

Biodiversity of amphibians in Yakutia – the most cold region of the Earth

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- Yakutia occupies the great part of Asia North-East, 3 millions 100 000 squared km (Fig.1). It is the most cold part of Earth with sharp continental climate, with winter in 8-9 months long and short hot summer. Winter temperatures may decrease till - 50-60°C and summer temperatures may reach to +30-38°C.
- 4 amphibian species live in such conditions. 2 of them, Siberian salamander *Salamandrella keyserlingii* and Siberian Wood Frog *Rana amurensis*, inhabit actually all forest zone and forest-tundra and in some sites may go to tundra till 71-72°N. Moor Frog *Rana arvalis* and Far East Frog *Rana chensinensis* inhabit southern part of Republic: the first one along Lena river valley and her small tributaries till 60°N and the second one –Aldan River basin till 60°N (Fig.2). The number of these species is low everywhere. Actually, they became to distribute in Southern Yakutia from 70-es of the last century, probably, because of climate warming.
- Watslav Seroshevski was the first researcher who discovered *Salamandrella keyserlingii* and *Rana amurensis* in the district of Cold Pole in upper Yana River region (Seroshevski, 1896). From that time, scientists do not stop to find wonderful the fact that these poikilothermic animals with thin and moist leather can survive in Cold Pole conditions. It relates particularly to *Salamandrella keyserlingii* which winters on the ground in some distance from water, under tree and shrub roots, under brushwood, old leaves, moss, at depth 15-18 cm where ambient temperature may reach - 35°C.
- We will discuss the biology of the mass species, Siberian Salamander and Siberian Wood Frog, because they are most adapted to Yakutia conditions.
- *Salamandrella keyserlingii* is distributed widely on all Yakutia territory. Its habitats relate to large and small river valleys and to alas and low-valleys lakes and marshes of interfluves (Fig. 3, 4, 5). The northern border of its range is near settlement Saskylakh in Anabar district (72°N) and in lower Yana and Indigirka Rivers this species distributed till 71°N.
- An adult Siberian Salamander has the next sizes in Central Yakutia: body length is 42-70 mm, tail consists of 0.9-1.9 from the body length, weight is 1.3-2.7 g. Sizes of Siberian Salamanders from Yakutian population are almost the same with these shown in literature data (Bannikov et al., 1971; Belimov, Sedalischev, 1977; Borkin et al., 1984)



Fig.1. Republic Sakha (Yakutia) – the most great subject of Russia

3,1 millions km²

Severe climate: 8 months of winter, 2-3 months of summer

Average temperature of a year is -11-15°C

Average temperature in January: -42-45°; in July: +14-17°

Absolute temperature minimum: -72°,

Absolute temperature maximum: +38°

Year precipitation: 250-350 mm.

Distribution of amphibians in Yakutia



Salamandrella keyserlingii



Rana amurensis

Fig. 2. Distribution of amphibians in Yakutia

1. *Salamandrella keyserlingii*
2. *Rana amurensis*
3. *Rana arvalis*
4. *Rana chensinensis*

- In Central Yakutia, Siberian Salamanders prefer river valleys where they are numerous in wet forest and shrub biotopes. Salamanders widely distributed among taiga-low-valley landscapes represented mostly with Ledum-larch forest , moist and boggy sedge and Calamagrostis-sedge-grass tussock meadows which are situated in upper reaches of small taiga “grassy” rivers without clear streaming. Salamanders also inhabit places near pure streams. They are distributed in lesser numbers among typical for Yakutian taiga dry larch taiga. Also, they are very common in forests of taiga-alas-lake landscapes what is a flat ground with normally developed hydrographical net and numerous treeless spaces – alases*. Near settlements, Siberian Salamanders are common in water bodies with boggy and mossy banks, on sedge-tussock biotopes, in small forests, in birch and willow groves near depressions on the banks, on slopes of native shores.

* Alas - it is the meadow depression with abrupt southeastern slope and gentle southwestern slope, formed with thermokarst process primarily, with lakes in the middle. A lake size may be from several hundreds of squared meters to tens of squared kilometers; depth may be 6-8 till 20-40 meters.



Fig. 3. Typical habitat of Siberian salamander in Lena River valley



Fig. 4. Habitat of Siberian salamander in alas-taiga region



Fig. 5. Shallow pond in the basin of shallow-valley river Ulakhan-Aan
what is typical habitat for Siberian Salamander



Fig. 6. Wintering station of *Salamandrella keyserlingii*.

Left: 16 September, 2013. Siberian Salamanders prepared for winter where revealed under these rotten stump in 70 meters from the lake

Right: Metallic fence was made at this place. Thermograph DS 1922L-F5 was installed near wintering Salamanders. This device was programmed for the measurement once at 3 hours. The data treatment was made with help of standart programm MS-Excel*.

* - detailed description of this device and its main characteristics may be seen here :
[/www.elin.ru/](http://www.elin.ru/)

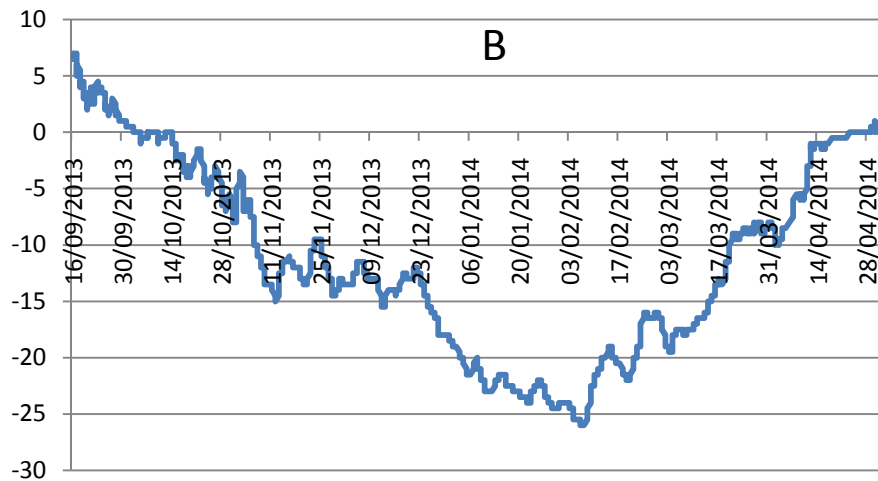
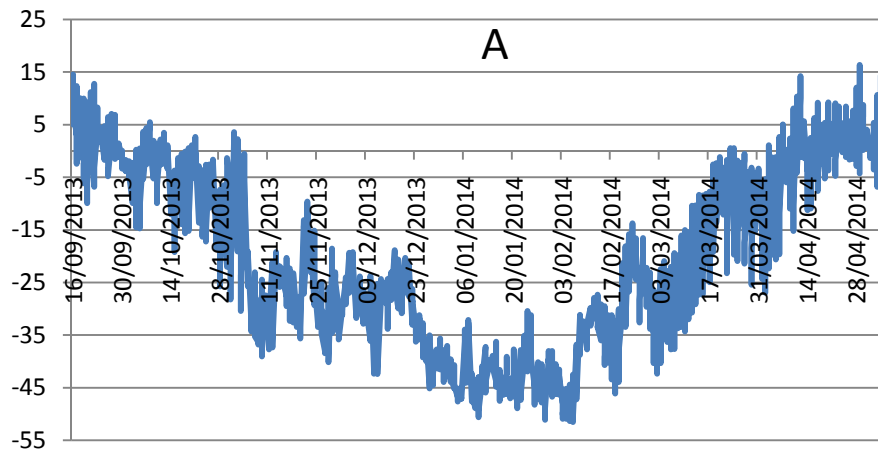


Fig. 7. Ambient temperature in period of *S. keyserlingii* wintering in 2013-2014 (from September, 16 till May, 5).

- A. Air temperature. Meteorological station data of settlement Pokrovsk in 30 km from the place of Salamanders wintering.
- B. Temperature under stump where Salamanders wintered.
- C. Siberian Salamander running from the wintering refuge at digging out of this on May, 16, 2014. Possible it used this place like a daytime hiding place. Three sleepy Salamanders still presented in wintering place on May, 5. Analysis of air temperature and temperature in the refuge of the Salamander had shown that graphic of temperature in wintering refuge with living Salamanders during winter changed as follows: first, in early November, it gradually fell to minus 7.5°C, then, until December 23, despite the 35-40-degree frost outside, it kept at minus 10-15°C and in early January it dropped to minus 20°C, and to early February, when the outside temperature reached minus 52°C, it fell down to minus 26°C. Then gradual increase in temperature started until the late April when it reached 0°C. In early May, the wintering refuge temperature was plus 1-2°C and Salamanders began to wake up.

Tab.1. A food of the *Salamandrella keyserlingii* in the Central Yakutia.

Main taxonomic units and their most common occurring representatives	(n – 100)	
	specimen *number	% of overall number
Mollusca (Limpaeidae, Planorbidae, Bithinidae, Pupillidae)	26/80	16,7
Araneina (Salticidae,, Thomisidae, Fgelinidae, Licosidae- Pirata, Pardosa, Argiopidae, Tetragnathidae, Lenyphidae, Erigonidae)	14/55	11,5
Hydrocarina	1/2	0,1
Odonata (larvae and imago)	8/8	1,7
Homoptera (Cicadellidae, Aphididae, Cixudae)	10/13	2,8
Hemiptera (larvae and imago)	13/13	2,8
Coleoptera (larvae and imago)	76/126	26,3
Neuroptera	2/2	0,02
Trichoptera	16/16	3,4
Lepidoptera (Noctuidae, etc., basically larvae)	2/2	0,02
Hymenoptera	16/18	3,8
Diptera (larvae and imago)	63/145	30,1

* In numerator - quantity of stomachs in which the given forage is met, in a denominator - quantity of copies of the given group met in 100 stomachs.

Siberian Salamander is eating the earthworm in terrarium

- The above data again demonstrate the Siberian Salamander's unique stability to cold action.
- *S. keyserlingii* withstands cooling up to -35°C in frozen state (Berman et al, 1984). It also withstands up to 4 freeze-thaw cycles at temperature changing from -10°C to $+5^{\circ}\text{C}$ (Berman, Meshcheryakov, 2012). In our case, of course, can be no question about any thawing of wintering newts: ambient temperature in their wintering place since the end of the first decade before the third decade of April held minus 7°C , in November and early December to minus 15°C , in January - the beginning February between minus 20-26 $^{\circ}\text{C}$, in the second half of February and the first half of March - from minus 22 to minus 14°C , in the second half of March - the first five days of April - from minus 8°C to minus 6°C , and in the second half of April the temperature in the shelter reaches 0°C and begins to shift to positive values to plus 1-2 $^{\circ}\text{C}$. Exactly at this time there is an awakening of overwintered individuals who in the early days of their active life can return to the wintering shelter. D.I. Berman in his doctoral thesis showed that the ability of Siberian Salamander to withstand extremely low temperatures is due to glycerol formed from his liver glycogen up to 17 % during the winter, and this glycerol is one of the most important anti-freezer.
- Feeding. Siberian Salamander's diet was learned by the contents of the stomach and it is relatively poor and includes mollusks, spiders, water mites, dragonflies, damselflies, bugs, beetles, lacewing, caddis flies, Lepidoptera, Diptera (Table 1). At the more careful study, we recently found that newt eats earthworms on occasion. Previously, it was learned that Siberian Salamanders can eat yearlings of the own species (Fig. 8)
- Seasonal rhythms of life. Wintering in a state of anabiosis lasts from the first half of September to early May. Wintering stops in the early May. The beginning of breeding in different habitats starts from May 5-15. Hatching of larvae from eggs starts in May 20 - June 10. Yearlings completed their larval development go to the land at the end of July - early August. In late August, the most juveniles in the Lena valley have average body size of 35-40 mm at the weight of 320 - 520 mg. Total body length of fingerlings before hibernation varies from 45 to 55 mm, weight - 500 to 750 mg. Yearlings going for wintering in alps habitats at sizes 35-45 mm, weights 400-600 mg .

- • Yet the first data on the distribution of amphibians in the northern regions of the Old and New Worlds (Nilsson, 1842; Cope, 1889; Werner, 1906; Nickolski, 1905 , etc.) have shown that the distribution far north of several species of these animals do not have enough convincing explanation. More or less satisfactory solution to this problem is found in the work of S.S. Schwartz and V.G. Ishchenko "Ways of adaptation in terrestrial vertebrates to living conditions in the Subarctic . Amphibians" (1971) showing the biological features of *Rana arvalis*, *R. temporaria* and *Salamandrella keyserlingii* which allowed them to inhabit the sub-Arctic areas. They can be reduced to increasing of development speed, omniphagae, and primarily a significant increasing of aquatic invertebrates in their diet, increased ability to create energy and high resistance to cold.
- • A feature of wintering Yakutian Siberian Salamanders is that they can tolerate very low temperatures being in the frozen ground or being frozen in the ice. As shown above, they successfully survive the winter in the valley of the Middle Lena in their places of hibernation at minus 20-26 °C.
- • This amphibian has a unique ability to endure long-term freezing. So, one adult Siberian Salamander found at a depth of 11 m has been identified with radiocarbon analysis in 90 ± 15 years old (Xherbak , Kovalyuh, 1973).
- • Comprehensive study on environmental adaptations of Siberian Salamander was published by Magadan zoologist D.I. Berman (1992 , 2002), and he with his co-authors (Berman, Leirikh, Mikhailova, 1984; Berman, Leirikh, Meshcheriakova 2010; Alfimov, Berman, 2010; Berman, Meshcheriakova, 2012).
- • They found that the Siberian Salamander is a species of animal perfectly adapted to a cold climate. It is its abilities to endure:
 - • 1) deep freezing during the winter (down to - 35 ° C);
 - • 2) multiple cycles of freezing - thawing which possible at fall and spring throughout the area as well as deep thaw in regions with moderately low air temperatures ;
 - • 3) prolonged stay without food for small positive temperatures (Berman, Meshcheriakova, 2012, p. 263).
- • In a special paper on breeding of Siberian Salamander, A.V. Alfimov and D.I. Berman (2010) have convincingly shown that Siberian Salamander inhabited Arctic territory own to the breeding in small and shallow water bodies freezing in the winter spring water of which warms up quickly because of the clock sunlight and protective role of thawing mud protecting from the cooling effect of the bottom frozen layers. The authors believe that these data are "directly related to the well-known rule to accelerating development of amphibians in the North, as it was said by Schwartz and Ishchenko " while they emphasize modestly: "Our data also doesn't shed light on the problem, however, we believe, can help correct formulation of the problem"

Siberian frog successfully overwinters in our cold climate conditions, but at the same time it uses a different strategy – frost-avoiding: when there is a sharp decrease in temperature it goes into hibernation in the deep "pits" under ice lakes, so it avoids negative temperatures, whereas evolution has developed the Siberian Salamander's ability to withstand the ravages of the cold.