CODEN [USA]: IAJPBB ISSN: 2349-7750

INDO AMERICAN JOURNAL OF
PHARMACEUTICAL SCIENCES

http://doi.org/10.5281/zenodo.1019465

Available online at: http://www.iajps.com Research Article

ASSESSMENT OF THE ENVIRONMENTAL QUALITY AND ITS CHANGES USING INDICATORS OF ASYMMETRY IN VERTEBRATES

Guzel R. Valeeva[1*] and Mikhail V. Karpov[2]

[1]Chair of Applied Ecology, Institute of Ecology and Environmental Management, Kazan (Volga Region) Federal University, Kremlevskayastr. 18, Kazan, Russia

[2]Institute of Ecology and Environmental Management, Kazan (Volga Region) Federal University, Kazan, Russia

Abstract:

Aim: *Environment quality estimation and its probable changes in the presence of anthropogenous influence on the Tatarstan republic natural reserved fond objects with fluctuating asymmetry method on different species of organisms was carried out.*

Methods*: Gathering of scientific material was carried out at the 2012-2013 years period at the natural reserved fond objects territory – Tatarstan republic state natural complex wildlife areas. For ecosystems estimation the morphometric parameters of most ordinary species of fish (roach, golden crucian, bream) and amphibians (pool and marsh frog) was used. Morphometric measurements results of indicator organisms was statistically processed, fluctuating asymmetry parameter was calculated, according received results the state of ecosystems was estimated.*

Results: *The state of some especially protected natural areas at the Tatarstan republic was estimated. Applicability of fluctuating asymmetry parameter for complex ecosystem estimation was proved. Received results can be used as a matter for ecological risk estimation methodic developing for Tatarstan republic territory.*

Conclusions*: The investigated areas ecological status was estimated as "relatively normal". Results analysis was shown the need of using different indicators for complex characteristic of environmental quality.*

Keywords: *fluctuating asymmetry, ontogenesis stability, bioindication, ecological monitoring, wildlife area, especially protected natural territory, background area, ecological estimation, ecological risk.*

Corresponding author:

Guzel R. Valeeva,

Chair of Applied Ecology,
Institute of Ecology and Environmental Management,
Kazan (Volga Region) Federal University,
Kremlevskayastr, 18, Kazan, Russia
guzelvaleeva@yandex.ru

QR code

Please cite this article in press as Guzel R. Valeeva and Mikhail V. Karpov., *Assessment of the Environmental Quality and Its Changes Using Indicators of Asymmetry in Vertebrates****, Indo Am. J. P. Sci, 2017; 4(10).***

INTRODUCTION:

A task of current importance for the development of an environmental monitoring system is the creation of approaches for obtaining an accurate quantitative characterization of the condition of natural ecosystems. The most interesting approaches are those intended to detect even insignificant deviations of the environmental parameters from the benchmark conditions, i.e. deviations that cannot possibly exert any effect on the viability of organisms [1, 2]. The most promising approach would be to find such characteristics whose changesarenon-specific responses to various alterations of the environmental conditions. One of these characteristics could be the stability of the development (ontogeny and morphology), which is the ability to produce a similar phenotypic effect under a specific range of environmental conditions.

Bilateral symmetry is inherent to some extent to most of the actively moving animals. Asymmetry, as a deviation from bilateral symmetry, is an indication of the suitability of a certain habitat for living organisms [3].

INITIAL DATA AND METHODS:

The material necessary for our study was collected in the period from May 20th, 2012 to September 25th, 2013, in the territory of several natural reserves of regional significance in the Republic of Tatarstan, namely in the following state complex natural reserves (SCNR): Kichke-Tan (Agryzsky District), Sviyazhsk (Verkhneuslonsky and Zelenodolsky Districts), Spassky (Spassky District), Chistye Luga (Chistopolsky District) and Kulyagash (Aktanyshsky District; the last one is in proposal stage) (Fig.1) [4].

The following species were used to assess the conditions of terrestrial and aquatic ecosystems:

- the most common and numerous species of fish— roach, crucian carp, bream;
- amphibians— pool frog or marsh frog.

The minimal number of specimens necessary and sufficient to assess the quality of the environment was determined to be one species from each studied group of terrestrial and aquatic organisms.
Also, regarding these specimens, we defined various score scales to assess the conditions of each organism according to the level of developmental stability [5].

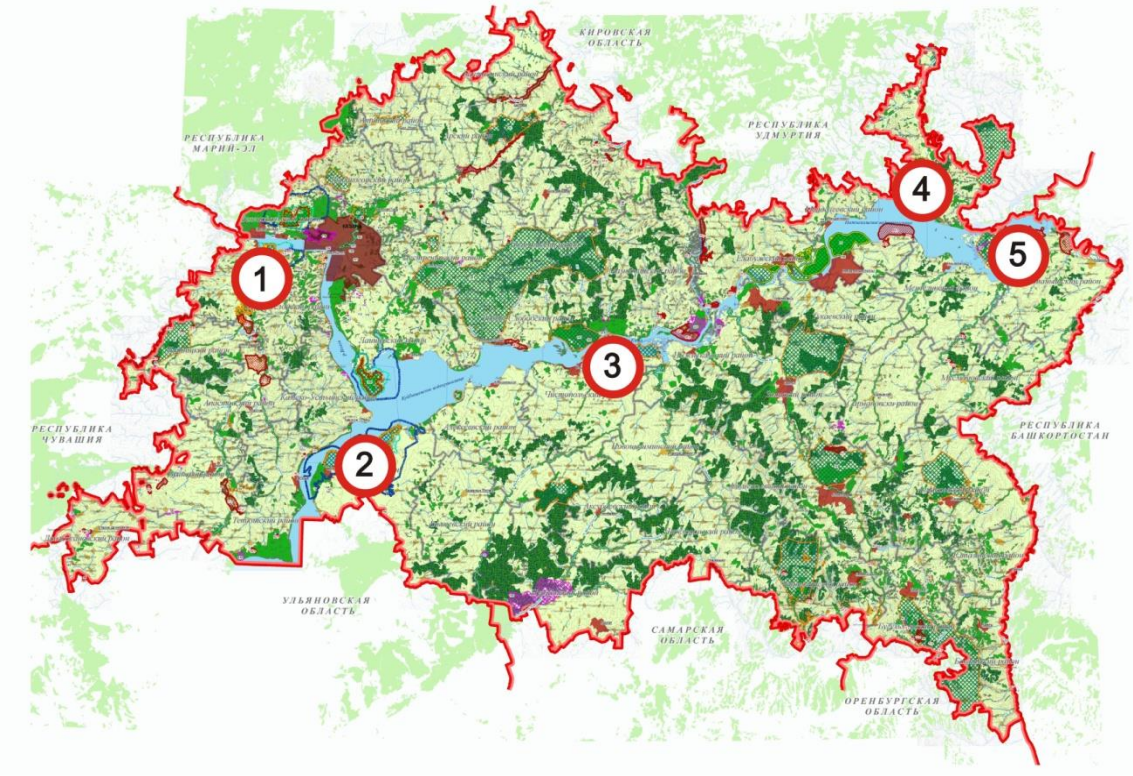

Fig.1.Map of the Republic of Tatarstan showing the position of the investigated especially protected natural territories (EPNT)

To assess the level of developmental stability in the ichthyological studies, we considered six to eight morphological traits that can be readily evaluated (Fig. 2). 1–7 meristictraits: 1 - number of rays in the pectoral fins; 2 - number of rays in the pelvic fins; 3 - number of rays in the inter branchial septum; 4 - number of gill rakers on the first gill arch; 5 - number of pharyngeal teeth; 6 - number of scales in the lateral line; 7 - number of lateral line scales with sensory canals.

To assess the developmental stability of the golden carp (*Carassius carassius*), we considered the following meristic traits (1–5): 1 - number of rays in the pectoral fins; 2 - number of rays in the pelvic fins; 3 - number of gill rakers; 4 - number of pharyngeal teeth; 5 - number of scales in the lateral line.

While working with the group of European green frogs (*Rana esculenta complex*) - marsh frog (*Rana ridibunda*), pool frog (*Rana lessonae*), we analyzed two groups of criteria: meristic traits regarding color and osteology (Fig. 3). We carried out an assessmentin living specimens using the suggested method. At this time, we excluded the osteological traits (12, 13) and the trait number 11 (Fig. 3). To obtain reliable results using this system of traits, we considered an extended minimum sample consisting of 30 specimens.

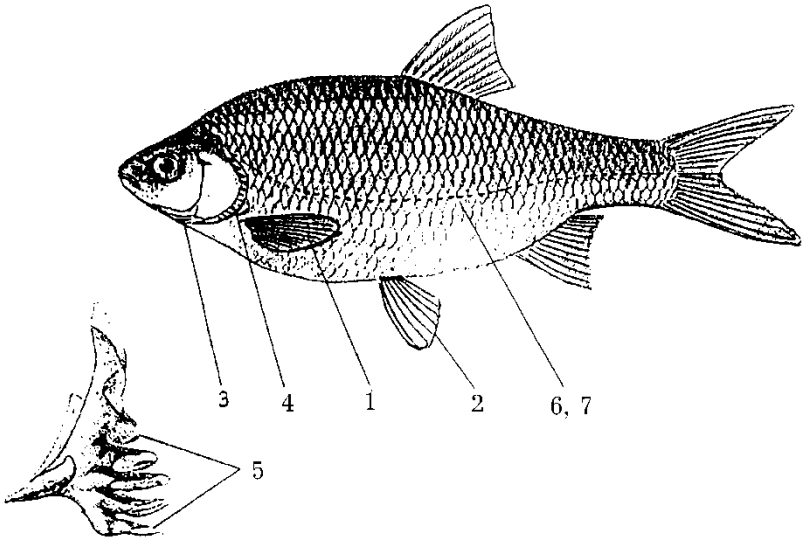

Fig. 2. **Morphological traits considered for the assessment of developmental stability of the bream (*Abramis brama*), golden crucian (*Carassius carassius*) and roach (*Rutilus rutilus*).**

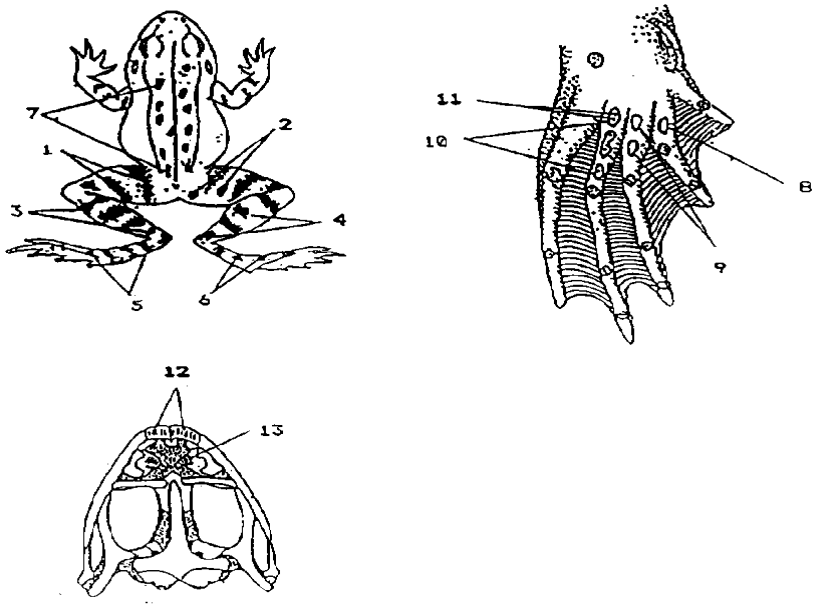

Fig. 3. **Morphological traits considered for the assessment of developmental stability of European green frogs (*Rana esculenta complex*): marsh frog (*R. ridibunda*Pallas); pool frog (*R. Lessonae* Camerano).**

1-13 - meristic traits: 1 - number of bands on the dorsal side of the thigh; 2 - number of spots on the dorsal side of the thigh; 3 - number of bands on the dorsal side of the shank; 4 - number of spots on the dorsal side of the shank; 5 - number of bands on the foot; 6 - number of spots on the foot; 7 - number of spots on the back; 8 - number of white spots on the plantar side of the second digit of hind limb; 9 - number of white spots on the plantar side of the third digit of hind limb; 10 - number of white spots on the plantar side of the fourth digit of hind limb; 11 - number of pores on the plantar side of the fourth digit of hind limb; 12 - number of teeth in the intermaxillary bone; 13 - number of vomerine teeth.

For the countable traits, the asymmetry value (*A*) for each specimen is defined as the difference between the left side structures (*L*) and the right side ones (*R*), i.e. $A = |L - R|/$. The integral indicator of developmental stability for the whole complex of countable traits is taken as the average frequency of manifestations of asymmetryper trait. This is calculated as the arithmetic mean of asymmetric traits perspecimen divided by the total number of traits considered. Consequently, the difference between right and left sides is not taken into account, only the presence of asymmetry is considered. This way, we exclude the possible influence of some highly deviated options [5].

A five-point scale for assessing an organism condition deviations from a conventional standard according to the value of the integral indicator of developmental stability for fish and amphibians is presented in Table1.[6].

Table 1: Organism condition deviations from a conventional standard according to the value of the integral indicator of developmental stability.

Grade	Ontogenesis stability parameter value for fish	Ontogenesis stability parameter value for amphibia	Organism status
I	<0,30	<0,50	Conditionally normal
II	0,30 - 0,34	0,50 - 0,54	Insignificant deviation from norm
III	0,35 - 0,39	0,55 - 0,59	Average level of deviations
IV	0,40 - 0,44	0,60 - 0,64	Essential deviation from norm
V	>0,44	>0,64	Critical state

DISCUSSION:

Assessment of the ecological condition of protected territories according to the indicator of fluctuating asymmetry (FA):

Specimens considered in the course of the assessment of the environmental quality at each location:

- EPNT «Kichke-Tan» (Agryzsky District): 43 breams, 20 marsh frogs.
- EPNT «Kulyagash» (Aktanyshsky District): 20 crucian carps, 30 pool frogs.
- EPNT «Sviyazhsk» (Verkhneuslonsky District): 20 breams, 20 pool frogs.
- EPNT «Спасский» (Spassky District): 20 breams, 20 pool frogs.
- EPNT «Chistye Luga» (Chistopolsky District): 20 roaches, 25 crucian carps.

The results of the statistical analysis of the collected data are presented in Table 2.

Table 2: Organisms ontogenesis stability parameter values for investigated especially protected natural territories (EPNT).

Investigated district	Ontogenesis stability parameter value	
	Fish	**Amphibia**
EPNT “Kichke-Tang” (Agryz district)	0,46 Critical state	0,66 Critical state
EPNT “Kulyagash” (Aktanysh district)	0,21 Conditionally normal	0,41 Conditionally normal
EPNT “Sviyazhsky” (Top Uslon district)	0,26 Conditionally normal	0,19 Conditionally normal
EPNT “Spasskiy” (Spassk district)	0,30 Conditionally normal	0,17 Conditionally normal
EPNT “Chistyeluga” (Chistopol district)	0,25 Conditionally normal	The assessment wasn't made

Table 3: Assessment of the environmental quality of state complex natural reserve in the period 2012–2013.

Especially protected natural territory	Amphibia (grade)	Fish (grade)	Environmental quality (average grade)
Kichke-Tang	5	5	5 Critical state
Chistyeluga	The assessment wasn't made	1	1 Conditionally normal
Spasskiy	1	2	1,5 Conditionally normal, similar to initial deviation from norm
Sviyazhsky	1	1	1 Conditionally normal
Kulyagash	1	1	1 Conditionally normal

The minimum value of the asymmetry indicator for fish morphological structures was detected in the Aktanyshsky District, while its maximum value was registered in the Agryzsky District.

Regarding the amphibians, the minimum was registered in the Spassky District.

With a view to planning for further practical environmental actions, we used a five-point scale to assess the environmental quality according to the degree of deviation of its actual condition from the ecological optimum. The ecosystem condition was determined by contrasting deviations of morphological traits in the most common bench mark species (model objects) from the benchmark(optimal) condition. The results of this assessment are shown in Table 3.
Environmental quality (in points): 1 - conditionally normal; 2 - incipient (insignificant) deviation from the standard; 3 - average deviation from the standard; 4 - considerable (significant) deviation from the standard; 5 - critical state.

Thus, the study of a species biomorphology and the internal processes associated with it makes it possible to disclose the mechanisms of its adaptation to current conditions of anthropogenic stress, thereby enabling to evaluate possible behavior under existing environmental regulations and also to change these regulations in the right direction.

These kinds of studies are particularly important due to the increasing anthropogenic influence on the environment. This influence determines the direction, the speed and the results of the selection of species, leading to the extinction of some species and the appearance of other ones. Protected wildlife reserves are good natural laboratories for investigations of this kind.

The results of our study show that Kulyagash reserve (Aktanyshsky District; currently in proposal stage) has an average score of environmental quality equal to 1, which corresponds to or is even lower than the quality indicators of other natural reserves existing and protected by the law in the Republic of Tatarstan. As a matter of fact, this may be accepted as a justification to designate this territory as a specially protected reserve.

Data variation indicators
The results obtained for the coefficient of variation (CV) calculated according to the indicator ofFAfor the considered data set are indicated in Table 4.

The CV is a measure of spread of a data set relative to its mean. The CV can be expressed as a percentage using the following formula:

$$V = \frac{\sigma}{\bar{x}} \times 100\%,$$

Where V is the required indicator, σis the standard deviation and $\bar{X}$is the mean of the data set.

It follows from the figures in Table 4 that the indicators of data variation for fish are quite different from those for amphibians. Perhaps this is due to the fact that amphibians are characterized by an indirect development following environmental changes during certain stages of their ontogeny and sequential adaptation.

This once again confirms the need for using various bio-indicators when one wants to obtain comprehensive evaluation of environment suitability. It should also be noted that the natural reserves considered in our study differ in their levels of data variation. This may be due to disparities in physical and geographical conditions.

Table 4: Fluctuating asymmetry parameter variation.

Organism / Group	Parameter	District				
		Agryz district	Aktanyshdistrict	Top Uslon district	Spasskdistrict	Chistopol district
Pisces	A	0,46	0,21	0,26	0,30	0,25
	V(A), %	38,55	95,11	66,33	53,01	79,8
Amphibia	A	0,66	0,41	0,19	0,17	-
	V(A), %	21,31	41,94	64,39	61,25	-

Reference territories role in the environmental risk assessment

In recent years, the Republic of Tatarstan is experiencing a rapid economic growth associated with an increasing interest of Russian and foreign investors, the government's efforts to develop the regional infrastructure, its production gaining access to international markets, and other factors. All these elements, undoubtedly, generate an increase in the level of anthropogenic pressure on the territory. There is a demand for the construction of new industrial facilities, which in turn makes it necessary to timely assess the environmental risks in order to ensure the ecological safety.

Nowadays, the main issues concerning the assessments of environmental risks are:

1. designation of reference territories (reference standards) for the identification of negative effects as such;
2. creation of express procedures that are comprehensive enough to assess the ecological condition of a territory and the changes taking place in it [10].

In this paper, we have successfully solved both issues. Firstly, we indicated several reference territories among the nature reserves of the Republic of Tatarstan and assessed their ecological condition. Secondly, we showed that the determination of the fluctuating asymmetry for different groups of organisms is a comprehensive screening procedure allowing to assess in a short time the environmental condition of a territory and the rate of the changes occurring in it.

The data obtained by our team may be used as the basis for the development of a method for assessing environmental risks.

CONCLUSIONS:

1. The ecological condition of the protected territories considered in our study can be evaluated as conditionally normal, with the exception of the SCNR Kichke-Tan. We estimate the condition of this reserve as critical. A probable reason for such deviations may be the proximity of the Nizhnekamsk Reservoir, whose level gradually began to rise in recent years. This circumstance has exerted a negative impact on the biocenosis of this territory.
2. Theminimum dispersion of data regarding FA is characteristic to amphibians. This fact is quite likely associated with biological and ecological features of these organisms. This suggests the need for using various bio-indicators with the purpose of getting a comprehensive insight into the ecological condition of the environment.
3. A more accurate depiction of the environmental conditions requires the use of various bio-indicators experiencing the influence of distinct factors, since the level of suitability of different habitats in one and the same territory may be subject to variations.
4. The results of our assessment show that the territory of the envisaged Kulyagash Reserve (Aktanyshsky District) has an average score of environmental quality equal to 1, which corresponds to or is even lower than the quality indicators of other natural reserves existing and protected by the law in the Republic of Tatarstan. As a matter of fact, this

may be accepted as a justification to designate this territory as a specially protected reserve.

REFERENCES:

1. Sadykov O.F., Farafontov M.G. Znachenie sistemy rannego preduprezhdeniya v ehkologicheskom monitoringe [The system of early prevention meaning in ecological monitoring]. Problemy ehkologicheskogo monitoringa i modelirovaniya ehkosistem [Ecological monitoring and ecosystem modelling problems]. Leningrad, Gidrometeoizdat Publ., 1989;4:242. (In Russian)
2.Z aharov V.M., Zyuganov V.V. To bilateral sign asymmetry estimation as some population characteristics. Ekologiya [Ecology]. 1980;1:10-16. (In Russian)
3. Zaharov V.M., Zyuganov V.V. To bilateral sign asymmetry estimation as a population characteristics.Ekologiya [Ecology]. 1980;1:10-16. (in Russian)
4. Gosudarstvennyi reestr osobo okhranyaemykh pri-rodnykh territorii v Respublike Tatarstan. Izdanie vtoroe [Tatarstan republic especially protected natural territory state register. Second edition]. Kazan, Idel-Press Publ., 2007;408. p. (In Russian)
5. Metodicheskie rekomendatsii po vypolneniyu otsenki kachestva sredy po sostoyaniyu zhivykh sushchestv (otsenka stabi'nosti razvitiya zhivykh organizmov po urovnyu asimmetrii morfologicheskikh struktur) [Metodi-cal recommendations for environmental quality estimation by living organisms state (organisms ontogenesis stability estimation by morphological structures asymmetry level)]. Moscow, 2003;28 p. (In Russian)
6. Zaharov V.M., Baranov A.S., Borisov V.I., Valeckij A.V., Kryazheva N.G., Chistyakova E.K., Chubinishvili A.T. *Zdorov'esredy: metodikaocenki* [Environmental health: estimation methodic]. Moscow, 2000.68 p.
7. Bogolyubov A.S.
Ocenka ehkologicheskogo sostoyaniya lesa po asimmetrii list'ev. [Forest ecological state estimation by leafs asymmetry]. Moscow, 2002. 10 p. (in Russian)
8. Gurtyak A. A., Uglev V.V. Ocenka sostoyaniya sredy gorodskoj territorii s ispol'zovaniem breezy povisloj v kachestve bioindikatora [Urban environment estimation whith birch as bioindicator]. Izvestiya Tomskogo politekhnicheskogo universiteta [*Tomsk polytechnical university news*]. 2010. T. 37, N 1. p. 200-204. (in Russian)
9. Khoroshen'kov E.A. Silver crucian fluctuating asymmetry in some reservoir of North-West Ciscaucasia. Molodoi uchenyi [Young scientist]. 2012, no. 8. pp. 5457. (In Russian)
10. Shvyryaev A.A., Men'shikov V.V. Otsenka riska vozdeistviya zagryazneniya atmosfery v issleduemom regione: Uchebnoe posobie dlya vuzov [Atmosphere pollutants influence risk estimation in investigated region: Textbook for universities]. Moscow, Moscow State University Publ., 2004, 124 p. (In Russian)