HERPETOLOGIA PETROPOLITANA

Proceedings
of the
12th Ordinary General Meeting
of the
Societas Europaea Herpetologica

12 – 16 August 2003
Saint-Petersburg, Russia

Edited by
Natalia Ananjeva and Olga Tsinenko

Saint-Petersburg, 2005

MORPHOLOGICAL DEVIATIONS IN POPULATION *Rana arvalis* NILSS. ON URBANIZED TERRITORIES: SPECTRUM, TOPOGRAPHY, FREQUENCY

V. L. Vershinin[1]

Keywords: morphological deviations, moor frog, urban ecology, morphogenesis.

INTRODUCTION

Decline of amphibian population together with their high sensitivity to changes in water and terrestrial habitats can be a serious warning about the beginning of a global ecological catastrophe (Halliday, 1998). Individuals with various morphological deviations often occur in amphibian populations being a part of their natural variability (Kovalenko and Kovalenko, 1996). The reasons of that are different: mutation process, parasites, inbreeding depression, developmental stress, abnormal regeneration etc. (Dubois, 1979; Borkin and Pikulik, 1986; Hebard and Brunson, 1963; Talvi, 1994). Many facts confirm the influence of environmental conditions on increase of the frequency of morphological anomalies (Cooke, 1981). The anomalies, arising as a result of developmental deviations and atypical regeneration, often can be determined by inhibition or activation of the thyroid function by pollutants, these may lead to suppression of proliferation and morphogenetic processes (Syuzyumova, 1985) and influence the level of metabolic processes (Tokar' et al., 1991). That is the reason why morphological deviations as well as the process of morphogenesis in this group of vertebrates may be sensitive indicators of environmental changes.

MATERIAL AND METHODS

The data below is a result of generalization of long-term investigations on the areas of urban development (Yekaterinburg, Russia) from 1977 to 2001 (14691 specimens) on froglets and adult *R. arvalis* in this area. City territory was conventionally divided into areas with the different levels of urbanization: zone II, multistory buildings; zone III, areas of low buildings; zone IV, forest parks of the city. Control sites with natural amphibian population (C) were located in the area situated in 23 km from the city. The acceptability of the typification was confirmed by the data of hydrochemical analyses. Overlap of the deviations spectrum was determined by the Morisita index:

$$C_{\mathrm{M}} = 2\frac{\sum an_i bn_i}{\frac{\sum an_i^2}{aN^2} + \frac{\sum bn_i^2}{bN^2}} aNbN,$$

where an_i are numbers of deviation i in population A; bn_i are the same for population B; *aN* are numbers of abnormal animals in population A; and *bN* are the same for population B (Hurlbert, 1978).

RESULTS AND DISCUSSION

The results indicate (Table 1) that *R. arvalis* froglets from populations in all zones differed significantly from each other ($\chi^2 = 15.8 – 86.0$, $p = 0.05 – 0.001$), but the differences between populations from zones II and III were not so significant as between the populations from urban territories and forest. Adult individuals from zone II significantly differed from those in the forest and forest park zones ($\chi^2 = 4.7$, $p < 0.05$; $\chi^2 = 6.7$, $p < 0.05$, respectively).

Among froglets, the deviation spectrum is significantly wider in zones IV and III. In population subject to the highest influence of urbanization (zone II) it increased to 13 types, which exceeds the control level. This definitely indicates qualitative difference of populations from zone II. Overlapping degrees in adult frogs were similar to those in froglets. The degree of overlap of the spectra of deviations calculated with Morisita index showed that age changes of deviation spectrum are much higher than similarity — in the forest population, 18.5%, in zone IV, 26.8%, in zone III, 17.3%. Only in zone II it is overlapped by 45.0%. The comparison shows that among adults there are no mandibular hypoplasia and non-flexible limbs which are lethal for the animal. Cluster analysis in juveniles (Fig. 1) showed that the greatest differences are recorded between animals from forest population and populations from zone II, III, IV. In adult frogs the spectrum of

---

[1] Institute of Plant and Animal ecology, Yekaterinburg, Russia;
E-mail: wow@ipae.uran.ru.

deviations in the forest population is close to that in zone IV and is far from that in zones III and II.

Percentage of individuals with iris depigmentation in froglets from urban populations was very significant (5.7% in zone II). Detailed studies of the frequency dynamics of this recessive mutation (Rostand and Darre, 1970) showed evidence for the presence of inbreeding depression in urban populations and for high mutagenesis in the urban environment (Vershinin, 2004). Having analyzed the nature and topography of abnormality frequencies, we noted that among juveniles there are differences between males and females. In comparison with females, general percentage of deviations in males was significantly higher ($\chi^2 = 4.07$, $p < 0.05$, $N = 6296$). I also found that the frequency of skeleton deviations in all males was significantly higher than in all females ($\chi^2 = 4.89$, $p < 0.05$). We suppose that this phenomenon is correlated with low general variability and ontogenetic stability of females in comparison with males. The frequency of bilateral variants of deviations was 38.3%. The study of proliferating activity and some morphophysiological parameters allowed us to suppose high degree of equilibrium of the morphogenetic processes and a decrease of the frequency of morphological deviations in stress environmental conditions. We found that there is a significant (p fluctuated between 0.0012 – 0.046) correlation between liver index and the froglet mitotic index. That, in our opinion, indicates the presence of adaptive changes in populations of urban areas. We think that there is resemblance in the processes of urbanization and domestication. It is expressed as changes in direction of natural selection and disappearance of some factors of natural mortality. We found an increase of the frequency of "striata" morph which is determined by a monogenic dominant mutation in the city area. The comparative analysis of the excitability of the nervous tissue in *R. arvalis* demonstrated that

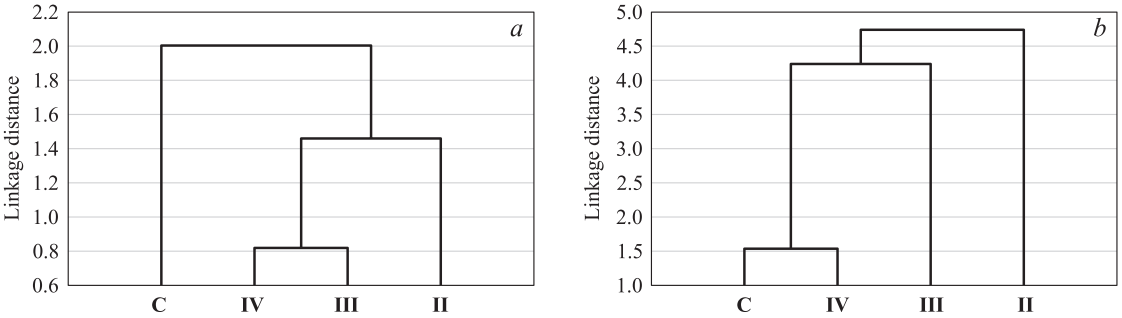

Fig. 1. Distances between groups of populations: *a*, juveniles; *b*, adults.

TABLE 1. Occurrence of Different Types of anomalies (%)

Type of anomalies	Zone							
	II		III		IV		C	
	adults	juvenilles	adults	juvenilles	adults	juvenilles	adults	juvenilles
Ectrodactyly	2.9	0.24	0	0.08	0.88	0.14	1.03	0.06
Sindactylty	0.96	0.03	0	0.16	0	0.03	0	0
Non-flexible limb	0	0.03	0	0	0	0	0	0
Hemimely	0	0.03	1.5	0.16	0.44	0.02	0	0.06
Brachymely	0.48	0.29	0	0.24	0	0.1	0	0.03
Ectromely	1.44	0.24	0	0.16	0.44	0.14	0	0
Eye defects	0	0.05	0	0	0.44	0	0	0.03
Iris depigmentation	0.48	1.65	0	1.8	0.44	1.2	1.0	0.34
Axial skeleton deformation	0.48	0.19	0	0.24	0.88	0.05	0	0.09
Mandibular hypoplasy	0	0.05	0	0.08	0	0.1	0	0.15
Pointed back pattern	4.3	1.46	3.0	0.47	0.44	0.14	1.0	0.03
Pigmentation defects	2.4	0.42	4.5	0.3	1.75	0.09	2.1	0.12
Edema	0	0.03	0	0.24	0.44	0.02	0	0
Total anomalies	28	177	6	50	14	119	5	30
N general	208	3766	66	1264	228	5835	97	3227
Total percentage	13.5	4.7	9.1	3.95	6.14	2.04	5.15	0.93

the excitation threshold of "*striata*" frogs (0.39 – 0.04; $N = 59$) was significantly ($F = 5.49$, $p = 0.02$) lower than in others (0.529 – 0.035). Environmental stress in urban conditions can influence ontogenetic process through nervous-hormonal axis which changes the spectrum of phenotypic variability. Thus the increase of phenotypical realizations in populations of the urban area is determined by high habitat heterogeneity, inbreeding depression under conditions of urban isolates and high mutagenesis, changes of the hormonal balance of morphogenetic processes by pollutants and selective survival of individuals with high stability of nervous system.

REFERENCES

Borkin L. and Pikulik M. M. (1986), "The occurrence of polymely and polydactyly in natural populations of anurans of the USSR," *Amphibia–Reptilia*, **7**(3), 205 – 216.

Cooke A. S. (1981), "Tadpoles as indicators of harmful levels of pollution in the field," *Environ. Pollut. Ser. A*, **25**, 123 – 133.

Dubois A. (1979), "Anomalies and mutations in natural populations of the *Rana* "*esculenta*" complex (Amphibia, Anura)," *Mitt. Zool. Mus. Berlin*, **55**(1), 59 – 87.

Halliday T. R. (1998), "Where have all the frogs gone?," *People Planet*, **7**(4), 22 – 23.

Hebard W. B. and Brunson R. B. (1963), "Hind limb anomalies of a western Montana population of the Pacific tree frog, *Hyla regilla* Barid and Girard," *Copeia*, **1963**(3), 570 – 572.

Hurlbert S. H. (1978), "The measurement of niche overlap and some relatives," *Ecology*, **59**(1), 67 – 77.

Kovalenko E. E. and Kovalenko Yu. I. (1996), "Sertain pelvic and sacral anomalies in Anura," *Russ. J. Herpetol.*, **3**(2), 172 – 177.

Rostand J. and Darre P. (1970), "Une mutation de *Rana esculenta*: la grenouille aux yeux noirs," *C. R. Acad. Sci. Ser. D*, **217**, 1414 – 1415.

Syuzyumova L. M. (1985), "Influence of the ecological factors on development and limb regeneration of *Rana arvalis* larvae on the background of thyreoid function inhibition by vitamin A," in: *Ékologicheskie Aspekty Skorosti Rosta i Razvitiya Zhivotnykh* [*Ecological Aspects of the Growth and Developmental Rates of the Animals*], Sverdlovsk, pp. 85 – 98 [in Russian].

Talvi T. (1993), "Naturally occurring limb abnormalities in anurans of the Estonia," in: *Progr. and Abstrs. of the 7th Ord. Gen. Meet. Soc. Eur. Herpetol., September 15 – 19, 1993*, Barcelona, p. 124.

Tokar' V. I., Zhavoronkov A. A., and Shcherbakov S. V. (1991), *Fluoride and Endocrine System*, Nauka, Novosibirsk [in Russian].

Vershinin V. L. (2004), "Frequency of iris depigmentation in urban populations of *Rana arvalis* frogs," *Ross. Zh. Ékol.*, **35**(1), 58 – 62 [in Russian].