Bulgarian Journal of Agricultural Science, 14 (No 2) 2008, 145-149
National Centre for Agrarian Sciences

AN APPROACH FOR GENETIC FISH GROUPS IDENTIFICATION USING ADAPTABILITY AND CHARACTERISTICS OF MORPHOTYPE

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Abstract

SIMONOV, V. M., 2008. An approach for genetic fish groups identification using adaptability and characteristics of morphotype. *Bulg. J. Agric. Sci.,* 14: 145-149

Taking into account adaptation abilities of fish at the age till one year and deleting individuals of low survivability from analysis, it is possible to distinguish more correctly groups (strains) by the analysis of complex of morphological characteristics. In that case, the distance between groups at morphological attribute multi-dimensional space increases, the values of canonical correlation increase, discrimination accuracy rises when using classification equations. The discriminant analysis revealed that identification of common carp and rainbow trout strains with the use of stress-resistant criterion, allowed the accuracy of distinguishing to multiple by 1.5, and the distance between groups to multiple more than by 3.

Key words: identification, discriminant analysis, survival, morphometrical characteristics, stress-resistance.

Introduction

The important task of aquaculture at conducting selection works, breeding and preservation of natural fish populations in collection industry is carrying out of reliable identification of their group belonging. The multidimensional statistical data analysis considering correlation structure of surveys connection in fish shapes gives a possibility to distinguish valuable breeds and species of fish by a complex of informative characteristics of morphotype (Andreyev and Reshetnikov, 1977; Kravtsov and Milyutin, 1985; Volchkov, 1995; Simonov and Kalmykov, 2005).

Nevertheless, this method is characterized by the following: an error of correct classification increases at comparison of closely-related cross-bred combinations and fish breeds, especially during the first year of life. (Cadrin Steven, 2000). This is determined by large variability of measuring values, by their high dependence on environmental factors of fish development, by feeding and keeping conditions, etc. All these causes decrease the accuracy of estimation of identification and distinguishing of breeds and breed fish groups.

There is a way of fish species and breeds identification which is based on genetic methods with the help of protein markers analysis of genes and segments in mitochondrial DNA (mDNA) and definition of genetic variance and divergence degree (Ludanny et al., 2006). However, despite high resolution, application of methods of molecular-genetic analysis requires eminently qualified maintenance staff. The pro-

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cess is getting complicated by a great amount of reagents and expensive equipment used, what results in its price and prime cost increase of distinguishing process because all these demand extensive financial expenses.

One of the reasons that causes increase of an error of fish breeds classification by morphotype characteristics is carrying out of the whole sample analysis without taking into account characteristics of fish heterogeneity regarding their vitality. Low vitality is determined by a row of gene mutations. As forming of fish morphotype has a polygenic base, in other words, is determined by influence of many genes, phenotypic deviations in fish with lower vitality (and which are eliminated by selection) cause increase of incorrectly classified fish percent as a result of morphotype discriminant analysis on the whole sample. The effect of stabilizing selection by polygenic system, which includes heterozygosis and co-adaptation of genes, appears in the following: more proof species against extreme influence of environment are those, which are close to a population average one on the basis of quantitative indications. One ought to think that formed by stabilizing selection adaptive gene complexes prove to be connected with "optimal" average phenotype, specimens, which deviate from "optimal" average phenotype, are characterized by lower adaptation (Shmalgausen, 1946).

Foregoing and our results received determined necessity to carry out a stress-resistant selection of young fish before the ranging analysis with the use of morphometrical characteristics under conditions of hard impact which allows to reject 20-25% of specimens with a lower vitality within 3-4 hours of testing. For a correct determination of survival it is necessary to use sharp and strong environmental changes, under which damage and death of sensitive specimens comes in a life resistance short time. A longer influence of harmful factors causes a change of fish selective rank. Though, there is no guarantee of the whole absence of adaptive reactions, but they are not able to develop to influence significantly on the level of genetic individuals distinctions by stability. (Ushakov, 1984).

Material and Methods

The work was conducted on a central experimental base of All-Russian Research Institute of Freshwater Fisheries (VNIIPRKh). The research objects were common carp fingerlings (0+) *Cyprinus carpio* (L.) of breed group "Moscow scattered carp" (MS) and strains of Germ/UNK – cross-breeds: German x Ukrainian-Niva-Kursk, (Germ) and reciprocal hybrids between them: MS x Germ and Germ x MS. The mass of being analyzed carp fingerlings was 18.7±3.3, 21.4±6.4, 19.9±3.8 and 19.7±3.7 g, respectively. There were used fingerlings (0+) of rainbow trout *Oncorhynchus mikiss*, got from breeders of collection stock of VNIIPRKh, and ones of gold trout *Oncorhynchus mykiss aguabonita* produced at a trout complex of VNIIPRKh. The last one was grown of eggs, brought from Adler Trout pedigree factory. The mass of trout fingerlings was 21.3±5.2 and 25.7±5.4 g, respectively.

A representative sample (a common sample – further in the text) and a representative sample of acute hypoxia-resistant fish (stress-resistant sample) were used for analysis of every investigated group. The methods which were developed by us earlier (Simonov and Ilyasov, 2001) were used for stress-resistance estimation for fish fingerlings.

Fish from every comparable were put together into tanks of water up to the density of 5 fish.l^{-1} at the water temperature of 16-18°C. Fish were isolated with a lattice from the contact with the surface and upper layers of water (3-5 cm from the surface), which imbued by air oxygen adsorbed from atmosphere. The death of 20-25% fish of the whole number of experimental fish was observed in 3–4 hours of testing. Survived fish (30-50 ones for every comparable breed strain) were picked out of tanks for conducting of full morphometrical description according to a traditional layout (Pravdin, 1966). The measurements of plastic characteristics were carried out on virgin material by a caliper with the accuracy of 1 mm.

The following characteristics were taken into account: AD – fish length without a caudal fin; AN- snout length; NP- eye diameter (horizontal); PO - postor-

bital head part; AO- head length; LM - head height at occiput; SHIR – forehead width; GH - maximum body height; IK - minimum body height; AQ - predorsal space; RD - postdorsal space; AV – anteventral space; AA – anteanal space; FD - caudal peduncle length; QS- dorsal fin's base length; TU - maximum dorsal fin height; YY_1 - pelvic fin base length; EJ - pelvic fin maximum height; VX - pectoral fin length; ZZ_1 - abdominal fin length; VZ- space between pectoral and abdominal fins; ZY- space between abdominal and anal fins, TOL – maximum body width.

Absolute values of morphometrical characteristics were converted into indices. The following thing was done so – head measurements were divided by head length, and body measurements were divided by body length (by Smith). One ought to notice, that when carrying out series of sequential computations accumulation of errors can occur, that is why in such cases it is recommended to take 2-3 digits more than necessary (Snedekor, 1961) in final form (in our case – estimations of discriminant function characteristics). Therefore indices were calculated with the accuracy of the ninth digit.

Incremental discriminant analysis was applied at creation of forecast equation. As a result of data processing performance criterions of comparable strains discrimination by morphotype were got: values ljambda λ, canonical correlation - r, maximizing distance by Mahalanobis – $\triangle^2$ (in this case its selective distance - D^2) between comparable groups in multidimensional space (distance by Mahalanobis).

Interbreed distances by complex of morphometrical characteristics were determined as distances by Mahalanobis between breeds' centroids in space of discriminant functions (Klecca, 1987). A set of informative characteristics of morphotype, playing a significant role for identification, and classification equations were determined. The quality of classification was determined by a magnitude of mistaken fish attribution to comparable groups (strains). Software package "StatSoft Statistica 6.0 was used for above mentioned operations.

Results and Discussion

The discriminant analysis revealed (Tables 1 and 2) that identification conducted on carp groups with the use of stress-resistant criterion, increased by 1.5 the accuracy of distinguishing strains investigated, and more than by 3 the distance between comparable groups (distance by Mahalanobis).

Table 1

Classification table of discriminant analysis conducted on morphotype characteristics for carp fingerlings of four breed groups

Breed groups of carp	Classification accuracy, %	
	A complete sample	A sample out of stress-resistant fish
MS	63.16	87.50
Germ	66.67	100.00
GermxMS	52.63	88.89
MSxGerm	78.95	85.71
Average	65.52	91.18

The validity of comparison increased too. The coefficient of canonical correlation for the whole sample had a significant value only for the first out of three functions (r_1=0.65, $p<0.05$), whereas correlation was highly reliable for all discriminant functions for a fish sample, chosen by survivability (r_1=0.80; r_2=0.74; r_3=0.70; $p<0.05$).

Carrying out of discriminant analysis on the whole sample has shown that gold trout differed well from rainbow trout by a complex of correlative characteristics (Tables 3 and 4). There was a distinctive significant magnitude of canonical correlation (r= 0.7) and high validity of classification (82.8%). Conducting of discrimination of trout's groups by morphotype for a sample of stress-resistant fish gave a possibility to improve the quality of identification: canonical correlation r = 0.93-0.96, group distinguishing is 100% faultless. The distance by Mahalanobis for stress-resistant trout samples proved to be more than in common samples (24.4 and 3.89, respectively).

Table 2

Results of linear discriminant analysis conducted on morphotype characteristics of carp fingerlings of four breed groups

Indices		Breed groups of carp: MS, Germ, GermxMS and MSxGerm	
		A complete sample	A sample out of stress-resistant fish
Informative signs		ZZ_1,LM,YY_1,VX,AD,AQ, TU,AO, ZY,VZ, TOL	ZZ_1,QS,AQ,EJ,YY_1,NP, TU,AO, VZ, SHIR, TOL
Discrimination characteristics	Discrimination functions		
% of dispersion accounting	1	61.86	46.24
	2	24.32	29.90
	3	13.5	23.87
Canonical correlation r	1	0.65*	0.80*
	2	0.48	0.74*
	3	0.38	0.70*
Distance by Mahalanobis:			
Max between: MS and MS x Germ		5.25*	16.65*
Min between: Germ and Germ x MS		1.81*	8.30*

* - significance at the level of $p<0.05$.

Table 3

Classification table of discriminant analysis conducted fingerlings on morphotype characteristics of trout

Breed groups of trout	Classification accuracy, %	
	A complete sample	A sample out of stress-resistant fish
Rainbow	75.86	100.0
Gold	89.66	100.0
Average	82.76	100.0

Use of oxygen deficit at work as a stress factor partly models natural selection of fish in closed basins, where rather considerable differences of hydrochemical characteristics can be observed quite often. Natural selection works not on separate characteristics, but on ontogenies in whole, what appears in reconstruction of correlation systems of characteristics. At the same time it is known that relative growth of parts in every organism is an important adaptive characteristic and is under tight control of stabilizing selection. Hereditarily determined correlations between characteristics are an important part of general correlation system, conditioning functional integrity of an organism (Shmalgausen, 1945, 1968).

It is possible to increase identification accuracy of selective valuable breeds and collection fish species in aquaculture by using multydimensional statistical technology of ranging analysis of morphometrical characteristics variability and by taking into account adaptive characteristics of investigated groups.

Conclusion

The research shows, that the use of adaptive characteristics at identification by morphotype allows to get a more correct result of distinguishing of strains compared to increase the distance between comparable groups in multidimensional space of morphometric indices significantly, to decrease prime cost of derivable final product (a breed group) due to rational conduction of selection during the first year of fish life. Identification by suggested method has better characteristics as it takes into account morpho-functional condition of compared fish populations. The use of identification methods by a complex of morphotype characteristics, taking into account the estimation of

Table 4

Results of linear discriminant analysis conducted on morphotype characteristics of fingerlings of different trout breed groups

Indices	Breed groups of trout: rainbow, gold	
	A complete sample	A sample out of stress-resistant fish
Informative signs	NP, IK, EJ, VX, TOL, AO, AA	IK, VX, ZY, RD, AO,VZ, FD, AV
Discrimination function characteristics:		
% of dispersion accounting	100	100
Canonical correlation r	0.70*	0.93*
Distance by Mahalanobis	3.89*	24.4*

* - significance at the level of $p<0.05$.

stress-resistance, will give a possibility to increase efficiency of selection genetic investigations, directed to creation and preservation of new selection achievements and collection fund of extra-valuable fish species, as well as ichthyologic research of natural ichthyofauna populations.

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Received February, 20, 2008; accepted for printing March, 15, 2008.