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Status of Amphibian Populations in Anthropogenic Landscapes of the Ural, Siberia and the Far East

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Abstract: In this paper, I present a brief review of studies on the amphibians in urban areas of the Ural, Siberia, and the Far East. Urban populations of amphibians display some important differences from those in natural landscapes, including range constriction and fragmentation, changes in local density, size and age class structure, maturation, fecundity, development, morphology, and physiology. Species of the forest complex are especially threatened by urbanization. The mechanisms of different anthropogenic influences are discussed.

Резюме: **Состояние популяций земноводных в антропогенных ландшафтах Урала, Сибири и Дальнего Востока.** *В.Л.Вершинин.* — Дается краткий обзор данных о биологии земноводных в городских ландшафтах Урала, Сибири и Дальнего Востока. Городские популяции земноводных имеют ряд отличий от популяций в естественных ландшафтах, включая сужение и фрагментацию ареала, изменение локальной плотности населения, изменение размерной и возрастной структуры, сроков наступления половозрелости, плодовитости, развития, морфологии и физиологии. Урбанизация особенно опасна для видов лесного комплекса. Обсуждаются механизмы антропогенных воздействий.

Analysis of both original and literature data on cities of the Ural, Siberia, and the Far East has permitted me to outline general trends in the effects of different anthropogenic factors on amphibian complexes as a result of industrial pollution and increasing urbanization. Some of these trends are similar to those observed in other vertebrates (Glivich, 1980). As was demonstrated on species complexes of small mammals, amphibians, and soil invertebrates, an overall decline in individual numbers and biomass occurs because of increased pollution and anthropogenic stresses. In addition, population dynamics change, species and trophic relationships change, species diversity decreases, new species are introduced, and fragmentation of continuous ranges into isolated patches with varying composition, population density, and heterogeneity occurs. Changes in reproductive strategy, population demography, and the structure of trophic relationships of amphibians and small mammals have been found. Both adaptive and negative changes in amphibian and rodent populations also were documented (Pyastolova et al., 1990).

Urban development gradually engulfs adjacent natural ecosystems. Initially, species composition of the batrachofauna of such regions is quite diverse and the

majority of species successfully reproduce (Larionov, 1973, 1976; Toporkova, 1977; Vershinin and Toporkova, 1981; Fedoseeva, 1987; Gureev et al., 1990). Human activity in some cases even can promote increases in the number of certain amphibian species because of the establishment of new breeding sites (Ishchenko, 1978b, 1989; Kuranova, 1989). However, such situations are random events or occur during the early stages of anthropogenic stress, and do not continue for long (Zhukov, 1984).

Initial effects of urbanization are characterized by overall range constriction and declines in the number of all amphibian species (Vershinin and Toporkova, 1981; Ilyashenko, 1984a), changes in species composition and proportions of their numbers (Zhukov, 1989), changes in population density (Vershinin and Krinitsin, 1985) and fecundity, increases in clutch asymmetry (Vershinin, 1990a), and an accumulation of pollutants.

During this period, the proportion of ecologically plastic and widespread species (*Bufo bufo, Rana arvalis* and *R.amurensis*) usually increases (Vershinin and Toporkova, 1981; Zhukov, 1989). The main form of economic activity benefitting these species is the development and creation of reservoirs (Ilyashenko, 1984b; Kuranova, 1984). During intermediate levels of change and over a long persistence of anthropogenic effects, typical forest species (*Salamandrella keyserlingii, Bufo bufo, Rana temporaria* and *R.amurensis*) disappear because of increased environmental pollution and sharp changes in vegetation (Tagirova, 1978; Vershinin, 1980; Ilyashenko, 1984b; Zhukov, 1984). This level of anthropogenic stress is characterized by an increase in the frequency of morphological anomalies (Vershinin, 1982, 1989; Mizgireuv et al., 1984; Basarukin, 1985; Flyax, 1986), an increase in the frequency of mutations (Vershinin, 1988), the appearance of anomalous clutches (Vershinin, 1990b), and physiological changes (Vershinin and Tereshin, 1991).

Amphibian assemblages living in highly transformed environments are characterized by the appearance of adaptive changes at the population level. Such changes are regulated by constraints on growth and development, and by larval and juvenile population dynamics (Vershinin, 1983; Gatiyatullina, 1989; Kuranova, 1989; Vershinin and Trubetskaya, 1992). Populations of the introduced frog *Rana ridibunda* are established at many sites; the persistence of this species is possible only in human-altered environments (Toporkova, 1978; Belimov and Sedalishchev, 1980; Zhukov, 1989; Yakovlev, 1990). For example, the population of *R.ridibunda* which lives in Verkhny Tagil City, Ural, reaches 10 to 12 thousand adult specimens; frogs of 30 to 80 g comprise 40% to 60% of the population. Such percentages are higher than the respective values for populations of many native species. At these high local densities, *R. ridibunda* may be a threat to the local batrachofauna (Yakovlev, 1990). Amphibian populations that are isolated in urbanized regions may form high population densities.

Amphibians are very good bioconcentrators of pollutants. High pollutant concentrations lead to changes in the metabolism of adults and/or to the deterioration of the process of normal formation of gametes. The frequency of anomalous clutches increased in all species studied by up to 44.6%. Pollution is a strong stress factor that accelerates the mutation frequency, increases developmental anomalies, and causes anomalous regeneration as well as neoplasms. The duration of embryonic development in urban populations is extended, whereas the total duration of larval development is shortened, because of thermal pollution of the environment (Vershinin, 1985; Kuranova, 1989).

Changes in population dynamics lead to the formation of different gene frequencies in succeeding generations, for example, an increase in the frequency of naturally rare morphs such as "striata" and "punctata," and in other phenotypic characters. Under conditions present in urban ponds, relatively large animals and those with high metabolic rates survive. In addition, behavioral and physiological changes occur. Such changes are related to the complex environment of a large city, and are exemplified by particularly high values of the relative mass of the heart and liver. The presence of special physiological adaptations leads to an increase in energetic costs which negatively influence reproductive potential.

High metabolic levels, the greater survival of large specimens, and the high level of environmental pollution all promote the formation of unusual size and age class population structures. Maturity is attained at an age of 2 to 3 years vs 3 to 4 in normal populations, and the total life span does not exceed 4 years vs 6 to 7 years in unpolluted habitats. This demographic peculiarity may be one of the causes of decreasing fecundity and increasing proportion of clutches with small eggs in urban populations.

Studies on the trends in microevolutionary transformation in amphibian populations has practical value. It permits researchers to look for suitable test subjects and parameters for quick estimation of the health of the environment, and to find latent negative threats in seemingly favorable ecosystems and populations (Vershinin, 1982, Pyastolova, 1985; Pyastolova and Vershinin, 1989). Many theoretical predictions based on bioindicators have been repeatedly verified by studies on the influence of oil (Danilova, 1985, 1990), radioactivity, and industrial pollution (Pyastolova et al., 1981; Pyastolova and Trubetskaya, 1989) on components of taiga, tundra and urban ecosystems. The data reported here indicate the presence of a complex set of adaptations to anthropogenic ecosystems which permit amphibians to maintain their presence despite changing conditions.

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