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Possibilities to restore the quality of mountain waters and increase fish production

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Abstract. In the last fifty years, mountain and foothill areas, and especially mountain waters, have undergone significant changes which unfortunately led to their continuous degradation, disappearance of terrestrial and aquatic flora and fauna, unexplained situation, do to more or less responsible anthropogenic actions. Given to this serious situation, we proposed a study to monitor the impact of such arrangements as sills and waterfalls for a partial restoration of living conditions for trout and restore these waters to their old productivity. In this respect have been made a number of facilities, colonization were performed with indigenous trout and track how they have evolved and developed over two years of monitoring. To see in what extent these arrangements have contributed to improve living conditions for trout, the results were compared with two other mountain streams with the same features, but no arrangements which have been populated with the same number and origin of trout.
Key Words: Biodiversity, degradation, mountain streams, facilities, conservation.

Introduction. Mountain waters, with their unique specificities, tumultuous and crystal, clear and cold which cross zones with unmistakable beauty and provides a livelihood for some of the most beautiful and spectacular fish (trout), who had to man a charm, have been and still remains attractive areas, exciting and soothing (Bud et al 2007a; Buruian & Grama 2005; Păsărin et al 2004).

Unfortunately, in the last 50 years, these mountainous areas and especially mountain waters, have undergone to significant changes that led to their continuous deterioration and drastic loss of terrestrial and aquatic fauna and flora, sad and inexplicable situation caused by the man of 21st century (Bud et al 2007b; Decei 2001; Negruţiu 1983).

Water pollution, aggressive and irrational exploitation, wastewater discharges, sawdust, metabolic products from households, intersection of forest roads, divestment of slopes by their timber, were many causes, that if we add global warming, we have the desolate picture that made mountain waters remain without any protection, flow rates were adjusted, increasingly decreased water quality, and living conditions for aquatic flora and fauna were considerably reduced, making impossible their presence and development (Bud et al 2010; Cristea 2007; Lujerdean & Bunea 2005).

These arguments have led us to approach a study to find the most appropriate ecological reconstruction of a mountain stream (Sălăşele) from Arieş basin.

Material and Method. The research was conducted during 2008 - 2010 and took into account estabilishments of some creek facilities on Sălăşele stream, leading to restoration of living conditions for salmons. In this respect the arrangement was made such as simple waterfalls and paved, stone sills and gouges in the bank on a section length of 3 km. To see the impact of these arrangements on environmental parameters, we got as controls two other mountain courses in the same area, with similar characteristics, which were populated with 1,250 juvenile rainbow trout each, from Gilău salmon breeding unit, with an average weight of 13.16 g, released on the three mountain

courses in early October 2008 and monitored 711 days, including two complete biological cycles (October 2008 - September 2009 and September 2009 - September 2010).

Were performed four control fishing with 50 samples of each stream, in June, May and September, when the measurements and weighing have been carried out, to see the evolution of the dynamics of growth in the existing conditions in the three studied mountain streams (Bud & Vlădău 2004; Păsărin et al 2004).

Specific targeted objectives were:

- rehabilitation of the Sălăşele stream by carrying out specific mountain water facilities;
- to determine the impact of made arrangements on environmental parameters, the conditions of life and shelter, and growth performance of trout;
- quantifying the differences of the growth performance between trout's from the experimental Sălăşele stream and control streams Ierţa and Huza;
- development of upland water recovery measures which are in various stages of decay.

Starting from the fact that the Sălăşele stream is generally low flow, bed with a moderate width and a relatively shallow water, respectively low banks and taking into account the type of arrangement that is suitable for such conditions, we chose arrangements as simple waterfalls, paved and stone dams. On a length of 3 km were built 10 simple cascade, 16 paved waterfalls and 12 sills or rock dams (Negruţiu 1983; Bud & Vlădău 2004; Păsărin et al 2004).

According to the colonization and recolonization technique of trout, in the early October the three streams, experimental Sălăşele, control Ierţa and Huza, have been colonized each with 1,250 trout spawns with an average weight of 13.16 g, on the the length of 3 km of each stream.

Further the physico-chemical characteristic values of water were monitored and the temperature of the external environment, monthly, throughout the year.

During the experiments in May and September control fishing were carried out, 50 individuals for each sample for 2009 – 2010, and they were measured for length and weight to highlight their growth.

The following indicators were calculated: daily weight gain and total weight gain, and were settled their differences and their significance between the samples from the three mountain streams considered.

Based on the results some mountain water recovery measures were developed and conclusions were drawn from experiment.

Results and Discussion. As a first aspect that emerges from the datas from table 1, is that the water temperature on the courses studied show low values during 2008, with an average of 7.6 °C on Sălăşele stream, 6.73 °C on Ierţa stream and 7.86° C on Huza stream, while the air temperature was an average of 10.90 °C (Table 1).

The most low water temperatures were recorded in January, and the most high in August, not exceeding 21.5 °C. These low values of water explains the lower growth of the fish in at least 6 months per year.

It should be noted that following the made improvements made on the Sălăşele stream, water temperature becomes constant and increases slightly compared to 2008, at 8.42 °C in 2009, and to 8.51 °C in 2010, compared with the annual average temperatures on the other two control streams, which remains at levels around 8 °C and below in all three years considered.

Compared to the outside ambient temperature, which increases slightly from year to year, water temperature is lower with 3.5 °C in 2008, 2.88 °C in 2009, and 3.40 °C in 2010.

If we follow the evolution of dissolved oxygen content in the water we find that the values are very close between the three studied streams until May 2008, whereupon, as a result of improvements made on Sălăşele stream, dissolved oxygen values increase significantly, exceeded 10 mg/L, confirming the positive impact of the waterfalls on the level of oxygen in water (Table 2).

Table 1

Evolution of water and air temperature during research (°C)

Stream	Year	Month												Annual average
		I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	
Sălăşele	2008	1.5	2.1	2.4	3.1	5.9	8.4	10.6	13.9	12.7	9.1	7.1	5.3	7.60
	2009	2.2	2.5	2.7	3.5	6.5	9.0	15.4	16.8	15.0	11.4	9.2	6.8	8.42
	2010	2.3	2.6	2.8	3.6	6.6	9.4	15.8	17.2	14.9	12.0	8.7	6.2	8.51
Jerţa	2008	1.5	2.0	2.5	3.3	6.2	8.7	11.6	16.1	10.6	8.4	5.7	4.1	6.73
	2009	1.5	2.0	2.6	3.7	6.1	8.7	14.9	18.8	15.2	9.9	7.4	5.0	7.99
	2010	1.8	2.2	2.6	3.7	6.3	10.2	16.4	18.6	14.4	8.9	5.5	3.8	7.87
Huza	2008	1.6	2.0	2.5	3.2	6.2	8.7	15.5	17.6	14.7	9.9	7.5	4.9	7.86
	2009	1.6	2.3	2.7	3.8	6.4	8.9	14.9	17.5	13.4	8.5	7.0	4.5	7.63
	2010	1.7	2.5	2.7	3.5	6.6	9.0	15.6	18.5	13.9	8.4	6.9	4.6	7.83
Air temperature	2008	3.2	3.6	4.9	6.2	12.3	15.8	19.4	20.5	18.7	11.8	8.8	5.8	10.90
	2009	3.8	3.8	4.9	6.4	12.5	16.3	20.8	21.0	18.8	11.5	8.7	5.6	11.18
	2010	3.8	3.9	5.0	6.5	12.8	16.6	21.2	21.4	19.6	11.9	9.0	5.9	11.47

Table 2

Evolution of dissolved oxygen on the three mountain courses (mg/L)

Stream	Year	Month												Annual average
		I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	
Sălăşele	2008	9.35	9.43	9.20	8.95	8.88	10.40	10.40	10.30	10.45	10.63	10.80	10.90	9.98
	2009	10.38	10.25	10.80	10.90	10.20	10.00	10.00	10.10	10.20	10.48	10.87	10.85	10.41
	2010	10.45	10.60	10.85	11.00	10.50	10.20	10.00	10.10	10.30	10.45	10.60	11.00	10.51
Jerţa	2008	9.20	8.90	8.85	8.90	8.60	8.50	8.40	8.50	8.55	8.67	8.95	9.25	8.78
	2009	9.70	9.57	9.45	9.37	9.25	9.12	8.85	8.50	8.95	9.10	9.30	9.50	9.23
	2010	9.60	9.55	9.40	9.30	9.20	9.00	8.75	8.40	8.50	8.80	9.10	9.20	9.07
Huza	2008	9.00	8.95	9.25	9.35	8.40	8.65	8.52	8.30	8.37	8.65	8.70	8.85	8.75
	2009	9.70	9.68	9.50	9.37	8.70	9.12	8.77	8.30	8.65	8.92	9.20	9.45	9.12
	2010	9.00	9.10	9.15	9.20	8.75	8.90	8.60	8.20	8.40	8.50	8.90	9.15	8.82

If in the first year of research, the annual average value of oxygen was higher than that of control streams with 1.2 mg/L on Ierţa stream and with 1.23 mg/L on Huza stream, in the coming years these differences increased. These results highlight one of the advantages provided by the made facilities on Sălăşele stream, namely to improve the most important component of the water making fish life possible and promote oxidation processes and mineralization of organic matter.

Following the evolution of biological material from colonization to considered stages until the end of the experiment, ascertain the appropriateness and timeliness of this experiment bringing important and suggestive data on the impact of specific improvements made on living conditions and growth performance.

According to the datas presented in table 3, at the colonization the weight of the three trout groups was similar in all the three streams, hovering around 13 g, with a really good variability, confirmed by the variability coeficient close to 18 %.

Even from the first control fishing differences ocures in behalf of the fish from Sălăşele stream, where the facilities were made.

Given that all of the three streams are relatively similar regarding their characteristics, the recorded differences on Sălăşele stream can be attributed to the new conditions that have benefited by the effects of facilites made.

Further, at the second control fishing, increasing differences can be found which maintain their influence till the end of experiment. Thereby, trout's from Sălăşele stream reach an average weight of 147.96 g, while on the Ierţa and Huza mountain courses, fish reach a more lower weight of 84.61 g and 78.93 g respectively which indicates less favorable growing conditions.

If we analyze the structure of captured trout at the end of the experiment function weight classes, find that trout's from Sălăşele stream, advantaged by better conditions for food and shelter created by made arrangements, falls in a proportion of 74 % in a weight rage between 131 and 190 g, meanwile samples from the other two control streams is not contained more in this weight range than up to 10 % and 8 %, which are conclusive and highly significant results (Table 4).

For a better highlight of the differences and importance of specific arrangements on mountain waters being in more or less degradation state we also considered body mass accumulation on established intervals.

The data's from table 5 can easily grasp the magnitude of these differences that distinguish both between the three groups, and depending on the season, being higher in the interval of May - September and lowest in winter (September - May). Compare to control, differences in body mass accumulation reach values of 63.35 g, higher than specimens from Ierţa stream, and with difference of 69,02 g to specimens from Huza stream, differences that we consider very large and significant.

Similar issues can be highlighted if we follow the evolution of average daily weight gain achieved during the 711 experimental days (Table 6). As expected, the daily weight gain is influenced by the refered period, being directly correlated with the temperature of the water and foraging possiblities, but in all cases, trout's from Sălăşele stream recorded higher values than trout's from the other two control courses, differences being significant and asured.

During the experiment, the recorded average daily weight gain was an average of 0.18 g at the experimental group, and 0.10 g and 0.09 g respectively at the controls, values which are in accordance within the performance of mountain water trout's in our country.

Table 3

The evolution of body weight in the three groups during the experiment under 3 October 2008 and 15 September 2010

Date	Group I - Sălăşele			Group II - Ierţa			Group III - Huza		
	Mean	SEM	V %	Mean	SEM	V %	Mean	SEM	V %
03 October 2008	13.18	0.34	18.05	13.14	0.33	17.80	13.16	0.33	17.73
03 May 2009	20.74	0.56	19.01	17.80	0.35	13.71	17.42	0.39	15.95
15 September 2009	65.80	3.46	37.20	30.87	1.65	37.89	32.92	2.35	50.54
03 May 2010	100.82	3.76	26.37	55.48	3.00	38.21	50.40	3.47	48.70
15 September 2010	147.96	4.42	21.14	84.61	4.02	33.59	78.93	4.05	36.24

Table 4

Weight calss structure of captured trout at the end of experiment (711 days)

Stream	n	Weight class																Average weight
		< 50 g		51-70 g		71-90 g		91-110 g		111-130 g		131-150 g		151-170 g		171-190 g		
		n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	
Sălăşele	50	2	4.0	3	6.0	2	4.0	3	6.0	3	6.0	9	18.0	20	40.0	8	16.0	147.96±4.42
Ierţa	50	7	14.0	12	24.0	15	30.0	6	12.0	5	10.0	3	6.0	2	4.0	-	-	84.61±4.02
Huza	50	8	16.0	11	22.0	16	32.0	7	14.0	4	8.0	3	6.0	1	2.0	-	-	78.93±4.05
Total	150	17	11.3	26	17.3	33	22.0	16	10.66	12	8.0	15	10.0	23	15.3	8	5.33	103.83±4.16

Table 5

Evolution of the total body weight accumulation per growth stage depending on the considered stream (g)

Period	*Days interval*	*Days*	*n*	*Group I - Sălăşele*		*Group II - Ierţa*		*Group III - Huza*	
				Mean	*SEM*	*Mean*	*SEM*	*Mean*	*SEM*
03 October 2008 - 03 May 2009	0-211	211	50	7.56	0.76	4.66	0.41	4.26	0.39
03 May 2009 - 15 September 2009	211-346	135	50	45.06	3.45	13.07	1.67	15.50	2.43
15 September 2009 - 03 May 2010	346-576	230	50	35.02	5.22	24.61	3.09	17.48	3.87
03 May 2010 – 15 September 2010	576-711	135	50	47.14	4.40	29.13	4.46	28.53	4.05
03 October 2008 – 15 September 2010	0-711	711	50	127.31	4.49	71.47	4.06	65.77	4.07

Table 6

Average daily weight gain evolution in the stage of growing depending on the considered stream (g)

Period	*Days interval*	*Days*	*n*	*Group I - Sălăşele*		*Group II - Ierţa*		*Group III - Huza*	
				Mean	*SEM*	*Mean*	*SEM*	*Mean*	*SEM*
03 October 2008 – 03 May 2009	0-211	211	50	0.03	0.003	0.02	0.002	0.02	0.001
03 May 2009 - 15 September 2009	211-346	135	50	0.32	0.02	0.09	0.01	0.11	0.01
15 September 2009 – 03 May 2010	346-576	230	50	0.13	0.02	0.09	0.01	0.07	0.01
03 May 2010 – 15 September 2010	576-711	135	50	0.40	0.03	0.25	0.03	0.24	0.03
03 October 2008 – 15 September 2010	0-711	711	50	0.18	0.006	0.10	0.005	0.09	0.005

Conclusions. Mountain waters degrading situations requires quick actions, leading to restoration of these streams and growth of fisheries productivity.

Depending on the specific conditions existing on each mountain stream, partially or totally degraded, different types of facilities can be set specific to those areas, leading to their recovery and to create better conditions of life and and welfare of trout.

We chosed to perform some facilities on the water courses we studied, such as simple waterfalls, paved and by stone, which led to the upgrade of the environment parameters, in particular of oxygen, and a good steady of water temperature.

Through the made arrangements, particularly favorable livelihood, forageing conditions, and shelter areas were created for fish, which led to a significant total body weight accumulation, and average daily weight gain.

Our results obtained by the conducted research confirmed timeliness, appropriateness and need for specific facilities, which leads to restoration of mountain flora and fauna, and especially creates conditions where the trout, this jewel of mountain water, to refind his presence.

In choosing the type of development will have to take into account all the particularities of each stream, and each section separately, to confirm their effectiveness.

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