Hedin, P. A., "A study of factors that control the compounds which compromise the boll weevil pheromone," J. Chem. Ecol., 3, 279-289 (1977).
Kerzhentsev, A. S., Automorphic Soils of the Chulym Region [in Russian], Dissertation, Moscow (1972).
Kolomiets, N. G., "The Siberian silk moth — a pest of flat tiaga," Tr. po Lesnomu Khozyaístvy Zapadnoí Sibiri, Novosibirskoe kn. izd-vo, No. 3, 61-76 (1957).
Kononova, M. M., Organic Substance of the Soil [in Russian], Izd. AN SSSR, Moscow (1963).
Korsunova, T. M., Korsunov, V. M., Vedrova, É. F., et al., "The effect of catastrophic successions on the change of soil characteristics in taiga landscapes," in: The Problems of Agronomic, Meliorative, and Forest Soil Science [in Russian], Krasnoyarsk (1978), 51-52.
Krasinskii, N. P., Volgina, K. P., and Kolomiets, N. G., "The biological composition of the needles of woody plants and larvae of the Siberian silk moth," Tr. po Lesnomu Khozyaístvu Zapadnoí Sibiri," Novosibirsko kn, izd-vo, No. 3, 77-84 (1957).
Poltavchenko, Yu. A., Essential Oils in Conifers of the Baikal Region and the Genesis of Monoterpenes [in Russian], Thesis, Irkutsk (1974).
Scheline, R. R., Mammalian Metabolism of Plant Xenobiotics, Academic Press, New York (1978).
Schopf, R., "The food quality of spruce needles for forest-damaging insects. 17. Quantitative studies on the food uptake and utilization of the sawfly *Gilpinia hercyniae* Htg. (Hym., Diprionidae)," Z. Ang. Entomol., 92, 137-149 (1981).
Schopf, R., Mignat, C., and Hedden, P., "The food quality of spruce needles for forest-damaging insects. 18. Reception of secondary plant metabolites by the sawfly *Gilpinia hercyniae* Htg. (Hym., Diprionidae)," Z. Ang. Entomol., 93, 244-257 (1982).
Smith, R. L., and Williams, R. T., "Implication of the conjugation of drugs and other exogencus compounds," in: Glucuronic Acid, Academic Press (London), 1966, pp. 457-491.
Waldbauer, G. P., "The consumption and utilization of food by insects," Adv. Insect Physiol., 5, 229-288 (1968).

ADAPTIVE CHARACTERISTICS IN GROUPS OF NARROW-MOUTHED FROGS IN A LARGE URBAN AREA

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A multiyear study of groups of narrow-mouthed frogs in urban habitats reports changes in the density, dispersion, genetic structure, and morphological variation of the groups. Several of the measured parameters indicate that groups have become adapted to a significant degree of human interference.

Microevolutionary changes in systems threatened by on-going urbanization and industrial growth are of theoretical interest since evolution may be more rapid than, and opposite in direction to, that in the natural environment (Shvarts, 1976). Responses of species to urbanization are varied. At present little is known about how synanthropic fauna originate (Chernov, 1975). Urban ecosystems, with one or several highly dominant species, lack diversity (Drozdov, 1969). Some species undergo a process of "synurbization" by making adaptations at the population level to urban conditions, resulting in the appearance of new regulatory mechanisms (Andrzejewski et al., 1978).

The narrow-mouthed frog is the most frequently encountered native amphibian in urban areas of the Urals (Vershinin, 1980a, 1980b, 1983b; Vershinin and Toporkova, 1981). Its abundance is great and its resistance to human influence high compared to other amphibians. In other regions this species is numerically dominant to the grass frog where habitat has been disturbed (Garanin, 1964; Astradamov, 1973; Toporkova, 1973). It is a model species for studying how amphibian groups become adapted to urban environments.

Beginning in 1977, during the reproductive period, direct counts were made of the numbers of egg clusters deposited by narrow-mouthed frogs in each of two ponds in habitats under observation within metropolitan Sverdlovsk. Starting with the 26th stage (Terent'ev, 1950) lar-

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val densities were determined by marking tadpoles with neutral red (Severtsov and Surova, 1979). Larvae and clutches were first marked for multiple recapture. Frogs were identified to clutch by toe clipping. Clutch densities were determined twice: once immediately after metamorphosis and again ten days later.

In July and August, 1984, amphibians were counted at sample sites (10 m by 10 m) in Sverdlovsk and near the Talitskii station. After sites were laid out debris was combed manually to locate frogs.

From 1977 to 1984 basic morphometric data (Terent'ev and Chernov, 1949; Bannikov et al., 1977) were taken on the frogs.

The counts showed that the greatest density of adult narrow-mouthed frogs (113/ha) occurred at Talitskii. Within the city limits the maximum density of frogs (64/ha) occurred in the most urbanized habitat (a zone of multistory buildings), while there were 38/ha in a zone of low-story buildings and 4/ha in a wooded park. These counts represent local densities within habitats. Obviously the mean density in the whole urban area would be lower.

The number of egg clusters laid per 10 m^2 of water in zones with different urban character was greatest in the wooded park (0.89) and smallest in the zone of multistory buildings (0.13), i.e., even though spawning area was of comparable size in terrestrial habitats (the majority of ponds in all zones having a surface area between 70 and 150 m^2) many fewer egg clusters were deposited in the most urbanized zones. This explains the high density of frogs in such habitats. Clutch counts at the sample sites were similar to those for adults (Table 1). The numbers of egg clusters per 10 m^2 in different urban zones are based on 1984 data, which on the whole agree with that from preceding years (Vershinin, 1983c).

Clutch and larval survival was estimated only for the 26th and 31st stages (Vershinin, 1983a). A greater urban mortality of clutches and of larvae for both stages is indicated. Data for 1984 is consistent with our prior findings. Because of a more exhaustive censusing of clutch and larval densities, fluctuations in the number of clutches and larval colonies established could be graphed from the early stages of development onward. For instance, for groups within the multistory section (zone II) an average of 0.92% of the larvae (from 28,000 eggs) survived to the 26th stage, while within the low-story section (zone III) 11.9% (from 79,000 eggs) survived. Survival to the 29th stage was 0.88% in zone II, 1.8% in zone III, and 4.0% in zone IV (Fig. 1).

High early-stage mortality in groups exposed to significant human influence is compensated by a decreased late-stage mortality (including the time of metamorphic climax). Survival to the 30th stage was 0.76% in zone II, 1.42% in zone III, and 1.6% in zone IV and to the 31st stage, 0.23%, 0.11%, and 0.58%, respectively.

Groups of frogs in zone II shared some specific characteristics. There was always an unusually high frequency of "striata" (Table 2), a biochemically different form (Dobrinskii and Malafeev, 1974) produced by the dominant allele of a diallelic locus (Shchupak, 1977). Vershinin (1983b) found that average body length in these clutches was significantly larger ($P = 0.01$) than clutches from other zones. This increase in average body size in highly urbanized areas has been noted for adults of the grass frog of the same age (Ushakov et al., 1982).

Values of the coefficients of variation for basic morphological characters in clutches and in adults of zones III and IV are low relative to those for rural populations; for zone II groups they are generally higher than for rural groups. In species less resistant to habitat disturbance, such as the Siberian newt and the grass frog, morphological variation is low

TABLE 1. Densities of Narrow-Mouthed Frogs (per ha) and Egg Clusters (per square unit of water) in Zones of Different Urban Character

Zone	Number				
	adults per ha	froglets per ha	sample sites	Clutches per 10 m^2	ponds
Multistory buildings	64	317	6	0,13	5
Low-story buildings	38	75	9	0,66	4
Wooded park	4	11	55	0,89	4
Talitskii station	113	—	15	—	—

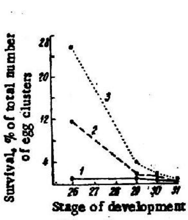

Fig. 1

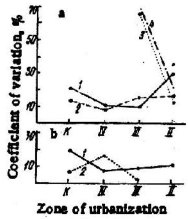

Fig. 2

Fig. 1. Survival of narrow-mouthed frogs to various developmental stages depending upon degree of urbani zation: 1) zone of multistory buildings; 2) zone of low-story buildings; 3) wooded park zone.

Fig. 2. Changes in coefficients of variation for basic morphological characters of amphibians as urbanization increases (based on 1981 data). K) Rural areas; II) multistory zone; III) low-story zone; IV) wooded park; in a: 1) relative width of the rostrum in froglets of narrow-mouthed frogs; 2) body length in froglets of narrow-mouthed frogs; 3) relative width of the rostrum in froglets of grass frogs; 4) body length in froglets of grass frogs; in b: 1) body length in adult male narrow-mouthed frogs; 2) body length in adult male Siberian newts.

in groups exposed to a maximum of human influence. The 1981 data for morphological variations (Fig. 2) in 542 clutches and 30 adult male narrow-mouthed frogs, in 292 clutches of grass frogs, and in 47 adult male Siberian newts are typical for the next three years.

It would appear, then, that a slight reduction in the suitability of a terrestrial habit or a disturbance to plant cover caused by human activity can lead to a drop in the densities amphibians. While numbers continue to decline, the amount of available habitat becomes reduce This favors a local increase in the density of groups near the centers of cities, where habit is often restricted to a narrow (2-4 m wide) strip of riparian vegetation.

The high mortality of early stage larvae living in conditions of pollution, isolation, low density favors the survival of viable individuals which are larger or whose phenotype rep sents a biochemical adaptation to urban conditions. Given this nonselective type of eliminat changes in the genetic structure of populations are to be expected (Shvarts, 1969, 1980). Th significant increase in the frequency of the "striata" morph provides evidence for this.

As habitat shrinks in size and the number of groups approaches some minimum value, popul tions, now composed of rather closely related individuals forced to interbreed, should become less stable due to the effect of inbreeding depression (Simberloff, 1983) and be led to rapid extinction. This, however, did not occur. It has been experimentally shown that genotypically similar amphibian larvae (those from the same clutch) inhibit one another's growth and development, maintaining the genetic heterogeneity of the group (Shvarts and Pyastolova, 1970). Apparently, this mechanism provides for increased variation within small urban colonies of nar row-mouthed larvae which makes them more likely to persist.

It is therefore proposed that adaptation at the group level is taking place. Groups undergoing such adaptation are highly stable in the face of human activity (indirectly demonstrate by the rise in morphological variation seen within the zone II groups) and such groups are capable, according to our year-to-year observations, of surviving indefinitely under novel conditions. This represents a shift of a population to a new adaptive peak where forces different from those in the natural environment prevail. The adaptations appearing in groups of narrow-mouthed frogs in the multistory zone do not, however, imply that they will persist even if habitat conditions continue to deteriorate. The greater stability of such groups is due to a slightly different normal response, compared to that of natural populations, in the

TABLE 2. Frequency of the "Striata" Morph of Narrow-Mouthed Frogs as the Sum of Observations Made between 1977 and 1984(%)

Zone	% "Striata" in adults	Total (N)	% "Striata" in froglets	Total (N)
Multistory buildings	39,3	61	43,5	312
Low-story buildings	35,1	37	26,7	101
Wooded park	31,0	58	24,1	911
Rural groups	16,0	25	22,5	364

face of man-made changes to the habitat. It is necessary to study and preserve small isolates which have a significant role in ecological patches, such as small urban ponds, for they are often the sole territorial vertebrates represented there.

LITERATURE CITED

Andrzejewski, R., Babinska-Werka, J., Gliwicz, J., and Gosscynski, J., "Synurbization processes in populations of *Apodemus agrarius*: characteristics of populations in an urbanization gradient," Acta Theriol., 23, 341-358 (1978).

Astradamov, V. I., "The role of anthropogenic factors in changing natural assemblages and their components (for example, in Mordovskaya, ASSR)," Author's Abstract of Doctoral Dissertation, Kazan' (1973).

Bannikov, A. G., Darevskii, I. S., Ishchenko, V. G., Rustamov, A. K., and Shcherbak, N. N., Guide to the Amphibian and Reptile Fauna of the USSR [in Russian], Prosveshchenie, Moscow (1977).

Chernov, Yu. I., Natural Zonality and the Animal Fauna of Dry Land [in Russian], Mysl', Moscow (1975).

Dobrinskii, L. N., and Malafeev, Yu. M., "A technique for studying the rate of liberation of carbon dioxide gas by small poikilotherms using an optical-acoustic gas analyzer," Ékologiya, 1, 73-78 (1974).

Drozdov, N. N., "Cultural landscapes as arenas for animal synanthropization," in: The Synanthropization and Domestication of an Animal Population [in Russian], Moscow (1969), pp. 59-60.

Garanin, V. I., "Information on the distribution and abundance of amphibians of the Volga-Kama region," in: Natural Resources of the Volga-Kama Region (The Animal Fauna) [in Russian], Nauka, Moscow (1964), pp. 127-133.

Severtsov, A. S., and Surova, G. S., "The impact of predators on a tadpole population of the grass frog, *Rana temporaria*," Zool. Zh., 58, No. 9, 1374-1379 (1979).

Shchupak, E. L., "The inheritance of the dorsal stripe by individuals of the narrow-mouthed frog," in: Informative Data of the Institute of Plant and Animal Ecology [in Russian], Sverdlovsk (1977).

Shvarts, S. S., "The evolutionary ecology of animals," Tr. Inst. Ékol. Rast. Zhivotn., Sverdlovsk, 65 (1969).

Shvarts, S. S., "Evolution of the biosphere and ecological forecasting," Vestn. Akad. Nauk SSSR, 2, 61-71 (1976).

Shvarts, S. S., The Ecological Mechanisms of Evolution [in Russian], Nauka, Moscow (1980).

Shvarts, S. S., and Pyastolova, O. A., "Growth regulators and larval amphibian development. I. Specificity of action," Ékologiya, 1, 77-82 (1970).

Simberloff, D., "What a species to survive," Nature Conserv. News, 33, No. 6, 18-22 (1983).

Terent'ev, P. V., Frogs [in Russian] Sovremmenaya Nauka, Moscow (1950).

Terent'ev, P. V., and Chernov, S. A., Guide to Amphibians and Reptiles [in Russian], Sovrem. Nauka, Moscow (1949).

Toporkova, L. Ya., "Amphibians and reptiles of the Urals," in: Fauna of the North, the Urals, and Western Siberia [in Russian], Sverdlovsk (1973), pp. 84-117.

Ushakov, V. A., Lebedinskii, A. A., and Grefner, N. M., "Analysis of the age structure of a population of the grass frog in an urbanized area," Vestn. Zool., 2, 67-68 (1982).

Vershinin, V. L., "Preliminary evaluation of the influence of anthropogenic factors on amphibians of Sverdlovsk," in: Problems in the Ecology, Rational Use, and Preservation of the Natural Resources of the Urals [in Russian], Sverdlovsk (1980a), pp. 117-118.

Vershinin, V. L., "The distribution and species composition of amphibians in the city of Sverdlovsk," in: Informative Data from the Institute of Plant and Animal Ecology [in Russian], UNTs AN SSSR, Sverdlovsk (1980b), pp. 5-6.
Vershinin, V. L., "Larval and clutch mortality in the chestnut-brown frog, *Rana arvalis* Nilss, *R. temporaria* L., along an urbanization gradient," in: Ecology, Man, and Problems in Natural Preservation [in Russian], Sverdlovsk (1983a), p. 89.
Vershinin, V. L., "Species composition and biological traits of amphibians in several industrial cities of the Urals," Author's Abstract of Doctoral Dissertation, Sverdlovsk (1983b).
Vershinin, V. L., "Species composition and biological traits of amphibians in several industrial cities of the Urals," Doctoral Dissertation, Sverdlovsk (1983c).
Vershinin, V. L., and Toporkova, L. Ya., "Amphibians in urban regions," in: Fauna of the Urals and the European North [in Russian], Sverdlovsk (1981), pp. 48-56.

SEASONAL CHANGES IN CARBOHYDRATE NUTRITION IN REINDEER

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In order to study the status of carbohydrate and energy nutrition in reindeer, experiments were conducted on six males in laboratory conditions in the winter and in the summer. High digestibility of dry material, cellulose, and the energy of lichen feed, which is unbalanced according to protein and mineral substances, was shown. The energy food value of 1 kg of the dry material of lichen feed constitutes 1.7-2.0 energy-producing food units (EFU). Reindeer are supplied with sufficient nutritious material and metabolic energy from summer feed.

Ecologic-physiological investigations (Kochanov and Veber, 1981) have shown that in conditions of insufficient intake of nutritive and mineral matter, various anomalies in the condition of metabolism with acidotic phenomena develop in reindeer in the winter. With conversion to summer feed, the conditions of acid-base equilibrium in the reindeer organism assumes a pronounced alkaline character. However, questions of carbohydrate nutrition of animals and energy nutrition of feeds depending on the season of the year have been inadequately studied.

With regard for the timeliness of this question, the condition of carbohydrate and energy producing metabolism was studied in reindeer when fed with lichen in the winter and green feed in the summer.

Experiments were conducted on six male reindeer in a laboratory of the Biological Station of the Komi Affiliated Society of the Academy of Sciences of the USSR. In the first group (n = 4) were two-year-old reindeer weighing 82 kg with fistulas of the rumen, in the second (n = 2) were yearlings with a duodenal T-branch. In the winter deer received 4-6 kg of lichen feed, in which Alpine moss (*Cladina stellaris*) constituted 73-78%. In the summer deer were fed with 10 kg of grass of the following botanical composition: mixed grasses, 83.5; legumes, 13; and, cereals, 3.5%. Animals received common salt without restriction. Each experimental period consisted of preliminary and record-keeping sections and concluded with the performance of a balanced experiment in two repetitions. Blood was taken in the morning from the jugular vein.

The concentrations of glucose and ketone bodies were determined in blood samples, and the content of cellulose, starch, and total sugars was determined in samples of feeds and feces. The nutritive value of feed in energy-producing food units (EFU) was determined directly, using a method of chemical oxidation of biological samples as modified by us (Kochan, 1982).

The dry material of lichen feed contained 20% cellulose, 0.2% starch, and 2.05% sugars. The consumption of dry material of lichen feed was similar for reindeer of both groups (Table 1). Calculated per 100 kg of live weight, consumption in the first group constituted 1067 g,

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