process and activities have not changed significantly in the last fifty years. Carp farming technology in ponds is based on many years of experience that is passed down from one generation to another. Further research and innovation considering recent climate change will be necessary to ensure overall carp production, to improve its resilience and to ensure its profitability. Biological processes in the breeding environment, necessary for maintaining optimal water quality, such as bacterial activity, primary production, i.e. phytoplankton production and its role in oxygen production, are mainly related to temperature. In the case of phytoplankton and autotrophic bacteria, there exists a relationship between temperature and the photoperiod. A change in temperature conditions can significantly change the ecological situation in the pond. This will require a change in established production protocols such as: feeding (the amount of food in relation to the temperature, which should be related to the length of the day and photosynthesis, frequency of feeding, production and consumption of natural food in the pond), fertilization (which accelerates the growth of bacterial populations, especially heterotrophic ones) and the frequency of removing sludge from the bottom of the pond.

Changes in temperature can lead to disruptions in the spawning season and thus in the time of fertilization of larval ponds, especially in the time of the first stocking of larval ponds. It would be appropriate to consider the mass production of larvae and juveniles under controlled conditions of closed systems and to have larvae available at a time when the temperature and general situation in the larval ponds are most optimal (Edmeades *et al*., 2019). Bearing in mind the possible problems and changes that may arise as a result of climate change, we suggest the following activities that could increase the resilience of the carp farming industry in Central and Eastern Europe:

1. Establish monitoring of physicochemical parameters related to climate change.
2. Monitor behaviour, especially the feeding behaviour of culturing carp species.
3. Monitor the growth of cultivated carp in different seasons and compare it with available data.
4. Encourage the development of management plans to ensure production.
5. Evaluate the effectiveness of new management practices in relation to climate change.
6. Develop strategic cross-border planning and modelling of the development of carp aquaculture under the impact of climate change.
7. Develop integrated data management platforms for decision making that provide access to key production parameters.
8. Develop an information system for carp aquaculture and a knowledge hub as an interactive and user-friendly website supported by dedicated (mobile) applications.

References

Edmeades, S., Jug-Dujakovic, J., Bajic, B., Van Der Celen, Ph. & Bilandzija, J. 2019. Croatia – Beyond the Pond: *A Vision and Roadmap for the Strategic Transformation of the Aquaculture Sector – 2020-2030* (English). Washington, D.C.: World Bank Group.

Kumar, D. 1992. *Fish culture in undrainable ponds, A manual for extension.* FAO Fisheries Technical Paper No. 325. Rome, FAO, 239 p.

Woynárovich, A., Moth-Poulsen, T. & Péteri, A. 2010. *Carp polyculture in Central and Eastern Europe, the Caucasus and Central Asia.* FAO Fisheries Technical Paper No. 554. Rome, FAO, 2010. 73 p.

The fat content of the skin-on fillet of Common carp (Cyprinus carpio L.) in the Waldviertel region (Austria)

Elisabeth Peham, Günther Gratzl and Christian Bauer
Federal Agency for Water Management, Institute for Aquatic Ecology and Fisheries Management, Ecological Station Waldviertel, Gebharts 33, 3943 Schrems, Austria,

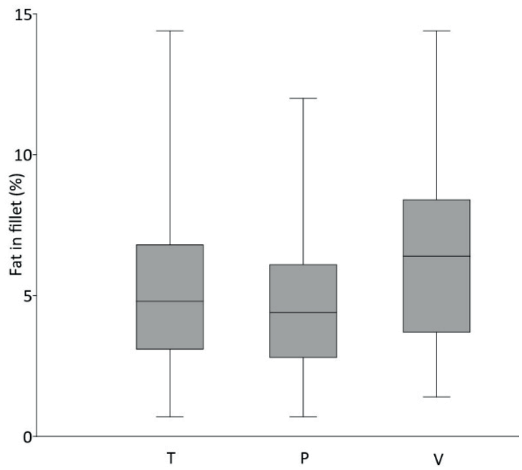
Introduction

In Austria, traditional carp pond farming uses natural food (zooplankton and benthic organisms) and supplemental feed (grains or members of the legume family) for the production of Common carp (*Cyprinus carpio L*.). The natural food provides the fish essential fatty acids and proteins (Dabrowski & Rusiecki, 1983; Tocher, 2003; Steffens, 2011) and supplemental feed is given to accelerate growth. The supplemental feed provides the carp carbohydrates, which increase the fat content in the meat (Kainz, 1984; Pfeifer and Füllner, 2008; Ljubojević *et al*., 2017). Unfortunately, the traditional carp pond farming faces the prejudice that Common carp is a fatty fish (Ljubojević *et al*., 2017; Klinkhardt, 2017). To terminate with this prejudice the first measurements of Austrian carp fat content were conducted in 2006 by the Federal Agency for Water Management (BAW), at its Ecological Station Waldviertel, which also offers interested fish farmers the service of measuring the fat content of carp.

Fat measurements of Common carp

The fat content in the fillet with skin was measured on live carp with the Distell Fish Fatmeter FM 692. For high measurement precision, every fish was measured four times on each body side. The Fatmeter automatically generates the mean value of these eight measurements. At least ten carps per pond were measured. In the years 2006–2020 BAW conducted measurements of carps from the Waldviertel region, which is the northwestern region of the northeast Austrian state of Lower Austria. The measurements showed an average fat content of 4.7 percent (n=594). In 2021 the Lower Austrian Association of Pond Farmers appealed to a big examination of the fat content of carp bred in the Waldviertel region. The 2021 study including 262 fat measurements, revealed an average fat content in the meat of 6.4 percent. A previous study showed that there is no correlation between fat content and size or weight (Bauer and Schlott, 2009). Furthermore, it was already observed, that the average fat content can be highly different between and even within farms (Bauer and Schlott, 2009, Bauer *et al*., 2011). In the Waldviertel region, the fat content of carp has increased slightly in recent years. In the first Austrian survey including 90 carps of three different farms, an average fat content in the trimmed fillet with skin-on of 4.5 percent was determined (Bauer and Schlott, 2009). Now, the average fat content for carp from the Waldviertel region is 5.2 percent (Figure 1).

Figure 1. Carp fat content over different periods



Note: T= all measurements made by BAW from 2006-2021;
P= measurements from 2006 - 2020; V= study in 2021.
Source: Author's own elaboration.

Common carp isn´t a high fat fish

Depending on the type of additional feed (type of grain or member of the legume family) various studies (Urbánek *et al.,* 2010; Pfeifer and Füllner, 2008) found highly varying fat contents. According to Nurnadia *et al*. (2011), four classes of fish can be distinguished based on their fat content: lean fish < 2 percent, low fat fish 2–4 percent, medium fat fish 4–8 percent and high fat fish >8 percent. Based on this classification carp from the Waldviertel region is a medium fat fish. Therefore, research showed that the prejudice, that Common carp is a fat fish is not true. Nevertheless, supplemental feed needs to be given with caution, because too much or the wrong carbohydrates can cause a high fat content.

For further information see poster: DOI: 10.5281/zenodo.8254550

References

Bauer, C. & Schlott, G. 2009. Fillet yield and fat content in common carp (*Cyprinus carpio*) produced in three Austrian carp farms with different culture methodologies. *J. Appl. Ichthyology 25*: 591–594.

Bauer, C. Gratzl, G. & Schlott, G. 2011. Qualitätskontrolle bei Speisekarpfenmit dem Fettmessgerät Distell FM 692. Fettmonitoring 2010. *Österreichs Fischerei 64*: 70 – 72. [German]

Dabrowski, K. & Rusiecki, M. 1983. Content of total and free amino-acids in zooplanktonic food of fish larvae. *Aquaculture 30*: 31-42.

Kainz, E. 1984. Karpfenteichwirtschaft 3. Teil. Österreichs Fischerei 37: 195 – 198. [German]

Klinkhardt, M. 2017. Europe´s carp farming needs new marketing ideas. *Eurofish Magazine 6*: 59-62.

Ljubojević, D., Dorđević, V. & Ćirković M. 2017. Evaluation of nutritive quality of common carp, *Cyprinus carpio* L. *IOP Conf. Ser.: Earth Environ. Sci. 85*. doi:10.1088/1755-1315/85/1/012013

Nurnadia, A., Azrina, A. & Amin, I. 2011. Proximate composition and energetic value of selected marine fish and shellfish from the west coast of peninsular Malaysia. *Int.Food Research Journal 18*: 137-148.

Pfeifer, M. & Füllner, G. 2008. Einfluss der Fütterung unterschiedlicher pflanzlicher Futtermittel auf die Produktqualität von Speisekarpfen. *Rundschau für Fleischhygiene und Lebensmittelüberwachung 4*: 146 – 152. [German]

Steffens, W. 2011. *Worauf kommt es bei der Zufütterung von Karpfen in Teichen an? Fischer&Teichwirt 6*: 228-230. [German]

Tocher, D. 2003. Metabolism and functions of lipids and fatty acids in teleost fish. *Reviews in fisheries science 11*: 107-184.

Urbánek, M., Hartvich, P., Vácha, F. & Rost, M. 2010. Investigation of fat content in market common carp (*Cyprinus carpio*) flesh during the growing season. *Aquaculture Nutrition 16*: 511 – 519.

The use of low-value cyprinid fish to create products that meet consumers' expectations

Tomasz Kulikowski and Olga Szulecka
National Marine Fisheries Research Institute, Department of Fisheries Economics, Gdynia, Poland.

Project background

In Poland, freshwater bream (*Abramis brama*), M and S sortiment, roach (*Rutilus rutilus),* M sortiment, and white bream (*Blicca bjoerkna*) are commonly regarded as low-value fish species. The total estimated production of such low-value species in lakes fisheries reached 321.7 tonnes in 2021, a decrease from 439.3 tonnes in 2017 (Wołos *et al*., in 2018, 2022).

From an environmental perspective, the significance of low-value fish species catches is notable. These catches contribute to the improvement of ichthyofauna structure and aid in the removal of excess nutrients, including phosphorus, thus influencing the overall ecological balance. However, despite the environmental benefits, the interest in these species among professional fishermen engaged in lake fisheries is generally low. This lack of enthusiasm can be attributed to the perceived absence of economically profitable sales opportunities associated with low-value fish.

Methodology

The project involved researching the expectations and capabilities of producers (lake fishermen), performing chemical analyses of raw materials and end products, developing model products and undertaking economic analyses of the production processes.

An important part of the project was devoted to consumer studies:

1. Qualitative consumer studies using a Focus Group Interview (FGI) method were held in three locations in Poland: Warsaw, Kraków and Gdańsk (each n=8 respondents). The FGIs were conducted at the beginning of the project, and the aim was to get knowledge about the consumer preferences of low-value fish species and related products.
2. Quantitative consumer acceptance tests of novel fish products were developed on the results of qualitative consumer studies and technological trials. The study was conducted in Warsaw, using the Central Location Test (CLT) method with a total sample size of n=100 individuals, including both women and men. The research used a sequential monadic test design with a blind test method to ensure unbiased assessments.

Results

FGI research identified that the main barriers to purchasing low-value fish are: the inconvenience associated with fish bones and the challenging processing procedures at home, including removal of scales. This finding emphasizes a significant consumer concern that may impact the marketability of these fish species. Consumer preferences create a demand for convenience products with no fish bones, with a notable interest in ready-to-eat (RTE) products, like burgers, fish balls, fish soups, pates etc. Consumers also expected these products to be crafted in artisanal conditions, promoting a perception of authenticity. Additionally, consumers expressed a desire for these products to be marketed as local, regional or Polish (with a transparent origin). For processed products, it is essential for consumers to have easily understandable ingredient lists. The preferred packaging material is glass, which is recognized as more environmentally friendly.

In response to determined consumer preferences, the following RTE boneless, sterilized products in glass jars were produced from mechanically separated fish meat and were tested in consumer acceptance test (CLT):

- roach fish balls with pearl barley groats in tomato sauce; and
- freshwater bream pâté with cranberries.

The pâté of freshwater bream with cranberries obtained an overall average rating of 7.63 on a 9-point hedonic scale (at 92 percent T3B - the percentage of responses in the top three ratings on the scale). The distribution of the top three ratings was as follows: 29 percent – Suits me, 53 percent – Suits me very well, and 10 percent – Suits me extremely. The T2B score (percentage of responses in the top two indicators on the scale) for purchase intent was 93 percent, with an average of 4.35 on a 5-point hedonistic scale.

Similarly, the roach fish balls with pearl barley groats in tomato sauce received an average rating of 7.87 on a 9-point hedonic scale (at 94 percent T3B). The distribution of the top three ratings was as follows: 26 percent–Suits me, 43 percent–Suits me very well, and 25 percent–Suits me extremely. The T2B score for purchase intent was 94 percent, with an average of 4.47/5.

Conclusions

Understanding consumer perceptions and preferences is crucial for shaping the market dynamics of low-value fish products. Strategies focused on addressing consumer concerns, providing convenience food products, and emphasizing local and transparent production practices can potentially enhance the acceptance and marketability of low-value fish and products made from them.

Consumer acceptance test results confirmed not only a highly positive overall opinion on the model products, but also a high interest in purchasing these products. Together with the results of physio-chemical analysis, which confirmed the high nutritional value of the products and economic feasibility studies, the consumer studies showed a high market potential for low-value cyprinids fish.

Acknowledgement

This work was conducted within the scope of the project „Reducing the negative impact of inland fisheries on the aquatic environment through innovative management of low-value fish species". It is part of the operation co-funded by the European Maritime and Fisheries Fund under the Operational Program „Fisheries and the Sea" 2014-2020, grant agreement No. 00001-6520.3-OR1100001/19.

References

Wołos, A., & Draszkiewicz-Mioduszewska, H. 2022. Volume and characteristics of lake fishery production in 2021. *In: Activities of fishing and angling entities in 2021. Economic, economic, environmental and climate conditions,* (red.) A. Cejko i A. Wołos, IRS, Olsztyn.

Wołos, A., Draszkiewicz-Mioduszewska, H., & Mickiewicz, M. 2018. Volume and characteristics of lake fishery production in 2017. *In: Activities of fishing and angling entities in 2017*, (red.) A. Wołos i M. Mickiewicz, IRS, Olsztyn.

Analysis of Ecosystem Services of an agro-environmental cell around fishponds

Priya Sharma[1], Gergő Gyalog[1], Mónika Varga[2]
[1]*Research Center for Fisheries and Aquaculture, Institute of Aquaculture and Environmental Safety, Hungarian University of Agriculture and Life Sciences, Szarvas, Hungary,*
[2]*Institute of Animal Sciences, Hungarian University of Agriculture and Life Sciences, Kaposvár, Hungary*

Carp culture is deeply rooted in Eastern Europe, where it not only provides a traditional source of food, but also contributes to a range of ecosystem services (ES). Beyond its economic value, carp culture promotes nutrient recycling, aids in water purification, and fosters habitat creation within aquatic ecosystems such as fishponds (Palásti *et al.,* 2020). Although many studies have attempted to quantify these ES, the subject remains under-researched (Turkowski and Lirski, 2011). The need for a new computational model-based bridge between possible human interventions and the assessment of ES for better cooperation between natural and human-managed processes remains a challenge. Through this research, we aimed to implement a combined model of dynamic balances and rule-based reasoning for the quantitative and qualitative assessment of ecosystem services of fishponds interacting with their closer and wider land use patches. The model development started with the collection of land cover-related information, water network, digital elevation model (DEM) (extracted from GIS databases), meteorological information, and available operational/management data. Considering that the carp production processes are vastly interacting with their neighbouring areas such as (e.g., reed, forest, agriculture, grassland, etc.), we developed a framework of an "agro-environmental cell model" for conceptual processes within and between the subsystems. Furthermore, the methodology of Programmable Process Structures (PPS) which can support the combined use of quantitative and qualitative sub-models, was used for the generation and simulation of the complex fishpond model (Varga *et al*., 2016, 2017, 2020a, 2020b, Varga & Csukas, 2017). As fish farms are not prepared to produce more detailed data for the identification and validation of a comprehensive pond model, we utilized the data and validated models from a series of pilot pond experiments, conducted with an emphasis on the food web-related phytoplankton and zooplankton groups. The resulting model was also tested for model-based scaling-up of production ponds, given the very limited amount of case-specific input data.

Acknowledgements

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References

Palásti, P., Kiss, M., Gulyás, Á. & Kerepeczki, É. 2020. Expert knowledge and perceptions about the ecosystem services and natural values of Hungarian fishpond systems. *Water (Switzerland)*, 12(8). https://doi.org/10.3390/W12082144

Turkowski, K. & Lirski, A. 2011. *Non-productive functions of fish ponds and their possible economic evaluation.* In: A. Lirski & A. Pyć, eds. *Carp culture in Europe. Current status, problems, perspectives*. IRŚ Olsztyn (Poland) Pub., 2011.

Varga, M., Balogh, S. & Csukas, B. 2016. An extensible, generic environmental process modelling framework with an example for a watershed of a shallow lake. *Environmental Modelling & Software*, 75: 243–262. https://doi.org/10.1016/J.ENVSOFT.2015.10.022

Varga, M. & Csukas, B. 2017. Generation of extensible ecosystem models from a network structure and from locally executable programs. *Ecological Modelling*, 364: 25–41. https://doi.org/10.1016/J.ECOLMODEL.2017.09.014

Varga, M., Csukas, B. & Kucska, B. 2020. Implementation of an easily reconfigurable dynamic simulator for recirculating aquaculture systems. *Aquacultural Engineering*, 90: 102073. https://doi.org/10.1016/J.AQUAENG.2020.102073

Varga, M., Prokop, A. & Csukas, B. 2017. Biosystem models, generated from a complex rule/reaction/influence network and from two functionality prototypes. *Biosystems*, 152: 24–43. https://doi.org/10.1016/J.BIOSYSTEMS.2016.12.005

Water quality in intensive Common carp (Cyprinus carpio L.) pond production

Jelena Stanivuk[1], László Berzi Nagy[2], Gergő Gyalog[1], Zoltán Vitál[1], Georgina Lea Fazekas[1], Uroš Ljubobratović[1]

[1] Hungarian University of Agriculture and Life Sciences, Institute of Aquaculture and Environmental Safety, Research Centre for Aquaculture and Fisheries (MATE AKI HAKI), Anna-Liget 35., H-5540 Szarvas, Hungary

[2] Agroloop Hungary Ltd., Illatos 7/A, H-1097 Budapest, Hungary

Intensive fish production contributes to meeting the ever-increasing global demand for food, supports food supply security, and reduces the overfishing of wild fish populations. Intensive production systems could also be more resource-efficient, using less water and land per unit of product compared to traditional methods. However, increasing environmental sustainability is crucial to avoid negative impacts on ecosystems.

In this trial setup, we monitored the impact of four factors on water quality: i) paddlewheel aeration rate (elevated/minor), (Kumar *et al.,* 2013); ii) feeding system (controlled/*ad libitum*), (Omar *et al*., 1987); iii) rearing density (high/low), (Karakatsouli *et al*., 2010); and iv) the presence/absence of co-cultured predator species (pikeperch in submerged cages), (Nilsson *et al.,* 1995). The trial was conducted as a multifactorial design (fractional factorial; model- 2^{4-1}) (Nicolaisen *et al*., 2014) to simultaneously perceive the significant impact on several water quality parameters; and their interactions. Water quality variables that were monitored regularly during the three months of research were: oxygen level, chemical oxygen demand (COD); ammonium level, total nitrogen (TN), total phosphorus (TP), pH, temperature, turbidity, and chlorophyll-a level. Zooplankton biomass was also regularly measured and recorded.

The feeding level and aeration rate proved to be the two strongest factors affecting the total organic load and temperature changes. Both negatively affected water quality ($p<0,001$). Higher stocking density also had some statistically significant negative influence. The presence of co-cultured predators had no effect on water quality variables, except turbidity, which was significantly affected by all the investigated factors. The aeration rate and the feeding level showed an effect on COD, TN, and chlorophyll level. TP and turbidity variation showed an inverse relation. The level of oxygen in the water did not vary significantly among combinations of aeration and feeding levels tested.

References

Karakatsouli, N., Papoutsoglou, E. S., Sotiropoulos, N., Mourtikas, D., Stigen-Martinsen, T., & Papoutsoglou, S. E. 2010. Effects of light spectrum, rearing density and light intensity on growth performance of scaled and mirror common carp (Cyprinus carpio) reared under recirculating system conditions. *Aquacultural engineering, 42*(3), 121-127. https://doi.org/10.1016/j.aquaeng.2010.01.001

Kumar, A., Moulick, S., & Mal, B. C. 2013. Selection of aerators for intensive aquacultural pond. *Aquacultural engineering, 56*, 71-78. https://doi.org/10.1016/j.aquaeng.2013.05.003

Nicolaisen, O., Cuny, M., & Bolla, S. 2014. Factorial experimental designs as tools to optimize rearing conditions of fish larvae. *Aquaculture, 422*, 253-260. https://doi.org/10.1016/j.aquaculture.2013.12.018

Nilsson, P. A., Brönmark, C., & Pettersson, L. B. 1995. Benefits of a predator-induced morphology in crucian carp. *Oecologia, 104*, 291-296. https://doi.org/10.1007/BF00328363

Omar, E. A., & Günther, K. D. 1987. Studies on feeding of mirror carp (Cyprinus carpio L.) in intensive culture 1: 1. Effect of type of feed and level of feeding. *Journal of Animal Physiology and Animal Nutrition, 57*(1-5), 67-74. https://doi.org/10.1111/j.1439-0396.1987.tb00009.x

Germ cell manipulation in Common carp - tool for conservation management

V. Kašpar[1], M.Pšenička[1], R. Franěk[1,2]
[1]University of South Bohemia in České Budějovice, Faculty of Fisheries and Protection of Waters, South Bohemian Research Center of Aquaculture and Biodiversity of Hydrocenoses, Zátiší 728/II, 389 25, Vodňany, Czech Republic.
[2]Department of Genetics, the Silberman Institute, the Hebrew University of Jerusalem, Givat Ram, Jerusalem, 91904, Israel.

Introduction

Common carp (*Cyprinus carpio*) is the fourth most cultured fish species in aquaculture, with production reaching 4 411 900 tonnes in 2019 (FAO, 2021). This species is reared both in Europe and Asia, with significant effort invested in establishing breeding programmes or programmes for conservation of genetic resources. Conventional methods for experimental isogenic line production are based on repeated uniparental inheritance. They produced double haploid individuals are rarely propagated to obtain isogenic lines and further maintained to facilitate their use in experiments.

Surrogacy using germ stem cell transplantation into a sterilized host is well suited for isogenic line production of fish or for conservation of genetic resources, because cryopreservation of milt has limited use for renewal of original lines. Surrogacy, conservation of germ stem cells or effective cultivation of germ stem cells in vitro, significantly expand the possibilities of conservation or breeding.

We attempted to overcome disadvantages connected with the conventional approach for conservation of genetic resources or isogenic line production using germ cell manipulation involving cryopreservation and surrogate reproduction technology. Novel methods of uniparental inheritance induction or cultivation of germ cells in vitro were optimized.

Materials and methods

A series of experiments were performed to develop an optimal procedure for cryopreservation of Common carp male and female early-stage germ cells. For tissue of ovary, a mixture of permeating and nonpermeating cryoprotectants (dimethyl sulfoxide - Me2SO, methanol - MeOH or propylene glycol – PG) were used to firstly identify the optimal composition of the cryomedia. In turn, concentrations (1, 1.5, 2, 2.5, 3 M) of cryomedia and addition of supplements (glucose, sucrose, trehalose) were tested to define the optimal condition favouring germ cell survival. For testicular tissue, after initial trailing of available cryoprotectants a wide range of cooling rates (0.5–10°C/min) and different concentrations of Me2SO were tested. A similar series of experiments was performed for ovarian tissue.

Verification of a suitable recipient for germ cells of Common carp was performed. We employed ablation of primordial germ cells, using injection of antisense oligonucleotide against dead end gene in goldfish. Therefore, we isolated cell suspension from cryopreserved and fresh gonadal fragments using trypsin/collagenase dissociation, enriched with gradient sorting. Isolated cells were injected into the body cavities of sterilized goldfish and their gonadal development was monitored. Goldfish surrogates were stimulated to spawn through a controlled temperature and light regime. Collected gametes were used for fertilization and genotyping using carp and goldfish specific primers. The next aim of this study was to develop a cold shock androgenesis protocol for Common carp based on gametes obtained from wild-type females and Koi males (recessive blonde phenotype). Combinations of different temperature treatments (0, 2, 4, 6, 8 °C) and cold-shock durations (15, 30, 45, 60, 75 min) were tested shortly after gamete activation (3 s after fertilization).

Optimization of the *in vitro* germ cell culture condition for short term cell culture involved testing of basal media (hESC, Stempro-34) and various types of feeder cells (RTG-2 and sertoli cells) with continuous monitoring of mitotic proliferation.

Results

Cryopreservation protocols for testicular and ovarian tissue based on Me2SO cryoprotectant and slow rate freezing -1 °C/min yielded 40-60 percent post-thaw viability. A cryopreservation protocol using a slow-rate freezing (1 °C/min) was developed using a Me2SO-based cryomedia and adding 0.3 M trehalose. Testing of available cryoprotectants and protocols for cryoconservation of testicular tissue resulted in the highest survival rate, achieved by using 2 M Me2SO and a cooling rate of -1 °C/min. Recovery and physiological activity of cryopreserved germ cells were confirmed after transplantation into sterile goldfish when cryopreserved germ cells retained a colonization rate comparable to non-cryopreserved control. Goldfish surrogates produced viable Common carp progeny confirmed by genotyping and typical phenotype. Both male and female gametes were obtained, even from a single donor confirming the feasibility of isogenic line production using transplantation from a double haploid donor without the necessity to reproduce a given individual again by uniparental inheritance. Results of cold-shock treatment testing showed that the optimal condition for egg nucleus elimination was a cold-shock at 2 °C for a 60 min duration. Double haploid induction performed on larger scale using 2 °C cold-shock for 60 min subsequently treated by a heat shock arresting first mitotic cleavage resulted in reduced fertilization and hatching rates for all replicates and a low yield of double haploid progeny (1.09-1.28 percent in experimental incubation, <1 percent in hatchery incubation).

Optimization of *in vitro* culture conditions indicated that germ cells cultured with hESC media and a RTG2 cell line as feeder possessed significantly higher proliferation and survival rate, compared to germ cells cultured with StemPro media and Sertoli cell line as feeder.

Discussion

This study aimed to introduce a novel and complex strategy capable to overcome shortcomings of the traditional procedures for isogenic lines production and to expand possibilities for conservation of genetic resources.

The study developed and optimized protocols for Common carp germ cell cryopreservation. Tissue from precious doubled haploid or even isogenic specimens can be safely stored in liquid nitrogen. As shown by transplantation experiments, germ cell-free gonads of goldfish were confirmed to provide a suitable environment for Common carp germ cells. Transplanted cells differentiated into functional gametes resulting in viable Common carp progeny.

Results obtained in this study are important for the implementation of new strategies in Common carp breeding, conservation of genetic resources, restoration of lines or development of clonal and isogenic carp lines.

References

FAO. 2021. FishStatJ Software www.fao.org/fishery/en/fishstat (accessed August 2023)

Acknowledgement

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Annex 1 – Agenda

Day 1. Thursday, 31 August 2023

Time	Event/Topic	Moderator/Speaker
09.00-09.30	Welcome speeches and opening	Prof. Dr. Csaba Gyuricza, Rector, Hungarian University of Agriculture and Life Sciences Mr. Gábor Csörgics, Head of Department, Ministry of Agriculture, Department of Aquaculture and Fisheries Management Dr. István Németh, President Hungarian Aquaculture and Fisheries Inter-Branch Organization (MA-HAL) Dr. Béla Halasi-Kovács, director of MATE AKI HAKI
09.30-09.45	Opening video: „The beauty of carp"	
09.45-12.15	**Keynote presentations**	
09.45-10.15	Status and trends in carp supply chain in Asia	Mr. Dong Zaijie, FFRC, China
10.15-10.40	Carp culture in Europe, history and recent trends	Mr. Catalin Platon, ROMFISH, Romania
10.40-11.00	**Coffee break**	
11.00-11.25	Carp in the global aquaculture scene	Mr. Bela Halasi-Kovacs, MATE AKI HAKI, Hungary
11.25-11.50	Role of EIFAAC in European carp aquaculture	Ms. Ana Gavrilovic, EIFAAC
11.50-12.15	The aspects of sustainable extensive pond aquaculture from a farm manager's point of view	Mr. Nandor Puskas, MA-HAL, Hungary
12.15-14.00	Buffet lunch	
14.00-17.40	**Thematic sessions**	
14.00-15.00	I. Session: Strengthening the role of Europe in global carp aquaculture	*Moderator:* Mr. Javier Ojeda FEAP *Panelists:* Mr. Dong Zaijie, FFRC, China Mr. Laszlo Varadi, NACEE/HUNATiP, Hungary Mr. Paweł Wielgosz, Polski Karp, Poland Mr. Zoran Radan, Croatian Chamber of Economy, Croatia
15.00-15.20	**Coffee break**	
15.20-16.20	II. Session: Pond aquaculture as European heritage. Discussion on possibilities to aware of traditional pond aquaculture (GIAHS, Intangible Cultural Heritage), environmental benefits provided by pond aquaculture	*Moderator:* Mr. Laszlo Varadi, NACEE/HUNATiP *Panelists:* Mr. Catalin Platon, ROMFISH, Romania Mr. Bernhard Feneis, VDBA, Germany Mr. Leo Kirchmayer, ÖVFA, Austria Mr. Bela Halasi-Kovacs, MATE AKI HAKI, Hungary
Time	**Event/Topic**	**Moderator/Speaker**
16.20-16.40	**Coffee break**	
16.40-17.40	III. Session: Development of carp rearing systems and technologies through innovation along its value chain	*Moderator:* Mr. David Basset, EATiP *Panelists:* Mr. Tamas Bardocz, ABT, Malta Vojtěch Kašpar, Czech Fish Farmers Association, Czech Republic Mr. Ferenc Levai, Aranyponty Co, Hungary Mr. Gergo Gyalog, MATE AKI HAKI, Hungary
19.00	**Gala Dinner**	

Day 2. Friday, 1 September 2023

Time	Event/Topic	Moderator/Speaker
09.00-10.00	Poster session	Mr. Uros Ljubobratovic, MATE AKI HAKI
	Thematic sessions	
10.00-11.00	IV. Session: Future opportunities in carp genetics and breeding	*Moderator:* Mr. Marco Frederiksen, Eurofish *Panelists:* Mr. Dong Zaijie, FFRC, China Mr. Martin Kocour JCU, FFPW, Czech Rep. Mr. Béla Urbányi, MATE AKI, Hungary Mr. Gyula Kovács, MATE AKI HAKI, Hungary Ms. Daniela Lucente, FAO Dep. of Fisheries and aquaculture
11.00-11.20	**Coffee break**	
11.20-12.20	V. Session: Recent and future challenges on carp health and welfare	*Moderator:* Mr. Bernhard Feneis, VDBA, Germany *Panelists:* Mr. Ilya Trombitski, Executive Director at Eco-TIRAS Intl Assn of River Keepers, Moldova Mr. Marton Hoitsy, MA-HAL Hungary Mr. Zsigmond Jeney, MATE AKI HAKI
12.20-13.00	Approval of Szarvas Declaration	Mr. László Váradi NACEE/HUNATiP
13.00-13.15	Closing remarks	Mr. Béla Halasi-Kovács MATE AKI HAKI
13.15-14.30	Buffet lunch	
14.30-16.30	Visit to HAKI Live carp gene bank and experimental infrastructures	Mr. Gyula Kovács, MATE AKI HAKI

Annex 2 – List of participants

AUSTRIA

Leo Kirchmaier
Landwirtschaftskammer NÖ and Austrian Lake Fisheries and Aquaculture Association

CHINA

Dong Zaijie
Department of Genetics and Breeding, FFRC

CROATIA

Ana Duda
Poljoprivredno Poduzeće Orahovica d.o.o.

Jurica Jug-Dujaković
M.J.D. CONSULTING

Kristina Majdenić
Poljoprivredno Poduzeće Orahovica d.o.o.

Sanja Marić-Šantor
Poljoprivredno poduzeće Orahovica d.o.o.

Marko Oršolić
Poljoprivredno Poduzeće Orahovica d.o.o.

Paola Pucić
Poljoprivredno Poduzeće Orahovica d.o.o.

Zoran Radan
Croatian Chamber of Economy - Croatian Aquaculture Association

Tomislav Slačanac
Poljoprivredno Poduzeće Orahovica d.o.o.

Boris Vidaković
Poljoprivredno Poduzeće Orahovica d.o.o.

Tea Vitina
Poljoprivredno Poduzeće Orahovica d.o.o.

CZECHIA

Vojtech Kaspar
University of South Bohemia in České Budějovice

Martin Kocour
University of South Bohemia in České Budějovice

Adolf Vondrka
Rybniční hospodářství, s.r.o.

DENMARK

Marco Frederiksen
Eurofish International Organisation

GERMANY

Bernhard Feneis
Association of German Inland Fisheries and Aquaculture (VDBA)

Peter Thoma
Association of Bavarian Professional Fishermen (Verband der Bayerischen Beruffischer e. V. -VBB)

HUNGARY

László Ardó
Hungarian University of Agriculture and Life Sciences

Péter Bársony
University of Debrecen

Zsolt Bartus
Fish-Coop Kft.

Emese Békefi
Hungarian University of Agriculture and Life Sciences

Rita Borbély
Jászkiséri Halas Kft.

Zsuzsanna Brlás-Molnár
Hungarian University of Agriculture and Life Sciences

Gábor Csoma
Fish-Coop Kft.

Gábor Csörgits
Ministry of Agriculture, Hungary

István Dankó
Aranykárász Kft.
Milán Fehér
University of Debrecen

Ferenc Lévai
Aranyponty Halászati Zrt.

Ferenc Fodor
Balatoni Halgazdálkodási Nonprofit Zrt.

Sándor Gorda
Körösvidéki Horgász Egyesületek Szövetsége

Gergő Gyalog
Hungarian University of Agriculture and Life Sciences

Béla Halasi-Kovács
Hungarian University of Agriculture and Life Sciences

Márton Hoitsy
Vet4Fish Kft.

Ákos Horváth
Hungarian University of Agriculture and Life Sciences

Zsuzsanna Jakabné Sándor
Hungarian University of Agriculture and Life Sciences

Zsigmond Jeney
Hungarian University of Agriculture and Life Sciences

Csaba Kakuk
Fish-Coop Kft.

Bence Kovács
Unio-SeaFood Kft.

Gyula Kovács
Hungarian University of Agriculture and Life Sciences

Zoltán Kovács
Tiszahalker kft

Lívia Diána Marsi
National Federation of Hungarian Anglers

Emese Melles
Biharugrai Halgazdaság
Péter Molnár
University of Debrecen

Zoltán Nagy
Hungarian University of Agriculture and Life Sciences

Janka Nagyné Biró
Hungarian University of Agriculture and Life Sciences

István Németh
Hungarian Aquaculture and Fisheries Inter-branch Organisation

Zoltán Pászti
Aquagarant

Nándor Puskás
Hungarian Aquaculture and Fisheries Inter-branch Organisation

Terézia Radóczné Kocsis
Institute of Agricultural Economics

Arpad Rideg
RIDEG & RIDEG FISH FARM KFT.

Priya Sharma
Hungarian University of Agriculture and Life Sciences

Jelena Stanivuk
Hungarian University of Agriculture and Life Sciences

Laszlo Stündl
University of Debrecen

Katalin Szentes
Ministry of Agriculture, Hungary

István Szűcs
University of Debrecen

Tamás Takács
Aquagarant

Mihály Tóth B.
Tóth & Tóth Kft.

Béla Urbányi
Hungarian University of Agriculture and Life Sciences

László Váradi
HUNATiP/NACEE

Gábor Vörös
Gálosi Bárka Kft.

LATVIA

Marcis Zingis
Latvian Fish Farmers Association

LITHUANIA

Juozas Antanavicius
National Association of Aquaculture and Fish Products Producers

Adomas Banikonis
National Association of Aquaculture and Fish Products Producers

Svirskis Darius
National Association of Aquaculture and Fish Products Producers

Rolandas Daumantas
National Association of Aquaculture and Fish Products Producers

Asta Grimbovskiene
National Association of Aquaculture and Fish Products Producers

Arvydas Jucius
National Association of Aquaculture and Fish Products Producers

Rolandas Morkunas
National Association of Aquaculture and Fish Products Producers

Vita Vaitkeviciene
National Association of Aquaculture and Fish Products Producers

REPUBLIC OF MOLDOVA

Gheorghe Diaconu
Întreprinderea Piscicolă Costeşti
Gheorghe Gheorghiu
Asociatia Nationala a Piscicultorilor din Republica Moldova

Ilya Trombitsky
ACVAGENRESURS

POLAND

Mariusz Cebeterewicz
Gospodarstwo Rolne

Vadym Husiev
Primeore Trading (Polska) Sp. z o.o.

Robert Idzikowski
Aller Aqua Polska Sp. z o.o.

Jakub Jarosz
Gospodarstwo Rybackie

Zbigniew Kreft
Aller Aqua Polska

Tomasz Kulikowski
MPR S.C.

Marcin Rakowski
National Marine Fisheries Research Institute (MIR-PIB)

Pawel Wielgos
Polski Karp

ROMANIA

Mariana Arcade
Fish Culture Research and Development Station Nucet

Liliana Athanasopoulos
Institute of Research and Development for Aquatic Ecology, Fishing and Aquaculture of Galati

Diadem Vasile Atodiresei
PIRANIA SRL

Jenica Atodiresei
PIRANIA SRL

Liliana Camelia Datcu
SC SARDA FISH SRL
Gheorghe Dobrota
Fish Culture Research and Development Station Nucet

Nicoleta Dobrota
Fish Culture Research and Development Station Nucet

Andrei Jalba
The Research-Development Institute for Aquatic Ecology, Fishing and Aquaculture – Galati

Gancea Marinela
Fish Culture Research and Development Station Nucet

Marica Nino
Fish Culture Research and Development Station Nucet

Gheorghe Nistor
Piscicola Botosani

Veta Nistor
The Research-Development Institute for Aquatic Ecology, Fishing and Aquaculture - Galati

Catalin Platon
ROMFISH

Silvia Radu
Fish Culture Research and Development Station Nucet

Dragut Sorin
Fish Culture Research and Development Station Nucet

Sorin Stefan Stanciu
The Research-Development Institute for Aquatic Ecology, Fishing and Aquaculture - Galati

SERBIA

Dimitrije Matić
Aller Aqua Balkan

Petar Pejčić
Aller Aqua Balkan

Zsolt Pintér
Aller Aqua Balkan

SPAIN

Javier Ojeda
FEAP

UNITED KINGDOM OF GREAT BRITAIN AND NORTHERN IRELAND

David Bassett
EATiP

EIFAAC - FAO

Ana Gavrilovic
EIFAAC Technical and Scientific Committee

EUROFISH

Éva Kovács
Eurofish International Organisation

FAO

Haydar Fersoy
FAO Regional office for Europe and Central Asia

Daniela Lucente
FAO Fisheries and Aquaculture Division

Annex 3 – Organizing committee members

International Organizing Committee:

Country	Name	Organization
Austria	Mr. Leo Kirchmayer,	Austrian Association for Fisheries Management and Aquaculture (ÖVFA)
Croatia	Mr. Zoran Radan	Croatian Chamber of Economy
Czech Republic	Mr. Michal Kratochvíl Mr. Vojtech Kaspar	Czech Fish Farmers' Association University of South Bohemia, Faculty of Fisheries and Protection of Waters
Germany	Mr. Bernhard Feneis	German Aquaculture Association (VDBA)
Hungary	Mr. Bela Halasi-Kovacs Mr. Laszlo Varadi	Hungarian Aquaculture and Fisheries Inter-Branch Organization (MA-HAL) HUNATIP/NACEE
Poland	Ms. Anna Pyc Mr. Jacek Juchniewicz	Polish Trout Breeders Association
Romania	Mr. Catalin Platon	Romanian Fish Farmers Association

Local Organizing Committee:

Name	Organization
Ms. Emese Békefi	Hungarian University of Agriculture and Life Sciences, Research Center for Fisheries and Aquaculture (MATE AKI HAKI)
Ms. Zsuzsanna Brlás-Molnár	MATE AKI HAKI
Mr. Gergő Gyalog	MATE AKI HAKI
Mr. Béla Halasi-Kovács	MATE AKI HAKI Hungarian Aquaculture and Fisheries Inter-Branch Organization (MA-HAL)
Mr. Gyula Kovács	MATE AKI HAKI
Mr. Ede Timmel	MA-HAL
Mr. László Váradi	Hungarian Aquaculture Technology and Innovation Platform (HUNATIP) Network of Aquaculture Centres in Central and Eastern Europe (NACEE)

Annex 4 – Conference contributing institutions and sponsors

Contributing institutions

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The Sixth International Carp Conference was organized in Szarvas, Hungary, on 31 August–1 September 2023. The conference was attended by 114 participants from 14 countries, representing a range of carp value chain stakeholders. The conference aimed to strengthen the "carp segment" within European aquaculture, improve the image of carp pond aquaculture as common European heritage, and to explore the opportunities for carp within "blue aquaculture". The conference also aimed to inform carp producers about the latest research findings and European policies.

The Sixth International Carp Conference approved the "Szarvas Declaration". The declaration recognizes the contribution of carp pond aquaculture to sustainable and healthy food production, its role in maintaining and protecting complex socio-economic and environmental values, and that carp farming is a unique segment within European aquaculture.

To increase carp production in Europe, policy and decision makers are urged to simplify administrative procedures, provide access to water and suitable locations for aquaculture, and arrange for compensation of damage to sustainable fish farming caused by cormorants and otters. Innovation is necessary for the sub-sector to maintain its economic viability and to attract youth to a career in aquaculture.

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