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Selection of Rainbow Trout Female Studs According to the Genetic Correlation and a Degree of Maturity of their Gonads with Morphometric Signs.

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ABSTRACT

In the process of evaluation it's important to determine the most fertile and early matured females of trout as the process of selection according to the weight isn't always correct. In order to solve this problem we present a research on the correlation between secondary and primary sexual characteristics of the Kamloops rainbow trout females. A quantitative correlation between an exterior, interior and morphological indicators and the gonads' weight has been revealed. As a result, it has been found out that the development of a one-year-old fish differs from the development of a two-year-old one. This is manifested in the uneven growth of individual characteristics. Arguably, secondary characteristics of one-year-old females influence the development of inner organs in an important way. Thus, correlation of the gonads' weight with the length of the postorbital part is 0.703 and with the width of the forehead 0.631. This statistic clearly shows that the volume of gills, quantity of gill rakers and arches influence the development of inner organs directly; to be exact they influence the maturity of gonads. Therefore, with the indirect selection according to these characteristics females will become mature quicker and they will be more enduring to changing conditions of the environment. Considerable changes take place when one observes biometrics of two-year-old females. The correlation between previously considered characteristics and reproductive products stays the same but new characteristics are added; they are pectoral fins and ventral fins. These characteristics are indirectly related to the weight and therefore, the length of a fish which stays true both for one-year-old and two-year-old females. To grow trout in the third fishing zone it's necessary to evaluate fish as soon as it is one or two years old in order to fasten the process of getting a new type of fish of the Volga region.
Keywords: rainbow trout, biometrics, determination, correlation, evaluation.

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INTRODUCTION

In the regions where there are limited opportunities for work and earning money trout farming can help providing employment and a stable income. Salmon enjoys a special status in the world fish industry due to some biological peculiarities and a complicated life-cycle. In particular, the freshwater aquatic species and anadromous ones can be grown, with tough juveniles attracting the foremost attention which are exploited intensely in commercial fisheries.

Nowadays the development of the aquaculture industry in inland waters is very promising. Pond trout farming refers here too. The main objects of it are rainbow trout, Kamloops trout, steelhead trout, Adler trout, etc. Rainbow trout is the most popular and widely spread object of polycyclic cultivation.

Maintaining the optimal level of genetic diversity is one of the most important tasks which should be addressed immediately, because reduction of genetic heterogeneity leads to deterioration of many qualitative indicators of salmon and rainbow trout populations in particular. A body form of the fish depends on a complex of genetic meanings and factors of the environment. When we understand genetic foundations of phenotypic variations in the form of a body we will become leaders in farming and adaptation of the body to the surrounding conditions will be high [1].

Nowadays the selection of fish is based mainly on the analysis of morphometric characteristics. Biochemical and osteological indicators are used more rarely. In doing so it is recommended selecting the best female studs through the analysis of 5 morphometric indicators: weight (W), length (L), the biggest height (H), the biggest thickness (Br) and the circumference of the body (O). It should be also noted that so far no due attention was paid to the correlation of the analyzed parameters and reproduction functions [2, 3].

Obviously it’s necessary to find characteristics which are signal indicators for the selection and which are not very much influenced by the environment. Osteological indicators meet these requirements fully. They are closely correlated with some indicators which are of paramount importance for the selection (this connection will be shown further); they are made in ontogeny, and except for its early stages they are not subject to the modification variability during the whole period of growing.

The scientific basis of the selection and breeding work which are clearly necessary in this situation can be a strict quantitative study of the structure of the indicators’ variability – components of productivity in the given material.

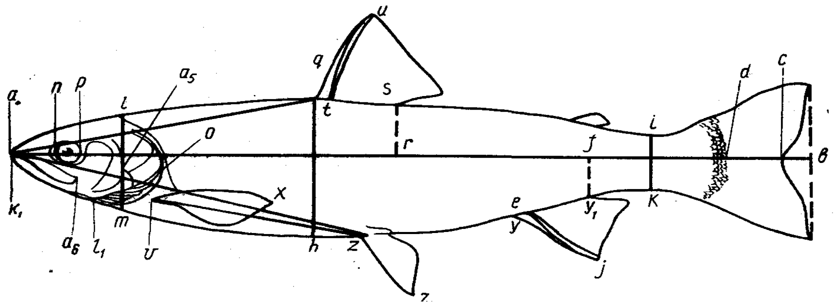
Potential benefits from this direction of the research are great. Data on the hereditary determination of the terms of the rainbow trout’s puberty and possibilities of changing them during the selection are scarce.

The aim of the work was searching for indicators which are “signal” ones towards reproductive products of the rainbow trout studs and are fairly unresponsive to changes of the environment, which are closely correlated with some indicators which are of paramount importance for the selection, which are made in ontogeny, and which are not subject to the modification variability.

Scientific researches known to us have no information about attempts to develop methods of individual characteristics of the maturity degree of the female studs during their life time, so this topic is relevant.

RESEARCH SUBJECTS AND METHODS

Female studs of different ages were material for the study; they were grown in the IP Hasanov full system trout farm of the Ulyanovsk region; we also did a research in the test laboratory for the quality of the biological entities, feeding farm animals and birds of the Ulyanovsk State Agrarian University. Studies of morphometric and biometric indexes, and external conformation indicators were conducted according to the generally accepted methods. Measurements were produced with the help of measuring tools in pic #1. To investigate the interdependence of indicators the following equation was used: W=a Lb, where W is the fish weight (g, mg), L is the fish length (cm, mm), “a” and “b” are coefficients. In a general manner this equation of a power type is known as the allometric level. Using this equation, parameters of interdependence of other indicators were calculated too. W – part of a body (weight of an organ); L – general sizes; b – parameters of the equation which are found by solving the equation with a logarithmic formula: log W = log a + b log L [4, 5, 6].



Pic 1: The outline of measurements of salmons, according to Smith, with changes

ab — length of all fish; ac — length according to Smith; ad — length without C; od — trunk length; an — length dug; np — diameter of an eye (horizontal); aa5 — length of a middle part of the head; ao — head length; po — postorbital part; lm — height of the head of a nape; forehead width (as at Karpov); ad6 — length of a maxillary bone; k_1l_1 — length of the lower jaw; qh — the greatest height of a body; ik — the smallest height of a body; aq — antedorsalny distance; rd — postdorsalny distance; az — anteventralny distance; ay — anteanalny distance; fd — length of a tail stalk; qs — basis length In; fu — the greatest height is D; uu_1 — A basis length; ej — the greatest height A; ox — length P; zz_1 — length is V; vz — distance between P and V; zy — distance between V and A.

Correlation interdependence, error and general average were calculated with the usage of the 7Stat programme and methodology.

To define the indicators which could let us compare body structure of trout of different ages the following indexes of body structure were used:

oblong form - 1 / H
thickness – Br / 1x100
and the coefficient of nutritional state – Mx100/L3

All accounted indicators were according to N.A. Plohinskiy [7, 8, 9, 10, 11].

RESEARCH FINDINGS

In the research the interdependence of the secondary and primary reproductive characteristics of the Kamloops rainbow trout females is presented. The received data on the body structure and age changes shows that the tempo of female studs' growth is rather quick; the difference in the average weight is statistically true according to the first threshold of probability of infallible forecasts P<0.05. Body mass growth at the age from one year old to two year old is 310.54±10.93-409.36±63.30g, which corresponds to the peculiarities of the trout growth (see table 1).

It has been also found out that as the juveniles of trout become older they become more of an oblong form and broader. Their nutritional state doesn't change with age and its value doesn't exceed standard ratios for the species. Nevertheless, variability of the body structure indicators is enough to differentiate the female studs according to their external conformation (table 2).

Data from winter pond stocking shows that one-year-old rainbow trout females can be evaluated by the secondary characteristics such as the width of the forehead (r = 0.631) with the average indicator 23.4±0.60 mm and the length of the postorbital part (r = 0.703) with the average indicator 34.47±0.39 mm (table 3). Due to the well-developed gills, gonads grow fast and the females become mature quickly. The direct correlation interdependence of the gonads and the fish weight also exists – r = 0.815.

Studying of the allometric dependence gives an opportunity to reveal the role of external factors and genetic diversity which shows in intra-species variability. It is known that external factors don't change the allometric indicator "a"; they change only "b", therefore, intra-species differences in "a" can be considered as genetic ones. The allometric indicator "a" is a more changeable value than absolute or relative sizes as it reacts to insignificant variations of the genetic membership of the population, and therefore using it it's possible to trap insignificant morphophysiological differences between populations in cases when they can't be found out by other methods.

Table 1: Variability of a constitution of producers of an rainbow trout

Index	One years old	Two years old	Cv, %
Body weight, g	310,54±10,93	409,36±63,3	37,11
Indexes:			
Rutting	3,91±0,03	4,22±0,01	0,02
thickness	8,42±0,02	10,28±0,02	0,02
Coefficient of fat nality	1,22±0,01	1,22±0,02	0,01

Table 2: Age-related changes in the exteriors of the rainbow trout

Sign	M±m	σ	Cv,%
One years old			
Gonads,	0,591±0,22	0,59	101,35
Length dug, mm	10,72±0,60	1,605	14,96
Postorbital part, mm	34,47±0,39	1,046	3,03
Width of a forehead, mm	23,4±0,60	1,61	6,89
Lower jaw, mm	38,37±0,85	2,25	5,86
Basis of D, mm	36,19±0,65	1,73	4,8
Height is D, mm	29,11±2,20	5,83	20,03
Length of P, mm	33,13±0,71	1,89	5,72
Length is V, mm	29,44±1,18	3,12	10,61
Length of fish, mm	294,81±4,98	13,19	4,47
Weight,	310,54±10,93	28,92	9,31
Two years old			
Gonads,	1,42±0,95	1,91	134,46
Difference with coevals	+0,829		
Length dug, mm	13,56±0,55	1,10	8,18
Difference with coevals	+2,84**		
Postorbital part, mm	37,78±2,58	5,17	13,68
Difference with coevals	+3,31		
Width of a forehead, mm	31,25±1,80	3,61	11,55
Difference with coevals	+7,85**		
Lower jaw, mm	45,07±2,40	4,81	10,68
Difference with coevals	+6,7*		
Basis of D, mm	40,3±2,27	4,55	11,26
Difference with coevals	+4,11		
Height is D, mm	31,14±2,38	4,76	15,31
Difference with coevals	+2,03		
Length of P, mm	38,77±1,38	2,76	7,12
Difference with coevals	+5,64**		
Length is V, mm	33,18±2,43	4,87	14,7
Difference with coevals	+3,74		
Length of fish, mm	322,2±17,23	34,47	10,69
Difference with coevals	+27,39		
Weight, g	409,36±63,30	126,61	30,92
Difference with coevals	+98,82		

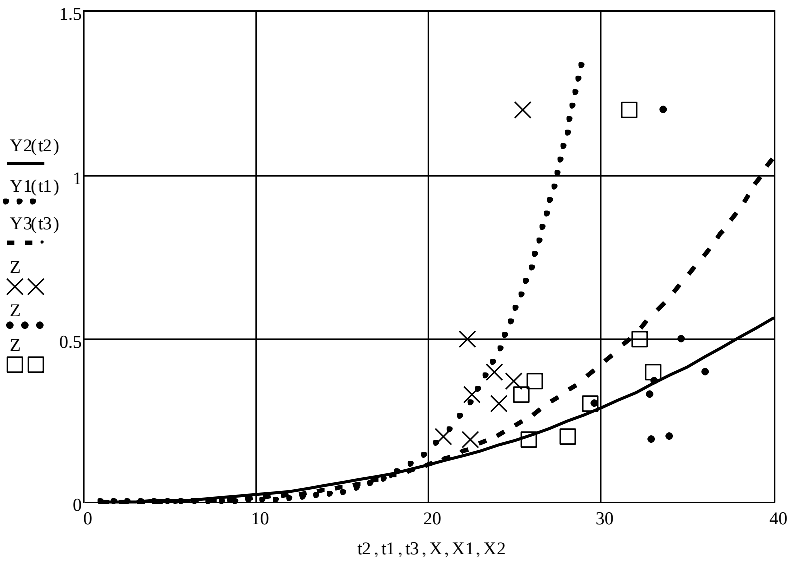
Reliable * P<0,05; **P<0,01

Table 3: Correlation dependence of indirect characteristics with the mass of gonads in annual females of rainbow trout

Index	Gonads	Длина рыла	Postorbital part	Forehead	Lower jaw	Basis the D	Height the D	Length P	Length V	Length of fish	Weight
1	1	-0,41	**0,703**	**0,631**	0,115	0,143	-0,824	-0,623	0,166	0,459	**0,815**
2		1	0,197	-0,07	-0,014	-0,341	-0,034	0,807	0,614	0,137	-0,547
3			1	0,229	-0,149	0,288	-0,725	-0,219	0,535	0,874	0,230
4				**1**	0.34	-0,571	-,0778	-0,08	0,158	-0,157	**0,757**
5					1	-0,122	-,0144	0,316	0,229	-0,552	0,462
6						1	0,282	-0,36	0,091	0,468	-0,185
7							1	0,175	-0,241	-0,394	-0,661
8								1	0.306	-0,345	-0,536
9									1	0,341	-0,039
10										1	-0,098
11											1

Table 4: Quantitative dependence of mass of gonads from minor the exterior of signs at one-year-olds of an rainbow trout

Coefficient / Index	«α»	«b»
Forehead width	$3,34\times10^{-9}$	5,89
Length of a chest fin (P)	$1,05\times10^{-4}$	2,33
Length of a belly fin (V)	$7,7\times10^{-6}$	3,21



Pic 2: Quantitative dependence of mass of gonads from minor the eksteryernykh of signs at coevals of an rainbow trout

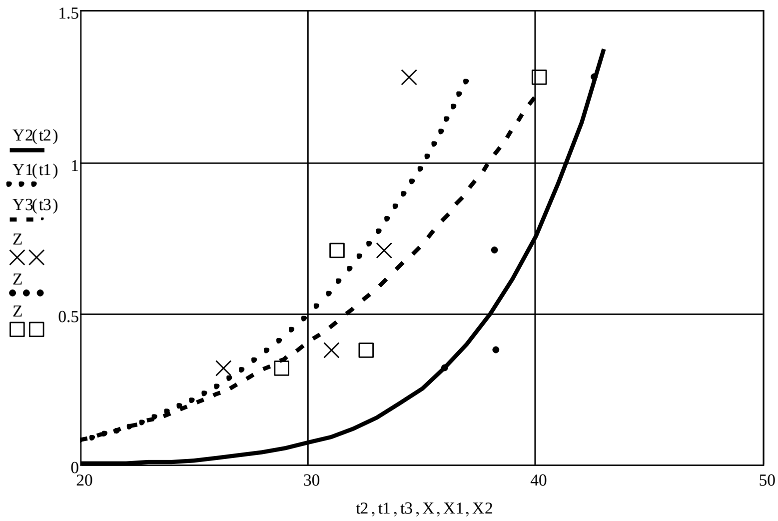
where X-average index of length of a chest fin; X1-average width of a forehead; X2-average length of a belly fin, Y1-relation of mass of gonads to width of a forehead, Y2-relation of mass of gonads to length of a chest fin, Y3-relation of mass of gonads to length of a belly fin.

Table 5: Correlation dependence of indirect signs with a mass of gonads at two-year-old females of an rainbow trout

Index	Gonads	Длина рыла	Postorbital part	Forehead	Lower jaw	Basis the D	Height the D	Length P	Length V	Length of fish	Weight
1	1	0,305	0,700	0,646	0,934	0,227	-0,724	**0,940**	**0,952**	0,805	0,881
2		1	-0,436	-0,510	0,033	-0794	-0,844	0,049	0,168	-,0306	-0,165
3			1	0,925	0,884	0,706	-0,104	0,782	0,699	0,936	0,906
4				1	0,758	0,882	0,055	0,832	0,758	0,972	0,929
5					1	0,366	-0,555	0,889	0,858	0,877	0,916
6						1	0,504	0,521	0,431	0,751	0,656
7							1	-0,469	-0,547	-0,178	-0,315
8								**1**	0,991	0,930	**0,970**
9									1	0,875	0,930
10										1	0,989
11											1

Table 6: Quantitative dependence of mass of gonads from minor the exterior of signs at two-year-olds of an rainbow trout

Coefficient / Index	«α»	«b»
Forehead width	$1,06\times10^{-7}$	4,51
Length of a chest fin (P)	$5,32\times10^{-14}$	8,21
Length of a belly fin (V)	$8,25\times10^{-7}$	3,85



Pic 3: Quantitative dependence of mass of gonads from minor the exterior of signs at two-year-olds of an rainbow trout

where X-average index of length of a chest fin; X1-average width of a forehead; X2-average length of a belly fin, Y1-relation of mass of gonads to width of a forehead, Y2-relation of mass of gonads to length of a chest fin, Y3-relation of mass of gonads to length of a belly fin.

For mathematical calculations indicators with a high correlation of interdependence were selected; allometric coefficients were calculated and graphics were made. According to the allometry data it can be argued that early mature females with the increased mass of gonads can be selected by the secondary characteristics of their external conformation and be placed in the self-maintained flock (table 4) [8].

Morphometric data obtained shows that as far as two-year-old rainbow trout females are concerned there is a high positive correlation between the increased mass of gonads and some of the earlier mentioned indicators. There is also a correlation between some other indicators: the length of pectoral fins (r = 0.940), the average length of those is 38.77±1.38 mm and the length of abdominal fins (r = 0.952), the average length of those is 33.18±2.43 mm. Besides, there is a correlation between the length of a lower jaw (r = 0.934) and the average length 45.07±2.40 (table 5).

There is a direct correlation between the length of a pectoral fin and the weight of a fish (0.970), which makes it possible to select fish not only according to their reproductive abilities but their meat qualities too.

During the research similar secondary external characteristics were selected in order to show the differences in ontogeny and stability of the development of two-year-old rainbow trout females in ontogeny (table 6).

While studying morphometry of a group of the two-year-old Kamloops rainbow trout females, changes of the correlation interdependence according to these indicators were noted. Thus, a respiratory system of one-year-old trout females plays the main role in the development of the reproductive products, but as far as two-year-old females are concerned, the allometric dependence is brightly shown by pectoral fins. It may therefore be said, that while selecting females according to this external conformation it might be possible to define a new type of trout based on the Kamloops breed; high fertility and early maturity will be its characteristics.

However, it's necessary to refer to the theory of the stability of the asymmetry development and take into consideration the bilateral parameters factor. That's why it's necessary to maintain a new gene pool of the Kamloops rainbow trout females in the self-maintained flock on a regular basis in order to avoid the excessive increase of homozygous individuals in the population. This method makes the selection in fish farming much easier because molecular-genetic investigations of the mitochondrial DNA and microsatellites are not necessary for it [12, 13, 14, 15].

CONCLUSION

Studies of the secondary morphometric indexes of the Kamloops rainbow trout give an opportunity of creating new early mature types of female studs desirable for reproduction. Indirect selection is a vital part of the modern evaluation of one-year-old and two-year-old studs. Using allometry data one can state that it's possible to select early mature females with the increased mass of gonads by the secondary characteristics of their external conformation and place them in the self-maintained flock.

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