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

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Abstract


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-
cess is getting complicated by a great amount of re-
agents and expensive equipment used, what results in
its price and prime cost increase of distinguishing pro-
cess because all these demand extensive financial ex-

One of the reasons that causes increase of an er-
ror of fish breeds classification by morphotype char-
acteristics is carrying out of the whole sample analysis
without taking into account characteristics of fish het-
erogeneity regarding their vitality. Low vitality is de-
termined 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 dis-

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 quan-
titative 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).

A representative sample (a common sample – fur-
ther 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 experi-
mental fish was observed in 3–4 hours of testing. Sur-
vived 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 ac-
count: AD – fish length without a caudal fin; AN-

Material and Methods

The work was conducted on a central experimen-
tal base of All-Russian Research Institute of Fresh-
water 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 miki, got from breeders of collec-
tion 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.

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characteristics were carried out on virgin material by
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The following characteristics were taken into ac-
count: AD – fish length without a caudal fin; AN-

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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; YY1 - pelvic fin base length; EJ - pelvic fin maximum height; VX - pectoral fin length; ZZ1 - 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 $\lambda$ (canonical correlation), $r$ (maximum distance by Mahalanobis – $\Delta^2$) 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

<table>
<thead>
<tr>
<th>Breed groups of carp</th>
<th>Classification accuracy, %</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A complete sample</td>
</tr>
<tr>
<td>MS</td>
<td>63.16</td>
</tr>
<tr>
<td>Germ</td>
<td>66.67</td>
</tr>
<tr>
<td>GermxMS</td>
<td>52.63</td>
</tr>
<tr>
<td>MSxGerm</td>
<td>78.95</td>
</tr>
<tr>
<td>Average</td>
<td>65.52</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Indices</th>
<th>Breast groups of carp: MS, Germ, GermxMS and MSxGerm</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A complete sample</td>
</tr>
<tr>
<td></td>
<td>A sample out of stress-resistant fish</td>
</tr>
<tr>
<td>Informative signs</td>
<td>ZZ₀,LM,YY₁,VX,AD,AQ,</td>
</tr>
<tr>
<td>Discrimination characteristics</td>
<td>TU, AO, ZY, VZ, TOL</td>
</tr>
<tr>
<td>% of dispersion accounting</td>
<td>61.86</td>
</tr>
<tr>
<td></td>
<td>46.24</td>
</tr>
<tr>
<td>% of dispersion accounting</td>
<td>24.32</td>
</tr>
<tr>
<td></td>
<td>29.90</td>
</tr>
<tr>
<td>% of dispersion accounting</td>
<td>13.5</td>
</tr>
<tr>
<td></td>
<td>23.87</td>
</tr>
<tr>
<td>Canonical correlation r</td>
<td>0.65*</td>
</tr>
<tr>
<td></td>
<td>0.80*</td>
</tr>
<tr>
<td>Canonical correlation r</td>
<td>0.48</td>
</tr>
<tr>
<td></td>
<td>0.74*</td>
</tr>
<tr>
<td>Canonical correlation r</td>
<td>0.38</td>
</tr>
<tr>
<td></td>
<td>0.70*</td>
</tr>
<tr>
<td>Distance by Mahalanobis:</td>
<td>Max between: MS and MS x Germ</td>
</tr>
<tr>
<td></td>
<td>5.25*</td>
</tr>
<tr>
<td></td>
<td>16.65*</td>
</tr>
<tr>
<td>Min between: Germ and Germ x MS</td>
<td>1.81*</td>
</tr>
<tr>
<td></td>
<td>8.30*</td>
</tr>
</tbody>
</table>

* - significance at the level of p<0.05.

Table 3
Classification table of discriminant analysis conducted fingerlings on morphotype characteristics of trout

<table>
<thead>
<tr>
<th>Breed groups of trout</th>
<th>Classification accuracy, %</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A complete sample</td>
</tr>
<tr>
<td></td>
<td>A sample out of stress-resistant fish</td>
</tr>
<tr>
<td>Rainbow</td>
<td>75.86</td>
</tr>
<tr>
<td>Gold</td>
<td>89.66</td>
</tr>
<tr>
<td>Average</td>
<td>82.76</td>
</tr>
<tr>
<td>Average</td>
<td>100.0</td>
</tr>
</tbody>
</table>

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 multidimensional 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
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.

References

Table 4
Results of linear discriminant analysis conducted on morphotype characteristics of fingerlings of different trout breed groups

<table>
<thead>
<tr>
<th>Indices</th>
<th>Breed groups of trout: rainbow, gold</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A complete sample</td>
</tr>
<tr>
<td>Informative signs</td>
<td>NP, IK, EJ, VX, TOL, AO, AA</td>
</tr>
</tbody>
</table>

* - significance at the level of p<0.05.

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The other morphotypes producing one dominant RFLP pattern were designated as Cenococcum, E-strain and Mycelium radicis atrovirens (MRA) based on their morphology. Morphotyping did not distinguish amongst major RFLP types for mycorrhizas classified as Amphineja-like, Piloderma-like and Rhizopogon-like A. We conclude that detailed morphological classification can be very useful as the primary method of ectomycorrhizal classification, when used in conjunction with molecular techniques. This approach will allow for an efficient use of research funds. Export citation. Copyright. Identification and characterization of the genetic changes responsible for the characteristic smooth-to-rough morphotype alterations of clinically persistent Mycobacterium abscessus. Mol Microbiol. 2013 Nov;90(3):612-29. doi: 10.1111/mmi.12387. To better understand the molecular mechanisms behind the S/R alterations, we analysed S and R variants of three isogenic M. abscessus S/R pairs using an unbiased approach involving genome and transcriptome analyses, transcriptional fusions and integrating constructs. PLANT GENETICS. RAPD and Allozyme Analysis of Genetic Diversity in Panax ginseng C.A. Meyer and P. quinquefolius L. E. V. Artyukova, M. M. Kozyrenko, O. G. Koren, T. I. Muzarok, G. D. Reunova, and Yu. N. Zhuravlev. We have previously studied genetic variation of wild and cultivated P. ginseng using RAPD and allozyme analyses [12, 16, 17]. In this study, genetic diversity of populations P. ginseng and P. quinquefolius was esit-mated by these two methods. Materials and methods. All cultivated plants were subdivided into two morphotypes, MI (14 plants) and MII (9 plants), which differed in their habitus and leaf plate form and color. Panax quinquefolius: 22 plants grown from seeds of American cultivated ginseng. An approach for genetic fish groups identification using adaptability and character-istics 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 survivabil-ity from analysis, it is possible to distinguish more correctly groups (strains) by the analysis of complex of morpho-logical characteristics. Table 1 Classification table of discriminant analysis conducted on morphotype characteristics for carp fingerlings of four breed groups. Breed groups of carp. MS Germ GermõMS ãMSµGerm Average. Discrimination of troutâ€™s groups by morphotype for a. sample of stress-resistant fish gave a possibility to improve the quality of identification: canonical corre A distinctly quantitative approach to hazard identification by Kolar and Lodge (2002) involves decision-tree analysis of ecological and biological characteristics of existing non-native species in a specific region to predict future invasive species from the same donor region. The aim of the present discussion paper is to propose a conceptual risk assessment approach for freshwater fish species that addresses the first two elements (hazard). Others were modified to reflect trends or characteristics of importance to freshwater fishes and their potential invasiveness (see Bruton, 1986; Baltz and Moyle, 1993; Moyle and Light, 1996; Jackson et al., 2001; Kolar and Lodge, 2002). Feeding guild (Section B5, Table 1): This group of questions replaces the WRA â€˜Plant typeâ€™ section.