2020–2021

BIENNIAL
REPORT


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FFPW USB, Vodňany, Czech Republic, 2022

BIENNIAL REPORT 2020–2021

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REPORT

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CENAKVA
South Bohemian Research Centre for Aquaculture and Biodiversity of Hydrocenoses


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1 Introduction

Who are we?

We are an enthusiastic team of people passionate about science in the fields of fisheries and protection of the water environment as well as biodiversity.

The Faculty of Fisheries and Protection of Waters is the smallest and at the same time youngest part of the University of South Bohemia in České Budějovice, which on the other hand constitutes no obstacles to it being one of the leading faculties regarding the contribution of scientific and practical outputs, great-quality instrumentation and other infrastructure, and a corresponding large number of professional scientific and academic staff.

What are we?

We are the most comprehensive institution in the field of fisheries and protection of waters in Central Europe with explorational and applied research, having the rights for associate professorship and professorship procedures, providing Bachelor's, Master's, and Ph.D. studies. The faculty has experimental facilities for studying and researching aquaculture, fish and crayfish culture, hydrobiology, toxicology, fish diseases, reproduction, and genetics, as well as a unique fisheries library.

Why are we here?

We are a research faculty bringing cutting-edge research knowledge directly to students and industry professionals. We aim to educate production fishermen with a positive relationship to the environment and conservationists with a pragmatic approach to production fisheries. We are pursuing a strategy for sustainable development of the so-called "Green FFPW". We would like to be a European leader in the fields of fisheries research and protection of the water environment.

Introduction

1

Dear readers, fellow workers…

The past two years have been marked by the pandemic situation associated with Covid-19. We have all had to deal with brand new situations that have hindered us in many ways, bringing a lot of difficulties. On the other hand, they have become real challenges. The closure of schools and workplaces forced us to move quickly into the digital world, including online teaching, work meetings, and even conferences. What should have taken years to formally implement "from above", we all acquired within weeks, even the staunchest opponents of modern approaches. We discovered the strengths and weaknesses of online platforms, learning to use them effectively. Today we know that we need to change some approaches in education, increase the availability and quality of learning tools and resources, be ready to use "contactless" forms of teaching, and make meaningful use of these available technological tools. The pandemic situation has also taught us the importance of working with sources of information, selecting them within their objectivity, and maintaining individual freedom as well as good interpersonal relations. I believe that we will take a lot of positives from this situation and use it in our teaching and scientific work.

Despite all the difficulties and adversities we have had to overcome in the last two years, we have managed to enjoy some amusement. We were able to celebrate together "live" the beautiful centenary of the Research Institute of Fish Culture and Hydrobiology, dance at the 2nd Faculty Ball, sing at the FROVfest, compete in cycling, and many other activities (see more in the chapters "Faculty Life" and "Lifelong Learning").

…and colleagues,

What does the future hold for us?

We must continue to actively seek out talented students, always improve the quality of our teaching, and carry on developing and improving the quality of our science. We are going to consolidate our privileged role in the development of science and research through our CENAKVA research centre, which was defined by the Government of the Czech Republic as a priority infrastructure for environmental development in the Czech Republic and abroad. You can find out about the interesting topics we address in Chapter 3 "Research at the Faculty". Further development and renewal of the available infrastructure as well as the healthy growth of the workforce will be essential.

As you browse the publications, you may notice some changes in the overall concept as opposed to previous issues. We decided that the faculty biennial report needed a change as well. I hope you will enjoy this format and find it full of interesting facts about the activities of our "FFPW".

I wish us all to undertake this endeavour in health and peace!!

2

Faculty life

We would like to show a different side of university life. We don't just "deal with" science, research, test tubes, and fish at the faculty. We can also have fun, let our hair down, make fun of ourselves, organize a ball or a festival, celebrate a hundred years, dress up as a frog and talk about our work. In 2020 and 2021, we were all affected by the pandemic associated with the COVID-19 virus. Despite all the adversity, we managed to carry out the events listed below.

The Centenary of our research institute in Vodňany

The Research Institute of Fish Culture and Hydrobiology in Vodňany celebrated its 100th anniversary. The celebration marking this important anniversary took place on Friday 3rd September 2021 and was attended by a number of prominent personalities.

The institution engaged in research on fisheries and hydrobiology was founded in Prague in 1921 and relocated to southern Bohemia in 1953. In 2009, the research institute became part of the newly established Faculty of Fisheries and Protection of Waters at the University of South Bohemia (USB) in České Budějovice. It was in front of the main building of the faculty in Vodňany that celebratory speeches were made by the former directors of the research institute, Professors Jan Kouřil, Otomar Linhart and Pavel Kozák, as well as the current director, Professor Tomáš Randák. Other speakers included the current Rector of the USB, Professor Bohumil Jiroušek, the President of the Academy of Sciences of the Czech Republic, Professor Eva Zažímalová, and the Governor of the Region of South Bohemia, Martin Kuba.

As well as the speeches, the programme, hosted by Vladimír Kořen, a prominent promoter of science and research in the media, included the awarding of commemorative medals. Among the personalities who had contributed to research in the field of natural sciences and who received the medal were Miroslava Kopicová, Pavel Punčochář and Professors Petr Ráb and Martin Flajšhans. The medal was also awarded to Václav Janeček.

Afterwards, the book "The centenarian, who does not age" was unveiled, which presents the centenary research at the research institute and subsequently at the faculty in an engaging and professional way through texts and photographs.

The ceremonial part of the programme was followed by a lavish buffet, where fish specialities were served alongside traditional dishes, and a tour of the faculty's workplaces.

On the same date, our good "neighbour", the High School of Fisheries in Vodnany, which was founded in 1920, celebrated its centenary as well. ◀

FROVfest

FROVfest is undoubtedly one of the most popular and traditional events. It is a student rock multi-genre festival. At the beginning of September, the town is filled with the sound of pleasant tones as well as the rumbling of metal bands. In addition to music, there is also a special programme for children. Despite the unfavourable pandemic situation, the organisers managed to hold the 8th and 9th festivals in 2020 and 2021. ◀

Representative ball

On 1st February 2020, the 2nd Representative ball of the Faculty of Fisheries and Protection of Waters USB took place in Vodňany. The evening was hosted by Jakub Plachta and the MP3 České Budějovice group, featuring also Latin American dancers. Regrettably, the 3rd Representative ball in 2021 failed to take place due to governmental measures. ◀

Night of scientists

The Night of Scientists was organized at the University of South Bohemia on 24th September 2021. We tried to present the working life at the faculty in an unconventional and entertaining way. In Nové Hrady, visitors had the opportunity to build their own microscope, while in České Budějovice, the god of the water element Poseidon welcomed visitors, even dubbing the successful ones with his trident. A larger-than-life frog was in charge of the programme focused on the river and life in it, and curious visitors were also impressed by an unusual night tour of the aquaponic greenhouse. Anyone hungry could satisfy their cravings with a delicious tasting of fish products. In total, over 500 people visited the FFPW USB. ◀

Open day

On 17th January 2020, the University of South Bohemia in České Budějovice organised an Open day. The Faculty was again involved in a splendid programme, welcoming seventy visitors. A presentation about the faculty and opportunities to study at the faculty had been prepared for the applicants, and was given by the Vice-dean for Study Affairs, Assoc. Prof. Martin Kocour. Throughout the day, the visitors could see the exhibits, shoot at the laser shooting range, try interactive educational models or taste products from the faculty shop Fish for Health. FFPW students also demonstrated carp processing. There was no Open Day in 2021 as people were unable to meet in person. However, we were given the opportunity to make 3-D tours of the faculty institutes and workplaces, and "open the doors" to visitors at least virtually. ◀

World water day

Put on your trainers and run with us for water! That was the challenge of the Faculty of Fisheries and Protection of Waters, which joined the global, virtual run in support of the World water day 2021.

The challenge lasted 7 days, aiming to raise awareness about the world water crisis and at the same time run approximately the length of the Blanice river, which flows through the city of Vodňany, i.e. 100 km.

The challenge participants managed to surpass this goal – more than twice! Each alone, yet together they ran a beautiful 250 km for water, setting in motion enthusiasts from among the faculty staff, their family members, pets, as well as the public and representatives of the town of Vodňany. Their efforts were also appreciated by the organizer of the World Run for Water, marathon runner Mina Guli. In total, 134 countries took part in the World Water Day Run and a fantastic 260,000 km were run. The aim of the challenge was to raise awareness that having clean water is not a matter of course for everyone, so it is important to be reminded of this issue. The MEVPIS FFPW USB Vodňany Centre regularly prepares awareness-raising events for the general public as part of the World Water Day celebrations. This year, it decided to join this virtual challenge due to anti-epidemic measures.

Unfortunately, this event was cancelled in 2020 due to the ongoing pandemic. However, we were not discouraged and on 20th March 2020 we got ready to clean a part of the municipal raceway that flows past the MEVPIS premises. ◀

Best university

The TÝDEN magazine compared universities in the country for the fifth time, the FFPW USB reaching the 1st place in the Agricultural, Forestry and Veterinary Sciences section. Several factors were reflected in the assessment: interest in studying at the faculty (admission chances), number of teachers working at the faculty, quality of science (publication outputs, important grants), and external evaluation (school rating in prestigious foreign rankings, etc.). ◀

Citation success: Scopus database

A group of authors associated with Stanford University, PLoS Biology and Elsevier company, published an analysis of citations from the Scopus database, assessing lifetime citation impact and citation counts in 2019. 359 people affiliated with Czech institutions are also included in the **list of the top 2% most cited scientists in their fields**. Twelve people work at the University of South Bohemia in České Budějovice, **four being from our faculty**, namely Jacky Cosson, Josef Velíšek, Otomar Linhart and Antonín Kouba.

Many congratulations!

Professorships, habilitations and honorary degrees *doctor honoris causa*

Prof. Milan Gelnar

On 15th December 2020, the President of the Czech Republic Miloš Zeman signed the Letter of Appointment for Professor Milan Gelnar (*1955). Prof. Gelnar delivered his lecture on "What is and is not sampling design? How to collect or not to collect data in contemporary ichthyoparasitology". After graduating from a grammar school in Bílovec, he was admitted to the Faculty of Science at Jan Evangelista Purkyně University in Brno (now Masaryk University) in 1975, where he studied the field of Professional biology with a specialization in parasitology, obtaining the academic title of RNDr. He was granted the scientific rank of Candidate of Biological Sciences (CSc.) in parasitology in 1985 on the basis of a successful defence of his dissertation. In 2000 he defended his habilitation thesis titled "Monogenea, selected aspects of biology and ecology" at the Faculty of Science, Charles University. During his professional career he worked at the Institute of Parasitology, Academy of Sciences in České Budějovice and at the Faculty of Science, Masaryk University. From 2003 to 2010 he held the position of Dean and since 2010 he has been the Vice-dean. He has devoted his professional activity to the topic of fish parasitology, becoming a recognized expert in this field. He has created an excellent research team with an international reputation and was awarded the Gold Medal of Masaryk University for his development and contribution to the Faculty of Science. ◀

Assoc. Prof. Miloš Buřič

Miloš Buřič, Ph.D., (*1982) was appointed Associate Professor of Fishery on 1st February 2021, having presented a lecture on "Crayfish Behaviour as a Tool for Studying Invasive Species and Changing Environmental Conditions" before the Research Board of the Faculty of Fisheries and Protection of Waters (FFPW USB). From 1997 to 2001 he attended the High School of Fisheries in Vodňany. He continued with studying at the Faculty of Agriculture, University of South Bohemia in České Budějovice. He completed his Ph.D. studies at the Research Institute of Fish Culture and Hydrobiology in Vodňany (2006–2009), defending his doctoral thesis entitled "Biology of spiny-cheek crayfish (*Orconectes limosus*, Rafinesque, 1817) under conditions of the Czech Republic and the study of factors influencing its invasive spreading". From October 2009 to April 2016, he worked simultaneously at the Trout Farm Mlýny as the head of operations and as a researcher at the Research Institute of Fish Culture and Hydrobiology in Vodňany. Since 2016, he has been an academic staff member of the FFPW, and in addition, he has been the head of the Laboratory of Freshwater Ecosystems since 1st December 2017. His professional focus mainly concerns the aspects of biology and ecology of crayfish and other freshwater invertebrates as well as some aspects of ecology of freshwater ecosystems. ◀

Assoc. Prof. Antonín Kouba

On 1st July 2021 Antonín Kouba, Ph.D., (*1982) was appointed Associate Professor in Ecology at Charles University after successfully defending his habilitation thesis entitled "Marbled crayfish, an emerging invasive species". He graduated from the High School of Fisheries in Vodňany. Subsequently, he obtained a master's degree at the Faculty of Agriculture, University of South Bohemia in České Budějovice and his Ph.D. degree while working at the Research Institute of Fish Culture and Hydrobiology in Vodňany (2007–2011). His doctoral thesis focused on intensifying young crayfish breeding. In the period of 2012–2017 he took the position of the Editor-in-Chief of the FFPW USB Editorial Board. Since 2017 he has been the Vice-dean for Science and Research. His scientific activities are mainly focused on crayfish biology, ecology and breeding, as well as issues of freshwater ecosystems and their vulnerability to human activities. ◀

An Official ceremony of awarding the honorary degree *doctor honoris causa*

On 26th November 2021, an official ceremony of awarding the honorary degree *doctor honoris causa* to **Johan Verreth** and **Marc Vandeputte** took place at the Town Hall of České Budějovice. These two prominent figures in the scientific world have been linked with our institution by a long-standing cooperation and friendship dating back to the 1990s. Both gentlemen are members of the FFPW USB International Board and the CENAKVA Centre, and are also involved in the joint European project called AQUAEXCEL, thus being significantly instrumental in the development of the faculty at an international level. We greatly appreciate that and would like to thank them.

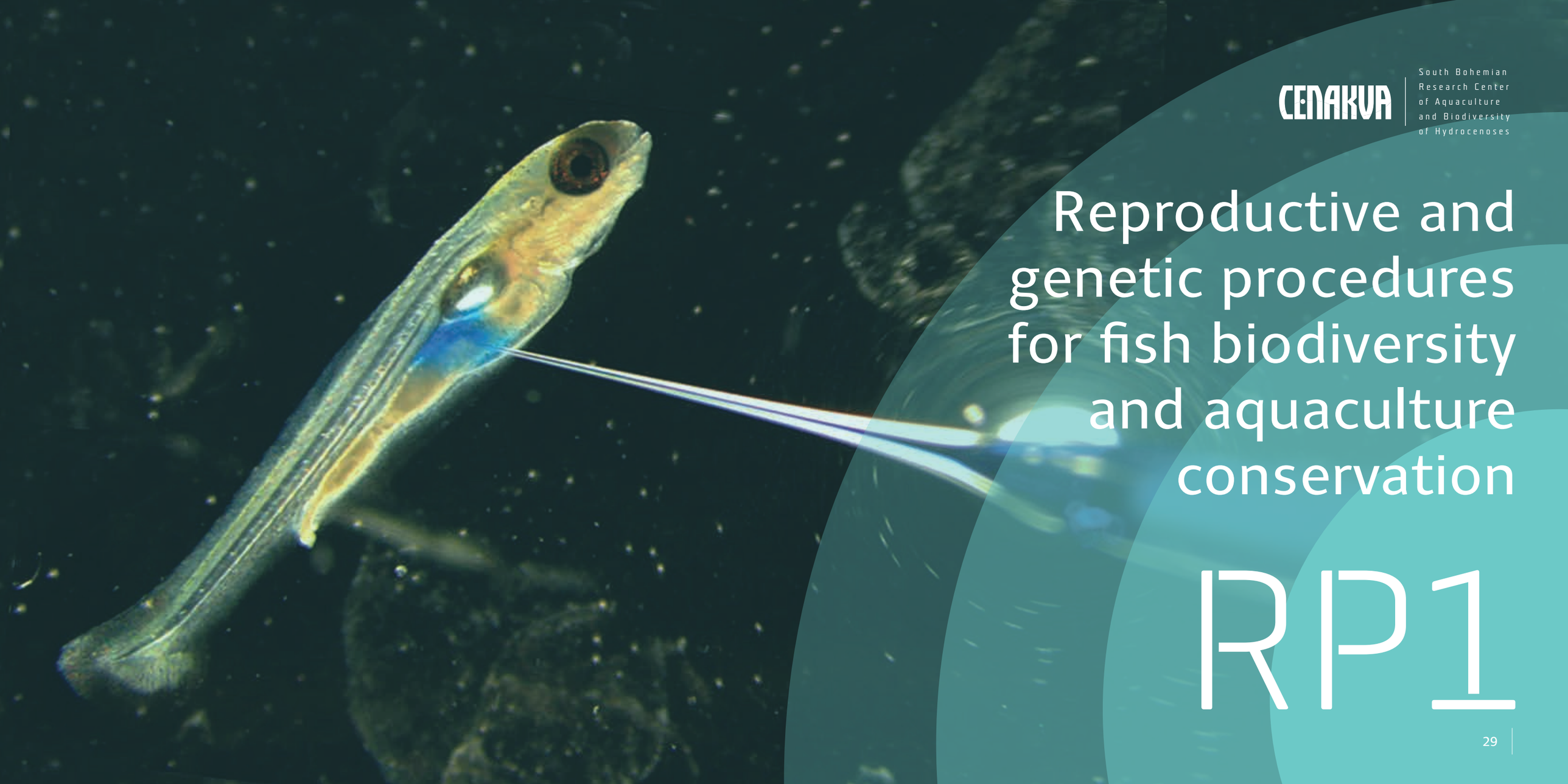
Professor Johan Verreth is an internationally recognised authority in the field of freshwater and marine aquaculture and fisheries. He has had a long-standing interest in the nutrition of aquatic organisms in different rearing systems, the adaptation of reared organisms to biotic and abiotic environmental conditions, and the impact of these organisms on water quality and the environment. Johan Verreth is a Professor Emeritus at the Department of Aquaculture and Fisheries, Wageningen University and Research, the Netherlands, which he also headed for many years. He has had an enduring relationship with the Faculty of Fisheries and Protection of Waters, specifically the Research Institute of Fish Culture and Hydrobiology, dating back to the time after the 1989 revolution. Besides the classical scientific cooperation, we adopted the so-called Wagening system of writing final doctoral theses, i.e. publishing a soft-cover modern-type thesis, and we got also inspired by the local system of teaching evaluation when we were establishing our Ph.D. studies at the Research Institute of Fish Culture and Hydrobiology. In 2015, the International Faculty and Centre Board was established with Prof. Verreth being elected to head the board. Criticism, recommendations, and also praise from the board have an impact on the overall development of the faculty, and regular evaluation is important for its sophisticated development. Based on the recommendation of the faculty, Prof. Verreth was nominated to the evaluation panel of the University of South Bohemia, where he serves as chairman. All the mentioned cooperation resulted in a partnership between the two institutions during the implementation of the international AQUAEXCEL project.

Associate Professor Marc Vandeputte is a respected expert in the area of genetics for the needs of sustainable aquaculture using different types of selection and breeding. His main species of interest are the common carp, the rainbow trout, the gilt-head sea bream and the European bass, but he is also involved in breeding crustaceans and oysters as the main aquaculture product of France. Marc Vandeputte was a member and later head of the INRA Fish Genetics Laboratory and now heads the INRAE-Ifremer Research group on Fish Genetics in Palavas les Flots, France. He is active in editorial boards of international scientific journals, evaluation panels and associations. Since 2015, he has been a member of the International Faculty and Centre Board. The joint collaboration between Marc Vandeputte and the Institute started already when Otomar Linhart was doing his internship in Angers, France. In 1995, Marc visited Vodňany for the first time and in 1998 the first joint publication was released (15 joint publications to date). Two French-Czech Barrande projects followed in 2001–2005, which were reflected in the key messages at the Czech Genetic Days conference in Brno in 2003 "How to breed carp appropriately in the future". Key papers from the project focused on the inheritance of utility traits in the carp were subsequently printed in Aquaculture (250 citations). The results became the basis for a change in the research focus regarding carp breeding in the Czech Republic from interbreed hybridization using the heterosis effect, introduced at the institute in 1975, to targeted selection of utility traits. He is also associated with the faculty in the field of projects, repeatedly coordinating the European project AQUAEXCEL, which brings together 22 major aquaculture institutes and faculties. Together with other European institutes, we offer our infrastructures in an open system accesss, including the funding of experiments for scientists from all over the world. We believe that AQUAEXCEL in particular has had a significant impact on putting CENAKVA on the scientific map of the Czech Republic, among the so-called large research infrastructures. AQUAEXCEL is also important for the focus of the faculty's research, which was especially evident in the laboratories of Petr Císař, Martin Pšenička and Martin Flajšhans. ◀

3 Research

CENAKVA

South Bohemian Research Center
of Aquaculture and Biodiversity
of Hydrocenoses



CENAKVA | South Bohemian Research Center of Aquaculture and Biodiversity of Hydrocenoses

Reproductive and genetic procedures for fish biodiversity and aquaculture conservation

RP1

RP1_ Reproductive and genetic procedures for fish biodiversity and aquaculture conservation

Head of the program: Assoc. Prof. Martin Pšenička, psenicka@frov.jcu.cz

The visions and goals of the research program:

A biodiversity conservation and development of a competitive freshwater aquaculture. A multi-disciplinary approach on a reproductive physiology and technology, molecular, cellular, quantitative and conservation genetics of individual species or higher taxa.

Also the development of reproductive technologies and germline stem cells bioengineering. The main goal is to establish an internationally acknowledged gene bank and improve competitiveness of European aquaculture with a significant share of the Czech Republic.

The results we have achieved:

To maintain the biodiversity of fish we have also contributed to the discovery of a unique way of sturgeon sperm maturation, which opened more possibilities for sperm preservation and reproduction. Our team described the unique process of sturgeon fertilization by multiple sperm at once, the so-called polyspermy. The researchers developed a method of cloning sturgeon based on nuclear transfer from the fin cell to the egg and monitored the unique development of the sturgeon's digestive tube.

By revealing specific features in the genome of beluga and sterlet, we created a simple method of identifying pure species and hybrids, which works reliably and to determine the species origin of caviar. The current living gene bank of sturgeon fish already includes 11 species – beluga, Siberian sturgeon, Russian sturgeon, ship sturgeon, stellate sturgeon, Adriatic sturgeon, shortnose sturgeon, white sturgeon, Atlantic sturgeon, and American paddlefish. Since the recognition of the Amur mirror carp at the end of 2014, the Genetic Fisheries Center has produced more than 100 million F1 hybrids with this breed for Czech and Polish fish farming. This is a good example of the immediate transfer of R & D results into practice.

Surrogate parenting in fish

Scientists from the Faculty of Fisheries and Protection of Waters have succeeded in producing offspring of the common carp (Cyprinus carpio) by transplanting germ cells into the goldfish (Carassius auratus). The method of "surrogate parenting" can also be used to save endangered fish species. A researcher who should take a lot of credit for that is Roman Franěk, Ph.D, from the Laboratory of Germ Cells, who completed his doctorate in 2019. During his Ph.D. studies he mainly focused on the reproduction of the above-mentioned fish species.

What is the principle of germ cell transplantation your research is based on?

Germ stem cells can be thought of as the raw material for building the bodies of organisms. Specialised cells develop during embryonic development. We can find them in individual tissues. Sexual cells have their embryonic, primordial form. As the fish matures, they differentiate and become either male or female – sperm or eggs. We can perform transplantation of germ stem cells. To develop and optimize the surrogacy, we are using zebrafish model. We isolate the primordial germ cells from one fish and transplant them into another, which subsequently becomes the surrogate parent.

How does this mechanism work in the common carp and goldfish?

We transplanted germ cells from a common carp into the body cavity of a goldfish fingerling with the aim to produce carp offspring. The carp germ cells were able to restart the production of gametes, sperm and eggs, in the surrogate goldfish parents. What's more, the transplanted male germ cells changed their sexual fate in the environment of the surrogate females, transforming into female cells. Therefore, what would have developed into sperm in the donor`s male carp body, developed into eggs in the female goldfish. Nevertheless, donor-derived egg contained the genetic information of the donor – the common carp. The goldfish then produces carp offspring. ↪

That doesn't sound so complicated.

The whole process is of course much more complicated. For the purposes of surrogate parenting, the fish must first become chimeras. In Greek mythology, it was a monster that had a body made up of different kinds of animals. In biology, it is a viable organism with cells from another or other organisms in its body. In the case of primordial germ cells, the future fish recipient must first be sterilized so that it cannot produce its own germ cells in addition to those of the donor. Sterilisation is carried out in various ways, including transgenic ways, for example by "switching off" genes. However, the germ cell transplantation itself is not genetic manipulation.

Who are the results of these experiments intended for? Could they be of any use, to production fishermen, for example?

These results are not intended for aquaculture. We do not assume, nor do we want, these goldfish swimming in the ponds to produce carp for Christmas. However, the surrogate parentage method can be used for breeding purposes and to produce experimental lines of the carp. Specific carp lines must be bred over a long period of time, which is demanding on space. In contrast, the goldfish is much smaller, and its breeding is simpler and cheaper. Regarding fish, only sperm can be cryopreserved, as the eggs are too large and will not survive the procedure. As opposed to that, female germ stem cells can be cryopreserved very efficiently. Thus, the female genetic material can be preserved for decades, and in the event of the loss of the precious breeds, the solution is to transplant the recovered germ cells into prepared sterilized goldfish to regain the desired carp offspring.

What else is interesting about the this study?

For example, it is the most distant surrogate parenting in vertebrates with successful production of viable offspring to date. The genera *Cyprinus* and *Carassius* are evolutionarily distant by approximately 34 million years. If we wanted to compare the evolutionary distance to humans, with more than a little imagination, a baboon could become a surrogate parent to humans, for instance. Much more importantly, the possibility of producing carp offspring through 10–100 times smaller individuals has been ascertained, opening up an alternative way of preserving and multiplying the genetic resources of this production-wise globally important species. At the same time, the possibility of surrogate parenting has been established in cyprinids with the potential to be used for the conservation of endangered members of this family, where the offspring of an endangered species will be produced through commonly bred species.

Is this method also applicable and usable for other fish species?

Surrogate parenting has similar potential for some endangered fish species, such as sturgeon. The largest and most endangered species of sturgeon, the beluga sturgeon, does not reach maturity before age of 20, while the much smaller sterlet as early as at the age of three years old. If we transplant germ cells from the beluga into the sterlet, we can obtain offspring from the beluga much earlier. Nevertheless, germ cells have a potentially wide range of applications in humans as well – for example, in situations where radiation treatment of a cancer patient may adversely affect his or her fertility. Transplanted stem cells can restore the ability of such an individual to have children. These methods are currently being carried out in primates and mice models. ◀

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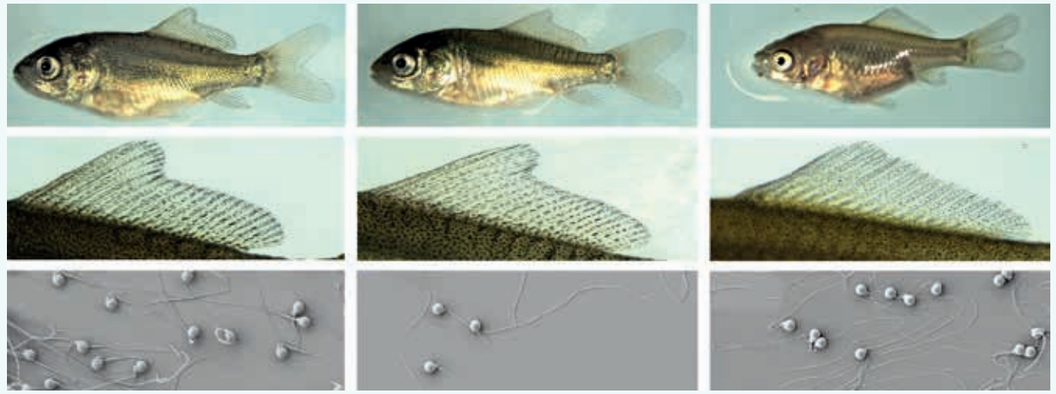
Franěk, R., Kašpar, V., Shah, M.A., Gela, D., Pšenička, M., 2021. Production of common carp donor-derived offspring from goldfish surrogate broodstock. Aquaculture 534: 736252. doi.org/10.1016/j.aquaculture.2020.736252

Project No. QK1910428: conservation of common carp genetic resources and generation of isogenic lineages by germ cell transplantation (National Agricultural Research Agency, 2019–2023)



How do freshwater fish sperm find the egg?

Most fishes are reproducing externally in the water, and this requires a broad set of evolutionary adaptations that will allow to support the whole process, including the specific structure of the gametes or features which support a new organism while developing in the water. These adaptations include in particular the evolution of a dense protective shield around the egg, which in most fish species has only a one tiny opening, called the micropyle, allowing the penetration of the spermatozoa through it.

Fertilization in the water entailed the appearance of a sophisticated system of spermatozoa motility initiation and further support of propagation using the "power" of external factors, e.g., ionic content or osmolarity of the medium serving as triggers. Many sea invertebrate organisms, which are broadcast spawners, use the water to spread the chemical signals from their eggs to the male gametes, allowing them to find each other. The scientists have uncovered the amazing membrane-associated system of receptors, channels and other molecules, making possible the precise guidance of the spermatozoa on its way to the egg in these marine invertebrates.

Freshwater fish are quite unique among all externally fertilizing organisms due to the specific conditions of the environment in which they live and reproduce. In particular, one of the features is the extremely low osmolarity, which acts very negatively on the reproductive cells. This condition makes the need for a specific support of cell encounters even more apparent. The eggs of many externally fertilizing freshwater fish species are released into the external milieu surrounded by a coat of ovarian fluid containing various ions, proteins, amino acids, sugars, etc. in proportions being ideal for supporting and protecting eggs and sperm against the harmful effect of freshwater.

There are data that show the positive effect of ovarian fluid or substances released by the eggs on the behaviour of male gametes and finally the outcome of fertilization. Some of the research results show the biased choice of genetic material from a specific parent caused by the presence of ovarian fluid, e.g. resulted from the enhanced sperm motility traits of a particular male. The specific mechanisms of this selection in externally fertilizing fish are still unclear, which makes further research in the field highly promising.

The members of the Laboratory of Reproductive Physiology are studying the phenomena of post-copulative female control over gamete encounter believing that new knowledge in this area will contribute not only to the fundamental physiology of reproduction but also to the optimization of artificial reproduction technologies. ◀

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Kholodnyy, V., Gadêlha, H., Cosson, J., Boryshpolets, S., 2020. How do freshwater fish sperm find the egg? The physicochemical factors guiding the gamete encounters of externally fertilizing freshwater fish. Reviews in Aquaculture 12: 1165–1192. doi.org/10.1111/raq.12378

Project 18-12465Y: An investigation of guidance mechanisms of spermatozoa in freshwater fish (Czech Science Foundation, 2018–2022)

Finding Egg

Fish with the highest chromosome count among all vertebrates originates from Vodňany

Polyploidization refers to the multiplication of one or more complete chromosome sets in an organism and represents an important step in evolution and speciation. Polyploidy, i.e. the status when the organism already has a higher number of chromosome sets in every cell, provides beneficial genetic flexibility and broader adaptive responses, i.e. additional gene copies theoretically allow evolution under reduced selective constraint and the acquisition of novel gene functions that contribute to adaptation.

The occurrence of polyploidy in vertebrates is rather sporadic compared to invertebrates and plants and is mostly restricted to amphibians and ray-finned fishes. The highest chromosome count of any vertebrate to date (2n ~ 446) was documented in ***Ptychobarbus dipogon***, a cyprinid fish from the Tibetan Plateau.

Critically endangered sturgeons, having undergone three whole genome duplication events, represent an exceptional example of ploidy plasticity in vertebrates. Three extant ploidy groups, combined with autopolyploidization, interspecific hybridization, and the fertility of hybrids are important issues in sturgeon conservation and aquaculture.

We studied the cases and outcomes of induced polyploidization. Artificial suppression of the first mitotic division alone, or in combination with suppression of the second meiotic division of functionally tetraploid zygotes (4n, C-value = 4.15) of Siberian sturgeon ***Acipenser baerii*** and Russian sturgeon ***A. gueldenstaedtii*** resulted in fry of various ploidy levels – diploid/hexaploid (2n/6n) mosaics, hexaploid, octoploid juveniles (8n), and dodecaploid (12n) larvae. Counts between 477 to 520 chromosomes in octoploid juveniles of both sturgeons confirmed the modal chromosome numbers of parental species had been doubled. This exceeds the highest previously documented chromosome count among vertebrates in the cyprinid fish Ptychobarbus dipogon and it demonstrates that the sturgeon genome can undergo numerous alterations of ploidy without severe physiological consequences, producing individuals with a range of ploidy levels and extremely high chromosome numbers. ◀

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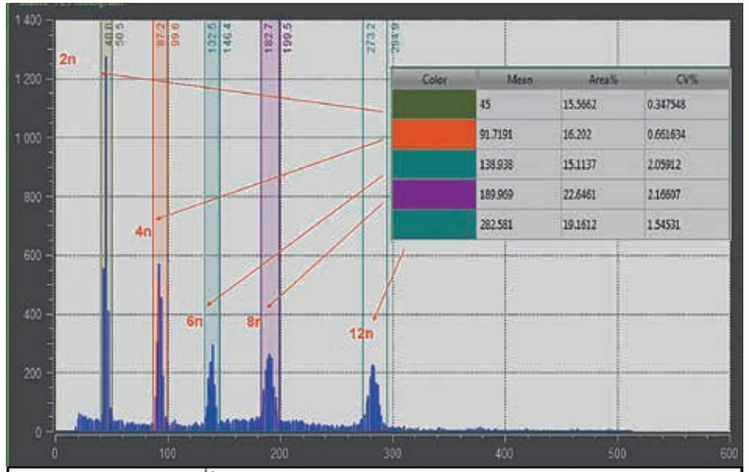
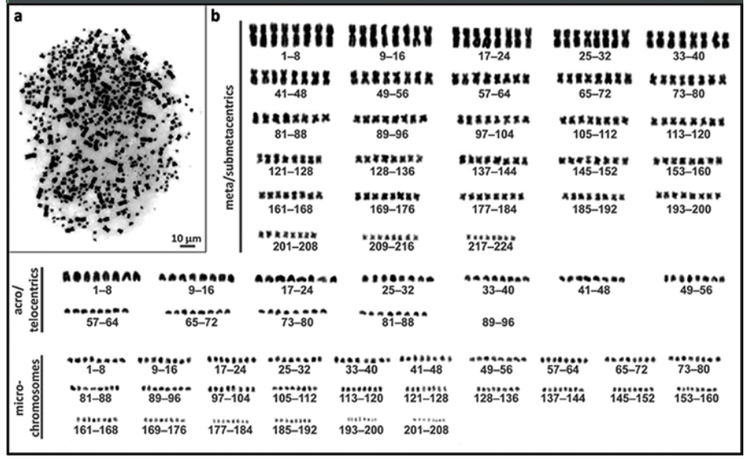
Lebeda, I., Ráb, P., Majtánová, Z., Flajšhans, M., 2020. Artificial whole genome duplication in paleopolyploid sturgeons yields highest documented chromosome number in vertebrates. Scientific Reports 10: Article No. 19705. doi: 10.1038/s41598-020-76680-4

Project No. GA18-09323S: Genome duplication in sturgeon evolution and impact on sturgeon biology (Grant Agency of the Czech Republic, 2018–2021)



Flow cytometry analysis of DNA content in a pooled sample of cells from four Siberian sturgeon larvae (2n/6n – mosaic fish; 4n – control; 8n – octaploid; 12n – dodecaploid).



Chromosomes of octoploid Russian sturgeon. (a) Metaphase spread obtained from leucocyte culture counting 520 chromosomes; (b) Corresponding karyotype composed of 224 metacentric/submetacentric chromosomes, 88 acrocentric/telocentric chromosomes, and 208 microchromosomes.

Learnings from an internship will be used in carp breeding

Martin Prchal, Ph.D., spent 2021 in France, where he completed an internship at the national research institute INRAE near Paris. He worked there on the rainbow trout genomics in order to learn new breeding techniques and to subsequently apply them at the faculty to breeding the common carp and other fish species.

In 2021, you spent a year at a French institute near Paris that deals with animal breeding. What was the aim of your internship?

I worked there in the GenAqua research team, focusing on breeding rainbow trout. In this research, we looked for specific positions in the DNA that might be related to an observed utility trait by comparing several thousand to tens of thousands of single-nucleotide polymorphisms (SNPs) within the genome. The most commonly observed traits are the growth rate, muscle fat content and disease resistance. However, the objective of my work was to study the genetic causes of resistance to hypoxia and hyperthermia in the rainbow trout.

How are these two factors related?

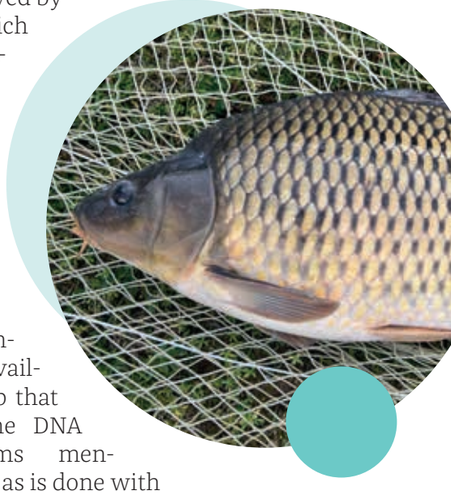
They go hand in hand. The higher the water temperature, the more oxygen the fish needs for its metabolism. Based on research into this resistance, I tried to delve deeper into the mysteries of genomics and statistical analyses that necessarily go with this issue.

Does this correspond with what you were engaged in at our faculty before your internship?

Prior to my internship, I was involved in carp breeding by estimating heritability and genetic correlations of major utility traits using a pedigree chart. However, research is shifting towards genomics today. Across the entire genetic information of a particular fish species, we search for stretches of DNA that explain the genetic variability of a trait, and we annotate genes that may influence the correct or incorrect function of that trait in those stretches. The goal of my internship was to learn these methods on the trout and bring the experience back to the faculty to try to apply them to the carp, for example.

Thus, to link new findings with what you were doing before...

Exactly. We have a carp breed called the Amur mirror carp. Our faculty has bred the so-called Vodňany line. We are now establishing its second generation, which we are breeding not only for faster growth but also for the type of scaliness, as the Amur mirror carp often does not have a typical mirror phenotype. Therefore, in addition to the fish with the best growth, we also select those with the desired scaliness. Both traits have a high degree of heritability, so they can be improved by selection, which will be reflected in subsequent generations. Nevertheless, the problem with the carp is that it does not have a commercially available SNP chip that can track the DNA polymorphisms mentioned above, as is done with the salmon or the rainbow trout. The use of genomics in carp breeding is therefore still considerably limited.



Is the development of selective breeding in other fish species on the horizon as well?

I hope so. We're planning a project on the burbot. We were approached by Jakub Vlček, a graduate of our faculty, who has been intensively involved in breeding burbot. We would like to concentrate on increasing the speed of growth rate in this species, which is the most important utility trait. The burbot is an interesting species that is the only representative of gadids in freshwater with an excellent taste of meat. Additionally, its liver is not only good for consumption but is also a rich source of vitamins A, D and K as well as other substances used in natural healing. ↪

How would you evaluate your internship in France in retrospect?

I found it to be very beneficial, even though I spent most of my time at the computer doing statistical analyses and unfortunately, I never once touched a fish. In fact, the coronavirus pandemic was still raging at that time, and so my work responsibilities were more or less confined to the office area. Owing to this, however, I learnt how to statistically evaluate genomic data and I have already been using these learnings here at the faculty. Nevertheless, I'm glad to be back, as I missed the contact not only with the fish but also with my colleagues from the lab as well as the Genetic Fisheries Centre. We have a great group that I can always rely on in the challenging genetic research. ◀

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Prchal, M., Kocour, M., Vandeputte, M., Kause, A., Vergnet, A., Zhao, J., Gela, D., Kašpar, V., Genestout, L., Bestin, A., Bugeon, J., 2020. Morphological predictors of slaughter yields using 3D digitizer and their use in a common carp breeding program. Aquaculture 520: 734993. doi.org/10.1016/j.aquaculture.2020.734993

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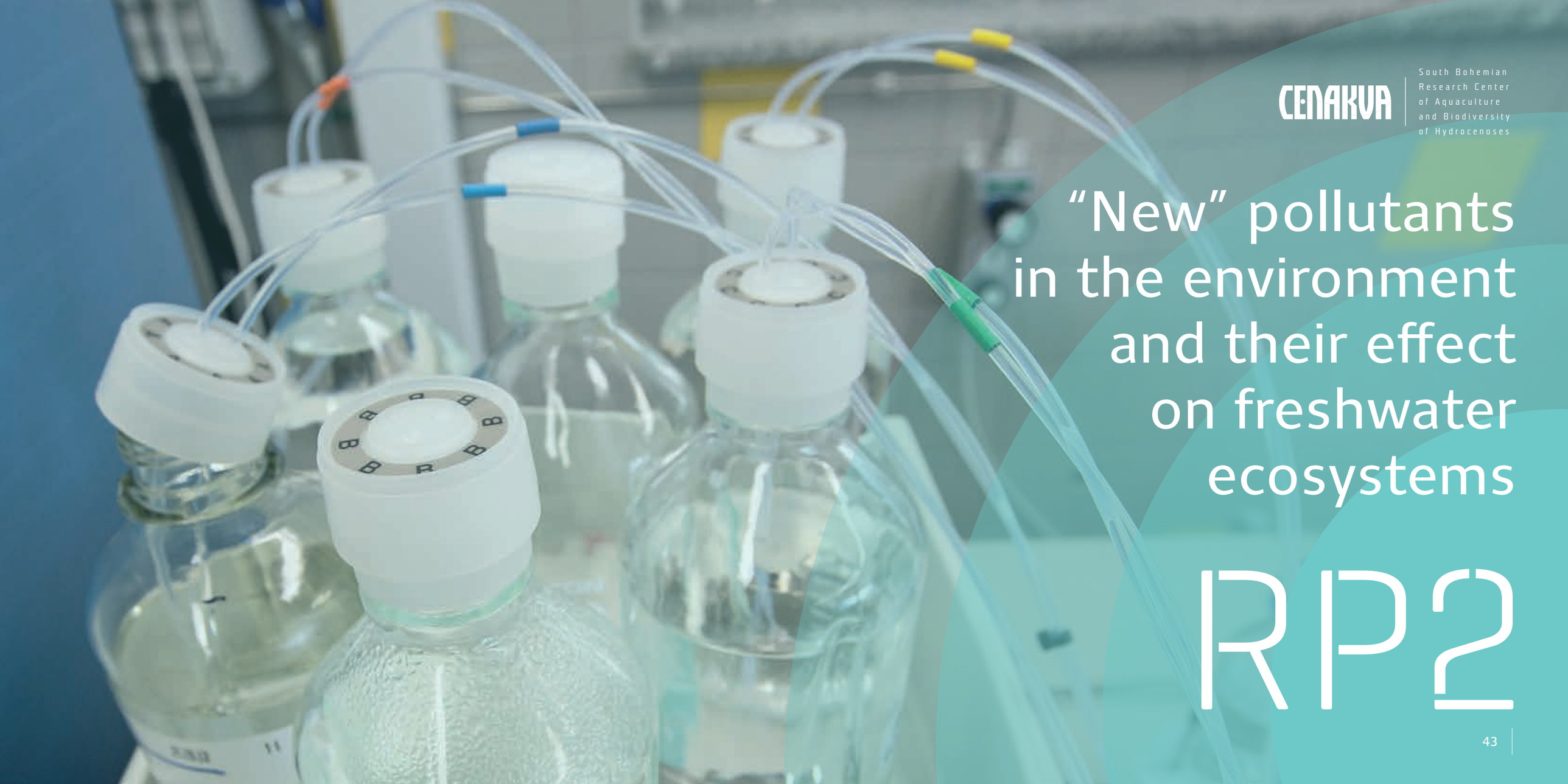
Project No. QK1910430: Innovation of technological elements in breeding the common carp to maximize the high potential of selection programs under pond management conditions (National Agricultural Research Agency, 2019–2023)

Project No. CZ.02.1.01/0.0/0.0/16_025/0007370: Reproductive and genetic approaches for conservation of fish biodiversity and aquaculture (Ministry of Education, Youth and Sports, 2018–2022)

New accommodation premises for scientists from abroad

The faculty is well aware of the importance of international cooperation, which includes visits and employment of foreign scientists. This inevitably entails the need for the availability of adequate accommodation facilities. On 10th June 2020, the ceremonial ribbon was cut at the new accommodation premises in Říční Street in Vodňany. The faculty now has three flats for postdoctoral researchers and foreign employees available as well as a maintenance facility for the technicians and caretakers. Previously, the entire building and the adjacent land were used by the town fishermen. In 2019, the FFPW managed to purchase the property and begin renovation. The renovated building can be found close to the MEVPIS centre, completing the pleasant and stylish environment of the whole premises. The reconstruction of the building was financed by the faculty funds with support from the Strategic Priorities Fund of the University of South Bohemia in České Budějovice. The reconstruction was undertaken by Mr. David Štefan, with the total cost of the project exceeding CZK 9 million including VAT. During the opening ceremony, a Memorandum of Cooperation was signed by the university representatives and the Mayor of Vodňany. ◀



CENAKVA | South Bohemian Research Center of Aquaculture and Biodiversity of Hydrocenoses

“New” pollutants in the environment and their effect on freshwater ecosystems

RP2

RP2_ "New" pollutants in the environment and their effect on freshwater ecosystems

Head of the program: Prof. Tomáš Randák, trandak@frov.jcu.cz

The visions and goals of the research program:

The presence of extraneous substances in the aquatic environment represents a significant factor influencing the health status of aquatic organisms, including their natural reproduction and behaviour. A spectrum of chemical substances produced and used by people has constantly extended. Significant sources of the environmental contamination are not only industrial activities and agricultural production, but also municipal waste waters. Despite the fact that these waters have been treated in wastewater treatment plants in developed countries, it has been evident that existing technologies cannot eliminate a broad spectrum of extraneous compounds. These compounds, mainly human and veterinary pharmaceuticals (hormonal preparations, medicine lowering high blood pressure, antibiotics, antidepressants, analgesics, antirheumatics, antiepileptics, statins etc.), components of cosmetic products, perfumes, detergents etc. and their degradation products or metabolites (summarized as PPCP – Pharmaceuticals and Personal Care Products) get into the aquatic environment through 'treated' waste water discharged from waste water treatment plants where they can affect present organisms. The fate of these compounds in the wastewater treatment plant technologies has still not been sufficiently examined. The issue of PPCP in the aquatic environment has been currently one of the main topics of world environmental research. More and more studies have emphasised the negative impact of extraneous substances originating from municipal waste waters on wild animals. The presence of PPCP and pesticides has been proven even in drinking water. At this time, there is basically no information concerning impacts of this type of contamination on entire ecosystems or trophic chains.

The objective of the program is excellent comprehensive research regarding the fate of 'new' extraneous compounds in aquatic and soil environments and a critical assessment of their impacts on exposed organisms and communities. These newly discovered findings have a key significance for economically meaningful strategic planning in the spheres of waste water treatment, drinking water treatment and landscape management.

The results we have achieved:

The research team have actively and regularly participated in the implementation of the national program for the monitoring of surface water quality, coordinated by the Czech Hydrometeorological Institute. It intensively cooperates with "Povodí" companies, wastewater treatment companies and drinking water treatment facilities in the field of micropollutants monitoring. Together with Norwegian (COWI) partner, we have repeatedly succeeded in international tenders focused on identifying new pollutants in environmental matrices.

Involuntary psychotherapy in rivers

Not many people realise that swallowing a pill to treat tonsillitis, headaches or depression affects the environment. Once eliminated from the body, these substances find their way through sewage treatment plants into the environment, where they can have a negative effect on aquatic organisms. What are the consequences of such massive use of pharmaceuticals by society as a whole? Kateřina Grabicová, Ph.D., from the Laboratory of Environmental Chemistry and Biochemistry at the Faculty of Fisheries and Protection of Waters researches micropollutants, including pharmaceuticals and personal care products.

Recently, a report about trout addicted to methamphetamine has circulated in the Czech and international media. Could you tell us what it is about?

This was a study that presented the results of an experiment in which our laboratory collaborated with scientists from the Czech University of Life Sciences. We ascertained that trout exposed to methamphetamine for a long time began to show signs of addiction and withdrawal symptoms after the source of it was removed. Methamphetamine is a very popular drug in the Czech Republic. It enters the wastewater together with its metabolite – amphetamine. Most sewage treatment plants are unable to remove these substances completely, so it is then found in surface water. In this experiment, the trout were exposed to concentration levels found in many Czech streams.

Does that mean that our streams and rivers are full of drugs?

That's certainly not the case. It refers to places where the "treated" municipal wastewater outflows. The degree of dilution is also a significant factor. For example, the wastewater flowing from the Prague sewage treatment plant into the Vltava river is not such a problem due to its high dilution. The situation is worse in cases where the treated wastewater forms a significant part of the total flow of the receiving water, as in the case of the Živný stream in Prachatice, which is our model site. We find pharmaceuticals and other selected micropollutants in fish and aquatic invertebrates at this location. ↪

What groups of foreign substances do you focus on in the laboratory?

Besides pharmaceuticals and personal care products, our team has recently been dealing with bisphenols, pesticides and perfluorinated substances, for example. As far as pharmaceuticals are concerned, we currently have a project focusing on psychoactive substances, as their consumption in society has been increasing recently. These include antidepressants, opioids and illegal drugs, and we are looking at their effect on the behaviour of aquatic organisms.

In what ways can these substances affect aquatic organisms?

The brain is the target organ of action of psychoactive substances, as they tend to bioaccumulate there. Behavioural changes occur in exposed individuals. In the case of exposure to the antidepressant sertraline, food intake was affected in exposed fish compared to control fish. After being exposed to tramadol, a painkiller, the fish were less daring, spent more time in hiding, and overall there was a breakdown in schooling behaviour. These substances also influenced the crayfish's behaviour – changes were observed in the speed of movement, time spent in hiding, or distance travelled by the crayfish. Exposure to citalopram (an antidepressant) or tramadol led to a reduction in food intake in dragonfly larvae, while exposure to real treated wastewater had the opposite effect.

What does this imply?

That there can be a big difference between the results of laboratory and field research. While in laboratory conditions, we study the effect of one, or at most a few drugs, in the aquatic environment, these substances act in the form of a mixture, or if you prefer a cocktail, which may contain a whole range of them. The micropollutants dissolved in this mixture can have a synergic but also opposite effect.

Let's go back to the meth-addicted trout. If people eat fish like that for lunch, does it affect them?

We are talking about very low concentrations – several nanograms per gram of fish tissue (ng/g). Moreover, the target organ of these substances is not the muscle tissue we consume. Pharmaceuticals mainly bioaccumulate in the kidneys and liver, and we have also found psychoactive substances in the brain. Twenty-five out of the seventy pharmaceuticals analysed were found in the individual organs of trout coming from the recipient where the treated effluent flows. The highest total concentration (500 ng/g) was found in the kidneys, and only up to 100 ng/g in the liver. Only four substances were found in the muscle at really low concentrations (less than 5 ng/g). Thus, there is nothing to worry about in terms of consumption of such fish.

Are there any solutions to clean the water of these foreign substances?

Certainly, it is the development of new cleaning technologies. As an example, I would mention a drinking water treatment plant that takes water from a river. In the upper reaches of this river, the concentration of micropollutants, mainly pharmaceuticals and pesticides, is at a low level. However, as the river flows through the landscape, the concentration of these substances in the river water increases. Existing technology for treating drinking water was not sufficient, therefore, new technologies such as granular activated carbon filtration had to be upgraded and incorporated into the treatment process.

I don't think this will be a cheap solution.

Definitely. However, research and development in the field of cleaning technology is at a very high level and has certainly not been stagnating. What is important is that we realise the importance of clean water. That is also why Israel is said to be a leading country in this respect. They live in an area where water is scarce and they purify seawater. The scarcity has taught them to value this natural resource.

How important is international cooperation in your area of focus?

For us it is absolutely essential. Among others, we collaborate with colleagues from laboratories in Sweden, Norway, Portugal, Great Britain, Slovakia and even Texas. And since 2013 we have been involved in an international project to detect illegal drugs in water flowing to wastewater treatment plants. The research takes place once a year over a one-week period in selected cities, when water samples are taken and monitored for the presence of drugs.

What did you find out?

While in Central Europe, including the Czech Republic and Slovakia, methamphetamine dominates, in Western Europe, for example in Amsterdam or other port cities, cocaine is "winning". This is linked to the socio-economic level of the population in these countries. ◀

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Prestigious EXPRO project

Holistic characterization of exposure and potential effects of complex chemical mixtures in the aquatic environment.

The project under the auspices of the Grant Agency of the Czech Republic has been implemented since the beginning of 2020, with a budget of almost CZK 50 million. Scientists from two institutions, the Faculty of Fisheries and Protection of Waters USB and RECETOX – the Faculty of Science of Masaryk University in Brno – take part in it.

We would like to develop a conceptual framework for risk assessment of chemical mixtures and improve the understanding of the cumulative risk from regulated and emerging bioactive chemicals present in surface waters. The methodology will combine innovative methods for exposure characterization using passive sampling, with bioanalytical tools for identifying its potential effects. A newly developed battery of high-throughput bioassays will address crucial mixture effects on endocrine disruption and (neuro) development, and also focus on relevant but little explored mechanisms of action including the disruption of thyroid hormone signalling. A combination of high-throughput target and nontarget analyses using advanced high-resolution mass spectrometry together with fractionation and pull-down approaches will enable to characterize complex pollution scenarios and identify responsible effect drivers. The predictability of the bioanalytical responses towards real environmental situations will be assessed by the investigation of ***in situ*** chemical impacts on exposed fish and invertebrates. ◀

Effluents from WWTPs are still a significant source of contamination for the aquatic environment with foreign substances.

Methamphetamine in the aquatic environment can elicit addiction in fish

Trout exposed to methamphetamine for long periods of time become addicted to it and show withdrawal symptoms after it is removed. This was ascertained by a team of scientists from the Czech University of Life Sciences Prague and the Faculty of Fisheries and Protection of Waters at the University of South Bohemia in České Budějovice.

Their research aimed to monitor the presence and effects of psychoactive substances in the aquatic environment, to which enter through municipal wastewater. The research included a laboratory experiment studying the effect of methamphetamine on the behaviour of the trout. "The fish were exposed to concentrations of this drug that are close to those found in the aquatic environment," explains Pavel Horký, head of the research from the Department of Zoology and Fisheries at the Czech University of Life Sciences. Methamphetamine is a very popular drug in the Czech Republic, as evidenced by its frequent presence in a number of monitored sites in our watercourses. Its highest concentrations have been found in locations where treated municipal wastewater flows in.

Psychoactive substances affect the nervous system in fish in a similar way to humans. The trout exposed to methamphetamine during the experiment began to actively seek out its source and reduced their movement, among other things. These changes were accompanied by the presence of amphetamine (a metabolite of methamphetamine) in the brain as well as a change in its overall metabolome. ↪

The results of this research also imply possible ecological connections. The frequent, even unnaturally high abundance of fish below the WWTP discharges can be partly explained by the abundant occurrence of food; however, some substances present in the wastewater (e.g. the researched methamphetamine) may attract fish even more to the pollution source. Wastewater also carries other chemicals into the water that are increasingly used by humans, giving rise to a cocktail of residues of pharmaceuticals, detergents, disinfectants and cosmetics, as well as drugs. "The presence of psychoactive substances in the aquatic environment may be associated with a loss of interest in food intake or a suppression of escape reactions from predators," says Tomáš Randák, head of the collaborating Laboratory of Environmental Chemistry and Biochemistry at the FFPW USB, describing the possible effects of drugs on fish. Drug addiction can have similarly negative impacts on wildlife populations as on human society. ◀

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Horký, P., Grabic, R., Grabicová, K., Brooks, B. W., Douda, K., Slavík, O., Hubená, P., Sancho Santos, E.M., Randák, T., 2021. Methamphetamine pollution elicits addiction in wild fish. Journal of Experimental Biology 224: jeb242145. doi.org/10.1242/jeb.242145

Project No. 20-09951S: "Living" water – complex response of aquatic animals to the presence of psychoactive substances from municipal pollution (Grant Agency of the Czech Republic 2020–2022)

Investing in the protection of water resources is the most meaningful thing to do

Possible uses of wastewater and sludge in agriculture, efficiency of treatment technologies in the degradation of selected micropollutants, or research on new pollutants Helena Švecová, Ph.D., presents the projects that she and her colleagues from the Laboratory of Environmental Chemistry and Biochemistry have been collaborating on with water treatment plants, scientists from the Czech University of Life Sciences and Norwegian partners.

Issues related to pollution by so-called micropollutants are crucial today. What projects are you working on in this regard?

There are several such projects, covering a wide range of pollutants. I would certainly mention the National Agency for Agricultural Research project "The Fate of selected micropollutants occurring in the treated water and sludge from the wastewater treatment plants, and in soil" (No. QK21020080, 2021–2023), which we are working on with colleagues from the Czech University of Life Sciences. We are researching the possibilities of using wastewater and sludge or compost from wastewater treatment plants in agriculture. We have beds with different types of soil and plants, such as corn, lettuce, carrots, and onions. We placed compost produced in the treatment plant in some of the beds, and a part of them is watered with treated wastewater. Our aim is to investigate the fate of the selected substances in the soil, or possibly in the plants

What substances are we talking about?

Various pharmaceuticals, UV filters and anti-corrosive agents. These are micropollutants commonly occurring in wastewater. We are observing how these substances are absorbed into the soil, or whether they are transferred to plants. The question is how the substances are metabolised in the plants and if their possible concentration in crops poses a risk to consumers, whether they are humans or farm animals.

Why is the use of wastewater in agriculture being considered?

It is related to drought and climate change. It is an adaptation to tackle water scarcity with

more pressure on using water for irrigation. A lot of wastewater treatment plants are more likely to switch to drying the waste sludge, incinerating it, and using it as an energy source. There are concerns about the use of wastewater treatment plant products in agriculture due to their contamination with the substances we are looking at in our research. We may prove that these fears are unfounded.

What stage of research are you currently in?

This is a three-year project that will end in 2023, hence we will have to wait for the final results. The important thing is that this is the first research directly in the field. Until now, the research has been carried out under laboratory-controlled conditions.

The risk of contamination by certain types of micropollutants has also been discussed in the context of drinking water resources.

This was the focus of the National Agency for Agricultural Research project "The occurrence of pharmacological and other pollutants from municipal wastewater in the basins of key waterworks resources of the Czech Republic" (No. QJ1530120, 2015–2018), which monitored the fate of selected substances in basins that serve as important sources for drinking water production, namely the basins of the Úhlava, Malše and Želivka rivers. We were interested in the water within the basin, the raw water that flows into the water treatment plant, and the treated water that flows out of the plant. We focused on pharmaceuticals as well as pesticides. We researched the fate of these substances within different phases of water treatment in the water treatment plants, specifically how technology affects their removal.

What conclusions did you reach?

We came to the conclusion that in many places we can no longer produce drinking water of sufficient quality without more expensive purification technologies. However, these technologies are very expensive, which also relates to the operational costs of maintaining them. Contract research is currently underway in the water treatment plant in Plav near České Budějovice. We are investigating to what extent granular activated carbon filters can degrade micropollutants and how the efficiency of these filters changes with time. The water treatment plant in Plav is considering which technologies to invest in next, and our research should help them to do this.

So what factors determine how clean the water that we drink is?

Besides the level of water treatment technology, it is of course the quality of the incoming water itself. For example, the Nýrsko reservoir on the Úhlava river boasts really clean water, which cannot be totally said about the groundwater, though. Research we are carrying out with the Czech Hydrometeorological Institute shows that groundwater gets contaminated with pesticides. However, this also applies, for example, to Římov on the Malše river. We are still finding pesticides in the sediments at the bottom, which have been banned for a long time. In addition to investing in treatment technologies, it makes the most sense to me to invest in the protection of water resources themselves.

You have also been cooperating with the Norwegian company COWI. What type of research is involved?

These are shorter-term contracts of a contractual nature. A company working with the Norwegian Environment Agency orders the monitoring of selected substances from us. They identify interesting, new micropollutants, sending us environmental samples, and we analyse them. It is an opportunity for us to investigate something new – substances that may subsequently also become the subject of our research. To strengthen bilateral cooperation, we have a small project from the Norwegian funds – Trolltunga – "Strengthening of the collaboration between the University of South Bohemia in České Budějovice and COWI AS in Water Monitoring" (No. 1404572019).

Is there another project you are working on?

We have an interesting cooperation with the Faculty of Science, University of South Bohemia, namely with Assoc. Professor David Boukal from the Department of Ecosystem Biology. It is a project of the Czech Science Foundation "Understanding the impact of combined stressors on freshwater biota: will climate change alter the impact of chemical pollution?" (No. GA20-16111S, 2020–2022). This involves a simulation of an aquatic ecosystem in special water tanks. In them, we investigate the combined impact of both chemical pollution (pharmaceuticals and pesticides) and climate change (temperature change) on freshwater organisms, especially invertebrates. ◀

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Project No. LM2018099: South Bohemian Research Centre for Aquaculture and Biodiversity of Hydrocenoses (Ministry of Education, Youth and Sports, 2019–2022)

Šauer, P., Švecová, H., Grabicová, K., Aydin, F.G., Mackuľak, T., Blytt, L.D., Henninge, L.B., Grabic, R., Kocour Kroupová, H., 2021. Bisphenols emerging in Norwegian and Czech aquatic environments show transthyretin binding potency and other less-studied endocrine-disrupting activities. Science of the Total Environment 751: 141801. doi.org/10.1016/j.scitotenv.2020.141801

Project No. 20-04676X: Holistic characterization of exposure and potential effects of complex mixtures of chemical substances in the aquatic environment (Czech Science Foundation, 2020–2024)

Wastewater reuse in aquaculture: to use or not to use?

Aquaculture is the fastest-growing sector of global food production. The continued growth and long-term sustainability require abundant water of sufficient quality. Reuse of wastewater is becoming an increasingly important consideration for aquaculture. Yet, safety issues emerge for water reuse in aquaculture.

Among other anthropogenic pollutants, pharmaceuticals represent an important concern. They are ubiquitously present in urban wastewater due to wide consumption and incomplete removal during conventional wastewater treatment. The consequent continuous discharge is affecting aquatic life.

In the current study, we tested the efficiency of a biological pond to remove pharmaceuticals from treated wastewater and assessed the risks of using the reclaimed water for fish production. Based on the results, the system appears useful as a tertiary wastewater treatment step to reduce present pharmaceuticals. Potential ecotoxicological hazards, including antibiotic resistance, were significantly reduced, which may be essential for the subsequent reuse of "treated" wastewater in aquaculture. ◀

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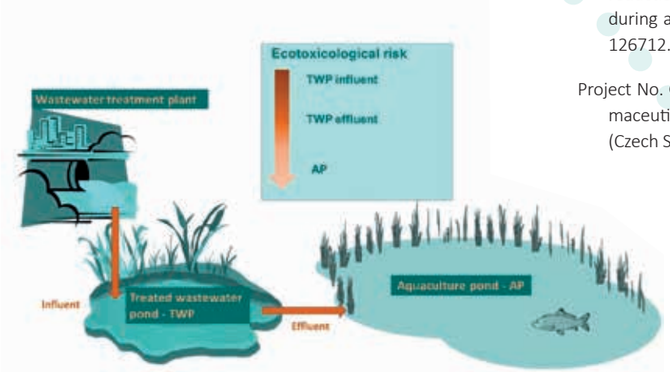
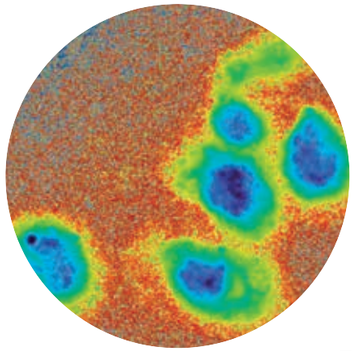
Fedorova, G., Grabic, R., Grabicová, K., Turek, J., Van Nguyen, T., Randák, T., Brooks, B.W., Žlábek, V., 2022. Water reuse for aquaculture: Comparative removal efficacy and aquatic hazard reduction of pharmaceuticals by a pond treatment system during a one year study. Journal of Hazardous Materials 421: 126712. doi.org/10.1016/j.jhazmat.2021.126712

Project No. GA18-15802S: Environmental transformation of pharmaceuticals in the common recipient of treated sewage water (Czech Science Foundation, 2018–2022)



Schematic overview of the researched ecosystem.



A unique method of optical microscopy

A breakthrough method that will allow a better insight into the interior of a living cell has been brought about by the research of scientists from the Laboratory of Experimental Complex Systems at the Faculty of Fisheries and Protection of Waters, University of South Bohemia, in Nové Hrady. Their quasispectral analysis of living cells will find use, for example, in studying tissues, but also in materials engineering. Most recently, the South Bohemian scientists have been cooperating with their Viennese colleagues, who want to use the new method to research the emergence and disorders of immunity to the SARS-CoV-2 virus.

The human body is made up of cells. If we want to understand it, we need to understand the function of the cells and their components. However, no one has seen so far what really happens in a living cell as there was no tool to see into the cell without altering it. These alterations are made either by chemical staining or by methods of molecular biology when genes for a coloured protein are being inserted into the genome of the cell. Both of these interventions are strong, either killing the cells directly or altering them fundamentally. In addition, they are often expensive and demanding extensive instrumentation and expertise. A team of scientists led by Prof. Dalibor Štys has developed a procedure to extract as much information from a cell as possible using a conventional microscope with a digital camera, i.e. a common piece of laboratory equipment nowadays. "The most important aspect of this method for studying tissues is that we can work with unstained samples and compare the results objectively with data obtained anywhere around the world," says the laboratory head Dalibor Štys. "In materials engineering, chemical staining cannot be used at all. Therefore, structural defects cannot be found in many cases until the component fails, for instance. This is what our quasispectral analysis using a conventional microscope with new mathematical techniques solves," he adds. "The latest activity is our collaboration with the Vienna Clinic for the Treatment of Immune Disorders, which is investigating the emergence and disorders of immunity to the SARS-CoV-2 virus. That is where our ability to rapidly and reproducibly detect a change in the state of a living unstained cell should be applicable," says Štys.

The new approach can be used not only in medical diagnostics, for example, in acute tumour diagnosis, but also in many other applications, including materials engineering and analysis of nanostructured materials. Frits Zernike was awarded the Nobel Prize in 1953 for a similar method, which requires more sophisticated microscopes, however. On the contrary, the 2014 Nobel Prize in Light Microscopy was awarded to Eric Betzig, Stefan Hell and William Moerner for methods that use stained cells. ◀

CENAKVA

South Bohemian Research Center of Aquaculture and Biodiversity of Hydrocenoses

Sustainable aquaculture with a responsible water and nutrient management

RP3

RP3_ Sustainable aquaculture with a responsible water and nutrient management

Head of the program: Assoc. Prof. Jan Mráz, jmraz@frov.jcu.cz

The visions and goals of the research program:

The vision of the research programme is the aquaculture as the future solution for maximum production of quality foodstuffs for people with minimum consumption of water and energy, minimum production of waste matters, minimum 'food miles' and minimum competition for resources with consumption regarding people and farm animals. The next objective is that the aquaculture industry, which is dependent on the supply of fish from oceans and pollutes aquatic resources, would become an industry independent on sea fishery with a negative balance of waste production.

The objective is to develop technologies enabling the maximum use of nutrients, wastes, including municipal waste of vegetable and animal origin, and energy for production of fish and plants with minimum released waste products and greenhouse gases into the environment. The key outputs of the RP will be mutually connected technologies for the production of fish, plants and other organisms with treatment and use of waste therefore enabling maximum use of nutrients directly on an aquaculture or aquaponic farm with minimum released waste products into the environment. The target results are those having a significant impact for the entire society, mainly for ensuring enough high-quality foodstuffs, minimization of the production of greenhouse gases, use of waste, reduction in food miles and thus a decrease in fossil fuels, decrease in water consumption and production of waste, decrease in water eutrophication and reducing dependence of aquaculture on fishery.

The results we have achieved:

The research team thanks to their applied research and broad national and international cooperation regularly contributes to technical and technological innovations and optimizations of intensive breeding of valuable fish species such as pikeperch (*Sander lucioperca*), perch (*Perca fluviatilis*), burbot (*Lota lota*) and other species. Recently, a special airlift system has been applied in fish culture practice to streamline water flow and sediment deposition in culture tanks. Furthermore, there was a description of the artificial induction of the production of triploid pikeperch and the optimization of the initial exogenous nutrition in pikeperch larvae using rotifers *Brachionus plicatilis*, that increases survival of reared fish by 30–40%. The research team was engaged in research of serious viral diseases of cyprinids species, which in recent years has contributed to increased carp mortality in ponds in spring and autumn. The team has developed a patented carp breeding technology with increased omega-3 fatty acids (Omega3carp) and tested its positive effects in the treatment of cardiovascular disease. Omega3carp has been available for several years on the pre-Christmas market. We are planning to build aquaponics research centres for the further development of sustainable aquaculture and other water and nutrient-efficient technologies.

Project Algae4fish: From microalgae to pikeperch

Recycling nutrients from wastewater, sustainable aquaculture, and economically attractive freshwater fish production – these are the keywords of the international Algae4fish project, which brought together scientists and fish farmers from Austria and the Czech Republic.

The idea of the project entitled "The Recycling of Nutrients from Agro-Industrial Residues by Cultivating Microalgae as Fish Feed" was to design and test a continuous integrated larval feeding system (C.I.L.F.S.) technology, which, thanks to an innovative feeding strategy, helps to improve larval survival and growth of economically valuable fish species. In the second phase, the project deals with the valorisation of nutrients from wastewater and their use to cultivate microalgae.

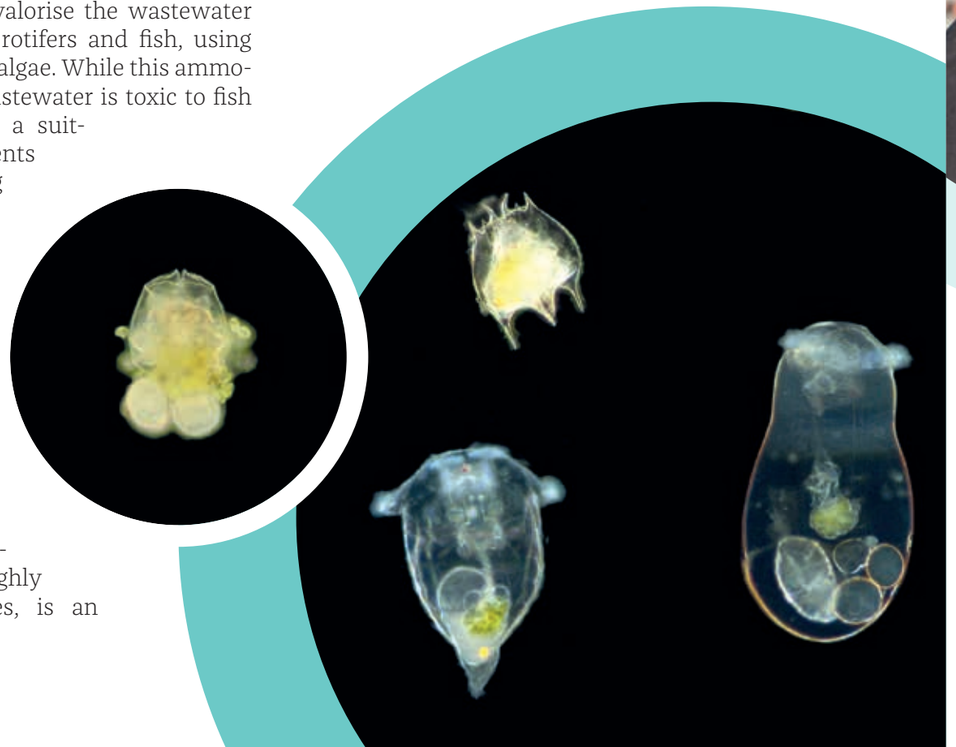
"We focused on the pikeperch, a fish highly valued in gastronomy. Recent research has ascertained that the survival and growth of the pikeperch in its early developmental stages are improved by feeding rotifers," says the project supervisor, Carlos Yanes Roca, Ph.D., from the Laboratory of Intensive Aquaculture. Rotifers are small zooplankton species that can be cultured in aquaculture facilities. The automated system we are developing is based on the natural food chain, where the selection of suitable strains of microalgae and zooplankton species can provide a diet rich in vitamins and essential fatty acids, which are vital for larval development.

The C.I.L.F.S. consists of a photobioreactor for cultivating algae, subsequently used to feed the rotifers. The rotifers are then produced in a high-density system, which provides food for fish larvae. The larvae are fed 24/7. The system includes software developed

by us, which monitors the production of both algae and rotifers and adjusts ***in situ*** feeding quantities based on plankton concentrations to optimise plankton and larvae growth.

The project's main task is to synchronize and streamline the entire fish feeding system, e.g. by finding different algae with desired nutritional values or by solving the time-demanding collection of rotifers. In addition to the pikeperch, the idea of the project is to apply our technology to marine fish species, which, like the pikeperch, have small mouths and a need for food with high nutritional value in larvae.

In the second, so-called green phase of the project, the idea is to valorise the wastewater produced by breeding rotifers and fish, using them to cultivate microalgae. While this ammonia- and nitrite-rich wastewater is toxic to fish and zooplankton, it is a suitable source of nutrients for algae. The recycling of nutrients not only from aquaculture but also from other agro-industrial residues is an added value of the project and thus represents a "green" environmentally friendly technology.



Intensive aquaculture, especially of highly demanded fish species, is an economically and technologically fast-growing sector. The project aims to make it more environmentally friendly and, at the same time, bring more profit to local producers.

The project partners are the Algatech Centre in Třeboň, Institute of Microbiology, CAS on the Czech side and BEST – Bioenergy and Sustainable Technologies GmbH, and Bundesamt für Wasserwirtschaft. ◀

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Aquaculture of the future: circular and sustainable

Circular bioeconomy stands on two central dogmas: "waste is not waste, but a resource" and "integrate, recycle, reuse, reduce and remanufacture". It has enormous potential and is one of the ways to achieve sustainable food production. Koushik Roy, a post-doctoral researcher from the Laboratory of Nutrition at the Faculty of Fisheries and Protection of Waters, had been concentrating on the issues of circular and sustainable aquaculture nutrition.

Why is it so important to introduce circular aquaculture today?

The UN predicts that 10 billion people will live on the planet by 2050, and protein demand will double. Present protein production (mainly animal-origin food) is already responsible for mankind's one-third emissions. There has much impetus on lowering mankind's trophic level and saying "vegetarian diet" is the future. It is now being globally realized that vegan diet alone cannot answer everything. 'Blue foods' (that is food coming from universal solvent, water) would be indispensable for human nutrition and environmental health by 2050. At the same time reduction of terrestrial meat consumption.

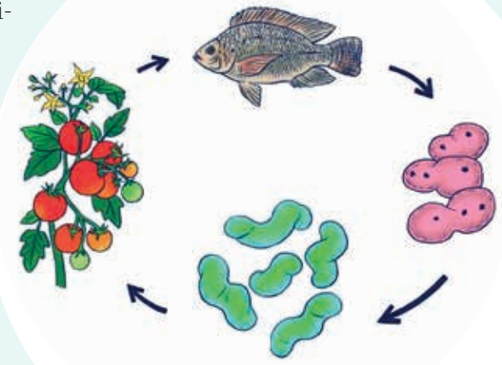
Our general attitude, increasing food production at any cost and unchecked consumption of what comes to our plate must be changed. Food production overall, be it plants or animals, needs to adopt a circular bioeconomy framework. With the world's waters already overfished, farmed blue foods (aquaculture) is now world's fastest growing food production sector. But for aquaculture to be panacea, it must change from a linear (high input, high emission) to a circular approach (low input, low emissions).

The Green Deal is also considered the European Union's strategy for a sustainable future. What role does aquaculture in particular play in it?

Imagine among all the food we eat, some groups of foods have the least environmental impact and improve human health. Fish is one of them. We have recently partnered and submitted proposal in a visionary HORIZON2020

project on achieving circular bioeconomy in European aquaculture. This topic is one of the priorities for the European Commission, as EU is looking forward to transitioning its food system towards better planetary health and human health. Making aquaculture "cleaner", more relevant, and a major supplier of animal protein, fats in European plate by 2030–2050 is expected to improve environmental performance of our current EU food system.

One of the challenges we have been working on at the faculty is the improved resource (space, nutrients, time, biomass) use efficiency of aquaculture in the Czech Republic. Also, recycling of wastes generated by aquaculture farms and reusing farmed biomass losses along farm to fork. Most importantly, better communication with the society for increasing consumption of fish to invest in a future of both environment health and human health in tandem. EU's strategy today as a global leader, will set an example for the developing regions in the world, who have to eventually follow it.



What technologies can be employed in circular aquaculture?

From design perspective, there are many technologies that efficiently use space, water, nutrients in loop. Integrated multitrophic aquaculture systems are the way forward. For example, recirculatory aquaculture systems combined with hydroponic plant production (aquaponics) or microbial, algal biomass production (flocoponics), periphyton, and floating vegetable raft-based pond fish farming, pond-in-ponds, spilt pond designs, integration of RAS and ponds, etc. But all these systems also need some inputs. For example, the artificial feed for fish, fertilizers for aquaponics, or a functioning aquatic food web in ponds. Circular aquaculture is the next level of thinking. How by-products or wastes from local agriculture, livestock and poultry, breweries, bakery, dairy, fish processing, food retail can be used to feed aquaculture. How pond food web's nutrient flow strength and weaknesses can be complemented with smart pond feeds using some of these wastes and using pond sludge for agriculture. Another thing is creating a direct link of biorefineries (invertebrates, microbes, algae, plant) of the future to serve raw materials in indoor, intensive aquaculture.

What other activities of your laboratory are heading in this direction?

We have been researching different essential oils that could replace antibiotics used in fish farming. What I see important is to promote the consumption of fish products from aquaculture among people. The team of my colleague Jan Kašpar has been working on creating valuable fish products that are also appealing to people. The project of Assoc. Professor Jan Mráz focused on developing new fish products for pre-school children, such as fish balls, ham and fish burgers, also worth mentioning. The objective of the project is to change the perception of fish consumption among the younger generation. However, a number of interesting projects can also be found in other laboratories at our faculty. For example, the colleagues from the Laboratory of Intensive Aquaculture are developing a circular system that uses agro-industrial residues to cultivate microalgae, which serve as food for rotifers, tiny zooplankton, subsequently fed to economically valuable fish species.

You also deal with various aspects of pond management. What is the situation with South Bohemian ponds?

Eating South Bohemian carp in a restaurant is the ideal solution in terms of environmental impact. Out of any livestock sector, extensive fish farming in ponds is by far the most environmentally friendly way of obtaining food. Moreover, fishermen provide an irreplaceable service to the Czech landscape by looking after the ponds and fulfilling their non-productive functions, such as stabilising the local climate or increasing biodiversity. The problem is that the rules that fishermen often follow in their management often no longer work given the changing climatic conditions, and this is particularly reflected in the deteriorating water quality in the ponds. We need to adapt to the changes. Central European fishponds suffer from strong eutrophication. This eutrophication is often related to the current feeding (farming) management in these fishponds, which does not consider the balanced nutritional needs of the growing fish. We have put forth concept of balanced pond feeds that improve resource (nutrient) utilization efficiency and stimulates fish to exploit better the natural food – in such a way that nutrient footprint is reduced. At the same time, feeding Czech food system's by-products to ponds and not competing on human-edible food resources to feed the ponds. Again, we are talking about the use of waste and its recovery.

It costs a lot of money to put different technologies into practice and make them attractive to the private sector. Moreover, the idea of the Green Deal, for example, does not enjoy much enthusiasm in the Czech Republic.

These changes cannot be introduced immediately; they need to be introduced step by step, gradually. In some European countries, aquaponic systems that work on the roofs of houses have been developed quite successfully. Personally, I think that the question of money and the will of the people is an important one, but one that can be solved. What I see as a bigger problem is the matter of 'biosecurity'. Working with waste, especially in the livestock industry, poses a threat in terms of various diseases, epidemics such as mad cow disease or Spanish flu, and requires great demands on safety. In this respect, aquaculture is much safer than other livestock farming. ↪

You come from India, does that affect the way you think about these issues?

The funny thing is circular bioeconomy is what we call poor man's strategy in India. Impoverished rural communities have adopted a circular way of life to become self-sufficient in household food security since time immemorial. Their kitchen/ food wastes are applied to their tiny kitchen garden with some chickens or ducks, and a small backyard pond with weed fishes. While their goat or cow graze on open access pastures. What Europe is thinking and implementing today, I think India will implement in two-three decades. Right now, Indian priority is food and employment security. Environmental consciousness is there, but also a luxury. For instance, water quality issues are not regulated nearly as EU which allows our ponds to produce on average 7,500 kg carp per ha per year (which is also consumed). But improving nutrient use efficiency of Indian food production systems will be relevant soon to cut down emissions. I want to be there at that moment, put all the good and unsuccessful experiences into that transition. Europe's leadership today, I see as an investment to my region in the future. By the way, my region (Hooghly) also has carp and ponds as a heritage like Czech Republic. We love fish, having a per capita fish consumption of 10 kg fish per person year. Despite regional heritage, I sometimes cannot ignore seeing how fish consumption in the Czechia is ignored. ◀

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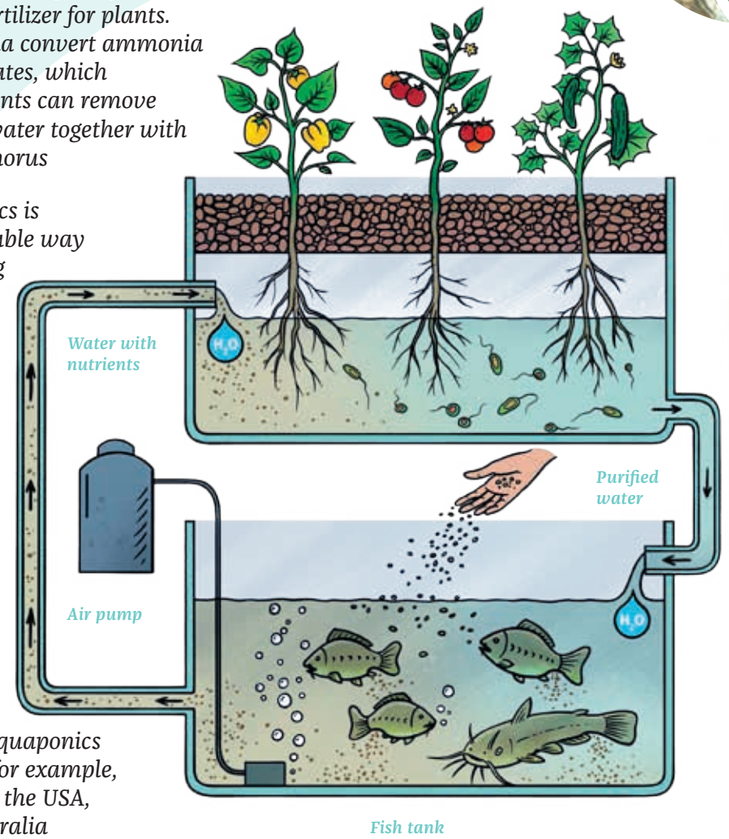
Project No. QK1920326: Aquaculture of rheophilous fish (National Agency for Agricultural Research, 2019–2021)

What is aquaponics?

Aquaponics is a food production system that combines fish farming with soilless plant cultivation.

- *Wastewater from fish is used as a fertilizer for plants. Bacteria convert ammonia to nitrates, which the plants can remove from water together with phosphorus*
- *Aquaponics is a sustainable way of farming*
- *Aquaponics requires 10x less water than traditional agriculture*
- *Aquaponics was already used by the Aztecs or the ancient Egyptians*
- *Modern aquaponics is in use, for example, in Israel, the USA, or Australia*




Fish produce waste (including ammonia)


Bacteria convert ammonia to nitrates


Plants use nitrates for growth


Water flow


Oxygen for fish and plants

Findings from the Aquaponic hall help companies

Aquaponics is a system of food production combining fish farming and soilless plant cultivation. It has great potential and can be instrumental in solving global problems for humankind. The Faculty of Fisheries and Protection of Waters has had an Aquaponic hall available for several years. The principles that aquaponics is based on are presented by Assoc. Prof. Jan Mráz and Radek Gebauer, Ph.D., from the Laboratory of Nutrition.

What is aquaponics?

In our case, it is a system that couples fish farming with growing plants without soil. The ancient Chinese farmed their rice paddies on this principle. Then, in the 1970s, scientists in Australia and the Caribbean began to develop modern aquaponics. The name was coined by combining two terms - aquaculture, i.e. the controlled breeding of fish, and hydroponics, i.e. cultivating plants in a medium other than soil. It creates a cycle in which fish and plants coexist in a mutually beneficial symbiosis.

How are fish farming and plant cultivation interconnected?

It's all based on the activity of a third component, bacteria. Their job is to convert waste substances from the fish, such as ammonia, which the fish excrete through their gills, into nitrates. That's the job of the so-called nitrifying bacteria. Other types of bacteria then break down the solid components of fish excrements into minerals and other substances. All of this is then distributed through irrigation to the plants, which are embedded in various inert materials or in polystyrene boards with roots freely floating in the water.

What inspired the creators of this system?

Nature. Aquaponics tries to emulate it. The ideal goal is zero waste. The plants clean the water and convert the carbon dioxide produced by the fish into oxygen. The water that evaporates through the plants is largely obtained through collecting rainwater. A system of solar collectors and heat pumps, together with sophisticated monitoring and control technologies, make the entire operation of the hall as environmentally friendly as possible.

Do you have any interesting foreign experience?

I personally (Radek Gebauer is answering) did an internship at the Leibniz-IGB in Berlin during 2018 and 2020. I worked under the guidance of Prof. Werner Kloas, who is one of the European leaders in the field of aquaponics. We focused on nutrient fluxes in aquaponics depending on feed and fish species. As part of my internship, I was involved in the Cubes Circle project (https://cubescircle.de/en/), which seeks to create a modular "zero-waste" aquaponic system by involving the larvae of the black soldier fly to process waste from aquaponics.

What are the main lines of research you are concentrating on in your aquaponics now?

There are generally two. The first one is focused on pest and disease management in aquaponics. For example, we have been testing some natural insecticides and looking at their effect on fish and bacterial cultures. The other project is aimed at finding the ideal balance between the fish feed that enters the system, and the quantity and quality of the nutrition obtained for the plants. We have also been trying to incorporate different forms of composting and vermicomposting into the aquaponic system. We try to follow the principles of the circular economy, which seeks to maximise the use of waste.

What kind of vegetables do you grow and what kind of fish do you breed here?

Mostly we grow tomatoes, peppers, cucumbers, aubergines, lettuces and various kinds of herbs. Regarding fish, we breed the Nile tilapia and the African sharptooth catfish, but we also tested the perch and carp. Nevertheless, the purpose of our aquaponic hall is purely experimental, not commercial. Our goal is not to produce as many vegetables as possible, but to carry out experiments that will make this technology commercially feasible and interesting for business. ↪

Is the commercial sphere interested in your findings?

Absolutely. We have had close cooperation with several private farms in the Czech Republic. We have been trying to improve their aquaponic technologies. Most greenhouses and aquaponic halls in our country were built by an unprofessional company, which constructed them poorly. These systems are loss-making. We are trying to correct them and eliminate the deficiencies. There has been a lot of interest in cooperating with us and we get contacted quite frequently.

What are the obstacles to the larger development of aquaponics in our country?

It requires higher input costs and, above all, high demands on management. It is sufficient to understand how to grow plants in a hydroponic greenhouse, while in the case of aquaponics, you need to master fish farming as well, which itself involves certain risks during its operation. It is difficult to combine expertise in both fields. The aquaponics operator must have comprehensive knowledge.

Which countries are leading in this respect?

Most notably Israel, the United States and also the Netherlands. The advantage of aquaponics is that it can be built anywhere, for example in the desert or in a high-rise building in the city centre, such as in the Hague in the Netherlands. Nonetheless, aquaponics in our country constitutes also a very promising field for the future. There has been a wide platform of scientists in Europe who share pieces of knowledge and take this revolutionary method forward. ◀

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Project No. LM2018099: South Bohemian Research Centre for Aquaculture and Biodiversity of Hydrocenoses (Ministry of Education, Youth and Sports, 2019–2022)

Can essential oils effectively preserve chilled stored fish? Yes and no

A large amount of fish is spoilt each year from post-catch to consumption. There is a growing interest in applying essential oils (EOs) as bio-preservatives to control the spoilage of chilled-stored fish. However, lots of information on the EOs' effects on chilled stored fish cannot provide a clear guide toward the appropriate application of EOs to restrain various spoilage microorganisms. In our recent article, we reviewed and meta-analyzed 180 scientific articles studying chilled stored fish to corroborate the promises of EOs in the chilled-stored fish industry.

We identified six EOs with extraordinary total microflora reduction potential for raw fish – citrus, mentha, origanum, thymus, zataria, and Zingiberaceae. Not all EOs can suppress all groups of specific microbes. Only origanum, Zingiberaceae, and thymus have complete-spectrum efficacy. Noticeably, they should be applied by the correct methods, e.g., hurdle technology, active film nanoemulsion, and special packaging. We also exposed the concertation effects of EOs on fish odour and flavour. It appeared that the low level of most EOs imparts little interference on the natural odour of fresh fish. Sensory deterioration in EO treated fish flesh is much slower than in normal refrigerated ones. ↪

Thus, selected EOs at mild concentrations with the right application method can promote chilled-stored fish' safety, sensory and shelf-life agendas.

Based on metadata analysis, the study provides clear-cut strategical support to good EO's application in chilled stored fish. ◀

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Project No. LM2018099: South Bohemian Research Centre for Aquaculture and Biodiversity of Hydrocenoses (Ministry of Education, Youth and Sports, 2019–2022)

Sustainable production of healthy fish in different aquaculture systems – PROFISH

This project is based on the cooperation of three institutions – the Veterinary Research Institute; the Faculty of Agronomy, Mendel University in Brno; and the Faculty of Fisheries and Protection of Waters, University of South Bohemia in České Budějovice. The research objectives are focused on studying the relations between fish, disease agents, and external conditions that affect the health condition as well as economics of fish farming. Individual activities are aimed at technological, zootechnical and nutritional factors; the effects of environmental pollution; and the use of antibiotics. The team of the Faculty of Fisheries and Protection of Waters consists of staff from the Laboratory of Aquatic Toxicology and Ichthyopathology, the Laboratory of Environmental Chemistry and Biochemistry, and the Laboratory of Controlled Reproduction and Intensive Fish Culture. Owing to the financial support of the project, the newly built building of the Laboratory of Infectious Diseases of Fish on the premises of the main FFPW building in Vodnany was equipped with instruments and technology. The newly created facilities provide the possibility of rearing pathogen-free fish and conducting infectious experiments. The laboratory facilities are used for diagnosing infectious agents causing diseases and for studying immune mechanisms in relation to infection. Dr. Ehdaa Eltayeb Eltigani Abdelsalam has been the new addition to the scientific team since 2021. Ehdaa comes from Sudan but completed her Ph.D. studies in the Czech Republic at the University of Veterinary Sciences Brno. During her studies in Brno, she mainly focused on the use of primary cultures from different species of wild animals for ***in vitro*** evaluation of the effect of toxic substances present in the environment on their reproductive activity and endocrine system function. She brought this topic to Vodňany, where she is currently working on the creation of primary cultures from various fish tissues and on the use of standard tissue cultures for ***in vitro*** infectious experiments. ◀

The AquaMona multitrophic farm combines fish farming with duckweeds production

The innovative project of the AquaMona multitrophic farm is located in the Irish midland, specifically on a peat extraction site in Mount Lucas, Co. Offaly. Peat was historically extracted here mainly for energy purposes such as burning in homes or in thermal power plants. The farm is located on the grounds of a wind park, with one of the wind turbine generating electricity specifically for the operation of the multitrophic farm. One of the people behind the concept of the farm was Assoc. Prof. Vlastimil Stejskal head of the Laboratory of Controlled Reproduction and Intensive Fish Culture. In 2019–2020, he carried out analyses on the farm to prove its functional capacity.

The farm is based on a combination of fish farming and growing duckweed. Duckweed are small, free-floating plants characterised by their high growth rate and high protein content. Their amino acid profile is very similar to that of soya, which is widely used as a component in fish feed.

At the AquaMona farm, the duckweed is produced in a system of sixteen channels approximately 100 metres long, which receive wastewater from four earthen split-ponds with intensive water circulation, where trout and perch are kept. The nutrients produced by the fish act as fertiliser for the duckweed, which remove nitrogen and phosphorus from the water, and the purified water is returned to the fish. The whole system thus fulfils the principle of a circular economy, which also utilizes usage of the otherwise fallow area of extracted peatlands, which are very poor in nutrients.

One of the conditions for the operation of the farm was to ensure water circulation in the system. This is achieved by eight airlifts and twelve paddle wheel aerators, powered by energy from the aforementioned wind power plant. However, it was important to solve problems with the wind, which is typical for the Midlands, causing the duckweeds to accumulate and overlap in some places, which resulted in dying lower layers, loss of function, and the adverse release of nutrients back into the system. Once a windbreak system was built on the farm, these problems ceased.

The choice of fish stock was also important. The farm was stocked with rainbow trout and European perch, with the total production of 32 tonnes of fish per year. Two native species of duckweed – the common duckweed ***Lemna minor*** and gibbous duckweed ***Lemna gibba***, were used as they are a key element in maintaining water quality from the end of May to the end of September. Green microalgae take over this function in other parts of the year. It was calculated that sixteen channels with duckweeds can remove 1.55 tonnes of nitrogen and 200 kilograms of phosphorus from the water per year. Following some analyses, the researchers concluded that the ratio between the duckweeds capacity and fish density in the AquaMona system was in balance during the summer period. In autumn, winter and early spring, green microalgae took over the function of the duckweeds.

Although the research work of Assoc. Prof. Vlastimil Stejskal in Ireland is now finished, the farm continues to operate, albeit hit hard by the coronavirus crisis in the form of the loss of some sales outlets. However, the most important finding of the AquaMona project is that the multitrophic farm project was proved to be technically feasible and economically interesting. The return of such a project is not immediate, but it is an important example of circular economy, where waste products are transformed into resources. ◀

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Project No. LM2018099: South Bohemian Research Centre for Aquaculture and Biodiversity of Hydrocenoses (Ministry of Education, Youth and Sports, 2019–2022)

The Green Faculty

The first photovoltaic power plant was built by the Faculty of Fisheries and Protection of Waters for the aquaponic hall in České Budějovice in 2018. After the experience gained and with the "Green FFPW – Ecological Faculty" vision, we began the first stage of the photovoltaic power plant project at the Genetic Fisheries Centre (GFC) in Vodňany in 2019. In the following year, we embarked on the second phase. A total of 102 panels with a capacity of 16.1 kWp were installed in the premises. In 2021, panels were also placed on the main building in Zátiší with a total capacity of 19.8 kWp. The energy generated from the sun significantly reduces operating costs. So far, the faculty has invested nearly one and a half million CZK, excluding VAT, in photovoltaic power plants.

Another step toward the "Green FFPW" vision was the purchase of three Škoda CitigoE iV electric cars. We are thus trying to meet the trend of reducing CO_2 emissions through an environmentally friendly means of transport. This is the first purchase of electric vehicles by the University of South Bohemia in České Budějovice. The electric cars are used by the faculty staff for travelling to classes between the faculty's institutes, and for shorter journeys around the town and its surroundings, with one available in České Budějovice and the remaining two in Vodňany. Charging stations are installed at both workplaces. The purchase of the Škoda CitigoE iV was co-financed by the State Environmental Fund of the Czech Republic. ◀

CENAKVA | South Bohemian Research Center of Aquaculture and Biodiversity of Hydrocenoses

Freshwater ecosystems in the era of global change

RP4

RP4_ Freshwater ecosystems in the era of global change

Head of the program: Assoc. Prof. Miloš Buřič, buric@frov.jcu.cz

The visions and goals of the research program:

Freshwaters are an essential source of water for drinking water treatment, industry, agriculture, aquaculture, as well as having important ecological and socio-economic significance. Environmental changes are substantially affecting this resource, which results in cascading effects in the functioning of freshwater ecosystems, and furthermore, they have a negative impact on both the water use and the quality of human life. Therefore, society needs information on the state and future of aquatic ecosystems, their protection, and the possibilities of their sustainable use.

Hence, the key objectives include understanding current and predicted processes affecting freshwater ecosystems and assessing their ecological and socio-economic importance. Our aims are to develop and apply biomonitoring methods to assess water quality and test appropriate model organisms, to use physiological, developmental, ecological and behavioural responses of aquatic organisms for experimental studies (from species to communities). Consequently we offer results of our research for application in water management, food science, aquaculture and in the protection of the aquatic environment.

The main areas of basic and applied research include biological invasions and freshwater biodiversity, the monitoring and evaluation of environmental changes in freshwater, and the development and use of new technologies in aquaculture and water quality monitoring.

The results we have achieved:

The results of the team are related to the basic biology of studied animals, their physiology, behavioural responses of each species and species interactions, as well as more complex ecological relations between predators and prey, or the position of key stone species in food chains.

We found that invasive species of crayfish and other organisms are able to adapt to adverse environmental conditions such as droughts, extreme temperatures, which is crucial in view of recent major changes in the aquatic environment such as climate change and anthropogenic environmental damage.

These features are often coupled with high reproductive potential and varied pathways of spread. Achieved results create space for further applications of biomonitoring systems using fish, crayfish and other organisms as biosensors. For early detection of contamination or disease, we use motion detection, behavioural and cardiac activity analysis. Some of the systems are already commercially exploited and we plan their extension among users in water supply, food and aquaculture industries.

I consider invasive species to be a society-wide problem

Assoc. Prof. Miloš Buřič is the head of the Laboratory of Freshwater Ecosystems at the FFPW USB in České Budějovice. He focuses on biological invasions in freshwater ecosystems, especially crayfish. In addition to monitoring their occurrence, he and his colleagues concentrate on researching their behaviour and impact on native aquatic organisms as well as entire ecosystems. "Not so long ago, we used to say that the marbled crayfish or the red crayfish, for instance, had no chance of surviving in our environment. Now we know that they do," he comments on the rapidity of the changes that have been taking place in our waters for a variety of reasons.

Rivers and their water are a suitable medium through which new species of animals and plants can enter our territory. Nevertheless, they don't usually come on their own, they are helped by man. In what ways?

Actually, the spread of animal species to new habitats is a natural process. However, since the Age of Discovery, humans have been the main driving force of the movement and spread of animals and plants. Until the 20th century or so, no one thought this would be a problem. As far as the Czech waters are concerned, we should certainly mention crayfish, fish (recently I would mention the round goby in particular), amphipods and bivalves, such as the zebra mussel, the Asian clam and the Chinese pond mussel. Nevertheless, there are more, of course, some not being evident at first sight, and their impact will only become apparent over time. The causes of their spread include the introduction and breeding of economically important species, transportation in the ballast water of vessels, unintentional or deliberate introductions by individuals, or perhaps the ill-advised release of aquarium species. The marbled crayfish also falls within these.

So what non-native crayfish species have been known to be present in our country?

Quite a lot has been said about the massive presence of the spiny-cheek and signal crayfish. As far as the marbled crayfish is concerned, its occurrence in the Czech Republic has been documented in only a few places so far. The occurrence of the red swamp crayfish has not yet been proven in our territory; however, I think it is only a matter of time before it happens. ↪

Is that a problem? Isn't it just the replacement of native crayfish species with non-native ones that we will eventually come to see as native?

I don't think so. I will give an example from our work on the Křesánovský stream near Vimperk. As far as the European crayfish is concerned, we would find one, maybe two adults per square metre. However, the signal crayfish is widespread in the stream at about ten times the density. Basically, they completely dominate the area. The European crayfish occurs in the stream as well, but only in its upper parts or randomly in small numbers among hundreds and thousands of signal crayfish. In the past, the stream was used to obtain trout for stocking, but today this is almost impossible because of the signal crayfish. The same has been happening in Great Britain. Invasive species of crayfish generally grow and mature faster and have higher fecundity. In addition, they are hardier and more aggressive, and transmit the crayfish plague, to which they are immune. Their negative impact on the functioning of the entire ecosystem is well described. Moreover, red swamp crayfish are very capable burrower.

I can imagine that if they will spread massively in the Třeboň region, for example, they could significantly disturb the pond dykes there.

People usually only become aware of a problem when it has an impact on the economy and business.

In this respect, I would mention the round goby. It is responsible for the decline of other fish species in the Elbe River, but also in the Great Lakes in North America, where it is abundant. It eats their eggs and fry. It is very hardy and adaptable. When I was recently driving away from the south of Bohemia for my holiday, I met a number of cars with yachts, often with water still running out of them. Where were they coming from? Some of them may have been coming from the Elbe River, heading for the Lipno Reservoir. If the round goby could make it across the Atlantic, why couldn't it make it from the Elbe to Lipno reservoir? Of course, that applies to invertebrates, too.

Maybe the yacht owners didn't even realize it.

They definitely didn't. I don't blame them for it, either. However, it shows that the most effective way to combat invasive species is through education. Some countries have already progressed in this matter. In Ireland, for example, fishermen are required to disinfect their boots or even their fishing gear before entering a fishing ground, so as not to introduce a pathogen, such as the crayfish plague. Its spores can be carried on fishing gear to new locations where populations of native crayfish species may be found. One way to prevent this might be not to visit multiple fishing grounds in one day. Undesirable transmission of pathogens can also occur when fish are stocked.

Could it happen that a species that is non-native to our country but cannot reproduce itself in our conditions becomes invasive?

It can – let's take the grass carp or the silver carp. The grass carp in particular is an economically valuable fish that has been brought to us for the purpose of reducing aquatic plants. Let's ignore the fact that other non-native, now invasive species were introduced along with its importation. As the temperature of the environment rises, these species may be able to reproduce in our country and may begin to spread uncontrollably, disrupting the ecosystem. A non-native species will become an invasive species. Just look at videos from North America to see what such a shift to an invasive group looks like. The silver carp is a skilled jumper, and its jumping shoals look spectacular, but I don't know if we'd like to see that spectacle here as well.

Can more effective use of legislation be the solution in the fight against invasive species?

The European Union has a strategy for combating invasive species, but it is the national implementation that is important. Regrettably, many things are only dealt with on an administrative level just to make sure that everything complies with the generally applicable rules, and there is no deviating from the path. However, in real life it is necessary to use common sense at the same time. Insensitive revitalisation can endanger or even destroy the protected native species that are present in the area. Elsewhere, fish ladders built in inappropriate locations can allow the spread of invasive species. It is necessary to know the specific situation, to communicate, to discuss, to inform, and to clarify, because invasive species are not just a topic that some biologists work on in the lab. It is a problem of the whole society, which unfortunately is only felt when it is too late. That's why it is essential to teach the society and draw it nearer to nature. ◀

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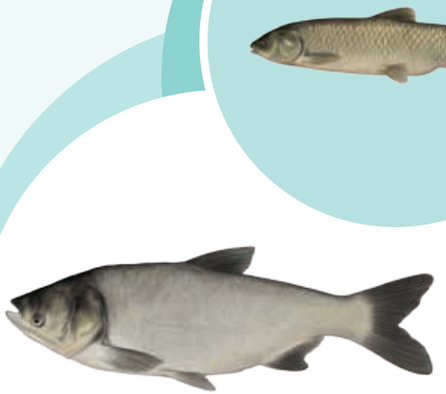

MoBi-aqua project

The Elbe River plays an important role in Germany as well as the Czech Republic, both in terms of water management and transport. The main course of the Elbe River and its tributaries constitute important habitats for many aquatic organisms. However, endangered species (e.g. the European crayfish, the European bullhead etc.) have very limited number of natural refuges in the Czech-Saxon border area, and in addition face increasing pressure from invasive non-native species that find the Elbe River as a suitable migration route.

The MoBi-aqua project, which was implemented in 2018–2020, aimed to monitor these biological invasions and to contribute to the protection of aquatic species diversity in the Elbe River and Eger River basins. The project area covered the whole of Saxony and three regions in northern Bohemia – Ústí nad Labem, Liberec and Karlovy Vary Regions, bringing together scientists from the Faculty of Fisheries and Protection of Waters at the University of South Bohemia in České Budějovice with researchers from the Institute of Hydrobiology at the Technical University of Dresden.

The general objectives of the project included:

- *monitoring in the wild by both research institutions in cooperation with the Czech and Saxon fishing associations and authorities*
- *genetic research on the Saxon and bordering Czech populations of the European bullhead, as it belongs among endangered species and its occurrence is declining rapidly in both regions*
- *experiments in artificial channels with streamflow allowing better understanding of the interaction between native and non-native species as well as clarifying ecological context*
- *intensive work with the public to make the society more aware of the issue and to give active citizens the opportunity to get involved*
- *the development of a mobile progressive web application to identify and report the presence of invasive or native aquatic animals*

As part of the project, a bilingual (Czech-German) website Mobi-aqua.eu was created, where the issue of species diversity and invasive species in these regions is presented in an attractive way. In addition to the web application, glossaries, a map of findings and other useful information, anyone interested can practice their knowledge of ecology by taking quizzes on the website. ◀

Redclaw – an aquaculture jewel or unwanted invader?

The team of authors led by Assoc. Prof. Antonín Kouba has published a comprehensive overview study of the redclaw crayfish. The redclaw crayfish, native to northern Australia and southern New Guinea, is among the largest freshwater decapods. It matures early and is highly fertile. Despite generally preferring slow-moving streams in its native range, it has a broad environmental tolerance, making it capable of establishing populations when introduced to a wide range of conditions and habitats. These biological and ecological features render it a highly suitable and popular species for aquaculture worldwide, the second most important crayfish species (after the red swamp crayfish). Also, its unique colouration fuels demand and value among aquarium enthusiasts, making it attractive for the aquarium pet trade.

Today, the redclaw crayfish is widely translocated (67 countries/territories), and various established wild populations (22 countries) have been reported worldwide. Information on its potential or observed impacts, however, is sparse and often anecdotal. To address this gap, we compiled a comprehensive review on this species, covering its taxonomy and description, biology and ecology, and distribution accompanied with documented introduction pathways. Based on these, biological and socio-economic classifications and species distribution modelling were conducted. We call attention to the importance of managing this prominent introduced species in the aquaculture and aquarium pet trade, especially in tropical and subtropical biodiversity hotspots. ◀

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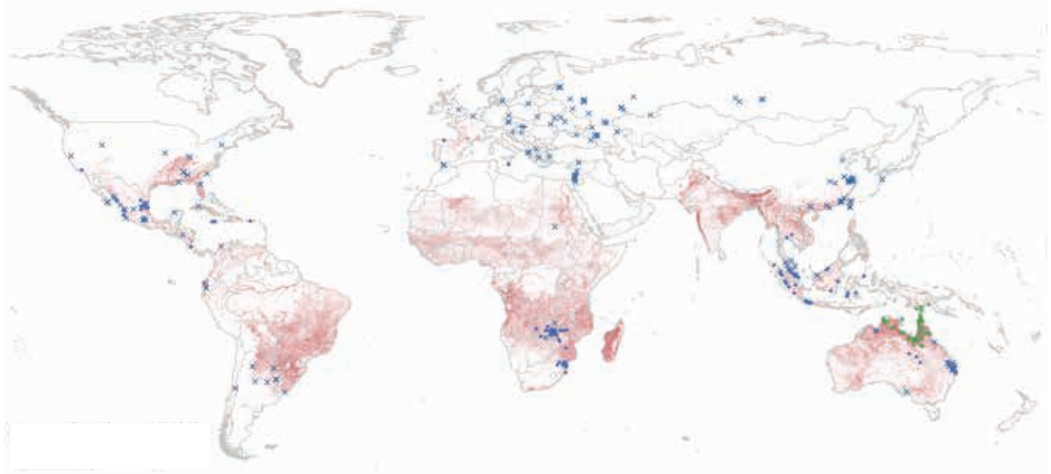
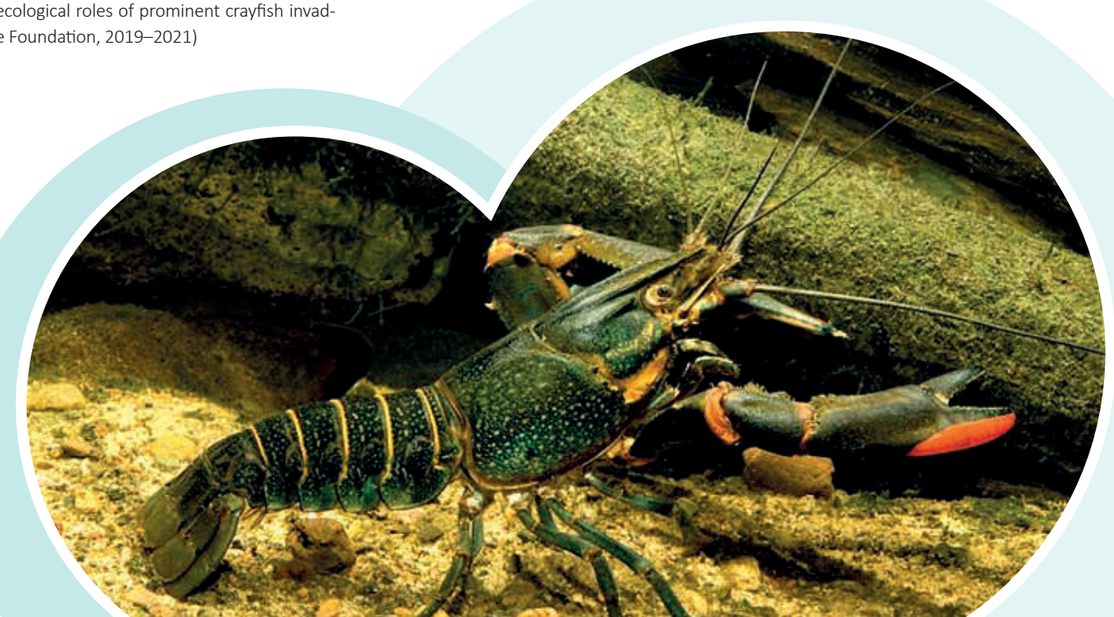
Haubrock, P.J., Oficialdegui, F.J., Zeng, Y., Patoka, J., Yeo, D.C.J., Kouba, A., 2021. The redclaw crayfish: A prominent aquaculture species with invasive potential in tropical and subtropical biodiversity hotspots. Reviews in Aquaculture 13: 1488–1530. doi.org/10.1111/raq.12531

Project No. GA19-04431S: Temperature-induced changes in the interactions and ecological roles of prominent crayfish invaders (Czech Science Foundation, 2019–2021)





Drones and camera traps are used to monitor piscivorous predators

Automation and objectification of piscivorous predator monitoring is the name of the project from the applied research programme of the Ministry of Agriculture of the Czech Republic, which was implemented at the Faculty of Fisheries and Protection of Waters in 2019–2021. The project's background, objectives and results are presented by the project's principal investigator Petr Císař, Ph.D., from the Laboratory of Signal and Image Processing in Nové Hrady.

Losses caused by piscivorous predators are a debated topic in the Czech Republic. What predators are we talking about? Who is affected by these losses and can they be calculated financially?

The predators primarily include the great cormorant and the Eurasian otter. They cause losses to commercially farmed fish populations as well as fish living in the wild. Financial compensation is granted to fishing enterprises or individuals and is calculated according to the methodologies currently in force. The methodology for the great cormorant and Eurasian otter is generally based on monitoring the presence of predators in a particular locality. Estimates of the cormorant numbers are made by the fishermen themselves based on daily observations at the ponds. Estimates of the otter numbers are carried out by monitoring the so-called otter residence tracks in a particular locality. It is actually the monitoring that constitutes a weakness of both methodologies, as it is based on human observation in the case of cormorants and indirect observation in the case of otters.

The objective of your project is to use modern methods to monitor these predators better. What are these methods?

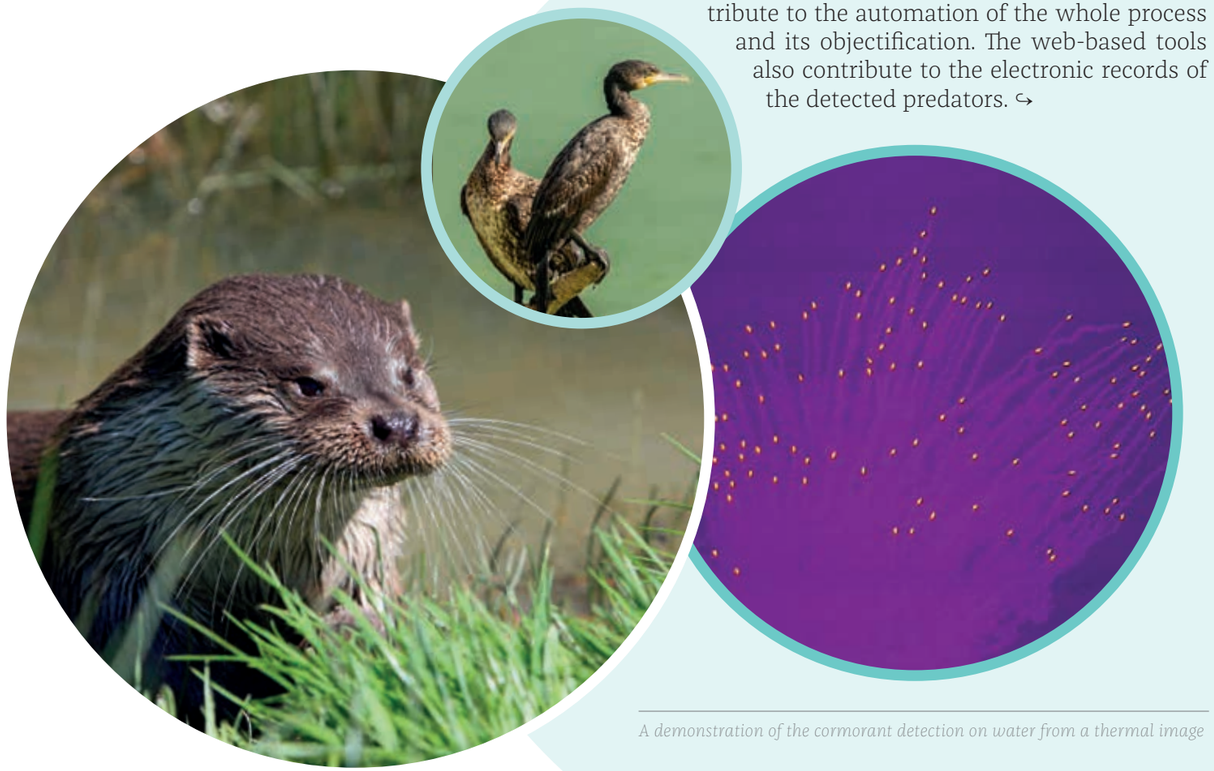
The methods use modern technologies to objectively determine the number of predators in the locations of breeding ponds. In the case of cormorants, we use drones with a thermal camera to photograph flocks of cormorants perched on ponds or adjacent trees. Subsequently, our web-based software automatically counts the cormorants from the thermal camera images, enabling fishermen to generate statistics on occurrences. In the case of otters, we use camera traps that can automatically record otters and other animals when they visit the pond. Web-based software using deep neural networks then automatically detects otters in the video footage, again allowing us to generate the otter occurrence statistics.

In which locations were the new methods tested?

Actually, the methods were tested on a system of ponds around Nové Hrady and at ponds around České Budějovice. In total, the methods were tested at 14 sites.

How will the new methods contribute to improving the monitoring of piscivorous predators?

The methods we have developed will contribute to the automation of the whole process and its objectification. The web-based tools also contribute to the electronic records of the detected predators. ↪



A demonstration of the cormorant detection on water from a thermal image

Do the monitored species of piscivorous predators have any specificities that also influence the monitoring method?

The otter is chiefly a nocturnal predator that moves along the ground following regular routes. Therefore, stationary camera traps are suitable for monitoring it. The cormorant is mainly active in the morning, but also during the day, while migrating between ponds. Hence it is necessary to use a mobile platform for its monitoring, which is just a drone with a camera.

Did you encounter any problems during the implementation of the project?

There were a number of difficulties, from the very different quality of camera traps and the need to search for cormorant flocks in order to obtain sufficient data, to the limitations imposed by the COVID-19 disease control measures. However, eventually we managed to develop two otter and cormorant monitoring systems that can be freely available to commercial and non-commercial entities.

What are the views of the groups in question – pond owners, fishermen, etc. – on the use of the new methods?

The solution was presented to the target group (fishermen, authorities responsible for loss compensation) at a workshop in 2021, being positively received. Further use of the system is now in the hands of the Ministry of Agriculture, as the project was primarily aimed at developing a solution for the needs of the ministry. ◀

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Pilferer, murderer of innocents or prey? The impact of the killer shrimp on crayfish

Freshwater ecosystems worldwide face the establishment of non-native species, which, in certain cases, exhibit invasive characteristics. The impacts of invaders on native communities are often detrimental, while the number and spread of non-native invasive species increase. This results in novel and often unexpected combinations of non-native and native species in natural communities. While the impact of invaders on native species is well-documented, the interactions in non-native invaders are less studied.

Sara Roje, a young scientist which succesfully defended Ph.D. thesis in 2021, together with her colleagues assessed the potential of an invasive amphipod, the killer shrimp (*Dikerogammarus villosus*), to cope with other established invaders in European waters, the North American crayfish represented by the signal crayfish (*Pacifastacus leniusculus*), and marbled crayfish (*Procambarus virginalis*). The main goal of this study was to investigate if the killer shrimp, besides their role as prey of crayfish (also confirmed here), can significantly influence their stocks by predating upon their eggs, hatchlings, and free-moving early juveniles. Our results confirmed that the killer shrimp predate not only on free-living juveniles and lost eggs but even directly on eggs and hatchlings attached to a female's abdominal appendages where they are incubated and actively guarded by a mother. Our findings illustrate the high voracity and competitiveness of killer shrimp as well as the unexpected boldness (or even impudence) of this small creature which can affect even much bigger animals by its pressure on their different developmental stages. Due to this aggressiveness, boldness, and voracity, the killer shrimp is not only possible prey for fish and crayfish but also their strong or even dangerous competitor. Species with smaller eggs and first developmental stages are more prone to the killer shrimp predation as presented by higher predation on the marbled crayfish eggs and juveniles than those of the signal crayfish. ◀

Sara Roje, Ph.D.

Roje, S., Veselý, L., Švagrová, K., Kozák, P., Kouba, A., Buřič, M., 2021. Pilferer, murderer of innocents or prey? The impact of killer shrimp (*Dikerogammarus villosus*) on crayfish. Aquatic Sciences 83: 5. doi.org/10.1007/s00027-020-00762-8

Project No. GA19-04431S: Temperature driven changes in interactions and ecological roles of prominent crayfish invaders (Czech Science Foundation, 2019–2021)

Cooperation with FAO

The Food and Agriculture Organization of the United Nations (FAO) and the Faculty of Fisheries and Protection of Waters entered into a Cooperation Agreement on 16th May 2019. Pursuant to this agreement, the faculty has been cooperating with the organisation in the following areas. The first activity is membership of the working group on genetic resources in aquaculture of the FAO Commission on Genetic Resources for Food and Agriculture. The second activity is the organisation of workshops focusing on sustainable aquaculture. In 2021, an online workshop was held in cooperation with CZECHGLOBE entitled: "Aquatic ecosystem conservation and the sustainable development approach to inland fisheries management".

The FFPW USB became one of the 17 founding members of the "Global Sustainable Aquaculture Advancement Partnership" (GSAAP) consortium initiated by the FAO and the Chinese Academy of Fishery Sciences. During the next period, we would like to open a discussion on the possibilities of collaboration between the FAO and the emerging European research infrastructure DANUBIUS RI, which is focused on studying the river continuum and river-sea interactions. The objectives and outputs of DANUBIUS RI activities are closely related not only to aquaculture but also to other agricultural activities around European rivers and littoral areas. During the Czech Presidency of the EU, two interns from the FFPW USB will be working as permanent representatives of the Czech Republic in Brussels (MFA of the Czech Republic). Both Ph.D. students in the field of fisheries are going to cooperate on the agenda related to fishing, fisheries and aquaculture. ◀

Food and Agriculture Organization of the United Nations

4 Studies

Degree programmes and fields of study

The Faculty of Fisheries and Protection of Waters provides higher education at all levels of studies – in bachelor's, follow-up master's and doctoral degree programmes. All programmes can be studied in a full-time or a combined form. The teaching of bachelor's and follow-up master's students is mainly carried out at the Institute of Aquaculture and Protection of Waters in České Budějovice – either directly on the campus of the University of South Bohemia in České Budějovice (building ZR) or in the neighbouring area (building on Husova St.). The largest number of the Ph.D. students work in the laboratories of the Research Institute of Fish Culture and Hydrobiology in Vodňany.

B.Sc.

Bachelor's degree programme

After completing a three-year study, the graduate obtains a bachelor's degree (B.Sc.). The Faculty of Fisheries and Protection of Waters offers two fields of study/programmes: **Fishery** and **Protection of waters**. Language preparation of the student is given emphasis in both fields of study/programmes; the graduate should be able to communicate in English both orally and in writing without any problems. In both fields of study, emphasis is placed on the student's language preparation; the graduate should be able to communicate in English both orally and in writing without problems. Full-time students complete professional and operational practical practice in a form of work placements in companies involved in aquaculture, water management and related fields. The students can also complete their practical training in a form of international internship, which are supported particularly by the Erasmus+ programme. Bachelor's degree courses at the faculty can only be completed in the Czech language.

The study field of **Fishery** combines professional knowledge in the area of biological-ecological relations of aquatic organisms with the knowledge of modern technologies and techniques in fish culture and production fisheries. Furthermore, students are introduced to the management of water protection and water management, including the associated legislation in fisheries and water protection. The graduates are qualified for activities related to fish culture and exercising fishing as well as hunting rights, and at the same time, they are prepared for professional work in areas linked to environmental protection, water management, and water quality at lower and middle management levels.

Similarly to the study field of Fishery, the **Protection of waters** programme combines knowledge from general subjects with professional and practical technological focus in a particular area. The graduates master the basic university issues of theoretical natural science subjects, which are further extended in the profiling areas of chemistry and ecology of the water environment, legislative protection and use of water within the EU, technological elements of wastewater treatment, waterworks engineering, water management, and water structures. Further areas studied include an understanding of the physical properties of water in different environments, the water cycle in the landscape, the influence of climate on the amount of water in the landscape, the trophic quality of the environment, and related fishery issues. The Protection of waters programme aims to train ecologically and technically focused professionals who will ensure compliance with and improvement of legislation on water and environmental protection at lower and middle management levels.

Dipl.-Ing.

Follow-up master's degree programme

After completing a two-year follow-up study, the graduate obtains a master's degree (Dipl.-Ing.). The faculty provides the possibility to study the follow-up master's degree in **Fishery and Protection of waters** in the Czech language, as well as in the English language. The same as for the bachelor's degree, the follow-up master's degree also focuses on quality language preparation and completion of professional practical training. ↪

The study field of **Fisheries and Protection of waters** is a complex field of study that combines and enhances knowledge of the biological, ecological and technological aspects of fisheries as well as the water management and protection of the aquatic environment. This degree programme addresses the issues of fisheries and water protection in an integral and comprehensive way, taking into account legislative requirements as well as modern trends and needs. Regarding fisheries, it particularly concerns special fish farming, reproduction and breeding, and with regard to water protection, it concerns the protection of water resources, measures to promote biodiversity of wild organisms, open water management, wastewater treatment and the aspect of the aquatic environment contamination. This degree programme is suitable for graduates of both bachelor's degree programmes provided by our faculty, nevertheless it can also be taken by graduates of related bachelor's degree programmes.

Ph.D.

Doctoral degree programme

Doctoral studies at the Faculty of Fisheries and Protection of Waters represent an interesting opportunity to continue acquiring scientific knowledge and extending the knowledge gained during the master's studies. Doctoral degree programmes are structurally research-based, with the students being part of research laboratory teams. The objective is to prepare students for future scientific, research or teaching careers in higher education or research institutions. Students can study either full-time or in a combined form both in Czech and English. Since 2020, the faculty offers two doctoral degree programmes: **Fishery** and **Protection of aquatic ecosystems**.

The studies in the **Fishery** programme focuses on the area of fishpond management, fish biology and farming, protection of fish populations, fishery management of open waters, maintenance of the hydrocenosis of open waters in accordance with current conservation approaches, and other related areas.

The study programme **Protection of aquatic ecosystems** enhances knowledge and skills particularly in environmental chemistry, toxicology, ecology of the aquatic environment, molecular biology and environmental protection. ◀

Our successful students and graduates

B.Sc. Kateřina Marková

Kateřina has been a successful and long-standing representative of the Czech Republic in fishing technique, known as casting sport. During her competition career she has won a total of 66 gold, 20 silver and 15 bronze medals. The 2020 competition season was cancelled due to the coronavirus situation, nonetheless Kateřina followed up her previous successes in 2021, when she won 5 gold, 3 silver and 1 bronze medals in both individual and team events at the Czech Republic Championships. She also continued her success at the World Championships in Budapest, where she won the title of World Champion in five disciplines, and the title of World Vice-champion in another four. In her spare time, she organises a number of after-school activities for children and also runs a business in the production of beauty products.

After graduating from the High School of Fishery in Vodňany in 2017, Kateřina began studying at the Faculty of Fisheries and Protection of Waters at the University of South Bohemia, graduating in 2021 with a degree in Fisheries. In the same year, she enrolled in a follow-up master's degree programme in Fishery and Protection of waters. The faculty has supported Kateřina several times during her studies through special scholarships for sportsmen, namely for excellent results in national or international championships, as well as special scholarships for sportsmen to facilitate participation in major sporting events and to support training and sports performance. Kateřina comments on her time at the faculty so far, *"The FFPW is a totally unique faculty, whose "family" approach to study resonates with me a lot. Despite the fact that studying at the faculty is quite demanding in terms of professional aspects, with the human attitude of both the students and the faculty there is always enough room for individual stance, making the studies at our faculty really enjoyable."* In the near future, she would like to continue her successful sporting career, where she develops not only herself, but also other young fishermen and children. At the same time, she wants to pursue her further studies at the FFPW as well as her business.

Dipl.-Ing. Martin Musil

At an early age Martin got completely hooked on sport fishing, which his grandfather and later also his father introduced him to. From the age of 13 he began to specialize in fishing for salmonids using artificial flies. He began to represent the South Bohemian Territorial Association and the Fishing Sports Club České Budějovice in this discipline, succeeding not only at the national level but also at the world level. As far as the national successes are concerned, Martin mentions winning in the highest league of the Czech Republic, countless medals from cup competitions, and a gold team medal from the Czech Republic Championship. Furthermore, he also added two gold team medals and one individual medal from the World Championships to his achievements in 2011. Nowadays, he coaches the Czech national junior team. In his two years of coaching, he has accomplished some more success – a bronze and a gold team medal. In his remaining free time he organises fishing after-school activities for children and popular educational lectures about fish and nature.

After graduating from grammar school, he knew he wanted to continue his family's fishing tradition, hence the Faculty of Fisheries and Protection of Waters was a clear choice for him. In 2019, he completed a follow-up master's degree in Fishery and Protection of waters, enrolling in a full-time Ph.D. degree programme in Fishery. He is currently working in the Laboratory of Freshwater Ecosystems, where he has been studying the interactions between invasive fish and crayfish species. He is a member of scientific teams researching ecological changes in today's ecosystems. Martin comments on his time at the faculty so far, *"I find my studies and my entire faculty activities incredibly fulfilling because I get to spend so much time outdoors, where I simply love it. In the future, I would like to be involved in making legislation and greater integration of scientific studies and opinions specifically in the creation and implementation of laws and regulations related to freshwater ecosystems. In 2022, I am going to undertake an internship at the Permanent Representation of the Czech Republic in Brussels, where I will be a member of a working team that will focus on fisheries and aquaculture issues in the EU. The faculty has always been completely supportive of me and other students in everything. One of the biggest priorities of the faculty is to encourage students' mobility abroad. However, the faculty also supports other student activities both in the form of scholarships and material and professional assistance, for which I am very grateful. Our faculty counts among the best and most prestigious in Europe in its field, therefore I needn't worry about my future professional life."*

Dipl.-Ing. Vít Profant

When Vít was deciding what direction to take after grammar school, his love for nature, water and especially fish prevailed. Hence he enrolled to study for the bachelor's degree in the field of Fishery. After passing the undergraduate exams he got his first opportunity to work abroad, namely in Scotland. In retrospect, he sees this opportunity as a kind of life milestone. During his follow-up master's studies, he took advantage of the Erasmus+ programme, doing an internship in AquaPri, a Danish company focusing on intensive farming of the pikeperch. He had originally planned to stay in Denmark for three months, however he eventually extended his internship to seven months. He not only gained work experience in Denmark, but also improved his English, while making a lot of friends and future colleagues.

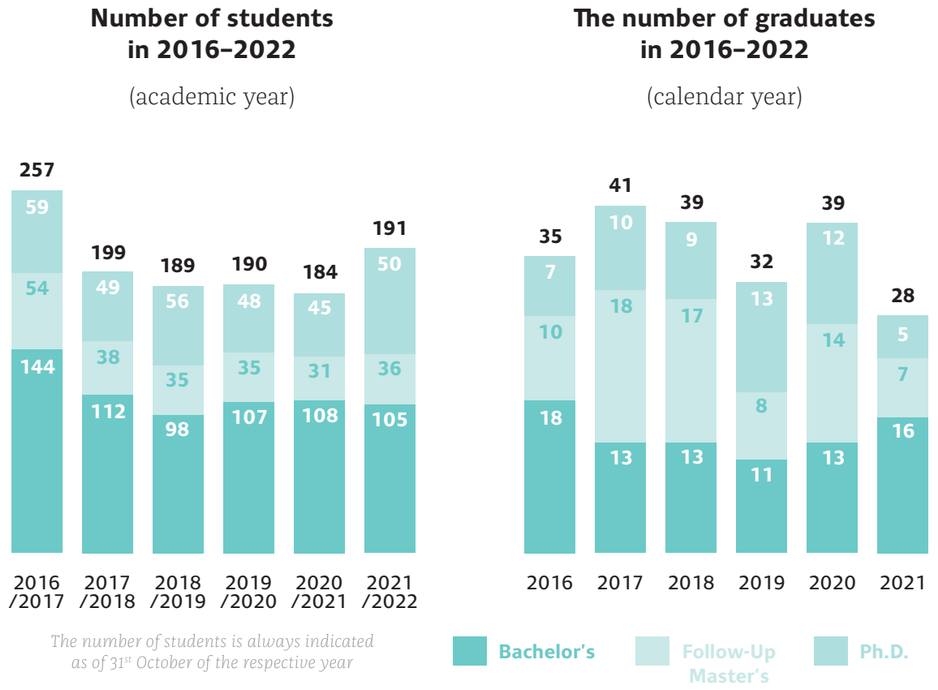
After returning from Denmark, Vít not only had to complete his studies, but also worked part-time as a lecturer in the Laboratory of Intensive Aquaculture under the supervision of Assoc. Professor Tomáš Policar, who also supervised his master's thesis. Owing to the internship, Vít prolonged his studies by a year, but on the other hand gained valuable experience in his field. Thanks to the contacts he gained through his work at the faculty and his internship abroad, he was offered several job positions during his studies. He decided to accept an offer from the Swiss company SWIFISH, where he currently works as a production manager and deputy head. Vít is an example of how a foreign internship can influence your whole life. He comments on his decision, *"It was not easy to make the decision to go abroad to work, especially with regard to my personal life and my girlfriend. In hindsight, however, I would say it was a good decision that strengthened our relationship and we learnt to enjoy our time together, which is not a matter of course. And the future? Who knows, but my heart is very much in Scandinavia..."*

B.Sc. Ondřej Bartoš and Dip.-Ing. Marek Kodras

Ondřej and Marek are connected not only by their studies at the FFPW USB and their love for water and nature, but especially by the "Friends of the Five-Leaved Rose Waters" association, chaired by Ondřej. The main interest of the association is the protection of aquatic ecosystems and organisms living in them. The team is composed of nature enthusiasts, who consult their activities with experts in science and research as well as private non-profit organizations and governmental institutions. The association strives to use the latest research trends across disciplines to truly help nature instead of harming it. Marek says about working jointly in the association, *"Together with Ondra, we have been working to improve the management of trout grounds and breeding streams, trying to motivate other fishermen through our activities. In the future, I am going to continue to devote myself to my current activities. I would love to be able to implement the revitalization of some of the destroyed sections of our streams or make at least a few obstacles on our streams passable for migrating fish. This would help significantly in strengthening the populations of the brown trout and the European grayling in our water territories, while at the same time setting an example and motivating other associations and organizations to do similar activities."* It should be mentioned that they are involved in the association in their spare time – Ondřej works for the Agency for Nature and Landscape Protection in Prague and Marek runs his own business.

Both Marek and Ondřej obtained bachelor's degrees in Fishery. Both of them also enrolled in the follow-up master's degree programme, but only Marek has completed it so far. Both agree that the great advantage of the faculty is its openness to students, who are given many opportunities for self-development. ◀

Number of students in 2016–2022



From the time the FFPW was established in 2009 until the end of 2021, 461 graduates successfully completed their studies.

Scholarship

The Faculty of Fisheries and Protection of Waters offers a large number of different scholarships. Full-time students can receive **merit and premium scholarships** for excellent academic results. Talented students and sportsmen can receive **extraordinary scholarships**. Since 2018, the faculty has also been awarding **extraordinary scholarships to support bachelor's students** with good academic prospects. The Dean may also award an **extraordinary scholarship** in cases worthy of special consideration, e.g. for representation or promotion of the faculty, for significant involvement in the activities of the FFPW research laboratories, etc.

The scholarships awarded

2020
CZK 580,000

2021
CZK 633,000

What else does the faculty offer to students?

Student excursions

Students have the opportunity to participate in a large number of excursions in the Czech Republic and abroad. Excursions to water management facilities, aquaculture enterprises and important protected areas are an attractive way to show students the practices they learn about in theoretical professional courses. Excursions in the Czech Republic usually last one or two days. Foreign excursions typically take place in countries such as Slovakia, Hungary, Austria, Germany and Poland. These are generally multi-day trips that allow students to visit several facilities, which they can subsequently compare with each other.

Due to the Covid-19 pandemic, excursions in 2020 and 2021 were substantially limited.

Student practical training/work placements

During their bachelor's and follow-up master's studies, students complete professional and operational practice in a form of work placements in companies involved in aquaculture, water management and related fields. Students can also undertake an internship abroad through the Erasmus+ programme.

International mobilities

Students at all levels of study can travel abroad under the Erasmus+ programme. The Erasmus+ programme gives students the opportunity to do study, work or graduate internships. In the case of a 3–12-month study internship at a university participating in the Erasmus+ programme, the student must obtain at least 18 ECTS credits abroad that are recognizable within his/her studies at the FFPW. The student may undertake a work or graduate internship of 2–12 months at any university, institution, organisation or company located in a country participating in the Erasmus+ programme.

In the years 2020 and 2021, international internships were limited due to the Covid-19 pandemic, yet 11 students from the FFPW (1 bachelor's student, 2 follow-up master's students and 8 doctoral students) did an internship in Denmark, Ireland, Germany, Portugal, Slovakia, Spain, Sweden and Great Britain.

Student's life

A lot of FFPW students are actively involved in the social life of the University of South Bohemia, either as members of student organizations and clubs or as visitors to social events. One of the most popular events organized at the Faculty of Fisheries and Protection of Waters is the Traditional admission ceremony of the second-year students (Fishery) into the fishing guild. The ceremony is organised by the first-year students of the follow-up master's degree programme and usually takes place in April at the Branišov Pond System near České Budějovice. This traditional event is attended not only by current students, but also by alumni, and the faculty academic and scientific staff. Unfortunately, the traditional admission ceremony was not held in 2020 and 2021 due to the Covid-19 pandemic. Nonetheless, we hope to renew this tradition in 2022. ◀

5 Lifelong learning

Lifelong learning

The lifelong learning at the Faculty of Fisheries and Protection of Waters USB is mostly coordinated by the International Environmental Educational, Advisory and Information Centre of Waters Protection Vodňany (MEVPIS/IEEAIC), which organizes conferences, seminars, lectures, summer schools, courses and workshops not only for the faculty, but also for the general public, companies, government and educational institutions (schools). The unit significantly participates in faculty educational activities in the field of fishery and water protection.

Our activities were significantly affected by the situation related to the coronavirus pandemic during 2020 and 2021. The total number of events was reduced by about a half due to anti-epidemic measures. Most domestic and international conferences and other events for the public were cancelled or postponed for the same reason.

We have filled the space created by anti-epidemic measures with a number of activities. For example, we innovated programs for kindergartens, primary and secondary schools, we established new collaborations with a number of our academic staff and Ph.D. students. We also learned to use the virtual environment more, to which we moved, for example, XVII. Fisheries and Ichthyology Conference, Food and Agriculture Organization of the United Nations (FAO) workshop 2021 or the celebration of World Water Day 2021, when we took part in the worldwide call "Put on sneakers and a run for water" as a part of this awareness-raising event. We have also enormously increased the time in which we ensured the promotion of the faculty, we have provided a 3D scan of the faculty buildings and, last but not least, we have started shooting many educational videos.

Of course, we did our best to carry out as many activities as possible, where course participants and visitors to our faculty could be physically present. These events included not only a number of educational programs and seminars, but also cultural and social events, among which we could mention, for example, jazz picnics or a very successful festival to celebrate the beginning of the academic year FROVfest. In total, the number of visitors in 2020 and 2021 was around 12,000.

In the MEVPIS Vodňany complex, we have planted large beds of ornamental flowers and edible shrubs, the fruits of which can be tasted by our visitors and course participants. We cleaned a part of the “Blanický náhon” raceway, especially from disposable wet wipes. At the same time, we thought about the overall vision of the area and in cooperation with the Museum of Natural History Semenec we prepared a "Study of modifications of the IEEAIC (MEVPIS) FFPW USB in Vodňany for educational activities", which we would like to carry out in the coming years. Last but not least, we participated in the preparation of various activities of friendly organizations. As an example, we present the cooperation with the Sladovna Gallery in Písek, with which we prepared the exhibition "Water Attacks Me", which was visited by approximately 10,000 visitors in 6 months.

Despite all the difficulties that the pandemic has brought to our lives, we have been able to implement the maximum possible actions under various measures and to maintain and even develop cooperation with both domestic and foreign partners. ◀

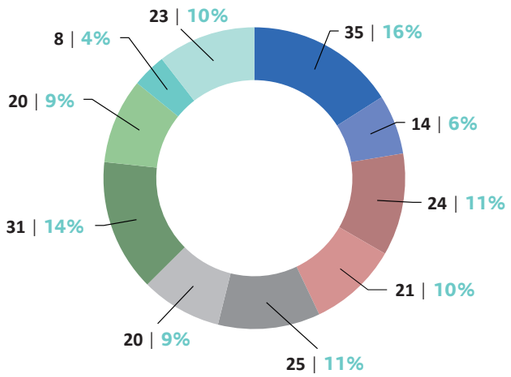
6

Faculty in numbers

Employees

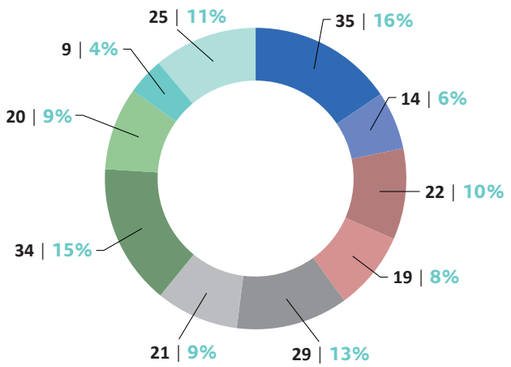
Average registered number of employees calculated as of 31st December 2020

221



Average registered number of employees calculated as of 31st December 2021

228



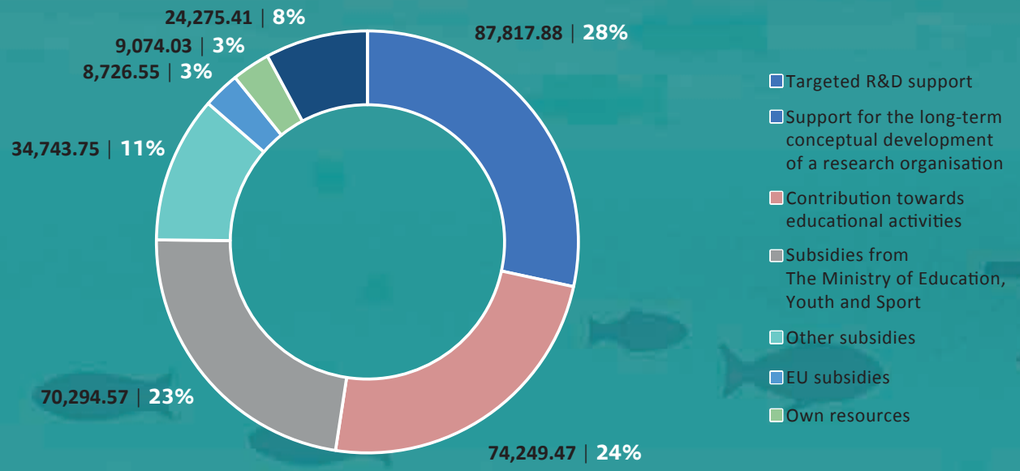
Academic staff ♂ Researchers ♂ Ph.D. students ♂ Technicians ♂ Office workers ♂

Academic staff ♀ Researchers ♀ Ph.D. students ♀ Technicians ♀ Office workers ♀

Economics

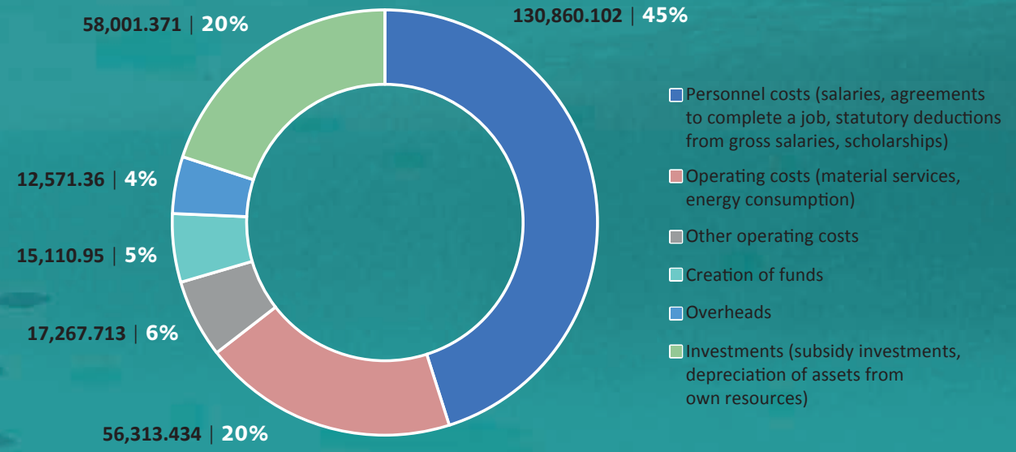
Sources of financing in 2020 including the Targeted Support Fund/Project Preparation fund in thousands CZK

293,000



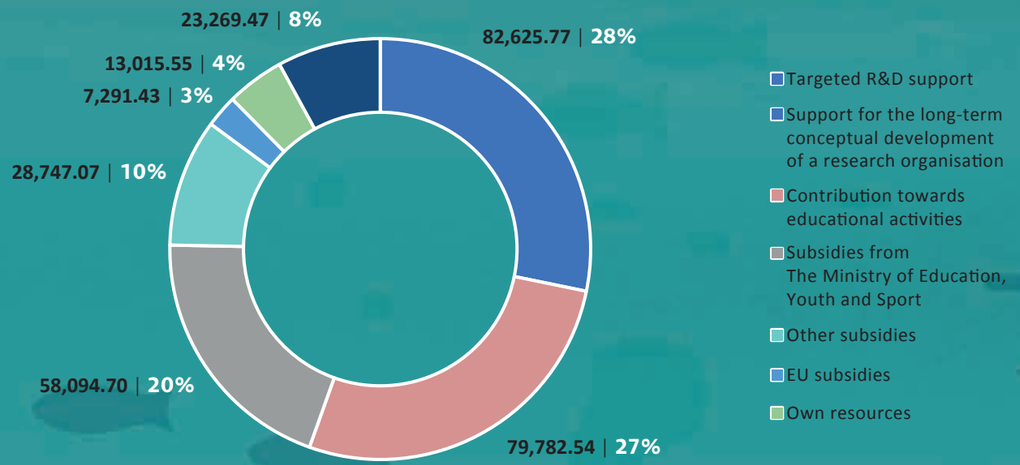
Expenditure of the sources in 2020 in thousands CZK

290,000



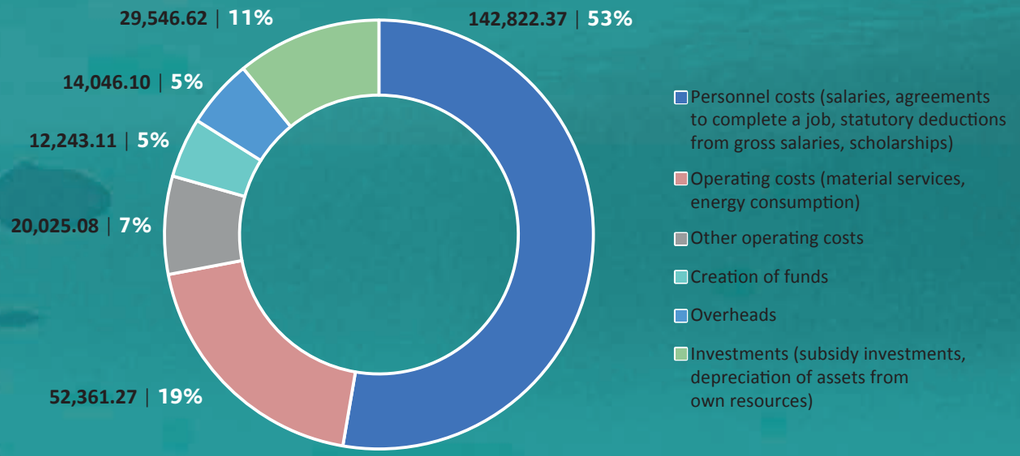
Sources of financing in 2021 including the Targeted Support Fund/Project Preparation fund in thousands CZK

273,000



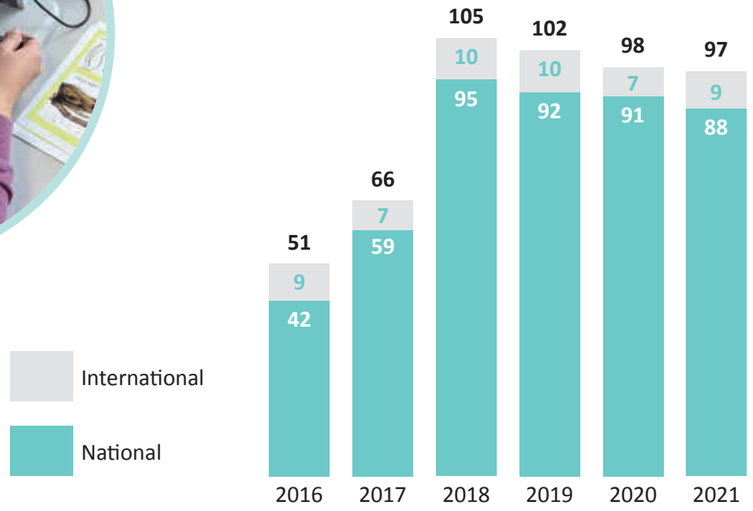
Expenditure of the sources in 2021 in thousands CZK

271,000



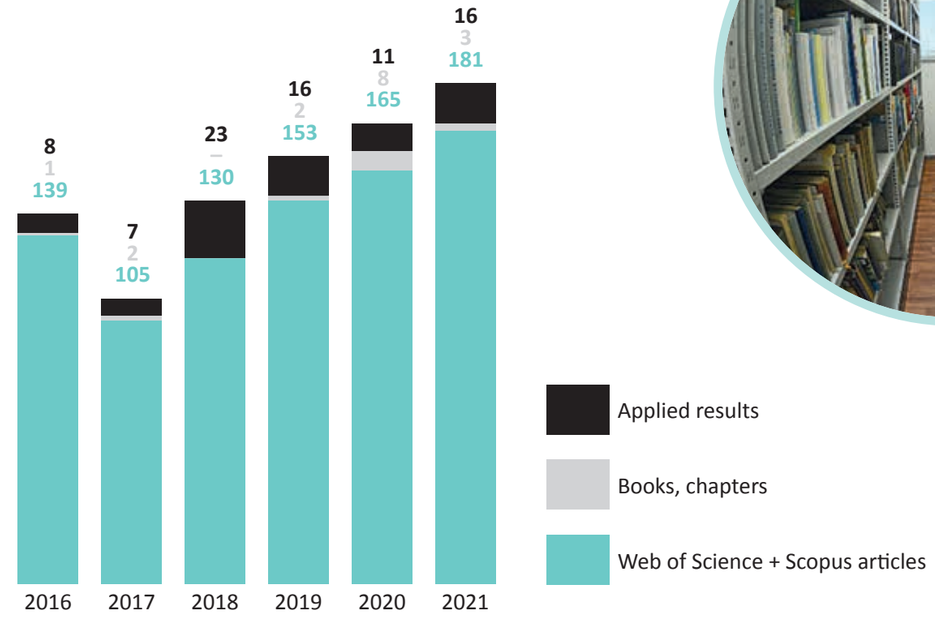
Running projects

National and international projects 2016–2021



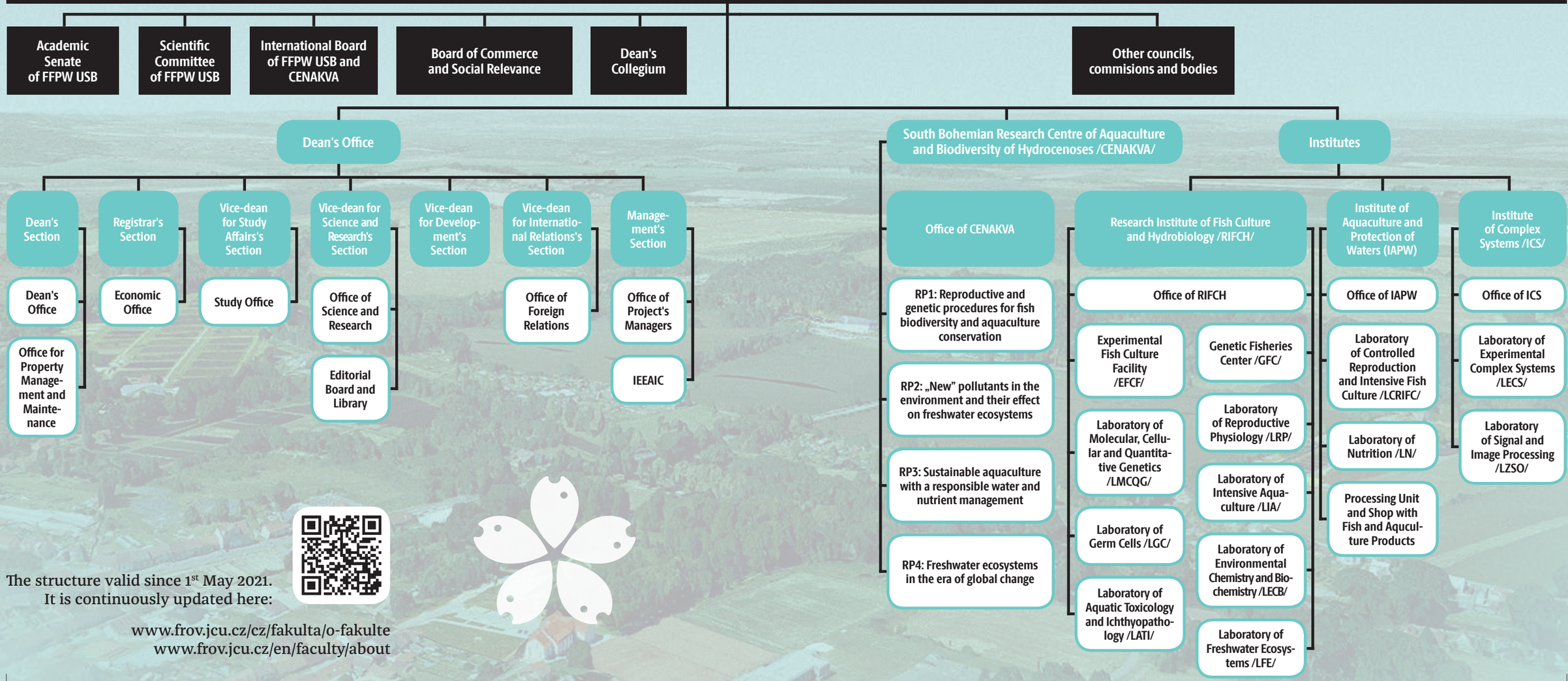
Publication

Publication activities 2016–2021



7 Faculty structure

FACULTY OF FISHERIES AND PROTECTION OF WATERS



The structure valid since 1st May 2021.
It is continuously updated here:

www.frov.jcu.cz/cz/fakulta/o-fakulte
www.frov.jcu.cz/en/faculty/about

Faculty Management

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** The Board of commerce and social relevance of the FFPW USB and CENAKVA replaced the Cenakva Centre Supervisory Board as of 3rd September 2021 .*

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Director, Czech Hydrometeorological Institute

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Director and member of the Board, SOVAK ČR

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South Bohemian Research Centre for Aquaculture and Biodiversity of Hydrocenoses (CENAKVA)

Brief overview 2020/2021

CENAKVA
South Bohemian Research Center of Aquaculture and Biodiversity of Hydrocenoses

221/228
employees consisting of

94/90 academic and scientific staff and

82/88 technical and office staff

165/181
Web of Science + Scopus articles

11/16
applied results

97/98
Projects consisting of

88/91 national projects

9/7 international projects

105/108
Bachelor students

36/31
Master students

45/50
Ph.D. students

8
ponds over 1 ha (total **41.2** ha)

68
experimental ponds (total **9.3** ha)

3
Institutes

1
Research center CENAKVA

14
Laboratories

293,000
273,000
budget in thousands CZK

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