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Examinations on alpine brown trout populations (*Salmo trutta* f. *fario*) in the province of Salzburg (Austria)

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Abstract

The present thesis is concerned with the examination of four alpine rivers in the mountainous part of the province of Salzburg (Austria). A special feature of these rivers is their isolation from usual fish migratory pathways, which would possibly favor the preservation of autochthonous populations of the brown trout (*Salmo trutta* f. *fario*). Beside hydromorphological habitat analyses, microsatellite DNA data were collected as well as isotope chemistry from otoliths. The data combination showed that two of the investigated populations are rather autochthonous; the others have already indicated more genetic introgression and influence by men. In addition, integrating data obtained from otolith microchemistry and microsatellite DNA can provide complementary information on the natal origin and genetic structure of brown trouts at any life stage. This information will be valuable for studies of the population dynamics and quality of mixed-stock samples collected from the alpine region. The hydromorphological analyses demonstrated that all four rivers have a high structural diversity and deserve the title "extreme habitat".

Keywords

autochthonous, S*almo trutta*, otolith, isotope, microsatellite DNA

Introduction

The brown trout (*Salmo trutta* f. *fario*) represents an important ecological component of natural river systems, especially in higher altitudes (Rhithral). Due to a long stocking tradition by allochthonous forms from whole Europe and their high economic benefit, natural wild-living brown trout populations became rare (WEISS et al. 2001). Therefore and also because of the high popularity of brown trouts, many scientists choose them as a model organism for investigations of animals within natural habitats. Besides, examinations on relict populations are spectacular, as they have become seldom in populated areas. Moreover, the increasing economic pressure on our river systems strengthens more than ever the necessity of preservation strategies for the whole aquatic fauna. For such an expedient preservation, knowledge about the current state including its natural dynamic is the first step.

In cooperation with the government of Salzburg, department for water protection (Gewässerschutz), it was attempted to get continuing information about habitat requirements, structure and size of brown trout populations living in an extreme ecosystems and to further acquire detailed information of the actual genetic and physiological condition. The selection of the rivers was based on special criteria. For increasing the probability to find autochthonous populations, the rivers or river segments should be isolated from usual fish migratory pathways as a result of their geomorphological development (JÄGER et al. 2004). In addition it was beneficial, if a genetic data set of the populations from previous studies has already existed. Based on these criteria the four alpine rivers Blühnbach (Pongau), Anlaufbach (Pongau), Fuscherache (Pinzgau) and Windbach (Pinzgau) were selected (Fig. 1).

Another aspect was the location within a protected area; inasmuch as such river systems should have been less anthropogenic influenced. In order to find populations which deserve protection, long-term management and monitoring can get organized more easily from official institutions, than in river systems with private holders, as well. The Anlaufbach and the Windbach are located within the "Nationalpark Hohe Tauern".

Methods

The study included a survey on abiotic factors in these habitats within epirhithral rivers of the alpine region, as well as the evaluation of quantity and quality of local trout populations.

Besides surveying several physical and chemical variables, a special method for habitat mapping was utilized, the so called „mesohabitat-mapping" (PARASIEWICZ 2007a,b, PARASIEWICZ & WALKNER 2007). This method quantifies the hydraulic diversity of habitats or river units by calculating its unique hydrosignatures. Actually, this is a measure which quantifies the variability in depth and flow characteristics within a defined section of a river. As additional feature, this method includes a determination of substrate qualities and quantities along river beds, as they are crucial for fish populations. The identification of brown trout populations was performed in cooperation

with the Department of Zoology at the University of Graz by means of mitochondrial DNA analysis and microsatellite techniques (WEISS et al. 2009). Additionally, application of morphometric techniques allowed a morphological classification of various trout populations (LAHNSTEINER et al. 2003). In order to identify past stockings events in these habitats, isotope analysis of extracted otoliths and the associated water samples were performed at the Department of Analytic Chemistry at the University of Natural Recourses and Life Science ("BOKU", Vienna). The detailed method was studied in STURM (2008).

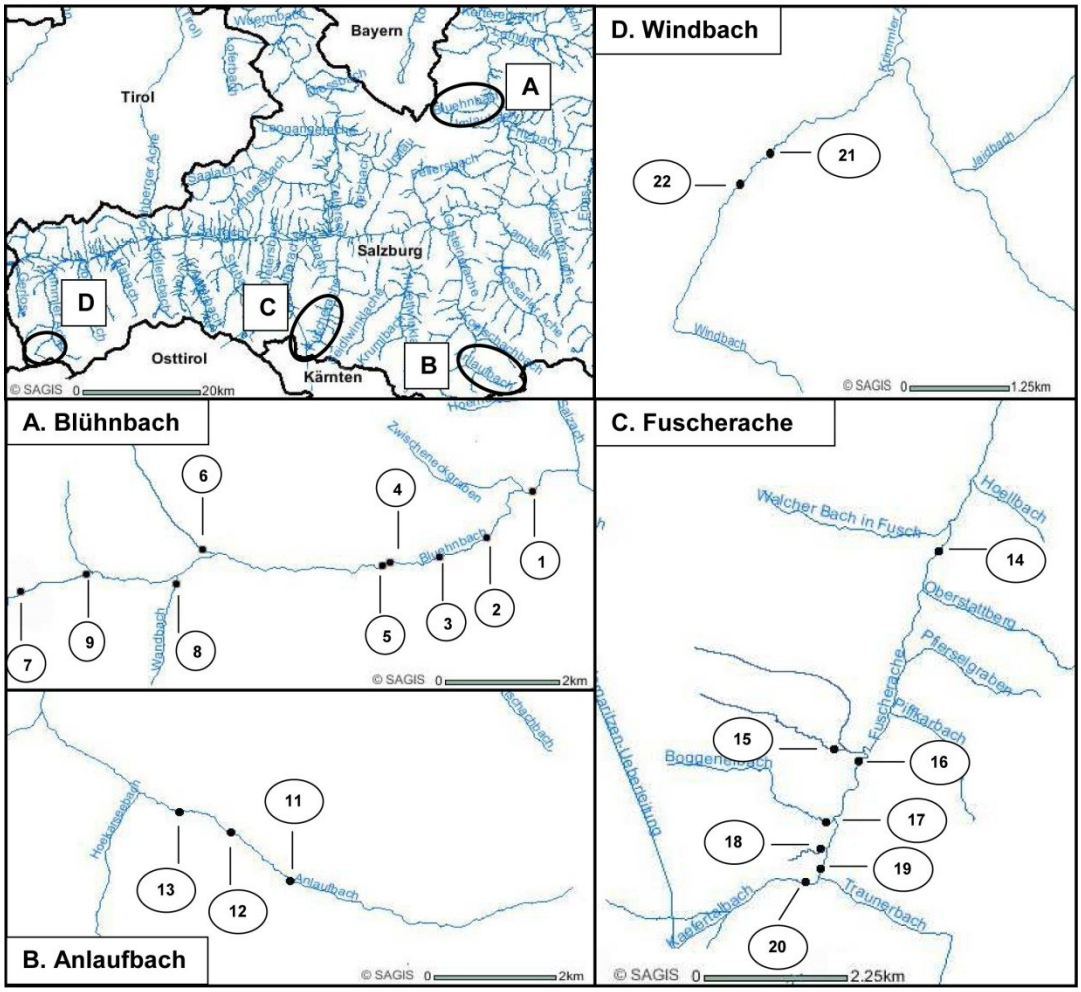

Figure 1: Investigation area and sample sites from the river Blünbach, Anlaufbach, Fuscherache, Windbach

Results

All abiotic variables of the estimated rivers indicate the presence of a high degree of nativeness in these alpine rivers as well as the necessity for highly adapted local fish populations in these special habitats. The rivers are characterized by extreme factors such as low electric conductivity (≤ 266 µS) low temperatures even in summer (≤ 14,4°C), high velocity (max. 1,5 – 2,3 m/s), high substrate dynamics and high gradients (4 – 8 %). As example, Huet (1949) fixed the upper limitation of the trout region with a gradient of 5%. According to Peter (1989), a gradient between 5 – 15 % appears as a limiting parameter, gradient higher than 15 % affects the conditions for a self-keeping fish population in a very unfavorable way.

Another important issue of this research was the estimation of the magnitude of human influences on isolated fish populations. The results clearly showed that even in isolated alpine rivers such influences could be readably detected. Considering all data (genetic, morphomertric and isotope), only two of the four prospected rivers, Fuscherache (Pinzgau) and Anlaufbach (Pongau), contained a mostly autochthonous trout population. In the other two rivers, Blühnbach (Pongau) and Windbach (Pinzgau), data revealed a more intense influence due to past stocking events. And though the examined rivers are all within the same drainage system, the genetic structure on microsatellite information is quite different among the populations, which implicates the development of local genetic variations in isolated habitats. The results can be compared with the studies DUFTNER et al. (2009) and LAHNSTEINER (2005), who also investigated the genetics of the present populations.

The combination of different data sources allowed the development of a statistical classification model to clearly separate autochthonous from allochtonous brown trouts. Especially the combination of microsatellite information and isotope data enabled this classification on a high level. The study indicates that otolith microchemistry and genetic information can provide unique and complementary information on the population structure of fishes. For trouts, otolith microchemistry can elucidate whether the fishes came from natural habitats or from hatcheries, but this information does not directly corroborate genetic structure.

The following morphometric analyses of the identified fishes revealed, that even if the genetic constitution of fish is autochthon, however, exhibit a different phenotype when they were hold in hatcheries than those, which stayed in native habitats the whole lifetime. In the opposite, genetic allochthonous fishes living under natural conditions, showed a more natural phenotype than typical hatchery fishes.

Another important detection was that genetic autochtonous fishes, which have been raised under nearly natural conditions, show adoptive characteristics like upstream movements and a higher fitness compared with conventional hatchery fishes.

Discussion

The ability of integrating different data sets like otolith microchemistry and microsatellite data offer significant possibilities of an integral identification of fish populations on the basis of individuals. Origin based questions as well as analyses considering nativeness and genetic fitness can be cleared. Furthermore, the data provide a holistic life-history of the examined population (CAMPANA et al. 2000). Also FREYER et al. (2007) emphasise the relevance of the integration of genetic and otolith isotopes investigation for identification of stocking structures in fish populations, as you receives not only information about the degree of anthropogenic interference but also about their dynamic (date of stocking, origin the of hatchery fish, etc.). Also specific migratory movements within short term scales can be answered from the isotope chemistry (KENNEDY et al. 2002, HOBBS et al. 2010).

The high physiological and ecological plasticity of the brown trout and the nativeness of habitat structures underline once more the needing of suitable and efficient protection management. To achieve that, however, an a priori identification of the trout populations as well as the elevation of the environmental situation of the fish habitat is absolutely necessary.

The variation in the genetic structure and the high adoptive degree of alpine brown trout population and the positive result of natural raised stocking fishes emphasise the support of a new and more effective stocking management, which improves the ecological value and decreases the economic effort at once (KLUPP 1991, UIBLEIN et al. 2000, SPARIC & WEISS 2008, WEISS et al. 2009). Due to the infrastructural and political possibilities, national parks and similar institutions are more than ever claimed in protection and preservation issues.

Conclusion

The acquired knowledge can be used to work out even more specific and efficient management strategies for the preservation and protection of native alpine river systems and their fish populations. This seems, as already mentioned, in times of the high pressure of utilisation especially on alpine rivers due to the waterpower industry and traditional fisheries exceedingly necessary.

The quality and quantity of the genetic loss and/or introgression in native brown trout populations by stocking or habitat loss as well as the preservation of habitat structures in alpine river systems will be of great importance, especially with regard to long-term management and conservation concepts. Moreover, alpine river systems can operate as prospective refugium for many aquatic organisms, whose ecological benefit improves constantly. All this should be grasped in the course of the implementation of the WRRL even more intensely and be discussed integrative in cooperation with the fishing beneficiaries and other interest representatives as well as governments and nature protecting organisations.

References

CAMPANA, S. E., CHOUINARD, G. A., HANSON, J. M., FRECHET, A., BRATTEY, J. 2000. Otolith elemental fingerprints as biological tracers of fish stocks. Fisheries Research 46: 343-357.

DUFTNER, N., WEISS, S., MEDGYESY, N., STURMBAUER, C. 2009. Enhanced phylogeographic information about Austrian brown trout populations derived from complete mitochondrial control region secuences. Journal of Fish Biology 62: 427-435.

FREYER, F., HOBBS, J., BAERWALD, M., SOMMER, T., YIN, Q. Z., CLARKE, K., MAY, B., BENNETT, W. 2007. Otolith microchemistry provides information complementary to microsatellite DNA for a migratory fish. Transactions of the American Fisheries Society 136: 469–476.

HOBBS, A., LEWIS, L. S., IKEMIYAGI, N., SOMMER, T., BAXTER, R. D. 2010. The use of otolith strontium isotopes (87Sr/86Sr) to identify nursery habitat for a threatened estuarine fish. Environmental Biology of Fishes 89: 557-569.

HUET, M. 1949. Aperçu des relations entre la penteet les populations piscicoles des eaux courants. Schweizerische Zeitschrift für Hydrologie 11:333–351.

JÄGER, P., MÜHLMANN, H., RAUDASCHL, S. 2004. Hydromorphologische Fließgewässeraufnahme von Salzburg 2003. Erhebung signifikanter hydromorphologischer Belastungen im Sinne der WRRL. Reihe Gewässerschutz 9. Amt der Salzburger Landesregierung.

KENNEDY, B. P., KLAUE, A., BLUM, J. D., FOLT, C. L., NILSOW, K. H. 2002. Reconstructing the lives of fish using Sr isotopes in otoliths. Canadian Journal of Fisheries and Aquatic Sciences 59: 925–929.

KLUPP, R. 1991. Besatzversuch mit drei verschiedenen Bachforellenherkünften und einem bacheigenem Wildstamm. Fischer & Teichwirt 42: 228-230.

LAHNSTEINER, F. 2005. Charakterisierung regionaler, autochthoner Fischarten mittels molekulargenetischer Methoden zur Erhaltung der Biodiversität in österreichischen Flusssystemen. Forschungsauftrag des Bundesministeriums für Land- und Forstwirtschaft. Abteilung II/A1. Wien.

LAHNSTEINER, F., JAGSCH, A., JÄGER, P. 2003. Unterschiede im Phänotyp von Bachforellen und Seeforellen aus rezenten Wildpopulationen, aus Wildpopulationen des 19. Jahrhunderts und aus Zuchten. Österreichs Fischerei 56: 298-306.

PARASIEWICZ, P. 2007a. Arena: The Mesohabsim model revisited. River Research and Applications 23: 893-903.

PARASIEWICZ, P. 2007b. Arena: Using Mesohabsim to develop reference habitat template and ecological management scenarios. River Research and Applications 23 (8): 924-932.

PARASIEWICZ, P., WALKNER, J. D. 2007. Arena: Comparison of Mesohabsim with two microhabitat models (Phabsim and Harpha). River Research and Applications 23(8): 904-923.

PETER, A. 1986. Abgrenzung zwischen Fisch- und Nichtfischgewässern. Schriftenreihe Fischerei Nr. 45. Herausgegeben vom Bundesamt für Umweltschutz Bern.

SPARJC, A., WEISS, S. 2008. Genetische Beurteilung von Bachforellen in Kärnten: Berücksichtigung ihres autochthonen Status. Download: http://www.uni-graz.at/steven.weiss/docs/ Post_report.pdf. 2008.

STURM, M. 2008. Migration studies of fish by measurement of strontium isotope ratios and multi-elemental patterns in otoliths using LA-ICP-MS. Masterarbeit Universität für Bodenkultur Wien.

UIBLEIN, F. A., JAGSCH, A., KÖSSNER, G., WEISS, S., GOLLMANN, P., KAINZ, E. 2000. Untersuchungen zu lokaler Anpassung, Gefährdung und Schutz der Äsche (*Thymallus thymallus*) in drei Gewäsern in Oberösterreich. Österreichs Fischerei 53: 87-162.

WEISS, S., KOPUN, T. H., WINKLER, K. 2009. Genetische Charakterisierung von ca. 140 Bachforellen (*Salmo trutta*) aus Gewässern Salzburgs. Reihe Gewässerschutz 17. Amt der Salzburger Landesregierung.

WEISS, S., SCHLÖTTERER,C., WAIDBACHER, H., JUNGWIRTH, M. 2001. Haplotype (mtDNA) diversity of brown trout *Salmo trutta* in tributaries of the Austrian Danube: massive introgression of Atlantic basin fish – by man or nature? Molecular Ecology 10: 1241-1246.

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