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FOOD ADAPTATION OF RAINBOW TROUT, *ONCORHYNCHUS MYKISS* (WALBAUM, 1792), AFTER INTRODUCTION IN ENVIRONMENT - EXPERIMENTATION ON RIVER PIAVE -

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ABSTRACT

In the middle flow of river Piave in the province of Belluno (Italy) 700 Kg of rainbow trout *Oncorhynchus mykiss* (Walbaum, 1792) of the legal size of fishing was introduced in 2009 (Zanetti *et al.*, 2009). In order to evaluate the possible impact of this action on the autochthonous populations, the feeding competition against the native Salmonids has been considered as a threatening factor. On this regard the stomach contents of 195 rainbow trouts have been analyzed, which had been taken by fishers of Basin number 10 “Acque Feltrine” in the same part of the river. The analysis of stomach contents has pointed out the presence of the only benthic macroinvertebrates in 83,1% of the cases analyzed. In addition, macroinvertebrates and fishes in 4,1% of the cases studied, vegetable material for 3,1% as well as macrophytes and macroinvertebrates in 1,5% have been found. The 8,2% of stomachs has resulted empty.

The feeding adaptation of rainbow trout has shown opportunist but it has also highlighted the preferences for specific taxa of macroinvertebrates.

The analysis has also revealed that the feeding adaptation is clear after the release in the environment; as a matter of fact, after one week already from such introduction, a great predation has been pointed out.

INTRODUCTION

The use of rainbow trout of the legal size of fishing introduced in the environment has a halieutic purpose only and it is nowadays preferred to other kinds of introduction since, if not rarely, the rainbow trout does not reproduce in Italian rivers and, therefore, it can not cause the phenomenon of genetic pollution, as notoriously occurs with brown trout, *Salmo [trutta] trutta* (Linnaeus, 1758).

In fact, the middle flow of river Piave is the habitat of marble trout, *Salmo [trutta] marmoratus* (Cuvier, 1817), inserted in the Enclosure II of “Habitat Directive”.

The introduction of grown-up rainbow trout in natural habitat represents, nevertheless, a serious threaten for autochthonous populations.

The aim of this analysis is the one of checking the impact of the introduction of rainbow trout in the environment (an allochthonous species in Italy), focusing the attention on one of the several factors that such operation can cause: the interspecific feeding competition.

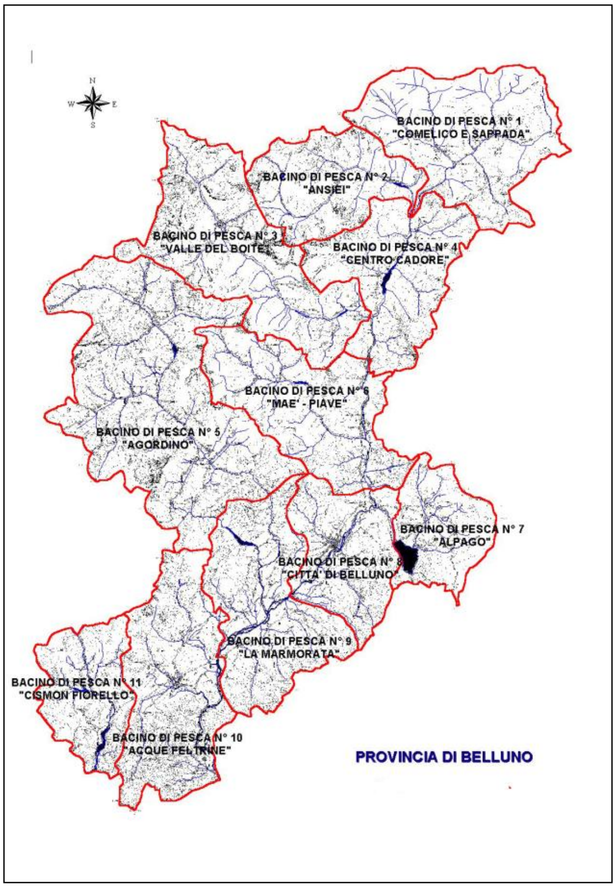
MATERIALS AND METHODS

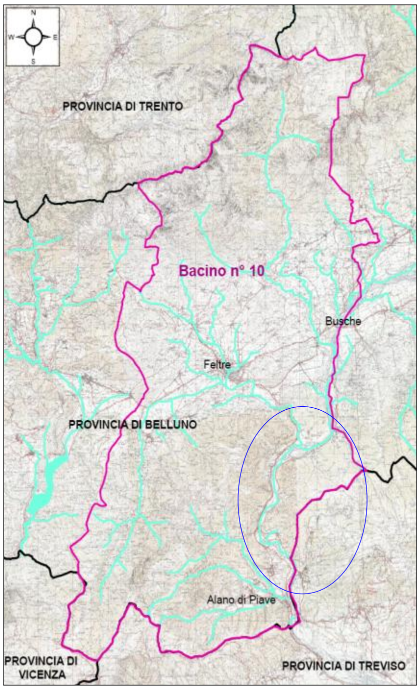
The researched area lies in the middle basin of river Piave in the province of Belluno (Italy), which is actually given in licence to the fishing Basin No. 10 “Acque feltrine” (Picture 1).

In this area on July 3rd and on August 7th, 2009 700 Kg of rainbow trout of the legal size of fishing have been sown.

With the help of local fishers 195 stomachs have been collected in a time limit from three to thirty days from the sowing date.

The stomachs have been stored in specific jars containing preservative liquid and then analyzed both from the qualitative and the quantitative point of view.





Pictures 1 & 2 - Division of the whole province of Belluno in its 11 fishing Basins (on the left) and a detail of the area of Basin n°10 where rainbow trouts have been fished (on the right)

In the case of discovery of partially decomposed macroinvertebrates into the stomachs, the number of eaten individuals has been obtained through the counting of cephalic capsules and/or through the reassembly of single parts.

The part of the stomach content indicated as exogenous represents the set of grown-up winged and earth’s insects.

Three indexes have been applied to the results obtained:

The selection index (Savage, 1931) indicated by the formula $W_i = A_i / D_i$, given by the relation between the abundance concerning the that prey in stomachs (A_i) and the availability of the same in the environment (D_i).

The Wi values close to 1 mean that there has been no selection of the prey whereas values lower or higher than 1 indicate respectively a negative and a positive preference towards the same prey (Oscoz *et al*., 2000).

The index of electivity (Ivlev, 1961) indicated by the formula $E_i = (r_i - n_i) / (r_i + n_i)$ is a variant to the previous *forage ratio* where r_i is the percentage of prey in the diet and n_i is the percentage of the same in the environment. The electivity ranges from -1,0 (negative preference) to +1,0 (positive preference). The value close to 0 means no food selection.

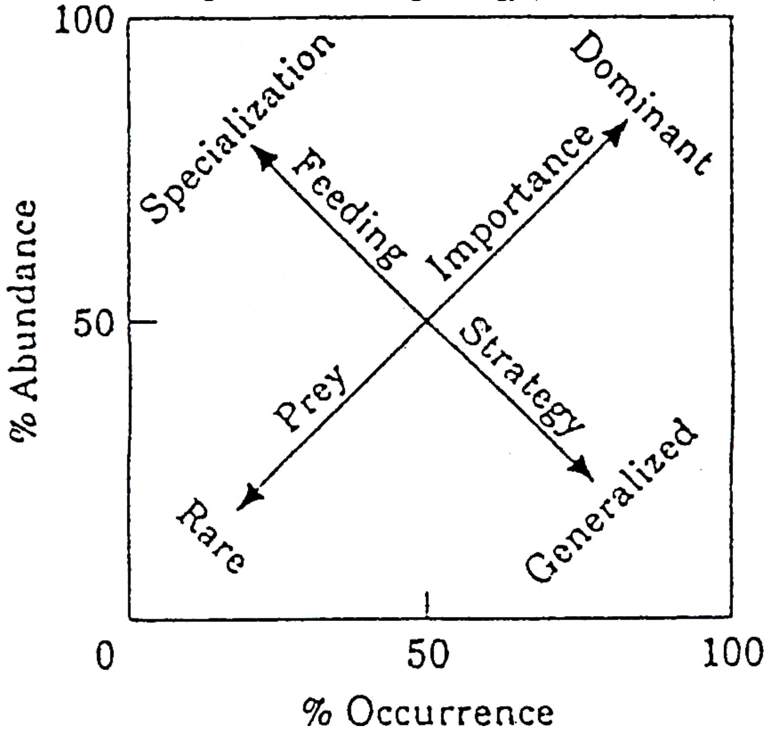
In the end the index suggested by Amudsen (1996) compares the specific abundance of the prey (P_i) with the frequent presence of the same in the stomach contents (F_i).

$$F_i = (N_i / N) \times 100 \qquad P_i = (\Sigma S_i / \Sigma S_{it}) \times 100$$

In the above formula N_i is the number of predators with that kind of prey in their stomach, N is the number of stomachs analyzed whereas S_i is the stomach content represented by the whole pray and S_{it} is the whole stomach content of predators’stomachs with the prey inside.

From this index the diagram of the feeding strategy generates, a bi-dimensional representation where every point has the frequency of prey presence in stomachs (F_i) and the abundance of that prey (P_i) as their coordinates (Picture 3). The diagonal which starts from the bottom on the right indicates the importance of the prey in the predator's diet, whereas the other diagonal underlines if the diet of the same predator is specific or general (Costello, 1990; Amudsen, 1996).

Picture 3 - Diagram of the feeding strategy (Amudsen, 1996)

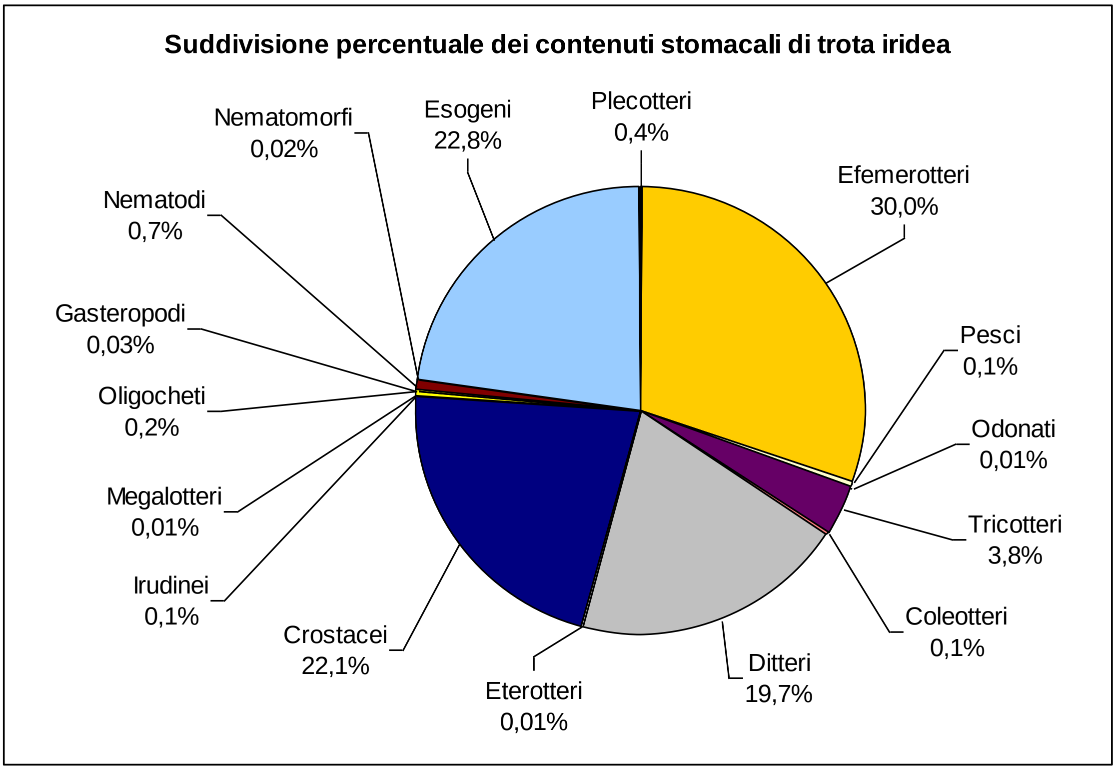


Afterwards the multivariate statistical analysis of available data has been carried out with PRIMER software in order to evaluate any possible similarities or differences inside the sample of stomach contents based on the similarity matrix of Bray-Curtis.
The non-metric MultiDimensional Scaling arrangement technique has been used converting the dissimilarity inside the sample into distances among the points.
Secondly the ANOSIM test (ANalysis Of SIMilarities) has been started, a non-parametric procedure which allows scientists to check if the differences among two or more groups of multivariate samples are significant or not (Clarke, 1993).
In the end the SIMPER test (Similarity percentage) has been finalized, a method aimed to evaluate which taxa are responsible more than the others for the differences among two or more sub-samples.

RESULTS

The analysis of stomach contents has given the following results: benthic macroinvertebrates in 83,1% of the cases analyzed, macroinvertebrates and fishes in 4,1% of the cases studied, vegetable material for 3,1% as well as macrophytes and macroinvertebrates in 1,5% have been found.
The 8,2% of stomachs has resulted empty.
The main taxa of eaten macroinvertebrates have been the following ones: Ephemeroptera (30%), Diptera (19,7%), Crustaceans (22,1%) and, in lower percentage, Tricoptera (3,8%).
A good percentage of Exogenous has been revealed (22,8%) (Picture 4).

Picture 4 - Percentage subdivision of the stomach contents

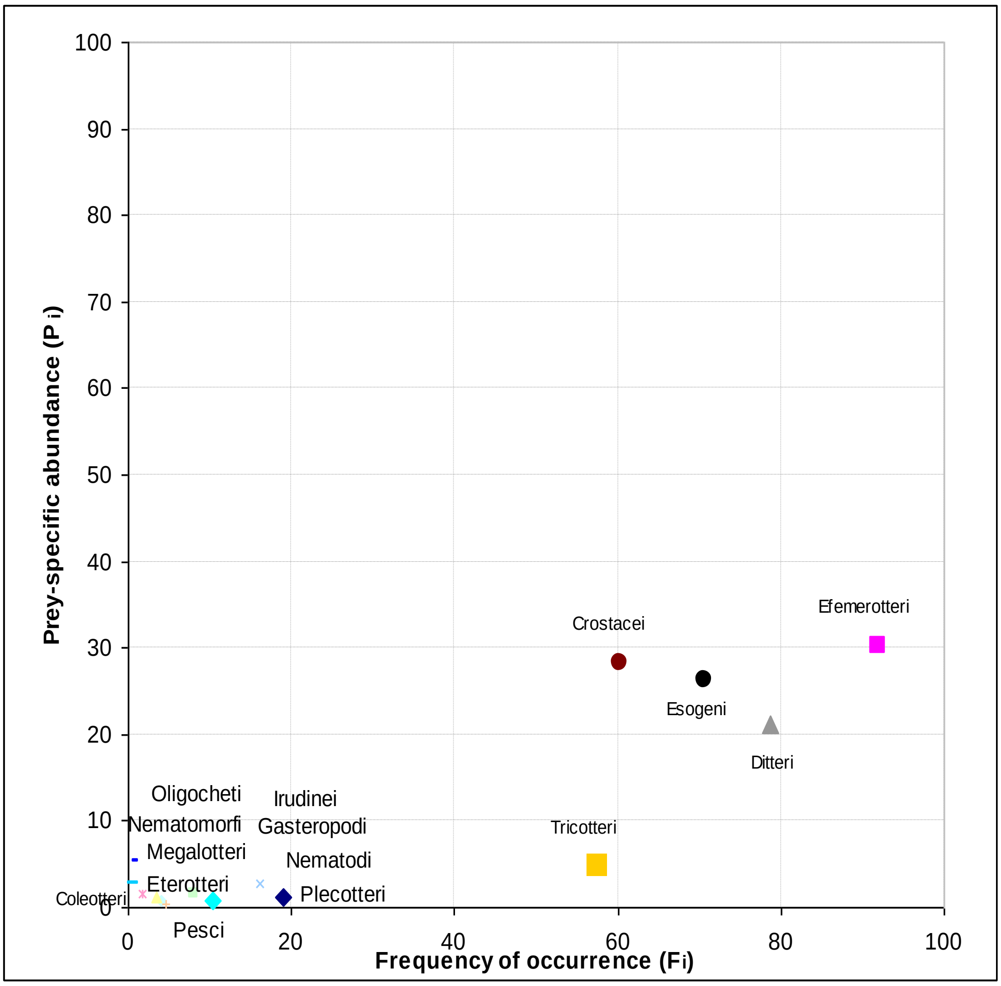


In eight stomachs fishes have been found, which belonged to minnow (*Phoxinus phoxinus*), bullhead (*Cottus gobio*) and trout (*Salmo trutta* spp.).
The application of Savage index (Table 1) has highlighted that the taxa characterized by a non-selection are Hydropsychidae family and *Baetis* and *Ephemerella* genera.
The Chironomidae family seems to be completely avoided, whereas Simulidae and Rhyacophilidae seem to be the favourable preys.
The application of Ivlev index (Table 2) confirms the results of the selection index.
According Amudsen index (Picture 5), Ephemeroptera, Diptera, Exogenous and Crustaceans have a great Fi but all of them have a prey-specific abundance lower than 50%.
The positioning of the points in the lower part of the graphic shows that the average contribution of the several feeding items to stomach contents is low and, therefore, the feeding strategy is mainly general even though, nevertheless, there are some preys which are the most favourable.

Table 1 - Results of Savage (S) and Ivlev (E) indexes

Macroinvertebrates	Savage index	Ivelev index
Baetis	1,06	0,03
Ephemerella	1,01	0,01
Hydropsychidae	1,33	0,14
Ryacophilidae	2,23	0,38
Simulidae	2,43	0,42
Chironomidae	0,12	-0,79

Picture 5 - Use of the preys in terms of feeding strategy from the side of the rainbow trout



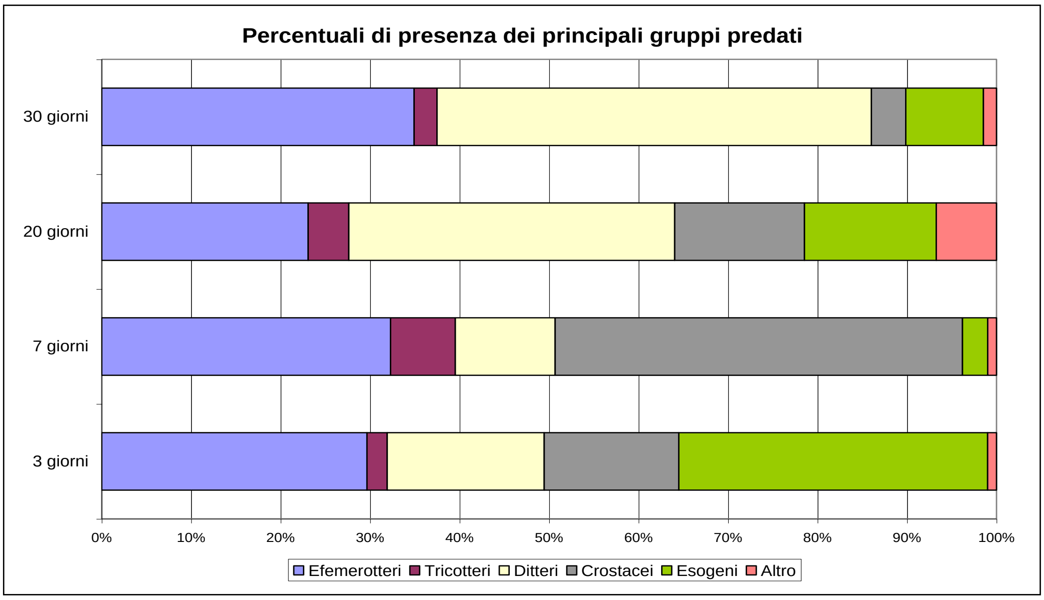
In order to evaluate the feeding adaptation of rainbow trouts introduced in the environment, the quantitative and qualitative variations of stomach contents varying from 3 to 7 to 20 and 30 days from the date of the last sowing have been considered (Table 2).

Table 2 - Food adaptation

	3 days	7 days	20 days	30 days
Stomachs analyzed	132	36	18	9
N° eaten macroinv.	10133	4473	1738	1094
Average n° of preys	76,8	124,3	96,6	121,6
N° of empty stomachs	19	1	1	1
% empty stomachs	14,4%	2,8%	5,6%	11,1%

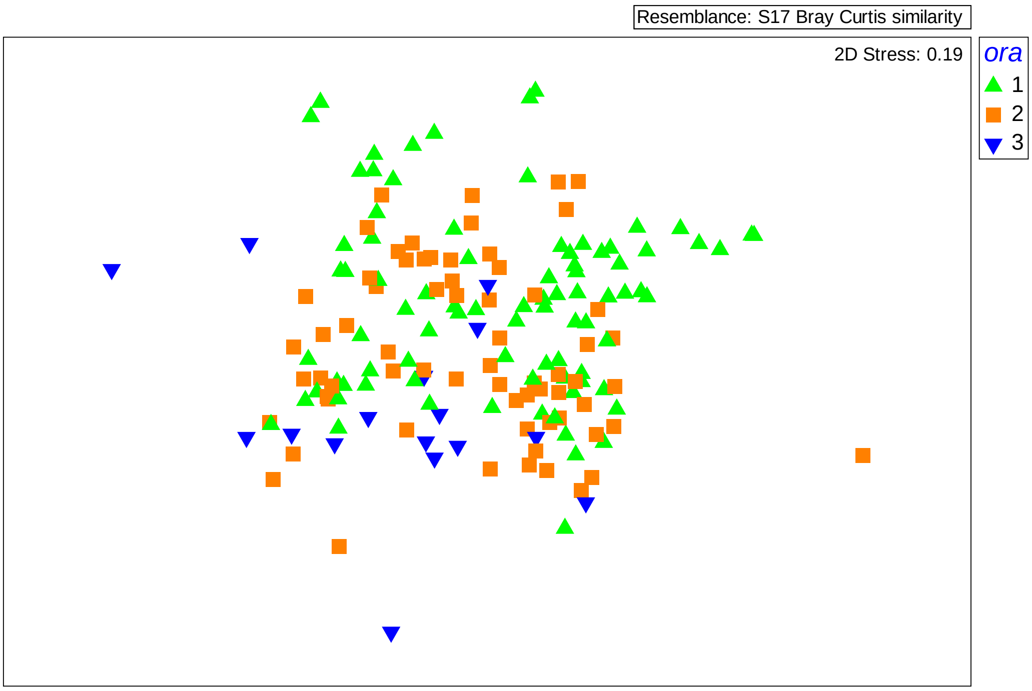
The average of individuals eaten in the 3 days after sowing is 76,8; from the 4th day to the 7th it is of 124,3 individuals, from the 8th to the 20th day it is of 96,6 and in the end from the 21st to the 30th day the average of individuals is 121,6 (Table 2).
In the picture n°6 Diptera undergo a significant increase from 3 to 30 days, whereas Crustaceans and Exogenous clearly decrease (although Crustaceans decrease with a swinging course). This latest data is important considering that the breeding rainbow trout is used to receiving food from outside (feed) and, therefore, it recognizes the Exogen as feeding spring.

Picture 6 - Percentages of the main groups present in stomachs within 3,7,20 and 30 days after sowing

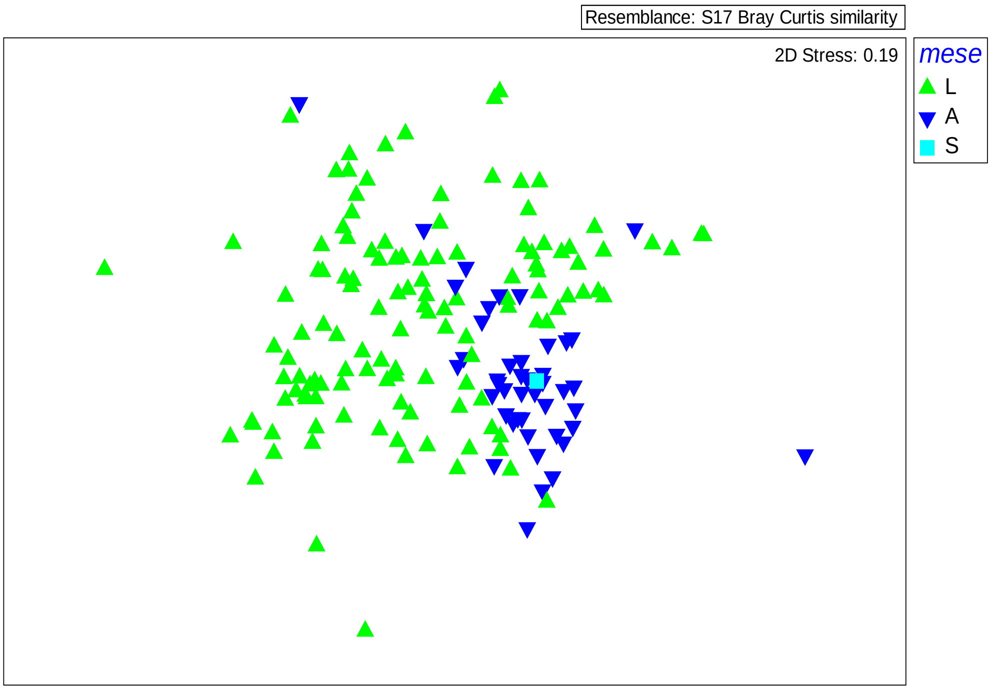


As far as the statistical multivariate analysis of data is concerned, it has been used with the aim of checking the similarities/dissimilarities considered on the composition of the diet within the sample.
Similarities/dissimilarities have been found dividing the sample into three different lots of sub-samples: according to the month of trouts fishing (July or August 2009) (Picture 7), the time of capture (dividing the sample in three intervals from 6.00 to 8.00 a.m., from 8.00 a.m. to 6.30 p.m. and from 6.30 to 8.30 p.m. considering the times of dawn and sunset of that time) (Picture 8) and according to the size of length (trouts long less than 25 cm, more than 28 and between 25 and 28 cm) (Picture 9).

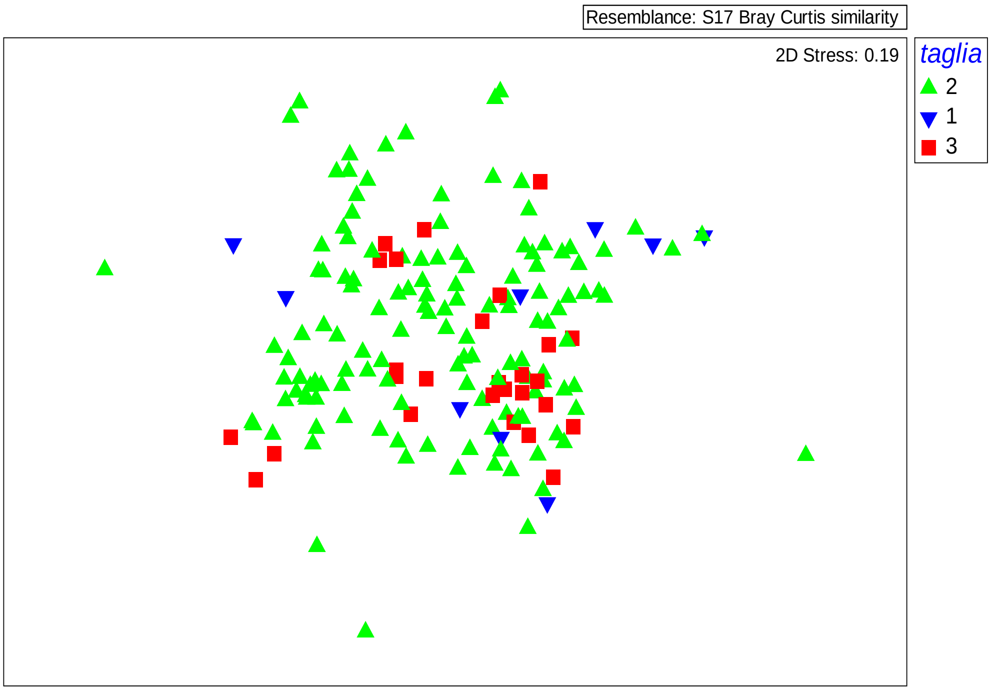
Picture 7 - Similarity between samples based on nMDS analysis - month comparison



Picture 8 - Similarity between samples based on nMDS analysis - time comparison



Picture 9 - Similarity between samples based on nMDS analysis - sizes of length comparison



In all three cases the almost total super-imposition of the sub-samples is emerged but with significant differences as far as macroinvertebrates taxa discovered in stomachs in two cases out of three are concerned, i.e. in the distinction between month and time of fishing.
As far as the analysis of similarities/dissimilarities for sizes of length is concerned, the ANOSIM test has revealed the lack of significant differences among the sub-samples. The

most important differences involved *Baetis* genus, Exogenous and Gammaridae, Chironomidae and Simulidae families.

CONCLUSIONS

From the results obtained it is evident that the diet of rainbow trout is mainly generalized including above all benthic macroinvertebrates, fishes, earth invertebrates and occasionally vegetable material as well. The rainbow trout has shown some preferences for Simuliidae and Ryacophilidae although it's marked opportunism.

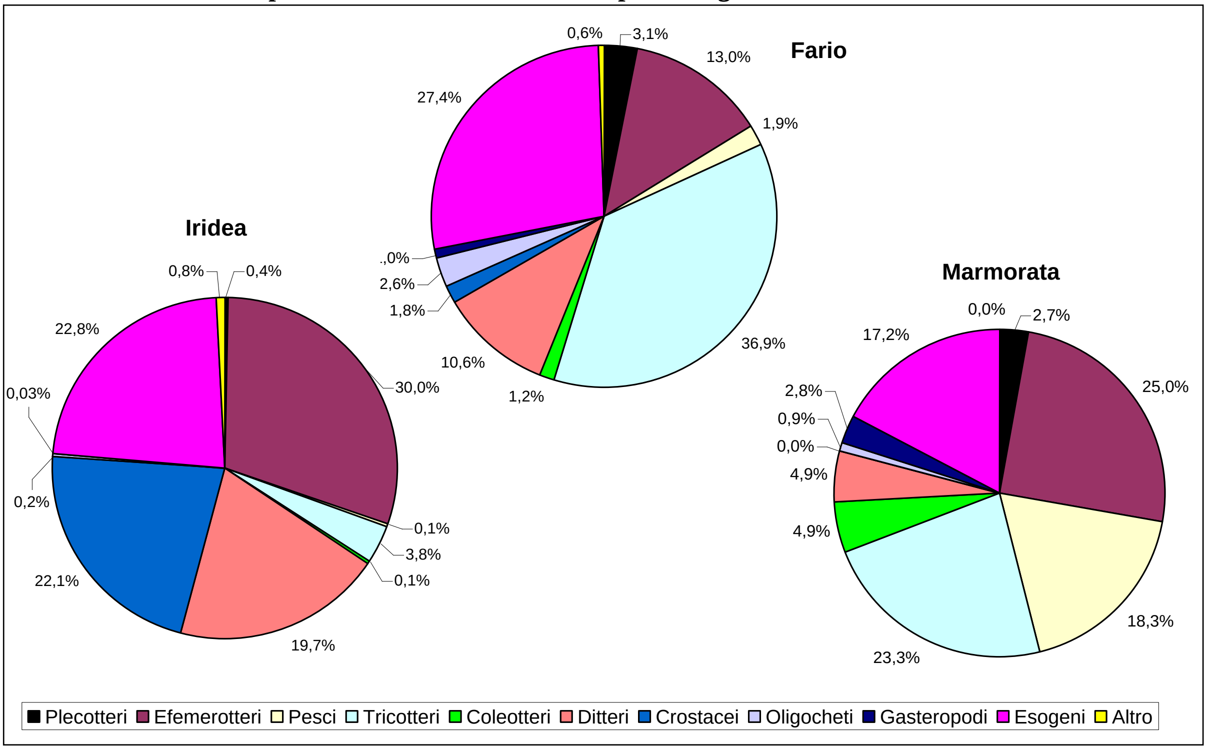
This research does not confirm the poor adaptability of individuals bred and introduced in the environment.

As a matter of fact, the results underline a feeding adaptation even after few days from the introduction in the environment. It could be expected that, as realised in other researches such as for example in river Sile in the province of Treviso (Zanetti *et al.*, 1992), there could be a feeding adaptation for the whole time. In the following graphic (Picture 10) it is possible to compare the stomach content of rainbow trouts of the current research with the one of brown and marble trout.

It is necessary to point out, nevertheless, that the data concerning the brown and marble trout come from the "Studio sull'alimentazione dei Salmonidi in provincia di Belluno" (Zanetti *et al.*, 1996), for which the data seems not homogeneous.

In spite of this, starting from the fact that the species considered and the area of experimentation are always the same, this graphic can supply an interesting reading key on the partial super-imposition among the examined species.

Picture 10 - Comparison of the subdivision as a percentage of stomach contents of Salmonids



The main differences concern Tricoptera, fishes, Diptera and Crustaceans, the first two orders are much more abundant in the stomach contents of marble trout whereas the Diptera and Crustaceans are more abundant in the contents of rainbow trout.

This can be explained through the different habits of the two species, since the marble trout has developed much better than the rainbow trout the predation strategy because it is wild and

used to living in the environment, whereas for the rainbow trout it is much more difficult to develop the research image of preys in the environment. Another difference is given by great inclination of the marble trout to eat fishes.
From the results of this analysis it is clear that feeding spectrum is nevertheless similar and that, therefore, the inputs with fishing targets produce an appreciable nuisance on indigenous species above all in consideration of the quick adaptation to the feeding in the environment of the fish fauna introduced.
Such practices should be eliminated or alternatively carried out with the same extreme caution and under strict scientific control.

REFERENCES

AMUNDSEN P.A., GABLER H.M., STALDVIK F.J., 1996 - A new approach to graphical analysis of feeding strategy from stomach content data-modification of the Costello (1990) method. J. Fish. Biol. 48: 607-614.
CLARKE K.R., 1993 - Non-parametric multivariate analysis of changes in community structure. Australian Journal of Ecology 18: 117-143.
HYSLOP E.J., 1980 - Stomach contents analysis - a review of methods and their application. J. Fish. Biol. (1980) 17: 411-429.
IVLEV V.S., 1961 - Experimental ecology of the feeding of fishes. Yale Univ. Press, New Haven, 332 pp.
KIDO M. H., HEACOCK D.E., ASQUITH A., 1999 - Alien rainbow trout (*Oncorhynchus mykiss*) (Salmoniformes: Salmonidae) Diet in Hawaiian Streams. University of Hawaii Press. Pacific Science (1999), 53 (3): 242-251.
KRUSKAL J. B., 1964 - Multidimensional scaling by optimizing goodness of fit to a nonmetric hypothesis. *Psychometrika*, 29: 1-27.
OSCOZ J., LEUNDA P.M., CAMPOS F., ESCALA M.C., GARCIA-FRESCA C., MIRANDA R., 2005 - Spring diet of raimbow trout, *Oncorhynchus mykiss* (Walbaum, 1792) in the Urederra River (Spain). Ann. Limonl. - Int. J. Lim. 2005, 41 (1): 27-34.
SAVAGE R.E., 1931 - The relation between the feeding of the herring off the east coast of England and the plankton of the surrounding waters. Fishery Investigation, Ministry of Agriculture, Food and Fisheries, Series 2 (12): 1-88.
ZANETTI M., LORO R., MARCON P., 1996 - Studio sull'alimentazione dei Salmonidi in provincia di Belluno. Atti del 4° convegno nazionale A.I.I.A.D. - Riva del Garda 12-13 dicembre 1991, pp. 367-378. Provincia Autonoma di Trento, Ist. Ag. di S. Michele a/A.
ZANETTI M., LORO R., TURIN P., GRAVA VANIN B., MARTIN M., 1996 - Studio sull'alimentazione dei Salmonidi in alcuni ambiti dei fiumi Piave, Sile e Meschio in provincia di Treviso". Atti del 5° Convegno Nazionale A.I.I.A.D. - Montecchio Maggiore (VI). 28-29 ottobre 1994. Ed. provincia di Vicenza, pp. 105-117.
ZANETTI M., TURIN P., BELLIO M., PICCOLO D., FOREST S., 2009 - Progetto di controllo e verifica delle immissioni di trota iridea (*Oncorhyncus mykiss*). Amministrazione Provinciale di Belluno, Settore tutela e gestione della fauna e delle Risorse Idriche.
ZANETTI M., TURIN P., BELLIO M., MACOR P., FOREST S., VIDOTTO M., 2010 - Piano di controllo atto a verificare le eventuali turbative dell'immissione di trote iridee di taglia legale di cattura nelle acque del bellunese. Amministrazione Provinciale di Belluno, Settore tutela e gestione della fauna e delle Risorse Idriche.
ZANETTI M., TURIN P., BELLIO M., MACOR P., FOREST S., VIDOTTO M., 2010 - Piano di controllo atto a verificare le eventuali turbative dell'immissione di trote iridee di taglia legale di cattura nelle acque del bellunese. Provincia di Belluno. Relazione tecnica. 79 pp. + all.