Conference Volume	5th Symposium for Research in Protected Areas 10 to 12 June 2013, Mittersill	pages 509 - 512

Monitoring of autochthonous brown trout *(Salmo trutta* f. *fario* L.) populations in different brooks of the National Park Hohe Tauern

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Abstract

Autochthonous fish species are severely threatened due to habitat deterioration and a wrong fishery management in European freshwaters. Sophisticated measures are needed for the support and conservation of the native fish populations in the Alps. In several projects we focused on the native brown trout with the aim of exploring its ability to survive and reproduce in these harsh environments. In the National Park Hohe Tauern, isolated rivers were chosen for the stocking of newly discovered brown trout of Danubian origin. Offspring fingerlings were marked by cutting the adipose fin and subsequently released. Different types of high mountain brooks, glacially influenced and spring-fed waters in altitudes ranging from 1300m to 2000m a. s. l. were chosen for long-term experiments. Barriers in the streams separate the stocked fish from downstream populations. Results include information about survival, age, growth, maturation, spawning time, preferred habitat structures and moving behaviour. From these results we gained important new insights about fish in such extreme environments. In particular, we conclude reasons and circumstances that influence life cycle components (survival of eggs, larvae and fingerlings) of this species and its performance in establishing self-reproducing populations in sensitive and harsh alpine environments.

Keywords

brown trout, autochthon, alpine streams, high altitude, population, stock, surviving, reproduction, discharge, floodwater, temperature

Introduction

Autochthonous fish species are severely threatened due to habitat deterioration and a false fishery management in European freshwaters. This work is focused on the native brown trout in the Alps with the aim of exploring their ability to survive and reproduce in these harsh environments.

Some data of this presentation is based on the Austria–Italia Interreg IIIA project "Trout Exam Invest", see: http://c719-71-22.uibk.ac.at/TroutExamInvest/. Although this project ended in 2007, the outdoor experiments in the National Park Hohe Tauern are still being continued. The results of an eight year monitoring period in these outdoor experiments are shown.

Methods

Different types of high mountain brooks, glacially affected and spring-fed waters in altitudes ranging from 1300m to 2000m a.s.l. were chosen for long-term experiments to establish self-reproducing autochthonous brown trout populations.

The streams showed high structural diversity and fulfilled all requirements that brown trout need to thrive in their life.

Artificial reproduction of autochthonous brown trout was performed; their offspring was marked and stocked for the experiments.

Barriers in the streams separate the stocked fish from downstream populations to keep the autochthonous population pure.

Monitoring of the brown trout populations was performed by annual electro-fishing in autumn.

Table 1: Basic characteristics of the three experimental water-bodies

Waterbody	Stream-type	Stream-order	River-basin	Geology*	Temp. (°C)	Conduct.	Coordinates		Altitude
	epirhithral	(Strahler)			min-max	(µS/cm)	Latitude	Longitude	(m a.s.l.)
Trojer Almbach	sprig fed	3	Drave	ACR	0° - 9,5°	133	46° 57´N	12° 17´E	1960 - 2010
Windbach	sprig fed	3, 4	Salzach	PCG	0° - 15°	24	47° 07´N	12° 11´E	1840 - 1950
Anlaufbach	glacial affected	3, 4	Salzach	PCG	0,5° - 10,5°	68	47° 10´N	13° 54´E	1320 - 1400
*According to: Geologische Übersichtskarte der Republik Österreich (map scale 1: 2 000 000), Geologische Bundesanstalt Wien, Austria, 1999.									
ACR Austroalpne Crystallines, PCG Penninic Central Gneiss									

Layout and site-specific results

Trojer Almbach

In the Trojer Almbach the allochthonous population of stocked rainbow trout, brook trout and brown trout of Atlantic origin was removed by several electro-fishing attempts in 2005. Within this fish-population only offspring of brook trout were noticed. Therefore it was very interesting to see if autochthonous brown trout can survive and establish a reproducing population in this extreme altitude at 2000 meters.

An initial stock with 450 marked two-year-old and a second stock with 400 one-year- old local brown trout of Danubian origin was performed. By annual monitoring, a good growth, but a steady slight decline of the population was observed. We interpret this fact as a natural decrease but also as due to negative effects of annual monitoring by means of electro-fishing. Most dubious was the fact that we never caught juveniles, although we observed spawning. By analysing this negative development, we conclude that a combination of several facts may result in losses during the sensitive stages of eggs, larvae or fry.

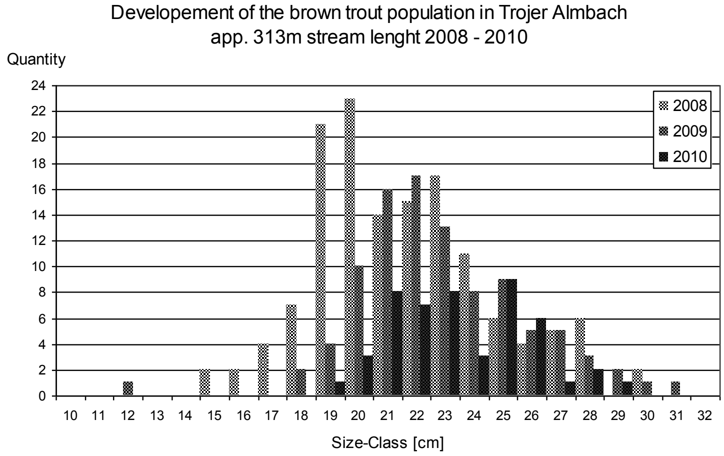

Figure 1: The length-frequency shows a steady shrinking of the population, individual growth, but no reproduction.

Reasons:

- Long lasting deep temperatures and low water levels in winter may lead to a freezing of spawning ground and loss of eggs.
- Deep temperatures result in delayed development of eggs and larvae, thus hatching may occur during times of high water levels with little chance of survival.
- Temperature-related slow growth implies that juveniles remain at a suitable prey size for larger fish for a longer time (cannibalism).
- Slow growth also implies that females will mature at a smaller body size. Small trout produce fewer eggs.
- Extraordinary flooding events
- Barriers impede compensative migration after floodwaters
- Low reproduction results in little survival for the sensitive larval and juvenile stages in harsh environments.

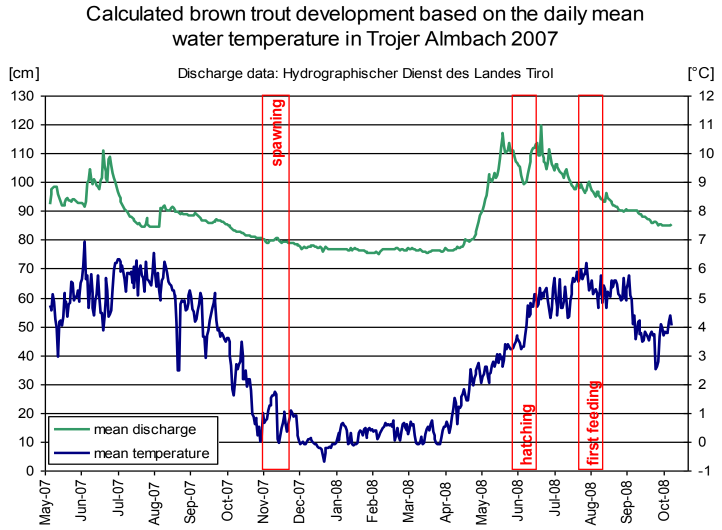

Figure 2: Observed spawning of brown trout in the middle of November. Hatching and first feeding was calculated using continuous temperature measurements. Both events take place in times of floodwater with little survival for larvae and juveniles.

Windbach

In 2005 an indigenous brown trout population was discovered in Windbach. The former stocked fish, originating from Anraser See, were removed by several electro fishing attempts and a new stocking with 2100 original Windbach offspring was conducted in 2007.

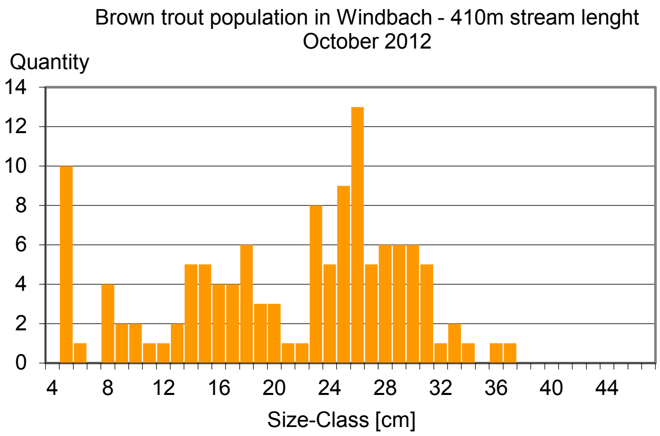

Figure 3: The length-frequency of the brown trout in Windbach indicates a self-reproducing population.

Five years after stocking an excellent brown trout population was observed. The initial stock from 2007 is represented in the size-class from 23cm to 30cm. Most of the smallest fish are their offspring, while the size-class between 12cm and 22cm descend from the original stock (Fig. 3).

Anlaufbach

In 2005 brown trout of Danubian origin were detected in the Anlaufbach. In this glacier-affected alpine stream annual floodwaters lead to a selected, highly adapted, but small population. To reinforce this endangered stock, marked offspring from the same population was stocked twice. A stable stock was observed for several years. In summer 2012 an extreme floodwater destroyed almost the entire brown trout population. Hardly ten percent of the population survived.

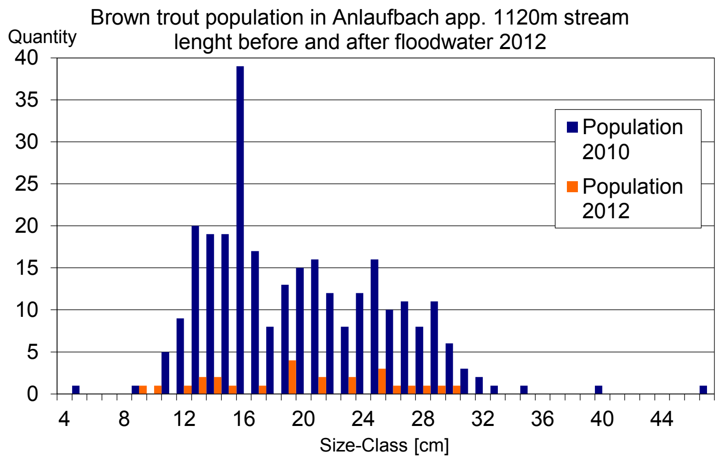

Figure 4: Brown trout population in the Anlaufbach before and after the high floodwater. Survival of all size-classes (orange) indicates a high adaptation of this indigenous species to floodwater situations.

General results

Survival

- Brown trout can survive in epirhithral streams up to 2000m a.s.l.
- Population survival depends on the survival rate of eggs, larvae, fry or juveniles.
- The continuity of a brown trout population depends on the dimension of several factors in their environment. Main negative events are floodwaters, suspended sediments, bed load, drift, low water, freezing, predation, barriers etc.

Growth

- Fish are poikilotherm organisms and therefore a long-lasting cold situation in high-lying streams leads to a delayed development and slow growth.
- Growth is a function of nutrition, temperature, genes, water-body, habitat and stress.

Maturation

- Brown trout males normally mature in the second and females in the third year of their life. Due to low temperatures, a one or two year delayed maturation of brown trout in comparison to low land brooks was observed.

Spawning time

- In our experimental sites, brown trout started spawning in the middle of November.
- Within the shortened day length in autumn, a rapid water temperature decrease seems to be a trigger for spawning.

Moving behaviour

- Through annual electro-fishing we noticed a high local constancy of naturally occurring and stocked brown trout in high alpine streams.

Discussion

Each stream has its own characteristics based on physical and chemical parameters. Apparently, suitable fish-streams are often wrongly appreciated. Alpine streams occasionally show their colour in interactions of discharge and temperature in time of the year. Temperature, discharge and floodwaters mainly manage the survival-rate of the sensitive development stages of fish.

The Windbach and the Trojer Almbach, which share similar physical characteristics, show how very slight differences in these extreme environments may decide whether stocked brown trout populations will persist or only exist temporarily. Against all expectations, the Windbach with the lowest conductivity, with high daily temperature fluctuations in summer and long lasting low temperatures in winter seems to be the most suitable stream for brown trout in our investigations.

In high altitudes, a temperature-dependent delayed development of the eggs may cause hatching to coincide with summer floodwaters resulting in lower survival rates of larvae. This seems to be the main reason for the absence of brown trout offspring in Trojer Almbach, although spawning was observed. In this high alpine stream the allochthonous brook trout can survive. This species is well adapted to harsh environments and hatching starts long before floodwaters arise. If only few brown trout offspring are able to survive in Trojer Almbach, an extinction of this population can be expected.

The Anlaufbach with glacially affected discharge represents a widespread type of alpine brown trout streams. Most of these show low production and small populations. A management of some of these alpine brown trout streams with very sensitive populations should be reconsidered and sometimes these streams are best left alone.

We do not know how strongly global warming will affect the alpine regions in the future, but there is a noticeable tendency towards more or heavier precipitations, resulting in high floodwaters. That might have a negative effect on many water bound organisms in alpine streams. The loss of some of these heavily affected streams as habitat for brown trout seems obvious.

Conclusion

This poster depicts an eight year monitoring period in three streams and shows expected and unexpected results. To prevent negative effects during monitoring, electro-fishing should only be randomly and cautiously executed in highly sensitive environments. Lacking any comparable long-time experiments in these harsh environments at altitudes between 1300 and 2000 meters a.s.l., this data makes no claim to be complete. The results underline the ability of autochthonous brown trout to adapt and show their limits as water-bound creatures in an extreme and quickly alternating climate.

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Zeitschrift/Journal: Nationalpark Hohe Tauern - Conference Volume

Jahr/Year: 2013

Band/Volume: 5

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