

Influence of food and age on breeding and reproductive performances in a rainbow trout population

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Abstract. In this work paper we want to found what is the relation between some morphological features and level of sexual products in a rainbow trout population of 3 and 4 years age. Also, we investigated the influence of extruded pellet fodder on quantitative roes and milt development in the two age categories. The effected researches put into evidence the superior development of females comparatively with males, indifferently on age, with significant and ensured differences. Following the roe quantity and number obtained from females of 3 and 4 years age, we observed that after use of extruded fodder are obtained both quantitative and also numerically superior performances comparatively to those ones obtained after feeding with classical pellet fodder and increase during age, the differences being significant and ensured. There were calculated also the correlations between morphological features taken in study and respective some reproduction indices and were established the directions in which exist real selection and improvement chances. After effected researches and obtained results come out a series of conclusions, following that their basis to be taken selection and improvement measures in view to increase breeding and multiplication performances.

Key Words: extruded pellet fodder, three years, four years, age, roe, milt.

Streszczenie. Celem niniejszej pracy było określenie zależności pomiędzy wybranymi cechami morfologicznymi a produkcją gamet w populacji pstrąga tęczowego w wieku 3 i 4 lat. Ponadto przebadano wpływ skarmiania paszy ekstrudowanej na ilość produkowanej ikry oraz mleczka w tych dwóch kategoriach wiekowych. Uzyskane wyniki potwierdziły, że samice rozwijają się szybciej niż samce niezależnie od wieku (różnice były istotne). Ponadto stwierdzono, że samice karmione paszą ekstrudowaną produkowały więcej ikry w porównaniu z tymi, które otrzymywały tradycyjny granulát. Różnice te były istotne i zwiększały się z wiekiem. Określono również korelację pomiędzy wybranymi cechami morfologicznymi a pewnymi wskaźnikami reprodukcyjności. W ten sposób wyznaczono kierunki, w których istnieją realne szanse na selekcję i ulepszenie. W wyniku przeprowadzonych badań wyciągnięto pewne wnioski dotyczące selekcji pod kątem osiągnięcia lepszych parametrów rozrodczości.

Słowa kluczowe: pasza ekstrudowana, 3-latki, 4-latki, wiek, ikra, mlecz.

Rezumat. În lucrarea de față am dorit să vedem care este relația dintre unele însușiri morfologice și nivelul produselor sexuale la o populație de păstrăv curcubeu de 3 și 4 ani. De asemenea, am urmărit influența furajului granulát extrudat asupra dezvoltării cantitative a icrelor și lapților la cele două categorii de vârstă. Cercetările efectuate au scos în evidență dezvoltarea superioară a femelelor comparativ cu masculii, indiferent de vârstă, cu diferențe semnificative și asigurate. Urmărind cantitatea și numărul icrelor obținute de la femelele de 3 și 4 ani, am constatat că în urma utilizării furajului extrudat se obțin atât cantitativ, cât și numeric, performanțe superioare comparativ cu cele obținute în urma furajării cu hrană granulată clasică și cresc odată cu vârsta, diferențele fiind semnificative și asigurate. Au fost calculate de asemenea și corelațiile dintre însușirile morfologice luate în studiu și respectiv unii indici de reproducție și s-au stabilit direcțiile în care există șanse reale de selecție și ameliorare. În urma cercetărilor întreprinse și a rezultatelor obținute s-au desprins o serie de concluzii, urmând ca pe baza acestora să fie luate măsurile de selecție și ameliorare în vederea creșterii performanțelor de creștere și înmulțire.

Cuvinte cheie: furaj extrudat, trei ani, patru ani, vârstă, icre, lapți.

Introduction. The fishing in world seas and oceans appears to reach a maximum productivity level, at least for the present stage, reason for what the specialist attention directs to continental pisciculture, which reveals permanent progress and increasing dynamics. The pisciculture was developed and is permanent developed by one hand by knowledge capitalization accumulated during the time, and by the other hand basis on the new scientific discoveries realized in alimentation, reproduction, selection and improvement domain. The new breeding methods in fresh waters have revolutionized the breeding projects and technologies, more and more cyprinids breeding farms, but especially more salmonid farms, succeeding to produce fish for market with a good price and during all the year. The statistic data of last years reveal a significant increasing of human fish consumption, but also of other aquatic organisms, which are in over 400 species from which about 200 are represented by fishes and the difference by mollusks, crustaceans and algae.

A very interesting aspect represents the fact that today human keeps his attention more and more on fresh fish consumption, followed by the frozen one or preserved by salting and smoking and a decreasing of demands referring to fish prepared as canned meat using different preservatives (see Table 1).

Table 1

New tendencies of fish use for human consumption
(% from total consumption fish; Bud et al 2007b; Bud, unpublished data)

Specification	1984	1988	1990	1992	1996	2000	2004	2008 (estimative)
Fresh fish	25.6	28.9	29.2	29.9	32.7	33.4	33.5	33.8
Frozen fish	34.0	33.8	33.8	33.6	32.9	33.5	33.4	33.4
Dry and smoked fish	20.8	19.8	19.6	19.2	19.0	17.2	17.3	17.0
Canned fish meat	19.6	17.5	17.4	17.3	15.4	15.9	15.8	15.8
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Salmoniculture is the second branch as importance of pisciculture and it has spectacular development both in our country and in the world majority countries which benefit of appropriate breeding and development conditions.

The salmoniculture acquired amplitude without precedent in the last 30 years because of the impulse of the scientific research in salmonid breeding domain in some advanced countries as concerns the mountain sectors: USA, Denmark, Norway, Japan, Holland, France, Italy, countries whose annual average productions have increased to hundreds or even thousands of tones.

The main levers of salmonid exploitations that come out from researches with applicative character and have conferred an intensive rhythm to piscicole exploitations centered on trout breeding have a pregnant dynamic character and can be nominee as follows: fodder granulation modalities' resolving destined for salmonid categories, mechanization and automation of fodder distribution process, elaboration of some recipes according to bio-physiological demands of species, use of improved biological material, electronic supervising of medial parameters, use of some super performing filters or bio-filters etc.

Today, in Romania, the pisciculture in cold waters has as subject the next species exploitation: rainbow trout (*Oncorhynchus mykiss* (Walbaum, 1792)), brook trout (*Salvelinus fontinalis* (Mitchill, 1814)) and brown trout (*Salmo trutta fario* Linnaeus, 1758) (Bud et al 2007ab; Cristea 1995; Pășărin et al 2007; Oroian 2007; Vlaic 2007).

Having in view above mentioned arguments, in present work paper we proposed to investigate the fodder and age impact, as well the interrelations between morphological features and reproductive performances in the rainbow trout of three and four years age, bred in the Fiad trout farm conditions (Bistrița Năsăud County, Romania, EU).

Material and Method. The biological material was represented by four lots of rainbow trout of three and four years age, fed with extruded pellet fodder (48% protein, 15% fat, 1% crude fibre, 8.8% ash, 1.2% total P, 40 mg/kg astaxanthin, 27.000 IU/kg vitamin A, 3.000 IU/kg vitamin D3, 350 mg/kg vitamin E, 500 mg/kg vitamin C) destined especially for breeding stocks, both before reproduction and also after.

Fish feeding was made two times a day *ad libitum*, every day, during one year period (365 days long).

From the four lots were randomly chosen 30 individuals, in equal proportions for the two sexes, in which were followed three morphological features, respective the body weight, total length and great perimeter, as well the next reproduction indices: the weight of sexual products (roes and milt), number of roes in average on individuals and respective their percent reported to body weight.

Also, we want to analyze, besides reproduction indices' value, the correlation level among them and the two morphological features taken in study. No in the last final, we proposed to estimate if the breeding stock age has or not influence and what is its size on reproduction indices.

All the data were statistically processed and are presented in tables that follow.

Results and discussion. As a prim aspect that comes out from the Table 2 data is that female rainbow trout of three years age used in reproduction is characterized by a good body development emphasized by an average weight value situated on 1017.40 g, with variation limits between 700 and 1318 g, relative good variability confirmed also by the variability coefficient situated on 14.23 %.

Table 2

Main morphological and reproductive features in female rainbow trout of three years age

Specification	Body weight (g)	Body weigh after stripping (g)	Roes' weight (g)	Number of roes (pc/female)	Gonadosomatic index (%)	Total length (cm)	Great perimeter (cm)
X ± sx	1017.40±26.44	785.24±39.91	232.16±14.86	2252.28±95.94	22.54±1.13	41.67±4.02	23.73±0.30
Minimal values	700.00	696.00	114.00	4.00	0.54	37.00	21.00
Maximal values	1318.00	1218.00	456.00	2791.00	34.60	46.00	27.00

In case of female total length analyzing and respective of thorax perimeter one we observe that the biological material taken in study is situated on values, which frame between normal limits for this age with a relative good variability confirmed besides by the reduced values of variability coefficients (5.32% in case of length and respective 6.82% in case of thorax perimeter).

Analyzing the reproduction indices' values we observe that in the biological material taken in study were obtained in average roe quantity of 232.16 g, but with large variation limits comprised between 114 and 456 g, which determine us to affirm that from this point of view the rainbow trout females present a high variability.

Following the roe number on each female, we observe that it is situated in average on 2252.28 pieces/female, value that we appreciate to be satisfactory, but we must remark that the existent variability among individuals is extremely large, from reduced values of four pieces until a maximal one of 2791 pieces. These results determine us to choose further descendants for the future reproduction nucleus among individuals that produce and eliminate a more greater roe number, respectively over the analyzed population average.

Also are interesting the results referring to gonadosomatic index that in the biological material taken in study was in average of 22.54%, with large variation limits, which permit us to choose by selection the plus variant individuals that can offer in short interval significant qualitative progress.

Analyzing the same aspects in male rainbow trout breeding stocks, according the Table 3 data we can take further succinct considerations.

Table 3

Main morphological and reproductive features in male rainbow trout of three years age

<i>Specification</i>	<i>Body weight (g)</i>	<i>Body weight after stripping (g)</i>	<i>Milt weight (g)</i>	<i>Gonadosomatic index (%)</i>	<i>Total length (cm)</i>	<i>Great perimeter (cm)</i>
X ± sx	851.76±67.17	821.16±40.82	30.60±7.47	1.80±0.14	36.50±0.58	23.17±0.48
Minimal values	485.60	465.00	6.0	1.23	32.00	18.00
Maximal values	1483.00	1250.00	77.60	3.40	46.00	28.00

The body weight, as results from data presented in Table 3, is in average of 851.76 g, more reduced comparatively with the females of same age, precisely with 165.64 g that represent over 16.2%, value that reveals a better precocity of females until three years age. Also, we must mention the fact that males taken in study were more uniform given to females, fact confirmed by the variation coefficient very low value of 0.31 comparatively with that one registered in females of 14.23%. With all these we can emphasis also the great variation limits between extremes, which are situated in almost 1 kg revealing the heterogeneity of the investigated material.

In case of males, the differences between weight before and after stripping are in general, as was possible, more reduced as result that the milt volume is more decreased than roes' one, being situated in our case to an average value of 30.60 g and with reduced variations among individuals. This aspect is very well emphasized also by the gonadosomatic index value that is only of 1.80% given to females in which the same index reaches until 22.54%.

An interesting aspect that we can mention is that under total length report the males have an average value of 36.50 cm, 5.17 cm smaller comparatively with females at the same age, while the great perimeter has alike values. These results are rather uncommon if we have in view that roes' mass in this case do not has any influence on thorax perimeter, the roes being placed in posterior side of the line on which are made perimeter measurements.

In case of same morphological and reproductive values in the rainbow trout of four years age come out next more important aspects. Thus, in females of four years age the average body weight was of 1969.60 g with large variations comprised between 1442 g and 2225 g, but with only 9.19% variability coefficient, which reveals that majority of individuals are grouped around the average value and only sporadic individuals have values significant distant from average (Table 4).

Table 4

Main morphological and reproductive features in female rainbow trout of four years age

<i>Specification</i>	<i>Body weight (g)</i>	<i>Body weight after stripping (g)</i>	<i>Roes' weight (g)</i>	<i>Number of roes (pc/female)</i>	<i>Gonadosomatic index (%)</i>	<i>Total length (cm)</i>	<i>Great perimeter (cm)</i>
X ± sx	1969.60±33.0	1554.22±43.4	414.72±14.4	5194.96±189.6	21.20±0.74	51.97±0.4	31.40±0.4
Minimal values	1442.00	1332.28	225.70	2708.40	11.09	46.00	27.00
Maximal values	2225.00	2085.00	498.98	6242.74	25.66	56.00	37.00

A very significant aspect is represented by the roe quantity in four years age females that reaches 414.72 g, superior value with 181.80 g given to three years age females, the difference being significant and ensured. Also, the roe number reaches the value of 5194.96 pieces, superior to that of females at three years age with 2842.68 roes, which is a significant difference: over 56%.

As it is a matter of course, increasing in length continues also between three and four years, the females of four years age reaching an average value of 51.97 cm, with a difference between years of 10.3 cm, and in case of great perimeter the difference is

more reduced to only 7.67 cm. With roe weight exception and their number, which presents large variations, the other features are relatively closed, the biological material of four years age being more uniform from this point of view.

As comes out very well from the Table 5 data, the males' body weight is also in this case inferior to females of same age, the difference being over 500 g with variability inside the lot situated to coefficient value of 12.84. Also, it comes out that given to females, which during aging almost have doubled roe quantity, the males' milt quantity is smaller comparatively to that obtained from males of three years age with 10.63 g. As result, also the gonadosomatic index in the males of four years age is smaller, respective of 1.37% given to 1.80% registered in the males of three years age.

Table 5

Main morphological and reproductive features in male rainbow trout of four years age

Specification	Body weight (g)	Body weight after stripping (g)	Milt weight (g)	Gonadosomatic index (%)	Total length (cm)	Great perimeter (cm)
X ± sx	1454.60±34.10	1434.63±41.85	19.97±1.54	1.37±0.10	45.17±0.48	31.60±0.40
Minimal values	1100.00	1335.90	7.32	0.48	40.20	27.05
Maximal values	1800.00	1745.85	37.82	2.35	50.06	36.12

From these data comes out that females of rainbow trout reach the best performances in age of four years, in return in males the most favorable reproduction values are realized at three years age.

Further, we want to put into evidence the interdependence between some morphological features and some reproduction indices, so to have a clear image of directions in which we will effect the selection and improvement and the direction on which will keep attention in future.

From the Table 6 data we observe that the most significant correlations are found between roe weight and body weight ($r=0.676$), between roe number and weight after stripping ($r=0.834$), between gonadosomatic index and roe weight ($r=0.912$) or between number of roes and weight of roes ($r=0.726$). Also, we must remark that there exist reduced correlations between body weight and roe number ($r=0.348$), with a very decreased significance limit.

Table 6

Correlative values between some morphological and reproductive features in female rainbow trout of three years age

Specification	r	Initial body weight	Weight after stripping	Roes' weight	Number of roes	Gonadosomatic index	Total length	Great perimeter
Initial body weight	Pearson coeff.	1.000	0.540	0.676	0.348	0.327	0.603	0.514
	Signif. limit	1	0.002	0.000	0.059	0.077	0.000	0.004
Body weight after stripping	Pearson coeff.	0.540	1.000	0.716	0.834	0.626	0.074	- 0.015
	Signif. limit	0.002	1	0.000	0.000	0.000	0.699	0.936
Roes' weight	Pearson coeff.	0.676	0.716	1.000	0.726	0.912	0.077	0.090
	Signif. limit	0.000	0.000	1	0.000	0.000	0.684	0.635
Number of roes	Pearson coeff.	0.348	0.834	0.726	1.000	0.756	- 0.102	- 0.097
	Signif. limit	0.059	0.000	0.000	1	0.000	0.591	0.611
Gonadosomatic index	Pearson coeff.	0.327	0.626	0.912	0.756	1.000	- 0.231	- 0.105
	Signif. limit	0.077	0.000	0.000	0.000	1	0.219	0.580
Body length	Pearson coeff.	0.603	0.074	0.077	0.102	0.231	1.000	0.436
	Signif. limit	0.000	0.699	0.684	0.591	0.219	1	0.016
Great perimeter	Pearson coeff.	0.514	0.015	0.090	0.097	- 0.105	0.436	1.000
	Signif. limit	0.004	0.936	0.635	0.611	0.580	0.016	1

In case of males, as results from the Table 7 data show, the correlations are more reduced and insignificant or in some cases are registered even negative correlations as happens in case of correlations' establishing between total length and milt weight ($r=-0.235$) or between great perimeter and milt weight ($r=-0.167$).

Table 7

Correlative values between some morphological and reproductive features in male rainbow trout of three years age

Specification	r	Initial body weight	Weight after stripping	Milt weight	Gonadosomatic index	Total length	Great perimeter
Initial body weight	Pearson coeff.	1.000	0.797	- 0.382	- 0.104	0.484	0.767
	Signif. limit	1	0.000	0.037	0.584	0.007	0.000
Body weight after stripping	Pearson coeff.	0.797	1.000	- 0.264	0.284	0.434	0.623
	Signif. limit	0.000	1	0.158	0.128	0.017	0.000
Milt weight	Pearson coeff.	- 0.382	- 0.264	1.000	0.382	- 0.235	- 0.167
	Signif. limit	0.037	0.158	1	0.037	0.210	0.377
Gonadosomatic index	Pearson coeff.	- 0.104	0.284	0.382	1.000	- 0.245	0.065
	Signif. limit	0.584	0.128	0.037	1	0.191	0.733
Body length	Pearson coeff.	0.484	0.434	- 0.235	- 0.245	1.000	0.276
	Signif. limit	0.007	0.017	0.210	0.191	1	0.140
Great perimeter	Pearson coeff.	0.767	0.623	- 0.167	0.065	0.276	1.000
	Signif. limit	0.000	0.000	0.377	0.733	0.140	1

In males, the positive and significant correlations are found only in case of great perimeter and respective body weight, as well between great perimeter and weight after stripping.

As comes out from this table data, the milt weight is not positive correlated with no one of morphological features taken in study, but contrary in majority of cases we have reduced correlations and possible negative ones.

In the rainbow trout of four years age (Table 8), the more increased correlative values are found especially between morphological features and more decreased between morphological and reproductive features, excepting the weight after stripping that is positive correlated with great perimeter ($r=0.268$).

Table 8

Correlative values between some morphological and reproductive features in female rainbow trout of four years age

Specification	r	Initial body weight	Weight after stripping	Roes' weight	Number of roes	Gonadosomatic index	Total length	Great perimeter
Initial body weight	Pearson coeff.	1.000	0.888	0.199	0.185	- 0.332	0.914	0.318
	Signif. limit	1	0.000	0.291	0.329	- 0.073	0.000	0.087
Body weight after stripping	Pearson coeff.	0.888	1.000	- 0.144	- 0.109	- 0.636	0.812	0.268
	Signif. limit	0.000	1	0.448	0.568	0.000	0.000	0.151
Roes' weight	Pearson coeff.	0.199	- 0.144	1.000	0.893	0.835	0.029	0.124
	Signif. limit	0.291	0.448	1	0.000	0.000	0.878	0.513
Number of roes	Pearson coeff.	0.185	- 0.109	0.893	1.000	0.748	0.102	0.143
	Signif. limit	0.329	0.568	0.000	1	0.000	0.590	0.450
Gonadosomatic index	Pearson coeff.	-	- 0.636	0.835	0.748	1.000	-	- 0.082
	Signif. limit	0.332	0.000	0.000	0.000	1	0.441	0.665
Body length	Pearson coeff.	0.914	0.812	0.029	0.102	- 0.441	1.000	0.281
	Signif. limit	0.000	0.000	0.878	0.590	0.015	1	0.132
Great perimeter	Pearson coeff.	0.318	0.268	0.124	0.143	- 0.082	0.281	1.000
	Signif. limit	0.087	0.151	0.513	0.450	0.665	0.132	1

From the data presented in this table and other data of the literature (Decei 2001; Păsărin et al 2004; Bud et al 2007ab) we can conclude that gonad products depend in more reduced measure on morphological features' values taken in study, but much more on water qualities and especially on fodder ones, respectively of exploited biological

material potential (see also Sylven & Elvingson 1992; Barnabe 1993; Doyle et al 1996; Su et al 1996, 1997, 2002). There are registered some significant correlations between morphological features on the one hand and respective between reproduction indices but only between them by the other hand.

Same data, with reduced significances, are found also in the males of four years age, between features taken in study (Table 9). Thus, the milt weight is positive correlated with the body weight, total length and great perimeter to values which do not surpass $r=0.42$, but the correlations increase if we take in calculus the milt weight and gonadosomatic index that reaches until a value of $r=0.944$, reduced values being registered also in case of correlations between milt weight and weight after stripping.

Table 9

Correlative values between some morphological and reproductive features in male rainbow trout of four years age

Specification	<i>r</i>	Initial body weight	Weight after stripping	Milt weight	Gonadosomatic index	Total length	Great perimeter
Initial body weight	Pearson coeff.	1.000	0.994	0.306	- 0.006	0.819	0.632
	Signif. limit	1	0.000	0.100	0.976	0.000	0.000
Body weight after stripping	Pearson coeff.	0.994	1.000	0.282	- 0.025	0.807	0.612
	Signif. limit	0.000	1	0.131	0.894	0.000	0.000
Milt weight	Pearson coeff.	0.306	0.282	1.000	0.944	0.331	0.421
	Signif. limit	0.100	0.131	1	0.000	0.074	0.021
Gonadosomatic index	Pearson coeff.	- 0.006	- 0.025	0.944	1.000	0.089	0.227
	Signif. limit	0.976	0.894	0.000	1	0.641	0.226
Body length	Pearson coeff.	0.819	0.807	0.331	0.089	1.000	0.649
	Signif. limit	0.000	0.000	0.074	0.641	1	0.000
Great perimeter	Pearson coeff.	0.632	0.612	0.421	0.227	0.649	1.000
	Signif. limit	0.000	0.000	0.021	0.226	0.000	1

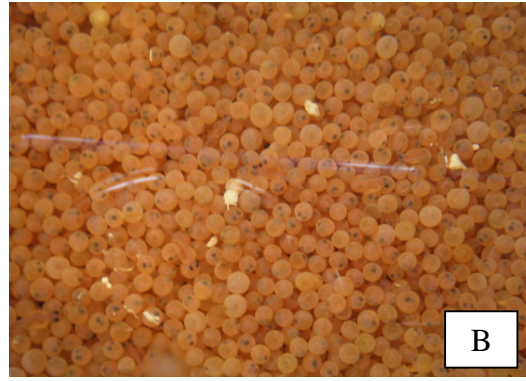
Conclusions. Our researches permit us to extract some more important conclusions, which we present synthetically further on. The medial conditions from trout farm, alongside the use of very good quality fodder, lead to obtain well developed biological material, with satisfactory reproduction performances and differentiated depending on age category taken in study. The biological material taken in study puts into evidence the fact that rainbow trout females have more increased growth rate than the males, both at three years age and four years one. The reproduction performances, characterized by indices taken in study, reveal significant increasing from three to four years in case of females, given to increasing of roe weight and their number. The biological material variability as concerns some morphological or reproductive features puts into evidence the possibility of a rigorous and efficient selection that will lead in future to obtain a more performing biological material. The existent variability among individuals of the four lots permits us to retain further on for reproduction nucleus the most performing individuals (plus variants), so their descendants will be characterized by performances superior to those ones realized in present. We suggest in future stage as very necessary a severe selection especially in males' level whose body weight is in present unsatisfactory for the considered age, so also the reproduction performances are more decreased. The obtained results after this experiment permit us to put into evidence also some interdependences between investigated factors and these correlations' size, by which we must to keep account in the exploitation process so the breeding and multiplication performances to be significantly improved.

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A



B



C



D

Plate 1. Fiad trout farm (Bistrița Năsăud County, Romania, EU); A- Tanks for brood stocks; B- Rainbow trout embryos; C- Rainbow trout male; D- Rainbow trout female.

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