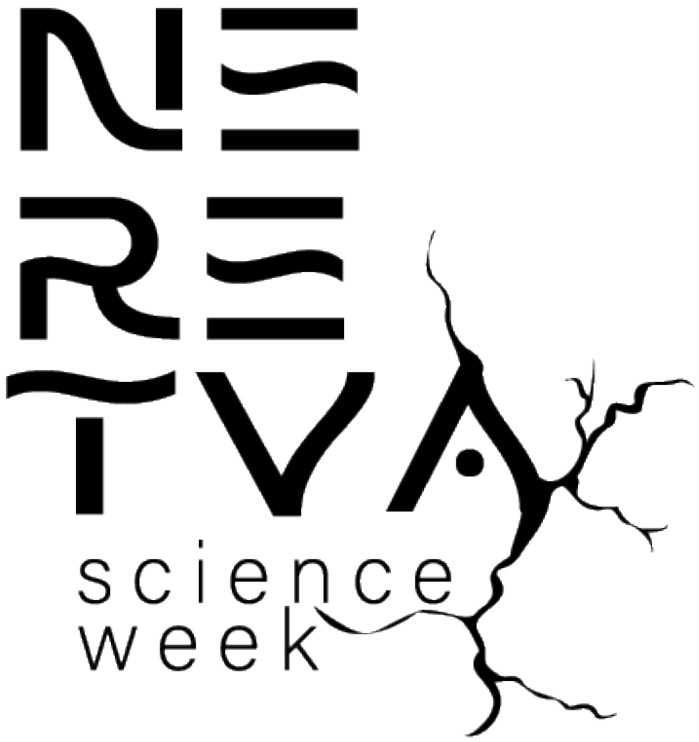
Science Week 2022: Neretva River, Bosnia and Herzegovina

Preliminary Report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Science Week 2022: Neretva River, Bosnia and Herzegovina

Preliminary Report

Editors:
Vera Knook (Riverwatch, River Collective)
Steven Weiss (University of Graz)
Gabriel Singer (University of Innsbruck)

Illustrations:
Vanja Lazić

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The authors would like to especially thank the following people for their patience and diligence in logistically organising and maintaining the field operations including constant support with communication and translation: Jelena Ivanic (Center for Environment), Vladimir Topic (Center for Environment), Sandra Josovic (Center for Environment), Ulrich Eichelmann (Riverwatch), Cornelia Wieser (Riverwatch), Amelie Huber (EuroNatur). We would also like to extend our gratitude to Boban Škrkar, the inhabitants of Ulog and Glavatičevo, the association of sports fishermen in Konjic and the fish association from Kalinovik for their support and warm hospitality.

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Preface

The Neretva River is 230 km long and flows through Bosnia and Herzegovina and Croatia before its confluence with the Adriatic Sea. While larger parts of the river network are already reservoirs, the Neretva and its tributaries upstream from Konjic are still free-flowing. Here, the river constitutes the heart of a karstic valley widely regarded as a natural heritage of regional significance, partly recognized as potential Emerald sites. And, here, the river is threatened by the construction of at least 25 new dams. This is a critical moment to collect data to provide evidence of what is at risk through building of dams in this valley, and increase public visibility of this valuable ecosystem.

From the 26th of June through the 5th of July 2022 a diverse team of scientists visited the upper Neretva River to collect data aimed at characterising this pristine and highly threatened riverine ecosystem. We focused on describing aspects of river-associated biodiversity by combining our expertises on various aquatic and terrestrial plant and animal groups. Furthermore, they studied the environmental conditions supporting this biodiversity and a selection of ecosystem functions it may drive in the particular setting of this river. In total, **48 scientists and 11 students from 7 countries** were involved in the field work. According to our various expertises we covered the topics **Aquatic Insects, Terrestrial Insects, Reptiles and Amphibians, Fish, Mammals, Birds, Vegetation, Subterranean Fauna, Food Web Structure and Trophic Diversity in Zoobenthos, Ecosystem Functional Diversity, Greenhouse Gases, and Physical Stream Habitats.**

The purpose of this report is to provide some very preliminary impressions, highlights and an overview from each of the specialty groups of what was done during this impressively international and collaborative effort. The data collected will be analysed in much more detail over the next months and a more extensive final report is expected by the end of the year 2022. Overall, all involved researchers were astonished by the pristine state of the surrounding forests and river bank vegetation, the amazing abundances of animals observed, and the unspoiled character of the river itself. While these results are only very preliminary, the initial reactions coming from this team of experienced scientists as well as the handful of highlights illuminated in this preliminary report should open some eyes to this precious, unique and vastly understudied ecosystem.

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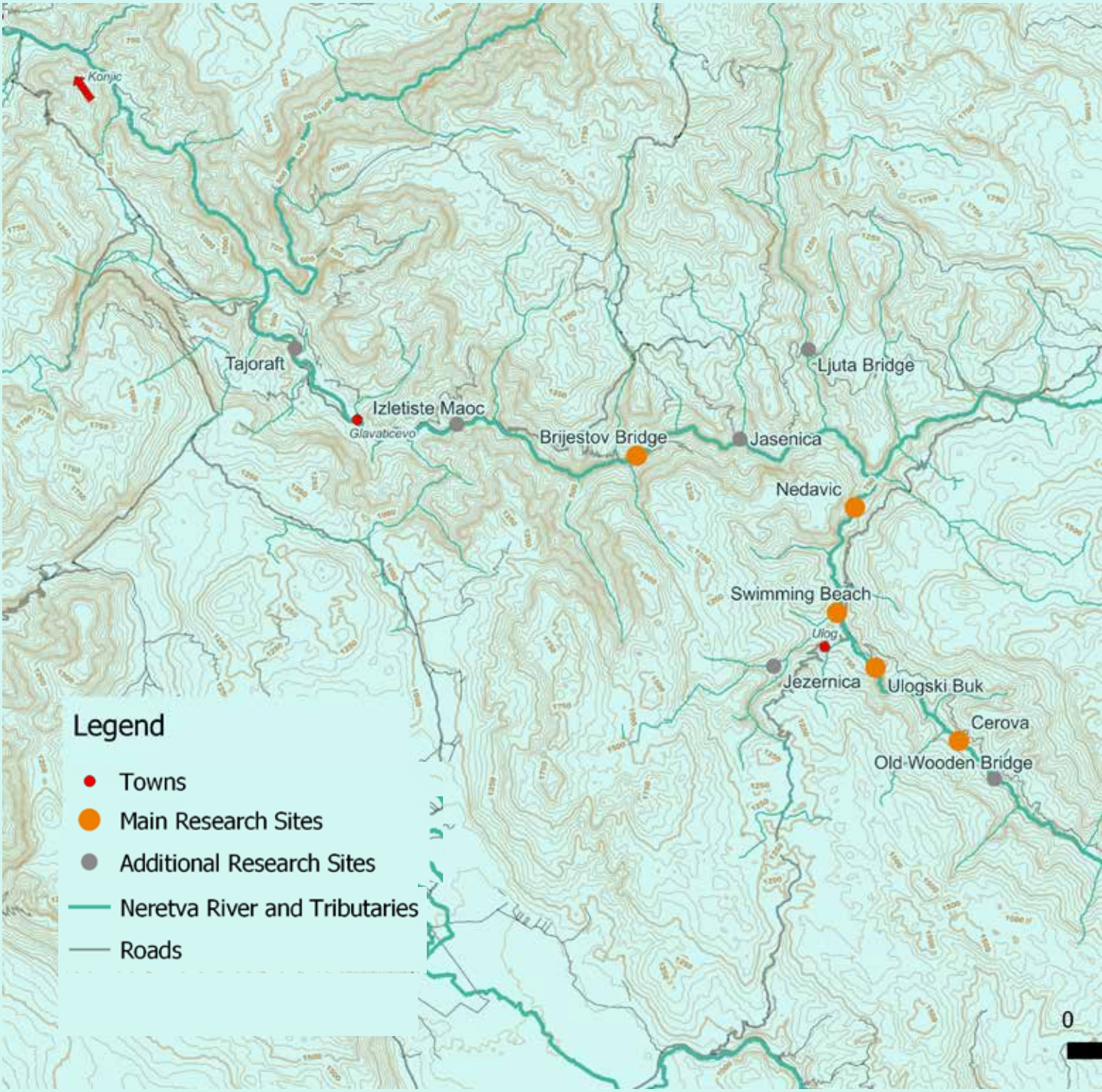
Overall Approach

The team of scientists set out with two objectives: (i) Collect data on aquatic as well as terrestrial river-associated biodiversity and (ii) assess potential impacts by hydropower development specifically on threatened habitat types and protected species. We want to achieve local assessments of flora, fauna and habitat by knowledgeable specialists and integrate those into an expert-based opinion on biodiversity and ecological integrity of the Upper Neretva at a regional scale, for example by understanding contributions of karst phenomena to system (i.e. river network-scale) heterogeneity and targeting potential effects of landscape fragmentation through hydropower development.



6 *Figure 1* - Overview map of the research area

Field work covered a dozen field sites that had been chosen during a reconnaissance trip in April 2022, stretching from just below the source of the Neretva River to the town of Konjic (Figure 1). Even though safety and accessibility had to be considered during selection of the sites in this exceptionally wild river network, the final set of field sites represents the length continuum of the river and covers important tributaries along the upper stretches of the Neretva River, between its source and the town of Konjic. Six sites were identified as main sampling sites and another six as additional sampling sites; the researchers were asked to visit at least the main sites and - if time allowed - also the additional sites. All sites are listed below and shown on the map. Some groups had more time and found additional sites to visit, or sampled from boats to achieve a more continuous impression. For some groups, the reporting is augmented with some existing information stemming from prior research efforts.

Table of Fieldwork Sites

#	Name	Coordinates	Main/Add.	River
1	Krupac confluence	43.32942, 18.42574	Main	Neretva
2	Old wooden bridge	43.36523, 18.36999	Additional	Neretva
3	Cerova	43.37887, 18.35621	Main	Neretva
4	Ulogski Buk	43.40527, 18.32304	Main	Neretva
5	Swimming beach	43.42414, 18.30837	Main	Neretva
6	Nedavic	43.458, 18.32121	Main	Neretva
7	Jasenica	43.48435, 18.27429	Additional	Neretva
8	Brijestov bridge	43.48227, 18.22665	Main	Neretva
9	Izletište Maoč	43.499, 18.14894	Additional	Neretva
10	Tajoraft	43.52945, 18.08061	Additional	Neretva
11	Jezernica	43.41121, 18.27837	Additional	Jezernica
12	Ljuta bridge	43.5103, 18.3078	Additional	Ljuta

In total, there were 48 scientists involved in the effort: 30 of them with specific taxonomic expertise (vegetation, reptiles, amphibians, fishes, terrestrial insects, aquatic insects, subterranean fauna, molluscs, mammals, bats and birds) and 18 covering aspects of environmental heterogeneity thought to support the river´s biodiversity and aspects of ecosystem functions and functional diversity that may be driven by biodiversity (food web structure, ecosystem functions, greenhouse gases and physical stream habitats).

Clearly, this effort to describe the Neretva River´s biodiversity and ecological integrity is limited in terms of expertise, spatial and temporal coverage. Future investigations may shed more light on this exceptional ecosystem.

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Conclusion

The initial findings as well as impressions of this diverse team of scientists were very consistent and underscore the remarkable state of the upper Neretva River. Although collectively all investigators commented on their limited ability to make an exhaustive survey in such a short time, there are nonetheless some clear results. All investigated sites were deemed to be in a pristine or nearly pristine state, including the surrounding riparian and valley forest ecosystem. The sheer abundances of particular species or species groups was remarked by many as something they have never or only rarely seen on the European continent. A relatively large number of endangered or protected species (i.e. listed in annexes of the European Habitat Directive or Bird Directive) was found. In just a few days of research effort we found evidence for large flagship carnivores (bear, wolf, wildcat and lynx), protected amphibians and endemic aquatic insects, invertebrate indicators of intact floodplain or riparian forest, high diversities of birds and bats and potentially undescribed subterranean crustaceans. The Neretva River is evidently also the last stronghold of the endangered softmouth trout. And while the researchers themselves were steadily surprised about the ecological richnesses of the valley, we also experienced first-hand how intensively the natural beauty of the place is used and enjoyed by humans on the weekend, when hundreds of nature-loving tourists visit the Konjic canyon by boat and evidently benefit from ecosystem services which the ecologically intact river provides to them. Indeed, the Neretva River is habitat for a high level of biodiversity including humans. Finding all this in one river valley underscores the extremely high conservation value of this ecosystem in its entirety.

> “The number of experts we bring to the river is as impressive as the river itself. And the concerted effort - we all land here like a spaceship on a new planet - generates a lot of momentum. We stand in awe before the richness of the place and the plants and animals we love to study, yet we can´t help but recognize that all we achieve is literally just a bit of scratching on the surface. I just hope that we can come back soon and will then still be able to learn more about the Neretva River.”
>
> *- Gabriel Singer, University of Innsbruck*

Vegetation

Dactylorhiza fuchsii
Common spotted orchid

"Investing in forests is an investment in the environment. Investing in the environment is an investment in the future."

- Emir Delić, Una National Park

Visited Research Sites

Involved Scientist

Emir Delić
Una National Park

Approach

Methods of visual observation and determination of different plant species were used. Plant species determination was done with the use of plant identification and botanical keys. The Braun-Blanquet sampling method, which is a standardised methodology for vegetation records, was used to survey large areas of surrounding vegetation.

Figure 2 - Maiden pink *(Dianthus deltoides* L.*)*

Figure 3 - Purple willow *(Salix purpurea* L.*)*

Highlight

The Neretva River showcases the enormous ecological importance of riparian black alder forests. They are known for their high biological diversity, preserving and protecting animal and plant species. Black alder and other riparian tree species serve as nesting and roosting sites for many species of birds, breeding sites for amphibians and reptiles, as well as hiding places from aerial predators. Their root structures form important aquatic and riparian habitat, but also prevent shoreline erosion and reduce the harmful effects of floods. Black alder ecosystems are highly threatened by drainage and canalization, that often happen in the context of "hydromelioration" activities, and the construction of hydropower plants. Here, along the Neretva, these riparian forests and habitats are threatened by dam construction. Subsequent changes in the flow regime will also cause bank erosion, leading to further species and habitat loss.

Preliminary Results

The flora of Bosnia and Herzegovina is one of the most diverse in the whole of Europe, with a high level of endemicity. This is emblematic of the Mediterranean Biodiversity Hotspot, to which it belongs, representing one of the 36 most bio-diverse regional ecosystems of the world. During the investigation of the flora of the upper reaches of the Neretva River in Ulog, more than 200 species of herbaceous and woody plants were recorded.

Figure 4 - Common spotted orchid *(Dactylorhiza fuchsii* (Druce) Soó*)*

Figure 5 - Adriatic lizard orchid *(Himantoglossum adriaticum H. Baumann)*

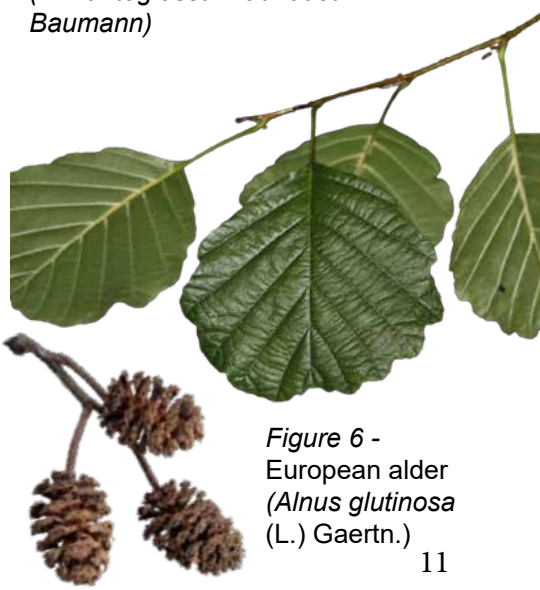


Figure 6 - European alder *(Alnus glutinosa* (L.) Gaertn.)

Reptiles and Amphibians

Rana graeca
Greek Stream Frog

"One of the best indicators of the pristine state of the Neretva River in this area are the recorded populations of Greek stream frog (*Rana graeca*) and yellow-bellied toad (*Bombina variegata*). I strongly believe that we should treasure and protect these areas of importance for biodiversity of not only Bosnia and Herzegovina but of Europe as a whole."

- Saudin Merdan, Center Dr. Stjepan Bolkay

Visited Research Sites

Involved Scientist

Saudin Merdan
Center Dr. Stjepan Bolkay

Approach

The structure of river-associated vegetation as well as the physical conditions in the flowing water demonstrated exceptionally high habitat heterogeneity that could potentially translate into high biodiversity. Bearing this in mind, the research sites were selected to include different types of habitats where amphibians and reptiles live, and in this way spatial coverage of the habitat diversity was achieved. Various sampling methods were used: individuals were registered visually, caught by hand or with a net for more detailed analysis, and then released back to the same place where they were collected. The research was done both during the day and at night. Also, the acoustic recognition of frog calls was used to record the presence of certain species.

Preliminary Results

Qualitative observations underline the richness of the fauna of amphibians and reptiles in the area of the upper Neretva River. A large number of species were found during field research, which is explained by the specificity of the habitat, large number of microhabitats, and the climate that prevails in this area. In total, I found 16 species of amphibians and reptiles from 10 families (Salamandridae, Ranidae, Bombinatoridae, Bufonidae, Hylidae, Anguidae, Lacertidae, Colubridae, Natricidae and Viperidae) in the upper reaches of the Neretva River. All registered species are indigenous to the area. Such a large number of registered species shows the exceptional quality and preservation of the habitat, demanding stronger efforts on the official protection of this area in order to maintain this state.

Highlights

Of all the registered species, special attention should be given to *Rana graeca* and *Bombina variegata. R. graeca* is a species endemic to the Balkan Peninsula and a strictly protected species according to the Regulation on Strictly Protected and Protected Wild Species of the Republic of Srpska. *B. variegata* is a species listed under Annex II and IV of the European Habitats Directive (and thus targeted for the creation of Natura 2000 sites) and is also strictly protected according to the Regulation on Strictly Protected and Protected Wild Species of the Republic of Srpska. In addition to the high abundance in the populations of these two species in the upper course of the Neretva River, the individuals appear morphologically very robust, indicating healthy populations and extremely high-quality habitats with plenty of food. I have not observed more robust and more numerous populations of these two species anywhere in Bosnia and Herzegovina, so it is extremely important to preserve these habitats in their original form.

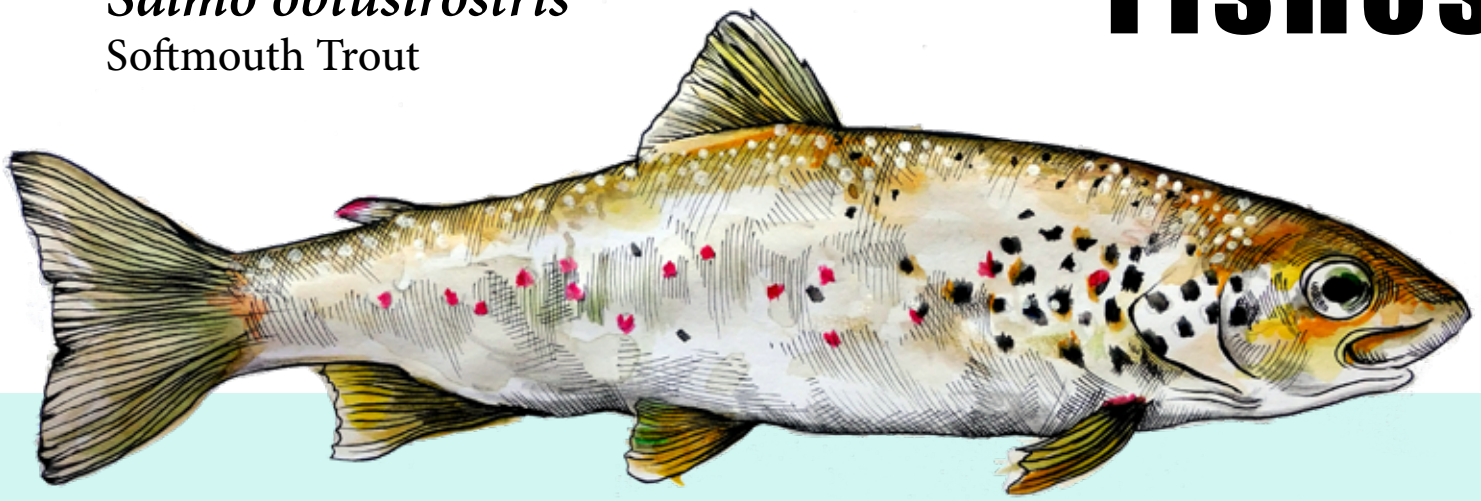
Figure 7 - Yellow-bellied toad *(Bombina variegata).*

The biggest threat to the amphibians and reptiles of this area is the potential construction of the planned hydropower plants. During construction, natural backwaters and channels for underground water are concreted, in order to avoid water loss, which would lead to the complete destruction of these habitats. Excluding water from its natural flow leads to a reduction in habitat area, affecting the amount of available food, the genetic diversity of species, and making them very easy prey, thus representing a huge threat to the preservation of healthy populations.

Figure 8 - Greek stream frog *(Rana graeca).*

Fishes

Salmo obtusirostris
Softmouth Trout



"This extremely rare and seriously endangered species is among the most enigmatic members of the Salmonidae family. Historically its relationship to other trout was misunderstood. Nowadays we know that it belongs to the genus *Salmo*, but the few remaining populations are all different, and thus their taxonomic assignment is controversial. The Neretva system contains by far the largest population of this species, and thus the last stronghold of this species on earth."

- Steven Weiss, University of Graz

"In comparison to the downstream stretches, the upper River Neretva and its river network are still mostly devoid of human-generated stressors that threaten the native fishes. The unclear taxonomic and native status of the non-salmonid species speaks for the little knowledge that we have about this remote and well-preserved river ecosystem."

- Predrag Simonović, University of Belgrade

Visited Research Sites

Involved Scientists

Kurt Pinter
BOKU University of Natural Resources and Life Sciences, Vienna

Thomas Friedrich
BOKU University of Natural Resources and Life Sciences, Vienna

Steven Weiss (Co-Lead)
University of Graz

Jakob Neuburg
BOKU University of Natural Resources and Life Sciences, Vienna

Predrag Simonovic
University of Belgrade

Sarah Höfler
blattfisch e.U., Austria

Approach

The Neretva River and its tributaries were sampled on four days. Upstream and downstream of Ulog, quantitative electrofishing was carried out. Further downstream, near Glavatičevo, the river is larger, and thus observations were made via snorkelling. In total, seven sites were investigated: six sites in the longitudinal course of the Neretva and one site in a tributary near Krupac. Measurements of the physical environment support the electrofishing data and describe the habitat composition.

In addition, at three sites eDNA samples were taken to get a more complete picture of the species composition in the investigation area.

Highlights

Upstream of a waterfall about three metres high in the tributary near Krupac several specimens of trout (*Salmo* sp.) could be detected. If they were not brought there by man, it must be a genetically pristine population isolated for thousands of years. Genetic samples will provide further information on their origin.

Another highlight was the detection of softmouth trout (*Salmo obtusirostris*) at Glavatičevo. This shy and difficult to detect species is yet to be sufficiently described and urgently needs scientific attention.

Figure 10 - Salmo obtusirostris at Glavatičevo
© Joshua D. Lim

Preliminary Results

Four fish species could be documented in the upper reaches of the Neretva River. These species can be addressed as trout (*Salmo* sp.), minnow (*Phoxinus* sp.), loach (*Barbatula* sp.) and bullhead (*Cottus* sp.). Further molecular biological analyses should provide detailed information about the species and their genetic lineage.

Figure 9 - Phoxinus sp. showing the typical spawning coloration.

In the longitudinal continuum, the typical pattern for brown trout populations could be observed: While the upper reaches are dominated by juveniles,in the further course of the river the density of juveniles decreases and that of subadults and adults increases. This pattern underlines the pristine and undisturbed character of the river network. Open river courses favour the development of natural population characteristics.

The fact that tributaries connected to the main river form important habitats for small fish species and juveniles was shown downstream of Ulog. There, a slow-flowing spring creek was sampled, which offered habitat especially for minnows, loaches and juvenile trout. As the river flows downstream, the number of species increases. A significant enrichment was the detection of the softmouth trout. It was found in the course of the snorkel survey at Glavatičevo. The animals mainly colonise deeper pools, which is why they are difficult or often impossible to detect with other sampling methods.

Discussions with local fishery representatives have shown that the highly endangered marble trout (*Salmo marmoratus*) still occurs in the area in specific locations.

The habitat surveys indicate a heterogeneous and richly structured streambed that provides adequate habitat for all species and age classes.

Terrestrial Insects

Deilephila elpenor
Elephant hawk moth

"My aim is to produce the longest verifiable species list in the shortest time possible with help of the iNaturalist community. Smaller animal species like insects and spiders along the Neretva River are completely unexplored, making this task even more exciting!"

- Gernot Kunz, University of Graz

Visited Research Sites

Involved Scientists

Branislava Dukić
Arbor Magna

Gernot Kunz
University of Graz

Hanna Gunzcy
Universalmuseum Joanneum

Wolfgang Paill
Universalmuseum Joanneum

Rolf Niedringhaus
University Oldenburg

Approach

During daytime we used sweep nets to collect butterflies and terrestrial bugs. Ground-dwelling insects were collected by hand and with aspirators. Nocturnal beetles were trapped with Barber traps exposed at selected sites for up to 3 days. Flying nocturnal insects were attracted by light traps and collected mostly close to basecamp locations near Ulog. For the ongoing identification of specimens specialists from across Europe are involved. So far, for butterflies and moths, our focus group until now, these were in particular Andreas Manz (Germany), Benjamin Wiesmair (Austria), Claudio Flamigni (Italy), Tomáš Dobrovský (Czech Republic), Christof Zeller (Austria), Petra Schattanek (Austria), Cornelia Niemetz (Austria) & Rudolf Ritt (Germany).

Figure 11 - Cicindela monticola albanica

Figure 14 - Morimus sp.

Preliminary Results

For butterflies and moths alone, we achieved around 500 observations on 9 localities. Most of the species were documented photographically and uploaded to the platform iNaturalist (https://www.inaturalist.org/observations?place_id=any&project_id=biodiversity-neretva&taxon_id=47157). The observations include at least 255 species of which 29 might be new records for the country of Bosnia Herzegovina (http://www.eu-nomen.eu). Only one registered species, *Ponometia candefacta* (Hübner, [1831]), is introduced, which speaks for the natural composition of the butterfly fauna. The study area around Ulog stands out in particular due to high densities of terrestrial insects and an extremely low percentage of introduced species.

With regard to the investigation of the beetle fauna, two records stand out: First, *Cicindela monticola albanica* Apfelbeck, 1909 is a rare cicindelid species endemic to the Balkan. It inhabits broad riverbanks with a mixture of grain and coarse sediments in initial to early succession stages. We found it immediately upstream of Ulog, its occurrence is likely along the whole upper course of the river. This species occurs from Croatia across Bulgaria, Serbia and Albania to northern Greece, but findings from Bosnia and Herzegovina are limited to three single data points more than 100 years old. A second remarkable species is *Dyschirius agnatus* Motschulsky, 1844. This species is a sensitive indicator of natural riverbanks, inhabiting the interstitial space close to the shoreline by digging in the ground. Our findings from the Neretva downstream of Ulog are the only actual evidence of this species from Bosnia and Herzegovina.

Figure 12 - Argynnis adippe & Argynnis paphia on a gravel bank at the site "Old wooden bridge".

Figure 13 - Euplagia quadripunctaria is a 'priority species' under Annex II of the Habitats Directive in the European Union. This specimen was caught around Kalinovik, but it was generally wider distributed in the study region.

Highlights

Finding large beetles in the 7-9 cm range like the European stag beetle (Lucanus cervus) or the European capricorn beetle (Carabus gigas) is exciting but also informative. While L. cervus speaks for intact forest ecosystems with rotting wood, the snail predator C. gigas is evidence for long and intact invertebrate food chains. Both spectacular animals were found close to the Neretva River near the Krupac confluence.

The cixiid planthopper (*Pentastiridius beieri)* is one of at least 100 registered species of hemipterans. It is critically endangered due to its restriction to gravel bank vegetation along natural rivers. Its finding is the first record for the Balkans.

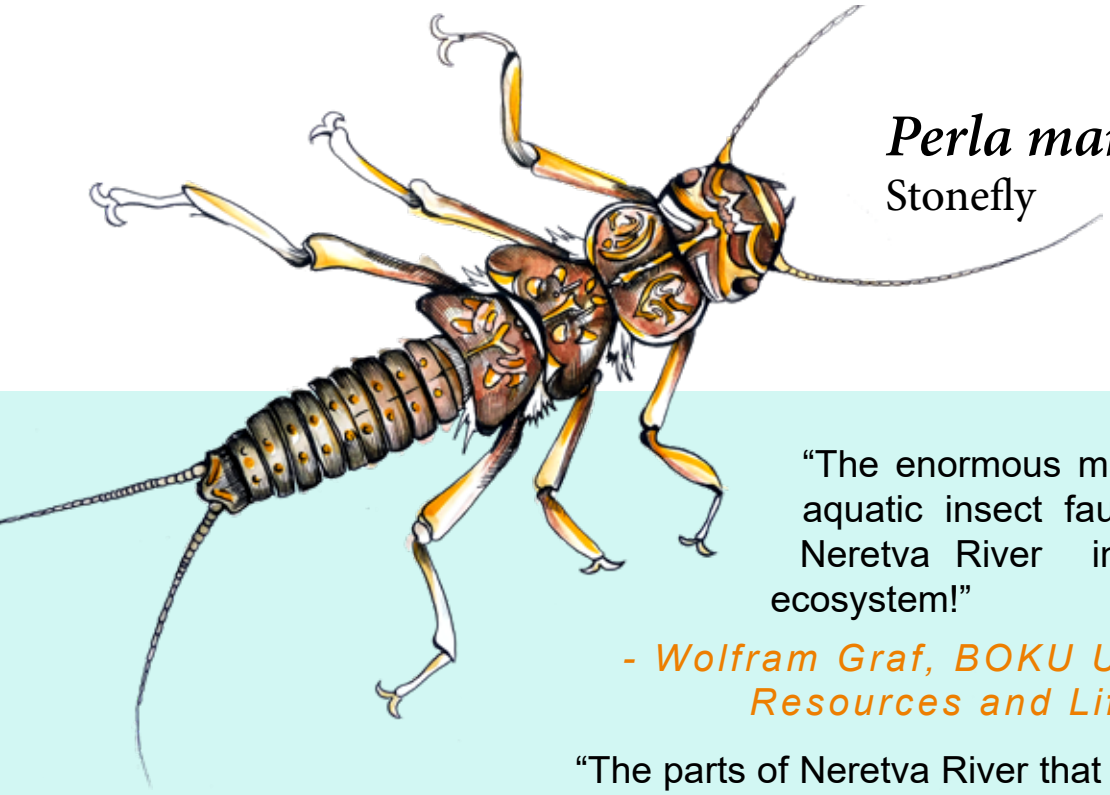







Figure 15 - Collage: From left to right: (a) High densities of insects, especially moths and caddisflies on the lightrap in Ulog © Gernot Kunz (b) Exploring the Rakitnica, a tributary of the Neretva © Vladimir Tadić (c) *Bombina variegata* (yellow-bellied toad) © Gernot Kunz (d) Sampling on the Rakitnica © Vladimir Tadić (e) Basecamp Ulog under the starry sky © Vladimir Tadić (d) Rafting the Neretva canyon between Glavaticevo and Konjic © Vladimir Tadić (e) *Aporia crataegi* (black-veined white) © Gernot Kunz (f) Collecting samples from the interstitial habitats © Vladimir Tadić (g) The Krupac tributary © Gernot Kunz (h) Introduction evening in basecamp Ulog © Vladimir Tadić

Aquatic Insects



Perla marginata - larva
Stonefly

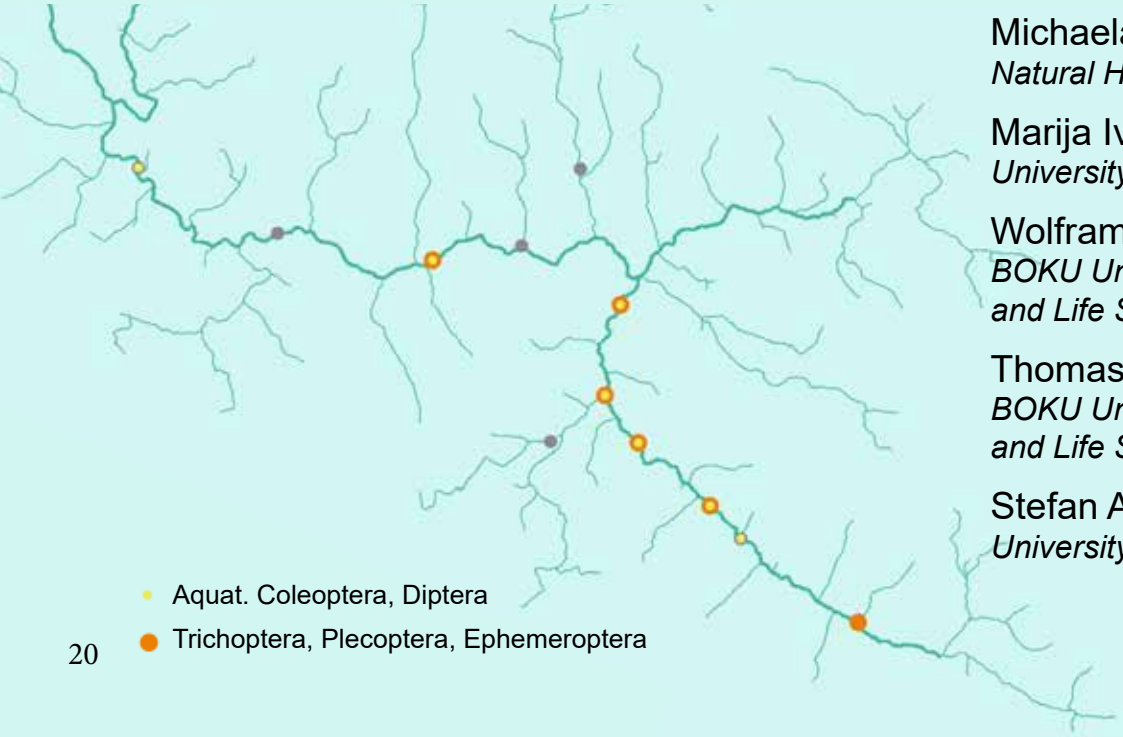
"The enormous masses of a species-rich aquatic insect fauna emerging from the Neretva River indicate a very healthy ecosystem!"

- Wolfram Graf, BOKU University of Natural Resources and Life Sciences, Vienna

"The parts of Neretva River that were studied in terms of aquatic dance flies are probably the most diverse and species-rich river habitats in the Balkans and beyond. My collecting efforts were limited to only a few days in a seasonally suboptimal time period, yet what I found makes me believe that with little additional effort in different times of the year and with some additional sites, the number of detected species of aquatic dance flies alone would rise to approximately 30."

- Marija Ivković, University of Zagreb

Visited Research Sites



Involved Scientists

Michaela Brojer
Natural History Museum Vienna

Marija Ivković
University of Zagreb

Wolfram Graf
BOKU University of Natural Resources and Life Sciences, Vienna

Thomas Huber
BOKU University of Natural Resources and Life Sciences, Vienna

Stefan Anđus
University of Belgrade

Approach

As specialists for specific groups of aquatic insects we used various methods and collecting tools, including sweep nets, hand nets, aspirators and light traps, in order to most thoroughly examine the composition of aquatic Trichoptera, Plecoptera, Ephemeroptera, Diptera, aquatic Coleoptera in the upper part of the Neretva River. Additionally, a more quantitative approach was carried out by multi-habitat-sampling using a D-frame net.

Preliminary Results

For the group of aquatic and water-related Coleoptera, after having taken a first look at the collected material, it can be stated that there are at least 50 species from 11 families found in the upper part of the Neretva River - among them was the rather rare riffle beetle *Stenelmis puberula*. Moreover, the family of mud-loving beetles Georissidae with two different species (*Georissus laesicollis* and *Georissus costatus*) was recorded for the first time in Bosnia and Herzegovina. The specimens of *Georissus* at the Neretva were found in sandy sediments along the waterline of sandbars, residual ditches and alluvial shores. All of these habitats are created and maintained by natural fluvial dynamics and thus most probably would be strongly affected by hydropower plants. Many species of *Georissus* are often found on national Red Lists and considered as already extinct or at least endangered.

After preliminary examining the aquatic Diptera samples 19 species from just one family, aquatic dance flies (*Empididae*), were found, among which 5 endemic species are confined strictly to the Balkan region. species confined strictly to the Balkan region: *Wiedemannia ariadne, W. artemisa, W. dinarica, W. kacanskae* and *W. microstigma.* Additionally, five species were recorded for the first time from Bosnia and Herzegovina: *Wiedemannia ariadne, W. angelieri, W. aquilex, W. mikiana* and *Clinocerella sorex.*

Regarding caddisflies (Trichoptera), up to now, 65 species are documented for the Neretva catchment. An investigation from 2015 listed 35 species. During the Science Week, 45 species were found. The majority are rheobiont species requiring flowing water, which means they will be seriously affected by damming. One third of all species are endemic to the Balkans, many of which have a restricted distribution. *Allotrichia marinkovicae,* for example, is known from very few sites worldwide. Due to the enormous amount of material collected from the light traps, identification is still in progress and more species may be detected.

Figure 17 - Hydropsyche mostarensis - a Balkan endemic species, described from the Mostar region

Figure 19 - Perla marginata - larva

Figure 18 - Stenelmis puberula

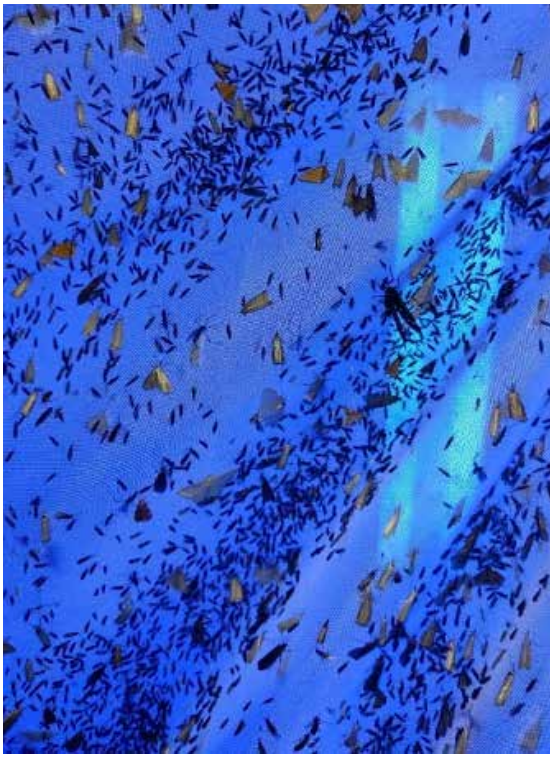
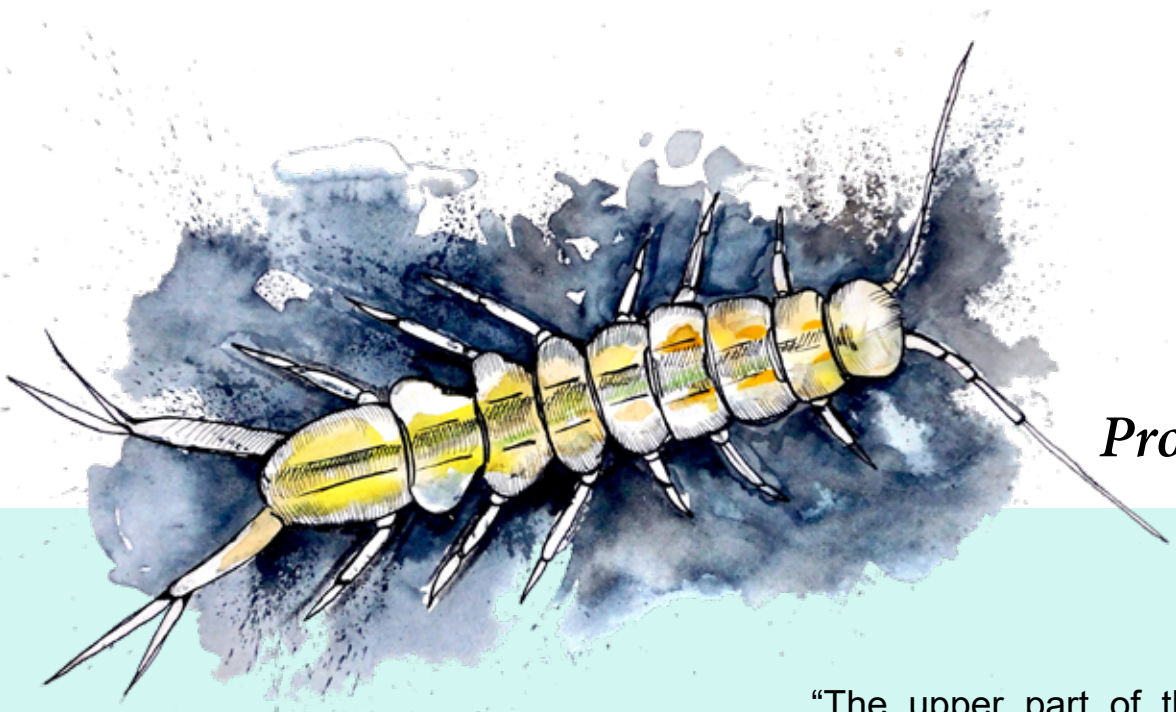


Figure 16 - Light-trap attracting mostly Trichoptera (the small dark moth-like insects of the genera *Agapetus*

Subterranean Fauna



Proasellus

"The upper part of the Neretva River gives an impression rarely seen: a pristine free-flowing river with no man-made obstacles in its way. The flow of the river and its fluctuations have created numerous gravel bars, providing habitat to specialised, often endemic subterranean species that live in the spaces between the gravel particles next to and below the riverbed. With the construction of the dams, these habitats would be destroyed - and the species driven to extinction before they are even discovered."

- Maja Zagmajster, University of Ljubljana

Visited Research Sites

Involved Scientists

Maja Zagmajster
University of Ljubljana

Špela Borko
University of Ljubljana

Ester Premate
University of Ljubljana

Behare Rexhepi
University of Ljubljana

Vojo Milanović
Centre for Karst and Speleology

Approach

The main focus of the study of subterranean species was sampling the Neretva River´s interstitial habitats and springs along the river and its tributaries. We also had the opportunity to sample subterranean animals in the cave "Velika Đeverđela", which was shown to us by a local guide. On gravel bars, we used mostly the Bou-Rouch sampling method and once the Karaman-Chappuis method. Springs were sampled with water nets or by directly collecting the animals from the stones. All samples were preserved in ethanol. They are currently being carefully examined and sorted into different taxa. Specimens will be further identified by taxonomists and by applying molecular methods when needed.

Highlights

Interstitial habitats are among the least studied habitats in the Dinarides, while caves and springs receive much more attention. To our knowledge, we generated the first data on aquatic subterranean species from the upper Neretva River. Although the interstitial samples contain many epigean species using such habitats, we can already confirm the presence of species of two subterranean crustacean genera, *Niphargus* sp. (Amphipoda) and *Proasellus* sp. (Isopoda), which are inhabitants of the groundwater. Given the generally high endemicity of subterranean species and the great diversity within these genera, they may even be species new to science!

Preliminary Results

We sampled subterranean aquatic invertebrates at five gravel bars and seven springs. In addition, we sampled subterranean terrestrial invertebrates in the "Velika Đeverđela" cave. Invertebrate samples collected at all sites are currently being sorted and determined based on morphological characteristics and DNA sequences. At this time, we can confirm that we collected *Niphargus* sp. at three sites and *Proasellus* sp. at two sites. The representatives of both genera were found in samples from the gravel bars close to Krupac confluence and the gravel bar "swimming beach" in Ulog, while *Niphargus* sp. was also found in a gravel bar near the Brijestov Bridge. The forthcoming molecular and morphological analyses will allow accurate species identification. We expect to find additional obligate subterranean species in the samples once all the material obtained has been sorted and analysed. In particular, we expect to find subterranean species among many sampled individuals of other crustacean groups (Ostracoda and Copepoda) and among tiny snails of the family Hydrobiidae.

Figure 20 - Two examples of amphipod species of the genus *Niphargus* sp., living in river interstitial in the Balkans. The body length of the specimens is only a few millimeters (up to 5 mm). © Teo Delić, SubBioLab.

Figure 21 - Example of blind isopod species of the genus *Proasellus* sp. from Bosnia and Herzegovina. The body length is about 5 mm, but the species we found was even smaller. © Teo Delić, SubBioLab.

Molluscs

Herilla bosniensis

"The tiny spring snails are important indicators for clean water on which they depend. Our findings of spring snails during the Neretva Science Week are evidence for the existence of springs with high quality water in the surroundings of the Neretva. It is foreseeable that a comprehensive survey of springs in the area will reveal a high spring snail diversity."

- Elisabeth Haring, Natural History Museum Vienna

Visited Research Sites

Involved Scientists

Michael Duda
Natural History Museum Vienna

Elisabeth Haring
Natural History Museum Vienna

Approach

To reach the main goal of gaining a comprehensive overview of the mollusc fauna at the upper Neretva River within a short time, river deposits were collected and sieved. River deposits are organic litter, e.g. small branches or leaves, which are flushed into piles during flood events. These deposits work as a filter, as they also accumulate empty mollusc shells from the surrounding areas. Furthermore, single specimens of larger snail species were also found by visual search in the water as well as on vegetation, stones and rocks.

Highlights

During our research, approximately 50 snail and one freshwater clam species representing 24 mollusc families were found. The most important result was the finding of at least three species of spring snails.

Figure 22 - Spring snail (*Bythinella* sp.) from a spring near Krupac.

Preliminary Results

While the highly dynamic upper Neretva River itself reveals low diversity of aquatic molluscs, we found them in the tributaries as well as in springs in the areas accompanying the river system. Moreover, the adjacent forests and rock formations harbour many land snail species and preliminary analysis revealed a high diversity of land snails along the river. A high diversity of land snails could also be detected by analysing river deposits, consisting mainly of forest inhabitants and rock dwelling snails.

About 50 molluscs species of 24 gastropod families could be found during our research, most of them were land snails and five represent freshwater snails. At least one species of pea clam, which are tiny freshwater mussels often not bigger than 1 cm, could also be found. Three springs were investigated in the forest close to the sampling sites, all harbouring spring snails. In addition, spring snails were also found in the deposits collected in the river. It is known that the distribution of some species covers various springs that are connected by underground water, others are rare endemics occurring even in single springs only. The three spring snail species found during the Neretva campaign still have to be identified by taxonomic experts for this group, of which only a few exist in the world. The genetic analysis will also help in identification.

Figure 23 - The picture above shows *Herilla bosniensis a member* of the door snail family. It ocurrs exclusively on limestone rocks. Here we see it at locality Nedavic. From a distance, the snail on the rock face is hard to spot.

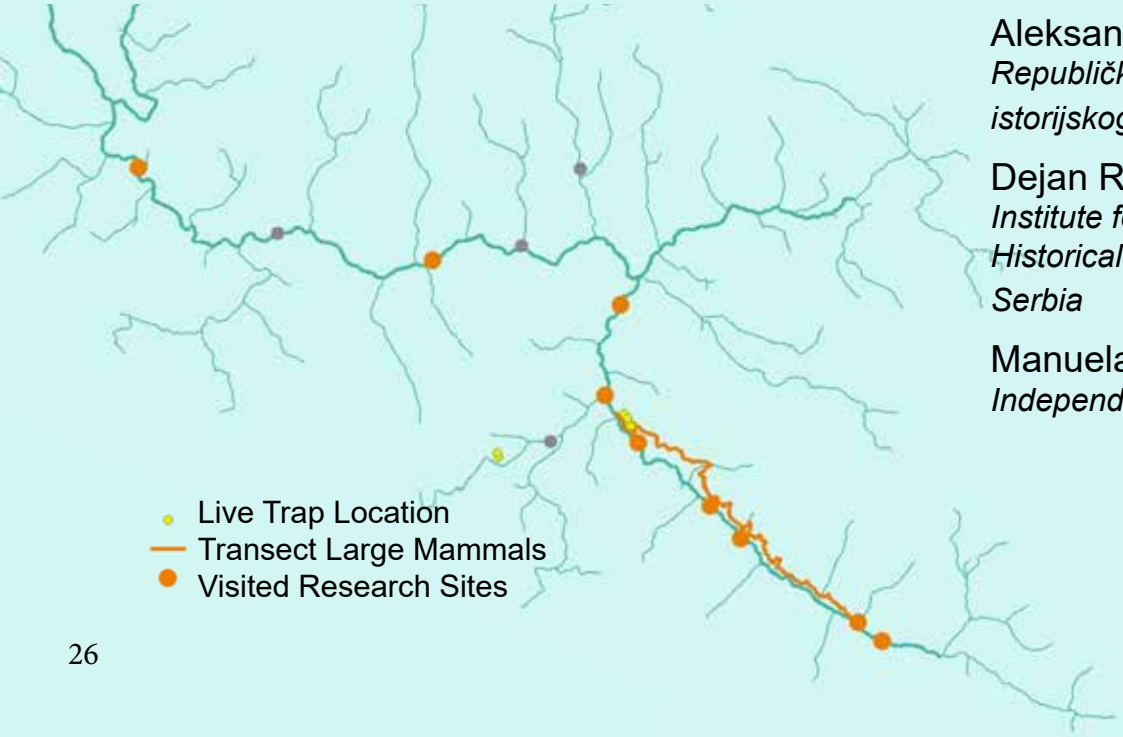
Mammals

Lutra Lutra
Otter

"Rarely does the living world manifest itself so clearly as in the basin of the upper course of Neretva River. The absence of human activities made it possible to illuminate the links of the complex food chain that exists in that river ecosystem. It should be noted that this area is one of the very rare areas in the country where the presence of all three species of large carnivores existing in Bosnia and Herzegovina have been confirmed; the brown bear (*Ursus arctos*), grey wolf (*Canus lupus*), and Eurasian lynx (*Lynx lynx*)."

- Aleksandra Penezic, Dejan Radosevic

Visited Research Sites



Involved Scientists

Aleksandra Penezic
Republički zavod za zaštitu kulturno-istorijskog i prirodnog nasljeđa RS

Dejan Radošević
Institute for the Protection of Cultural, Historical and Natural Heritage, Serbia

Manuela Habe
Independent Researcher

Approach

Small Mammals - During the small mammals surveys, we used live traps (68 in total) that were placed within 6 polygones (4 localities). Each polygon was checked twice per day during the research period of 3 days. In order to detect the presence of other mammal groups, line transect surveys were used on dirt roads during the daytime and after the sunset, with headlights. The surveys were carried out over a length of 5 km upstream and 5 km downstream from the bridge in Ulog, along the right side of the Neretva River, as well as on 5 km of dirt road from Ulog to Crvanjsko jezero (lake). Direct (observation) and indirect (scats, tracks and other signs) evidence of mammal presence were recorded.

Figure 25 - Lynx track, L:7cm W:6,5cm

Figure 24 - Lutra lutra (scat)

Large Mammals - Tracking and opportunistic camera sampling were the methods of choice to detect large mammals. Camera-trapping is considered the most labour-efficient method for producing a species inventory, yet this technique was limited by our overall short total sampling period. Due to limited access to local information and scarce literature, one scouting day was carried out before the Neretva Science week. Based on geographical information a road transect (20km) was chosen (dirt road, leading along the right side of the Neretva River, Ulog - Krupac Confluence). Additionally, we recorded all mammal tracks along the roads or paths down to the main research sites (10km) and along the transects for the camera trap setup (4km). The road transect was investigated three times (mornings; MON, WED, FRI) with focus on wet and sandy parts. Each research site was visited once in the course of the five research days and the additional research transects accordingly. The camera transects were tracked on the day of setup and removal.

Preliminary Results

During the 3 days of surveys mammal species classified into five orders were identified (Eulipotyphla, Rodentia, Carnivora, Cetartiodactyla and Lagomorpha). Along the transects we identified 14 larger and 2 small mammals.

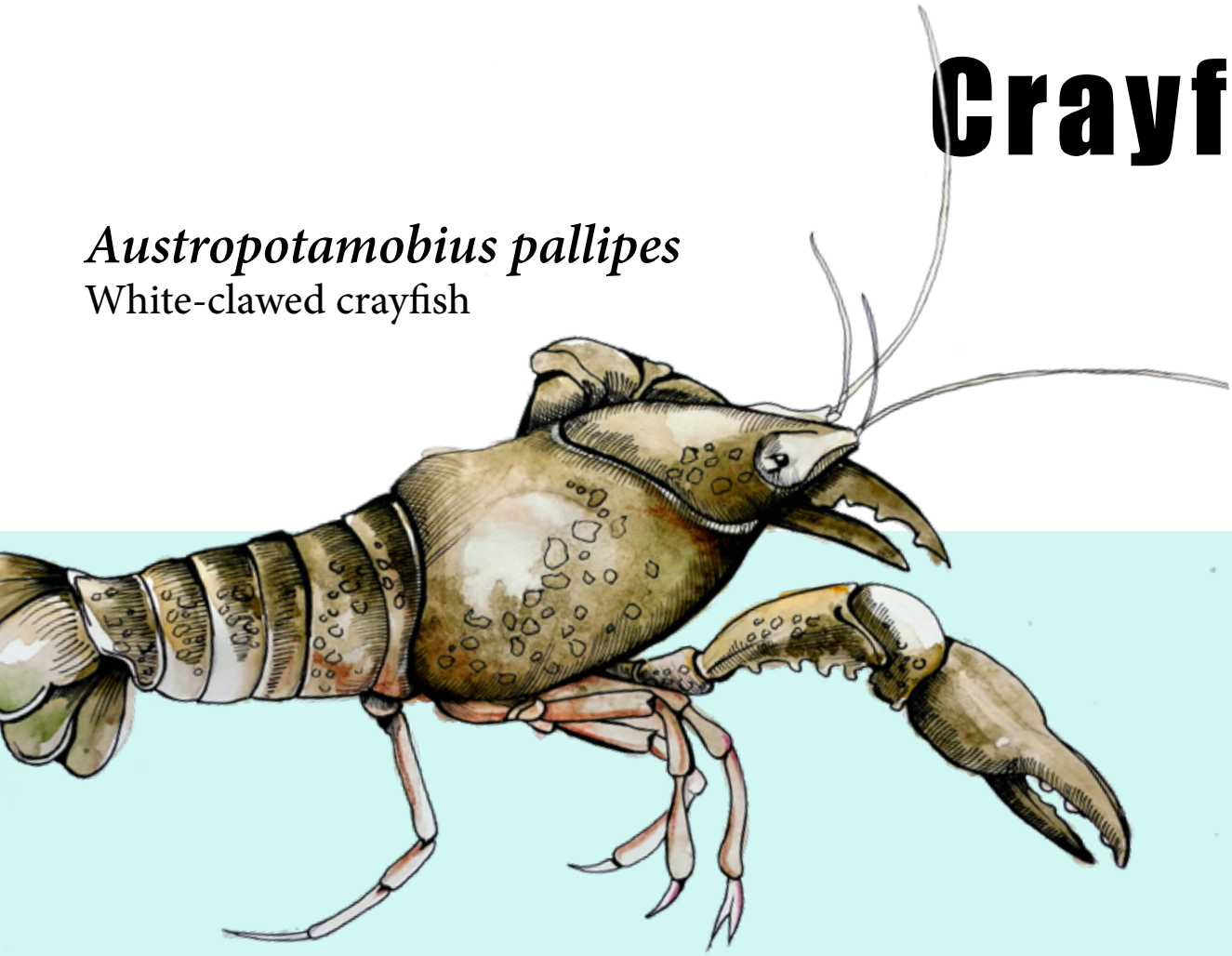
While the camera trap setup for only two nights brought no successful record, we could reconfirm the presence of the European brown bear (*Ursus arctos)*, grey wolf (*Canis lupus*) and the European otter (*Lutra lutra*). Moreover, recorded tracks indicate the presence of the European wild cat (*Felis silvestris)* and the Eurasian lynx (*Lynx lynx*).

Figure 26 - Blind Mole (*Talpa caeca)* approx. 2 km south-east of Ulog

Figure 27 - *Ursus arctos* (scat) approx. 3 km south-east of Ulog

Crayfish

Austropotamobius pallipes
White-clawed crayfish



"The native crayfish will be one of the first victims of the dam. The fluctuating water level due to the operation will destroy their habitats downstream."

- Sarah Höfler, blattfisch e.U.

Visited Research Sites

Involved Scientists

Sarah Höfler
blattfisch e.U., Austria

Wolfram Graf
BOKU University of Natural Resources and Life Sciences, Vienna

Thomas Huber
BOKU University of Natural Resources and Life Sciences, Vienna

Steven Weiss
University of Graz

Approach

While native crayfish were not initially on the study programme of the Science week, their high densities in the Neretva made it impossible to overlook them. This is especially true since crayfish are among the most endangered animal groups worldwide and they are also good indicator species for the condition of water bodies. Therefore, the shore or shallow overflowed gravel areas were specifically searched at four locations by turning over larger stones. The caught individuals were recorded in pictures and some specimens were taken to the laboratory for identification. In addition, genetic samples were preserved, which may be helpful for a more detailed examination.

Highlights

In the area downstream of Glavatičevo, the white-clawed crayfish (*Austropotamobius pallipes)* was present in extraordinary densities. It mainly colonised scoured bank reaches in slower-flowing areas, but is also found along the entire river banks. Their great variance in colour shades from light grey-brown to red was remarkable.

Figure 28 - White-clawed crayfish *(Austropotamobius pallipes)*

Preliminary Results

Crayfish were found in varying densities at all four sampling sites investigated, with the densest populations in the Glavatičevo area (Site 6). The crayfish specimens found were identified as white-clawed crayfish (*Austropotamobius pallipes*) based on the identification characteristics. This is also consistent with the information provided by Trožić-Borovac (2011).

At present, it cannot be ruled out - although it is rather unlikely - that there is also the stone crayfish (*Austropotamobius torrentium*) in the upper reaches of the river or that the individuals found can be assigned to several genetic variants. However, further investigations and genetic analyses are necessary for final clarification.

Areas along gravel banks with coarser gravel and washed-out banks, where niches/caves and the extensive exposed root systems of riparian alder are used as refuges, were the preferred habitats. The flow velocities in these areas were below 0.5 m s -1 under the given low flow conditions. Based on the observations and the hydromorphological conditions, it can be assumed that high densities of white-clawed crayfish can be found in the entire upper reaches of the Neretva. The population can thus be considered exceptional in the European context. This is of particular importance as *A. pallipes* is listed in Annex II and V of the Fauna-Flora-Habitat Directive of EU (Council Directive 92/43/EEC of 21 May 1992 on the Conservation of Natural Habitats and of Wild Fauna and Flora, 1992) .

Within Bosnia and Herzegovina, the Neretva River is described as the main area of distribution of the white-clawed crayfish (Trožić-Borovac, 2011). The IUCN has also pointed out that the Balkan rivers are last important refuges for the European freshwater fauna and especially for the native crayfish, a group of species threatened by many human impacts (Richman et al., 2015). Outbreaks of crayfish plague show that there is also an acute endangerment situation for the white-clawed crayfish in Bosnia-Herzegovina (Mrugała et al., 2017). Effective protection of native crayfish in the Upper Neretva is therefore of considerable importance, both on a national and international level. Destruction of habitats through the construction of further dams or the operation of power plants will have a significant impact on this species.

References

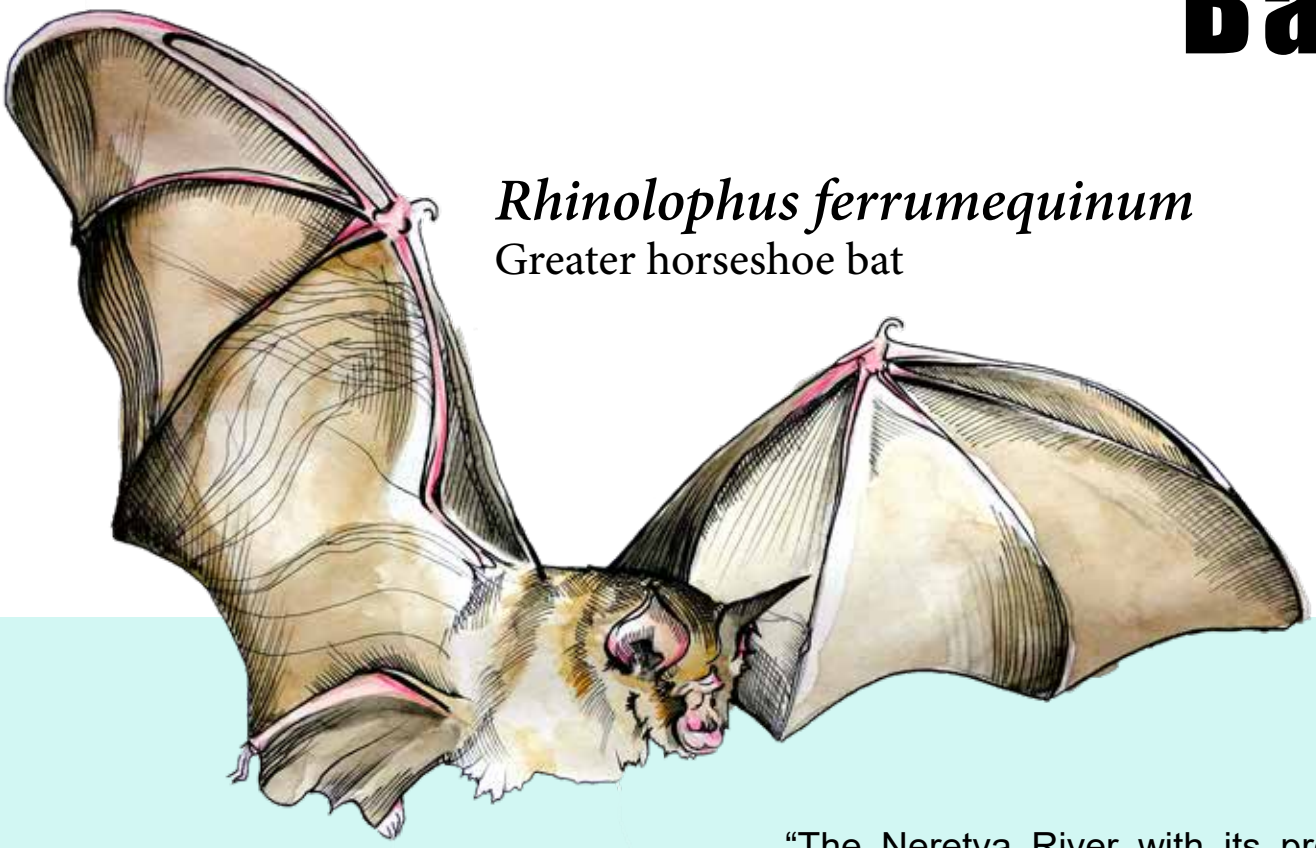
Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora, (1992).

Mrugała, A., Šanda, R., Petrusek, A., Marić, D., & Vukić, J. (2017). Recent acute crayfish mortality reveals Aphanomyces astaci presence in Bosnia and Herzegovina. Journal of Invertebrate Pathology, 150, 73–75. https://doi.org/https://doi.org/10.1016/j.jip.2017.09.004

Richman, N. I., Böhm, M., Adams, S. B., Alvarez, F., Bergey, E. A., Bunn, J. J. S., Burnham, Q., Cordeiro, J., Coughran, J., Crandall, K. A., Dawkins, K. L., Distefano, R. J., Doran, N. E., Edsman, L., Eversole, A. G., Füreder, L., Furse, J. M., Gherardi, F., Hamr, P., … Collen, B. (2015). Multiple drivers of decline in the global status of freshwater crayfish (Decapoda: Astacidea). Philosophical Transactions of the Royal Society B: Biological Sciences, 370(1662), 1–11. https://doi.org/10.1098/rstb.2014.0060

Trožić-Borovac, S. (2011). Freshwater crayfish in Bosnia and Herzegovina: the first report on their distribution. Knowledge and Management of Aquatic Ecosystems, 401. https://doi.org/10.1051/kmae/2011048

Bats

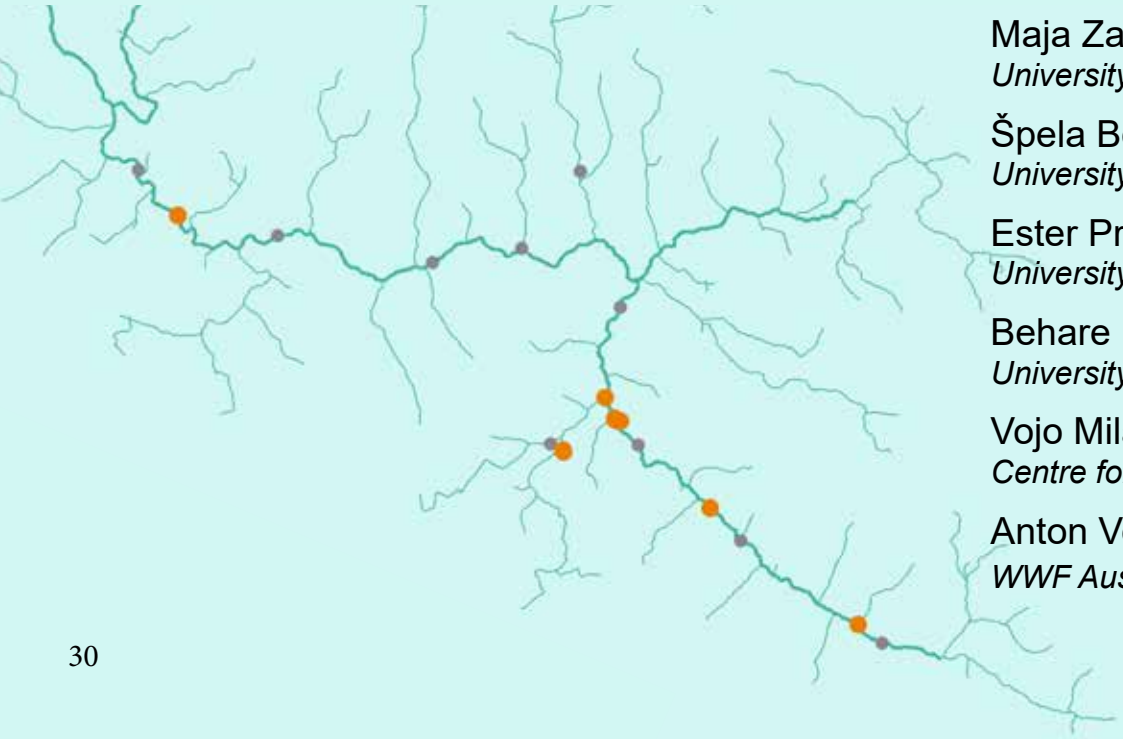


Rhinolophus ferrumequinum
Greater horseshoe bat

"The Neretva River with its preserved forests, natural caves and buildings in its surroundings represents a very interesting area for bats. During the Neretva Science Week, at least 12 species of bats were detected, which is more than one third of all species present in the country. This number could increase when the echolocation records are analysed. This is an amazing result for such a short period of research!"

- Maja Zagmajster, University of Ljubljana

Visited Research Sites



Involved Scientists

Maja Zagmajster
University of Ljubljana

Špela Borko
University of Ljubljana

Ester Premate
University of Ljubljana

Behare Rexhepi
University of Ljubljana

Vojo Milanović
Centre for Karst and Speleology

Anton Vorauer
WWF Austria

Approach

We used different methods to detect as many bat species as possible. During the day, we searched for them at potential roost sites. We examined abandoned buildings in the area of Ulog and checked two caves: “Velika Đeverđela” and the entrance part of “Mala Đeverđela”. During the nights we set mist nets near or above the Neretva River, on the edges of the forest or between the buildings. After a bat was caught in the net, we immediately measured and determined the individual and released it on the spot. We also surveyed bats by recording echolocation calls with bat detectors. Automatic bat recorders were placed at selected sites near the Neretva River on three nights at three different locations, while manual bat detectors were used at some sites and bat calls were recorded for later analysis.

Highlights

Three bat species of the highest conservation concern in Europe were caught in the upper Neretva River: Greater horseshoe bat (Rhinolophus ferrumequinum), Lesser horseshoe bat (Rhinolophus hipposideros) and Greater mouse-eared bat (Myotis myotis). These three species are listed in Annex 2 of the European Habitats Directive, which demands designation of special areas of conservation. Thus, the upper Neretva region should be considered such an area for these bats and included in the European conservation network.

Preliminary Results

Among the bats captured in mist nets or observed during fieldwork, we identified at least 12 species belonging to two families: Rhinolophidae and Vespertilionidae. The lesser horseshoe bat (*Rhinolophus hipposideros*) was found in buildings and in caves, including groups of pregnant females in some abandoned buildings of Ulog. One individual of the greater horseshoe bat (*Rhinolophus ferrumequinum*) was caught in the mist net near Ulog. The most successful night in mist netting was on the Neretva River near Krupac confluence, where six different bat species belonging to the genera *Myotis* and *Pipistrellus* were caught, while at another site, *Eptesicus* and *Nyctalus* species were caught The bat calls are currently being reviewed and analysed to provide a complete overview of the recorded species.

Figure 29 - The greater mouse-eared bat (*Myotis myotis*) caught in the mist net close to the Krupac confluence. © Ester Premate, SubBioLab.

Birds

Cinclus cinclus
White-throated dipper

"It's not only the Neretva River itself, but also the surrounding cliffs and old-growth forests that make this area a spectacular biodiversity hotspot."

- Andrey Ralev, CEE Bankwatch Network

Visited Research Sites

Involved Scientist

Andrey Ralev
CEE Bankwatch Network

Approach

Nesting bird species and their habitats were researched in the Neretva River valley between Ulog village and the confluence of Krupac stream. Transects for birds in forest and riparian habitats between one and three kilometres long were done during the mornings and late afternoons. At the hottest hours of the day, observations of soaring birds were conducted from points with a good view to cliffs and hilltops. All birds seen or heard were registered.

Highlights

The Upper Neretva River and its tributaries are the primary habitat for goosander (*Mergus merganser),* common sandpiper (*Actitis hypoleucos)*, Eurasian dipper (*Cinclus cinclus)*, grey (*Motacilla cinerea)* and white (*Motacilla alba)* wagtails. The riparian alder forests (a priority habitat according to EU guideline 91E0) support a variety of passerines and woodpeckers. Old-growth oak and hornbeam forests, meadows and cliffs along the rivers are also key for the conservation of bird fauna - several species of European importance breed there, including honey buzzard (*Pernis apivorus)* and red-backed shrike (*Lanius collurio)* and probably many more species downstream from Ulog village.

Figure 30 - Common sandpiper *(Actitis hypoleucos)* at Neretva River

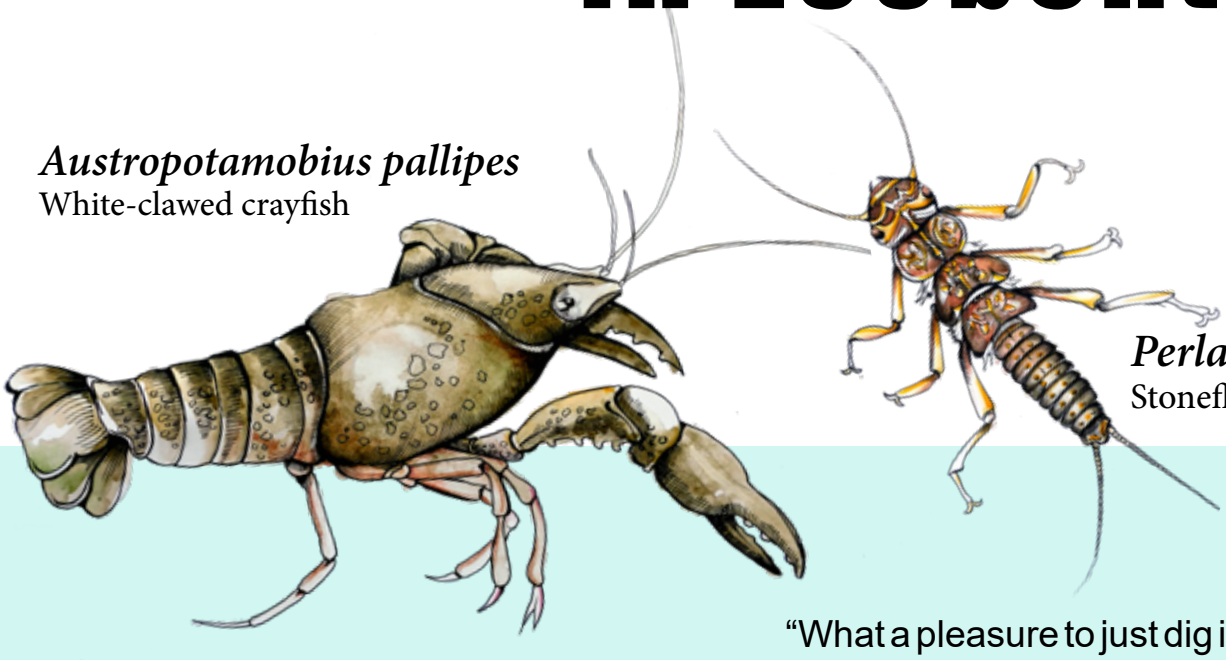
Preliminary Results

A total of 41 species of birds were found in three days. Goosander (*Mergus merganser*) and Eurasian sparrowhawk (*Accipiter nisus)* were additionally found by other teams. The results add to the information provided by bird research done in the area in previous years. The complex of breeding species related to the rivers, old riparian, oak and hornbeam forests, as well as to cliffs and meadows is a strong argument for the consideration of the investigated area as a site of the Emerald conservation network. Eurasian honey buzzard and red-backed shrike are protected in the EU Birds Directive and the Bern Convention. Goosander, probably breeding in the area of Glavatičevo, is also an important find, as the species is a relatively new breeder in Bosnia and Herzegovina. Besides birds, observations of otter (*Lutra Lutra*) scat and Atlantic stream crayfish (*Austropotamobius pallipes*) were made all the way up to the wooden beach - underlining the necessary consideration of the Neretva River as part of the Emerald conservation network.

List of Species and Number of Observations

Pernis apivorus — 1
European honey-buzzard
Buteo buteo — 2
Common buzzard
Columba palumbus — 1
Common wood-pigeon
Cuculus canorus — 4
Common cuckoo
Upupa epops — 1
Eurasian hoopoe
Dendrocopos major — 3
Great spotted woodpecker
Picus viridis — 4
Eurasian woodpecker
Falco tinnunculus — 2
Eurasian kestrel
Oriolus oriolus — 5
Eurasian golden oriole
Lanius collurio — 2
Red-backed shrike
Garrulus glandarius — 2
Eurasian jay
Corvus corax — 1
Common raven
Poecile palustris — 4
Marsh tit
Cyanistes caeruleus — 1
Eurasian blue bit
Parus major — 2
Great tit
Hirundo rustica — 2
Barn swallow
Cecropis daurica — 4
Red-rumped swallow
Phylloscopus collybita — 12
Common chiffchaff
Aegithalos caudatus — 2
Long-tailed tit
Sylvia atricapilla — 20
Eurasian blackcap
Sitta europaea — 5
Eurasian buthatch
Certhia brachydactyla — 5
Short-toed treecreeper
Troglodytes troglodytes — 4
Eurasian wren
Cinclus cinclus — 3
White-throated dipper
Turdus philomelos — 20
Song thrush
Turdus merula — 5
Eurasian blackbird
Erithacus rubecula — 5
European robin
Luscinia megarhynchos — 7
Common nightingale
Motacilla cinerea — 6
Gray wagtail
Motacilla alba — 3
White wagtail
Fringilla coelebs — 10
Common chaffinch
Coccothraustes coccothraustes — 4
Hawfinch
Chloris chloris — 2
European greenfinch
Anas platyrhynchos — 7
Mallard
Streptopelia decaocto — 2
Eurasian collared-dove
Actitis hypoleucos — 1
Common sandpiper
Otus scops — 1
Eurasian scops-owl
Dryobates minor — 1
Lesser Spotted Woodpecker
Delichon urbicum — 40
Common house-martin
Curruca curruca — 1
Lesser whitethroat
Carduelis carduelis — 2
European goldfinch
Mergus merganser — 1
Common merganser

Food Web Structure and Trophic Diversity in Zoobenthos



Austropotamobius pallipes
White-clawed crayfish

Perla marginata
Stonefly

"What a pleasure to just dig in the mud day by day to discover such beauty as a part of a university course! But sometimes you need a beer and Balkan music for the identification..."

- member of the Invertebrates-Crew, Innsbruck University

Visited Research Sites

Involved Scientists

Edurne Estévez Cano
University of Innsbruck

Jan Martini
University of Innsbruck

Davina Dietrich
Student at University of Innsbruck

Simone Sahler
Student at University of Innsbruck

Fabian Vassanelli
Student at University of Innsbruck

Sara Widera
Student at University of Innsbruck

Gabriel Singer
University of Innsbruck

Approach

In the frame of the Science Week and a project study at the University of Innsbruck we focused on taxonomic and functional biodiversity along the Neretva River. By taking multi-habitat samples we characterised the macroinvertebrate community at nine sampling sites distributed in the studied river. This sampling method allowed us to identify and quantify benthic invertebrates. We further collected available food resources (algae and organic matter) and aim to analyse food webs and trophic diversity using stable carbon and nitrogen stable isotope analysis. In general, we expect a high taxonomic diversity due to high heterogeneity and undisturbed riverbed habitats. We also expect a high functional or trophic diversity, changing along the river continuum with the available food resources and environmental conditions.

Highlights

Cordulegaster sp. (Dragonfly) is a genus with high requirements in terms of water quality and is a typical inhabitant of small, pristine rivers. One of our highlights! Although the overall highlight is the continuously high alpha diversity and high abundances in general.

Figure 31 - Golden-ringed Spiketails (Genus *Cordulegaster*) © *Gernot Kunz*

Preliminary Results

For now, isotope analysis and further lab work is needed. However, during our first analysis of the data (identification and counts) we were surprised from the continuously high biodiversity along the river continuum. In fact, we counted a median of 38 taxa (mean 36 taxa) per site (min. 26 in site 1, max. 50 in site 6). EPT (Mayflies, Stoneflies and Caddisflies) summarise well known orders of macroinvertebrates in river systems and are commonly used for water quality analysis, due to their low tolerance to pollution. A percentage value of 15 % is relatively low and indicates poor water quality, whereas values above 30 % can be classified as good (Barbour et al. 1996; Barbour et al. 1999). A median share of 63,6 % of EPT-taxa was calculated for each spot, with a minimum of 53,5 % at site 0 and a maximum of 82,0 % at site 7. For the abundance of EPT we calculated a median of 15,936 individuals per m2, with a minimum of 7,600 at site 6 and a maximum of 34,144 individuals per m2 at site 8. Considering that we did not identify specimens to species level due to time issues and taxonomic knowledge gaps in the region, we expect a much higher species richness. In comparison to other pristine headwaters, this is a rather high amount (Huttunen et al. 2017). From our field observations we conclude that the upper Neretva River, at the present state, exceeds many natural drainage basins in its mean alpha diversity.

Figure 32 - Identifying invertebrates late into the night

References

K.-L. Huttunen, H. Mykrä, J. Oksanen, A. Astorga, R. Paavola & T. Muotka (2017): Habitat connectivity and in-stream vegetation control temporal variability of benthic invertebrate communities. SCIENTIFIC Reports. *7: 1448. DOI:10.1038/s41598-017-00550-9.*

Barbour MT et al (1996): A framework for biological criteria for Florida streams using benthic Macroinvertebrates. Journal of the North American Benthological Society 15. *185–211.*

Barbour MT et al (1999): Rapid bioassessment protocols for use in wadeable streams and rivers. Periphyton, benthic macroinvertebrates and fish. 2nd edition. US Environmental Protection Agency, Office of Water, Washington, *DC. EPA. 841–B-99-002.*

Ecosystem Functional Diversity

Alnus glutinosa
European alder

"Ecosystem functions are the backbone of ecosystem services that rivers provide to human societies, for instance, water purification. A healthy, functional river needs to maintain a flux of water, organisms and resources along its course, but also an exchange with its terrestrial surroundings. The construction of dams along the upper Neretva will seriously compromise the functional integrity of the river, and therefore the ecosystem services provided to local communities."

- Rubén del Campo, University of Innsbruck

Visited Research Sites

Involved Scientists

Rubén del Campo
University of Innsbruck

Barbara Jechsmayr
Student at University of Innsbruck

Veronika Settles
Student at University of Innsbruck

Melanie Stroeder
Student at University of Innsbruck

Gabriel Singer
University of Innsbruck

Approach

The main aim of our research was to investigate how ecosystem functions and functional diversity change along the continuum of a karstic, free-flowing river. We hypothesised that maximum diversity of functions will occur in middle river sections. We measured a subset of fundamental ecosystem functions (Table 1) from the Neretva headwaters to downstream sections. We used a diverse set of field and laboratory techniques to measure these functions, from the long-term exposition of oxygen and light loggers to measure ecosystem-scale metabolism, to short-time incubations in chambers to measure the activity of biofilm on stones.

Studied functions	**Methods**
Stream metabolism	*Record of dissolved O2 and light changes using loggers*
Biofilm-related functions	*Primary production and respiration using light/dark incubation of stones in chambers* *Enzymatic activities (phosphatase and phenol-oxidase)*
Organic matter decomposition	*Mass loss of cotton strips over time*
Microbial respiration	*Incubation of cotton strips over time in chambers*
Dissolved organic carbon degradation	*Biodegradation assay in bottles*

Preliminary Results

So far, we got results from organic matter decomposition rates and enzymatic activities of biofilm related to the uptake of phosphorus (phosphatase) and the degradation of terrestrial carbon (phenol-oxidase) (Figure 28). We found a great variability of ecosystem functions along the studied sites from up to downstream. Organic matter decomposition rates were highest in the most upstream sites as expected (site 1). Phenol-oxidase activity was low in general but we got maximum values at mid-section sites (site 4). Phosphatase activity showed an evident longitudinal gradient, from low values upstream to very high downstream (sites 9-10).

Highlights

Our results so far suggest a clear zonation of ecosystem functions along the Neretva River continuum as expected in a free-flowing river. Headwaters showed highest values for organic matter decomposition rates, while sites in mid-sections presented a high productivity and the uptake of phosphorus by biofilm. Large downstream sections presented the highest phosphatase activity but low phenol-oxidase, suggesting the dominance of autotrophic functioning. This functional zonation of the Neretva indicates a specialisation of different sections of the river in different ecosystem functions and services. This functional diversity would be totally lost in the scenario of the construction of planned dams in the area.

Figure 33 - Fieldwork

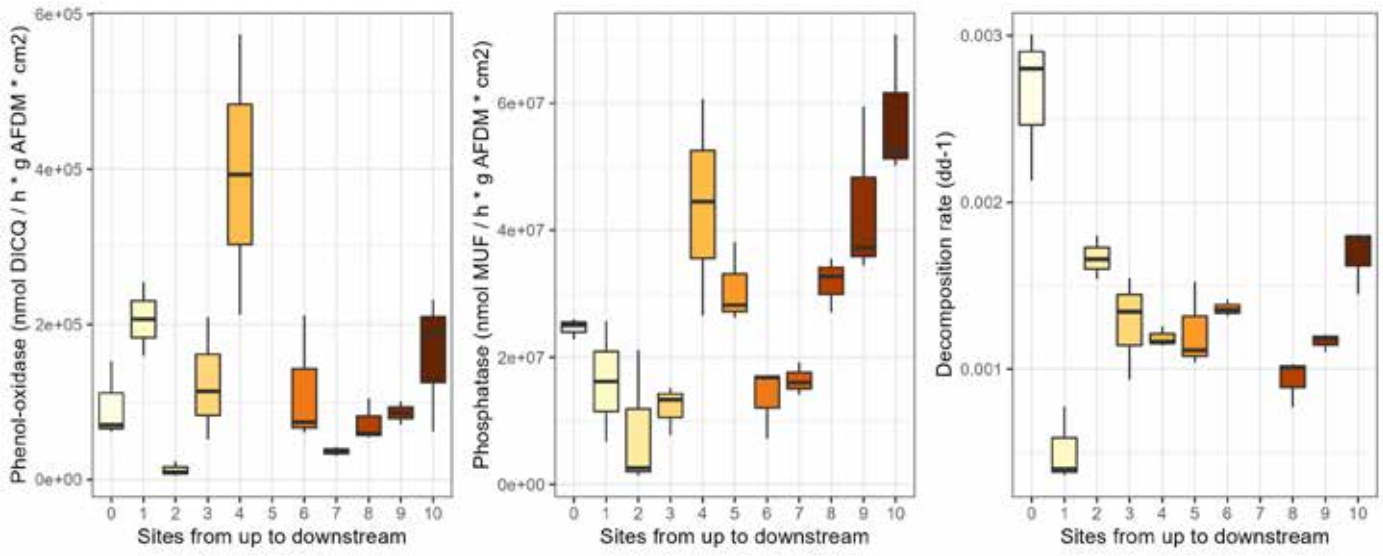


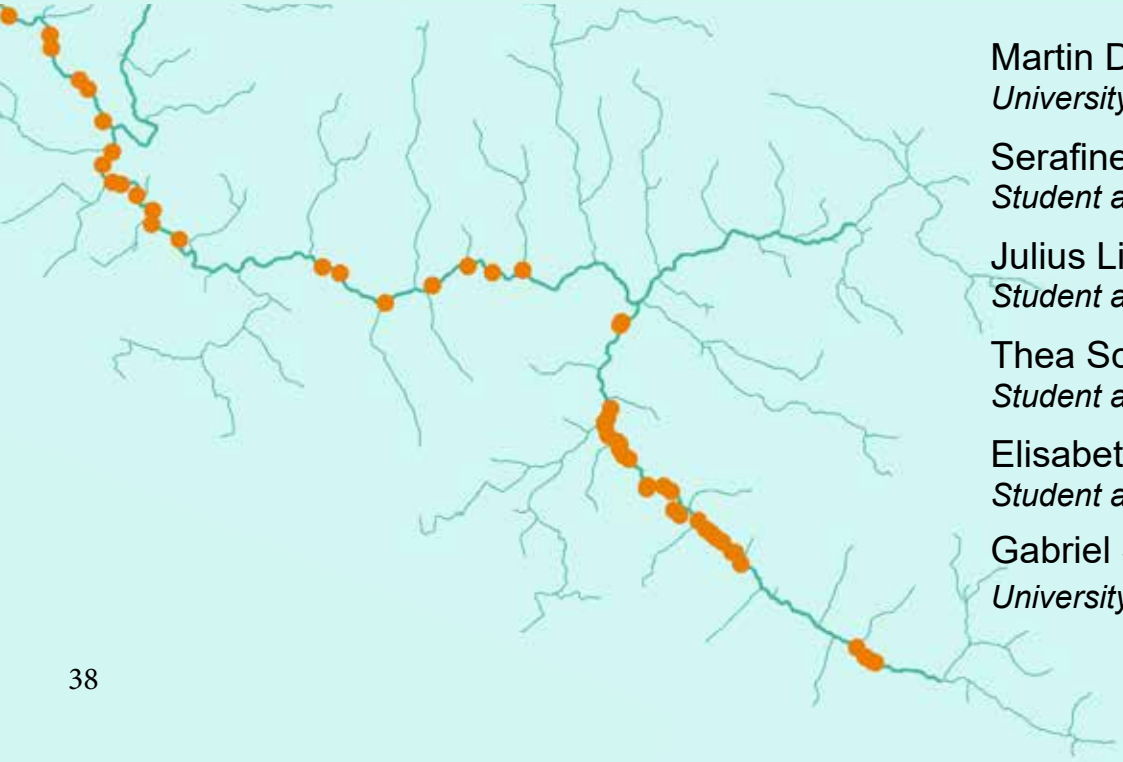
Figure 34 - Boxplots showing changes in phenol-oxidase, phosphatase activities and organic matter decomposition rates along the study sites in the Neretva river. Boxplots are ordered from left to right from up to downstream illustrating changes in ecosystem functions along the Neretva river continuum.

Greenhouse Gases

"A river processes organic material. If the river flows freely, primarily CO_2 is produced. Once the flow regime is interrupted by dams, organic material is also processed to methane. And this, as we all know, is a much more potent greenhouse gas (GHG) and therefore very harmful to our climate."

- Martin Dalvai Ragnoli, University of Innsbruck

Visited Research Sites



Involved Scientists

Martin Dalvai Ragnoli
University of Innsbruck

Serafine Kattus
Student at University of Innsbruck

Julius Lissy
Student at University of Innsbruck

Thea Schwingshackl
Student at University of Innsbruck

Elisabeth Weninger
Student at University of Innsbruck

Gabriel Singer
University of Innsbruck

Approach

We measured the concentration of the two most important greenhouse gases (GHGs), carbon-dioxide (CO_2) and methane (CH_4) in the water phase. The goal was to map dissolved GHG concentration along the free-flowing length continuum of the upper Neretva River. In order to cover as many river kilometres as possible, we measured and took water samples while walking, swimming, kayaking and rafting down the river.

The measurement of dissolved gas concentration is based on an equilibration principle – water from the river is mixed with atmospheric air to reach an equilibrium between both phases. Afterwards, the concentration of GHGs is measured in the gaseous phase and concentration in the water phase is derived. We used two different equilibration methods: For less accessible sites, the headspace method was used. Here water and ambient air are collected in a syringe and equilibrated by intense shaking. Afterwards the concentration of the equilibrated air is measured at stable conditions in the lab. For easily accessible locations and for measurements from the raft, we used our self-built Fast-Response Automated Gas Equilibrator (FaRAGE). The FaRAGE (adapted from Xiao et al. 2020) consists of a closed gas loop which is continuously equilibrated with water by circulating both phases with a pump. Thereby the gas concentrations can be measured in-situ in real time. Additionally, dissolved gas concentration was measured at three different sites for a time period of 24 hours to assess how the eventually uncovered spatial gradients of concentrations may be influenced by sampling at different daytimes.

Figure 35 - The FaRAGE in action: Water and atmospheric air are mixed in the left syringe and the tube. From the right syringe, gas is pumped to the gas analyzer and the water discharged.

Figure 36 - The group measuring gases while rafting the lower canyon section to Konjic.

Preliminary Results

Diurnal fluctuations in CO_2 concentrations have been observed at all three sites. This is explained by the change in the ratio of photosynthesis and respiration, induced by light availability. Even though these diurnal fluctuations are present, the measured spatial variation is higher (fig. 3A). We hypothesise that this high spatial variation in dissolved GHG concentrations results from the karstic nature of the landscape.

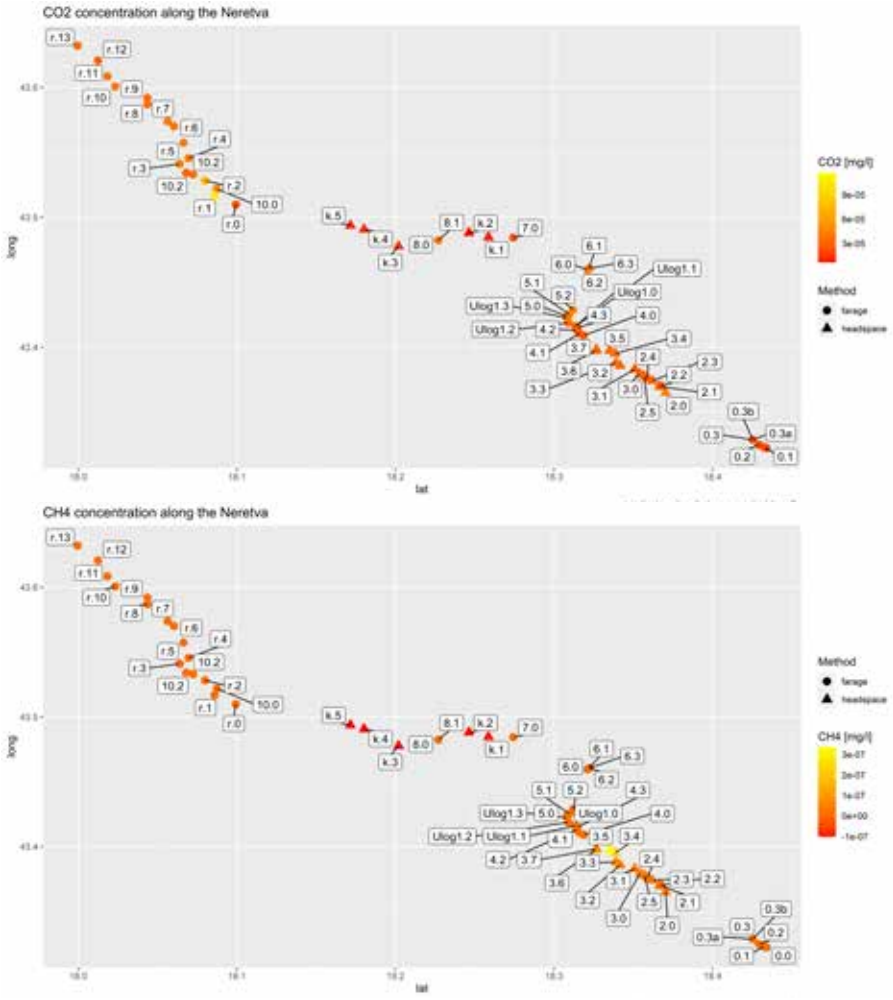
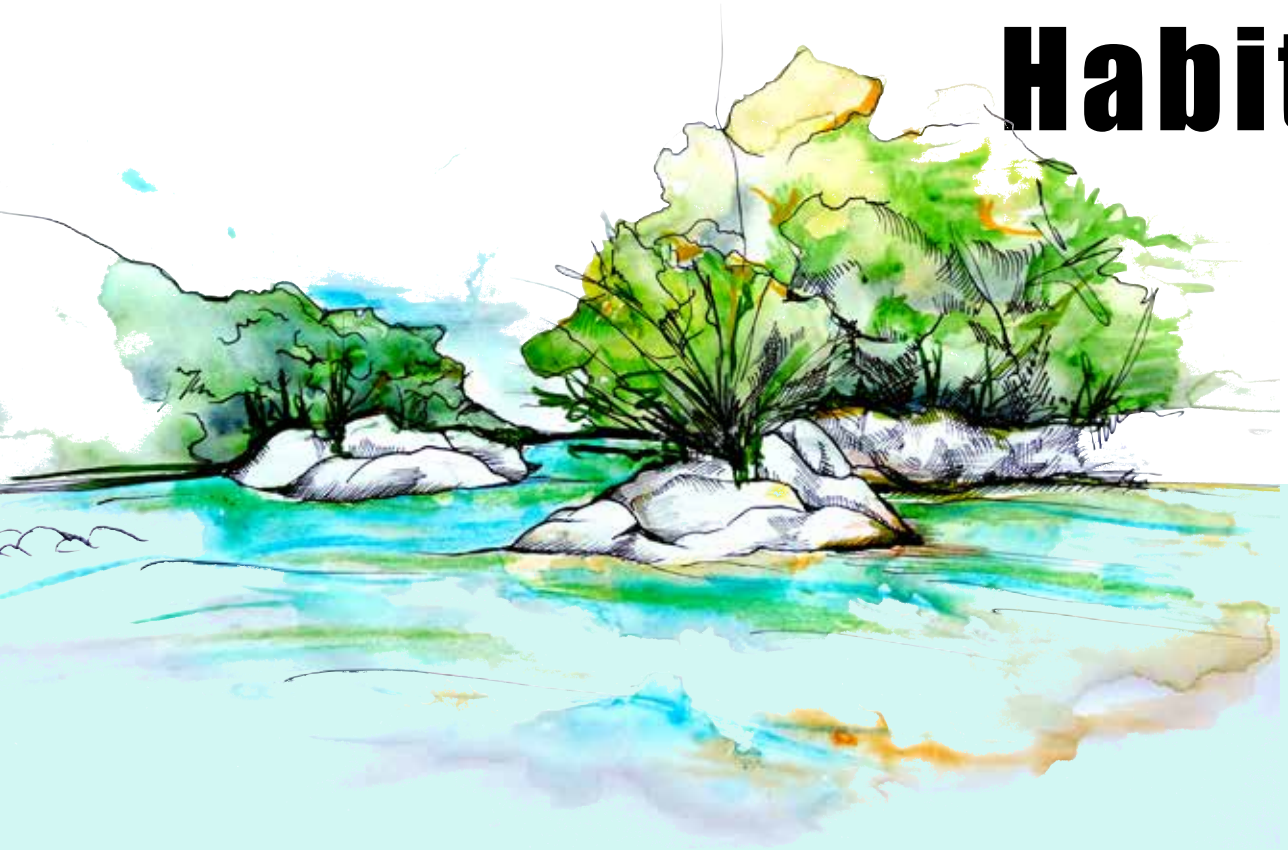


Figure 37 - This graph shows the CO_2 and CH_4 concentration (in mg/l) along the Neretva River, with a high variability along the measured continuum. The sites with the prefix "r." and "k." were not reachable by car or foot and therefore sampled via raft and kayak, respectively.

Physical Stream Habitats



"The most impressive and inspiring aspect of the upper Neretva River is its natural beauty and pristine condition, which begins with the surrounding forests and ends with the crystal clear, cold, flowing waters, numerous springs, river bank vegetation and primarily coarse substrates. It is extremely rare to have such an unspoiled riverine landscape anywhere in continental Europe."

- Steven Weiss, University of Graz

Visited Research Sites

Involved Scientists

Steven Weiss
University of Graz

Sarah Höfler
blattfisch e.U., Austria

Matthew Talluto
University of Innsbruck

Approach

Systematic stream profiles were measured at 10 metre intervals for between 80 and 120 metres at each of the investigated sites. Point transect estimates of water depth, flow-velocity, substrate size, overhanging vegetation and under-cut banks were made, resulting in hundreds of data points per site. These profiles were done precisely at locations where quantitative electro-fishing, and to some extent macrozoobenthic sampling was carried out. The data can be used to characterise in-stream physical aspects of the sites themselves, but also the longitudinal changes along the course of the river. Additionally, variation in river width, and estimates of flow discharge can be made. These characterizations will also be evaluated with respect to faunal changes that other specialist groups note along the longitudinal course of the river.

Figure 38 - Steven Weiss taking field measurements of river width, depths, substrate size and water flow with a point-transect approach.

Highlights

The almost complete lack of anthropogenic disturbance or erosion was very impressive, reflected in the composition and distribution of the river bed substrates. A particularly interesting feature of the Neretva River are its floodplain forest sections dominated by *Alnus* sp. and creating incredibly diverse habitat. Such floodplain forests are really quite rare to observe in a stream with such a mountain character.

Preliminary Results

The uppermost sites of the Neretva were dominated by very coarse substrates of rock (3.2 – 10 cm), cobble (10 – 26 cm) or boulder (26 – 100 cm) sizes, with very little fine substrate. Flow velocities were moderately high (mostly 0.3-0.7 m/s) and depths primarily under 50 centimetres, but occasional deep pools reaching nearly two metres in depth. Woody debris was common, occasionally blocking the entire river profile. Despite this primarily mountain stream character there were occasional side channels and pools of still water, and some zones 50 metres wide of thick floodplain forest with a multitude of downed trees and river substrates and deposition dominating the forest floor. Most points along the banks displayed overhanging vegetation, occasionally reaching over the entire width of the river. River widths varied from three to 16 metres in these upper reaches. With increasing distances downstream, the river increases in volume with a very gradual but noticeable decrease in substrate sizes, with more frequent occurrence of gravel (2 – 16 mm), pebbles (16 – 32 mm), and rocks, but still large substrates or even bedrock were found at all sites, and fine sediments were rare, except in side channels or riparian pools. River widths and depths increased but remained highly variable, with more pools over two metres deep, and widths occasionally approaching 30 metres. At the most downstream sites, deep pools connected with swift-flowing glides and riffles (flow velocities near and sometimes exceeding 1 m/s) were more common.

Figure 39 - Site No. 5, just downstream from Ulog. Here the river begins to widen and some side channel habitats are visible.

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