

New Stands of Species of the *Paramecium aurelia* Complex (Ciliophora, Protista) in Russia (Siberia, Kamchatka)

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New stands of *P. primaurelia*, *P. biaurelia*, and *P. dodecaurelia* were found in Russia. *P. primaurelia* was recorded in Tulun (Siberia, Irkutsk region) and in three stands situated on the Kamchatka peninsula: in Lake Chalaktyrskoye, in the Valley of Geysers, and Petropavlovsk Kamchatski. *P. biaurelia* was also found in Tulun and in two stands in the vicinity of Lake Baikal and the Buriatia region. *P. dodecaurelia* was recorded in Cheboksary in European Russia and in other stands situated in Asian Russia: Novosibirsk, the vicinity of Lake Baikal, Buriatia, Kamchatka (Petropavlovsk Kamchatski, Lake Chalaktyrskoye, and Nalychevo). These data extend the ranges of species of the *P. aurelia* complex in Russia, however, this large territory remains understudied.

Key words: *Paramecium aurelia* species complex, species distribution, climatic zones.

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The *Paramecium aurelia* complex is composed of 15 species known world-wide (SONNEBORN 1975; AUFDERHEIDE *et al.* 1983). Some of these are cosmopolitan, as *P. primaurelia*, *P. biaurelia*, *P. tetraurelia*, and *P. sexaurelia*, while others are limited to certain regions, environments, or even to habitats (cf. SONNEBORN 1975; PRZYBOŚ & FOKIN 2000; PRZYBOŚ & SURMACZ 2010). However, not all parts of the world have been studied accurately or sampling was done there only occasionally, as in Central and South America, Australia, Africa and some regions of Asia. In North America only the USA was studied carefully; the majority of species of the *P. aurelia* complex were recorded there (SONNEBORN 1975). In Asia, more frequent sampling was performed only in Japan and in Asiatic Russia (PRZYBOŚ & SURMACZ 2010; POTEKHIN *et al.* 2010). Europe was investigated on a large scale, i.e. 531 habitats were studied (PRZYBOŚ *et al.* 2010) and we were able to evaluate the frequency of species occurrence.

The enormous (17 075 200 km²) territory of Russia has been representatively sampled in some regions only (in European and Asian Russia) thanks

to the efforts of Maria Rautian and coworkers. Most samples were collected in the northwest of European Russia, and also in the Asian part: southwestern Siberia (Omsk and Novosibirsk and their vicinities), southeastern Siberia (Altay, Krasnoyarsk, Kemerovo regions) and now in the Baikal region (Tulun, Irkutsk and some places in Buryatia) and Kamchatka peninsula. The presence of the following species was recorded in the European and Asian parts of Russia: *P. primaurelia*, *P. biaurelia*, *P. triaurelia*, *P. tetraurelia*, *P. pentaurelia*, *P. sexaurelia*, *P. septaurelia*, *P. novaurelia*, *P. decaurelia*, and *P. dodecaurelia* (several papers were published between 2004-2010, cf PRZYBOŚ *et al.* 2004 and POTEKHIN *et al.* 2010). It is important to mention that some species, i.e. *P. tetraurelia*, *P. sexaurelia* and *P. septaurelia*, were found only in the European part of Russia, and in warm or moderate temperature zones.

Before 2004 sampling was done occasionally and in result some data concerning the occurrence of the *P. aurelia* species complex were collected. In the European part of Russia the presence of *P. primaurelia*, *P. biaurelia*, *P. triaurelia*, *P. pen-*

taurelia, and *P. novaurelia* was recorded (data can be found in PRZYBOS *et al.* 2004) and in the Asian part of Russia only a few sites were sampled and the presence of *P. primaurelia* and *P. biaurelia* was found (data in POTEKHIN *et al.* 2010).

The present paper concerns the occurrence of species of the *P. aurelia* complex mainly in Asian Russia (Siberia, Kamchatka) and also in Cheboksary situated in the European part of Russia.

Sampling on the Kamchatka peninsula seems particularly interesting because of the occurrence of geysers creating very special conditions in water bodies. The northwesterly movement of the Pacific plate has created the Kamchatka volcanic province. This is one of the world's examples of large scale subduction of an oceanic plate at a very active convergent boundary. The result is a chain of very large andesitic stratovolcanoes. A long history of plate convergence has created parallel volcanic mountain belts that now form the core of the Kamchatka peninsula. The eastern mountain range is the youngest and contains most of the active volcanoes. Most of the calderas date from about 30,000 to 40,000 years ago, and most of the present cones on the stratovolcanoes have formed entirely in the last 20,000 years. Kamchatka's line of volcanoes continues southwards along the Pacific margin, through the Kuril Islands and into Japan. In some parts of Kamchatka there are hot springs and geysers with different chemical composition. Mixing with ordinary waters, they determine a set of different living conditions.

Although Kamchatka lies at a similar latitude as Great Britain, cold arctic winds from Siberia combined with the cold Oyashio current result in the peninsula being covered in snow from October to late May. Kamchatka generally has a subarctic climate, is much wetter and milder than eastern Siberia, and is essentially transitional from the hypercontinental climate of Siberia to the rain-drenched subpolar oceanic climate of the Aleutian Islands. There is considerable variation, however, between the rain-drenched and heavily glaciated east coast and the drier and more continental interior valley.

Material and Methods

Material and method of sample collection

Water samples (10-50 ml) with plankton were collected by M. Rautian and A. Beliauskaya in 2009 and 2011 from different kinds of water bodies. The collecting sites are presented in Table 1 and marked on the maps (Figs 1 & 2 present sampling sites in Siberia, the Irkutsk region and the Kamchatka peninsula).

On the Kamchatka peninsula, samples were collected in the Valley of Geysers, Lake Chalaktyskoye, Nalychevo and some ponds in Petropavlovsk Kamchatski. River Geysernaya collects waters from many geysers, hot springs, fumaroles; therefore the temperature can vary greatly in different parts of the river. The average temperature in the sampling points was 26°C. It is important that the average temperature in Geysernaya river (samples designated KVG) is higher than in other water bodies. Samples were collected at many sites located at a distance of several kilometers. Sample KVG133 was collected in an inflow separated from the main river by a ridge.

Method of species identification

SONNEBORN's (1970) methods of species culture and identification were used. Paramecia were cultivated on a lettuce medium inoculated with *Enterobacter aerogenes*. Species of the *P. aurelia* complex were identified by mating the investigated strains with the mating types of standard strains of particular species. The following standard strains were used: *P. primaurelia*, strain 90 (Pennsylvania, USA); *P. biaurelia*, strain Rieff Scotland; *P. pentaurelia*, strain 87 (Pennsylvania, USA); *P. dodecaurelia*, strain 246 (Mississippi, USA).

The studied strains were identified as *P. primaurelia*, *P. biaurelia*, and *P. dodecaurelia* on the basis of conjugation between the complementary mating types of the strains under examination with the corresponding ones of the particular species. The survival of hybrids was examined in F1 and F2 generations, according to SONNEBORN's (1975) recommendations.

Results and Discussion

New stands of *P. primaurelia*, *P. biaurelia*, and *P. dodecaurelia* were found in Russia in the investigated stands (Table 1).

P. primaurelia was recorded in Tulun, the Irkutsk region (strain TRB 99-9) and in three stands situated on the Kamchatka peninsula, Petropavlovsk Kamchatski (KPK 143-17, KPK 143-18), in Lake Chalaktyskoye (strain KCH 183-7) and in the water bodies of the Valley of Geysers (22 strains designated KVG). The latter region is very interesting because of its geology (volcanoes and geysers), creating very specific ecological conditions. It is also interesting that only this species was recorded there (stand KVG) in several samples designated 108, 109, 110, 111, 125, 127, 128, 133, 140, 141, and 143, as well as all paramecia isolated from particular samples represented only

Table 1

New stands of species the *Paramecium aurelia* complex in Russia

Geographic origin	Strain designation (index of the clone)	Species
Cheboksary (European part of Russia)	ChD 5-1	<i>P. dodecaurelia</i>
	ChD 8-2	
	ChD 8-16	
	ChD 10-1	
Novosibirsk	NRB 217-3	<i>P. dodecaurelia</i>
Tulun, Irkutsk region, Angara's basin	TRB 99-3	<i>P. biaurelia</i>
	TRB 99-8	
	TRB 99-22	<i>P. primaurelia</i>
	TRB 99-9	
Baikal Lake (neighbourhood)	BL 15-11	<i>P. dodecaurelia</i>
	BL 15-12	
	BL 26-10	<i>P. biaurelia</i>
	BBR 178-8	
Bolshiye Koty, small river near Baikal Lake	BBK 196-1	<i>P. biaurelia</i>
Buriatia region (east from Baikal lake)	ZB 67-1	<i>P. dodecaurelia</i>
	ZB 67-5 (2 clones)	
	ZB 98-1	<i>P. biaurelia</i>
Kamchatka, Petropavlovsk Kamchatski	KPK 175-4	<i>P. dodecaurelia</i>
	KPK 175-11	
	KPK 175-13	
	KPK 156-7	
	KPK 143-17	<i>P. primaurelia</i>
	KPK 143-18	
Kamchatka, Lake Chalaktyrskoye	KCH 182-1	<i>P. dodecaurelia</i>
	KCH 183-6	
	KCH 180-1	<i>P. primaurelia</i>
	KCH 183-7	
Kamchatka, The Valley of Geysers	KVG 108-2	<i>P. primaurelia</i>
	KVG 108-6	
	KVG 108-9	
	KVG 109-2	
	KVG 110-4	
	KVG 110-5	
	KVG 110-9	
	KVG 111-1	
	KVG 111-4	
	KVG 111-5	
	KVG 125-5	
	KVG 125-8	
	KVG 127-3	
	KVG 127-4	
	KVG 128-5	
	KVG 128-13	
	KVG 133-1	
	KVG 133-3	
	KVG 140-13	
	KVG 141-3	
	KVG 143-1	
	KVG 143-9	
Kamchatka, Nalychevo peninsula, Nalychevo Lake	KNN 128-13	<i>P. dodecaurelia</i>

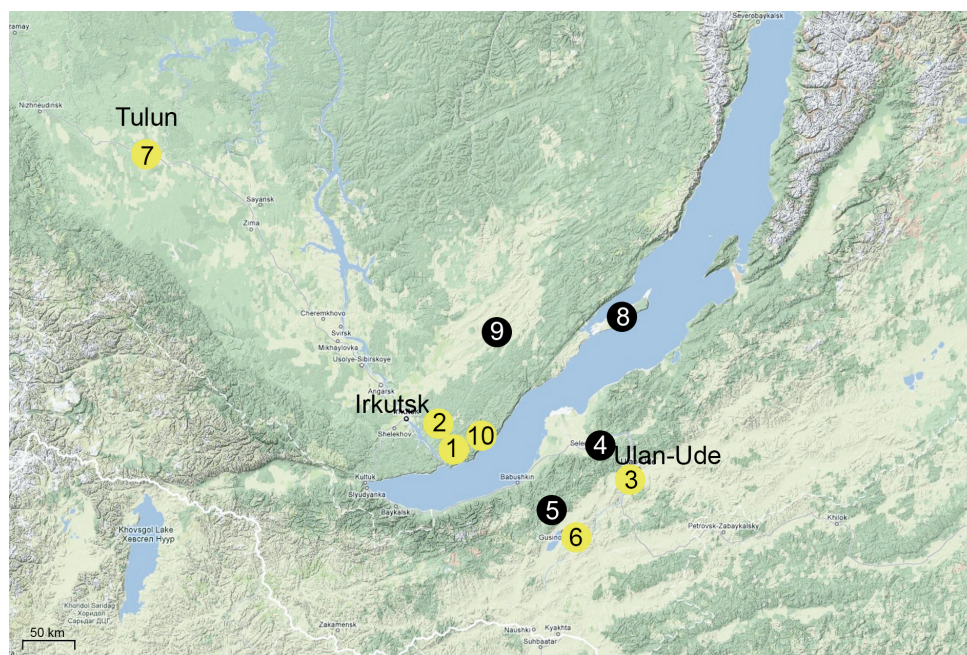


Fig.1. Map representing the Irkutsk region with collecting sites of the *P. aurelia* species (yellow circles) and other species of *Paramaecium* (black circles) marked by numerals. Letters (as BL etc) designate particular samples. 1. Listvyanka: BL14 (*P. caudatum*), BL15 (*P. bursaria*, *P. aurelia* spp.), BL16 (*P. bursaria*, *P. caudatum*), BL26 (*P. caudatum*, *P. aurelia* spp.), BL28 (*P. bursaria*). 2. river Bolshaya: BBR41 (*P. bursaria*), BBR44 (*P. caudatum*), BBR49 (*P. caudatum*), BBR51 (*P. caudatum*, *P. bursaria*, *P. putrinum*), BBR53 (*P. caudatum*), BBR54 (*P. caudatum*), BBR56 (*P. caudatum*), BT158 (*P. caudatum*), BBR168 (*P. caudatum*), BBR174 (*P. caudatum*, *P. bursaria*), BBR177 (*P. caudatum*), BBR178 (*P. bursaria*, *P. aurelia* spp.), BBR179 (*P. caudatum*), BBR180 (*P. caudatum*, *P. bursaria*), BBR181 (*P. caudatum*), BBR182 (*P. caudatum*), BBR189 (*P. bursaria*). 3. Transbaikalia, Ulan-Ude: ZB67 (*P. aurelia* spp.). 4. ZB73 (*P. caudatum*), ZB75 (*P. caudatum*). 5. ZB89 (*P. putrinum*), ZB94 (*P. caudatum*), ZB96 (*P. caudatum*). 6. ZB98 (*P. aurelia* spp.). 7. Tulun: TRB99 (*P. caudatum*, *P. aurelia* spp., *P. multimicronucleatum*), TRB101 (*P. bursaria*, *P. aurelia* spp., *P. multimicronucleatum*), TRB104 (*P. caudatum*), TRB105 (*P. caudatum*). 8. Olkhon island: BOR111 (*P. caudatum*), BOR120 (*P. polycaryum*), BOB130 (*P. calkinsi*, *P. bursaria*, *P. caudatum*). 9. Bayandinka river: BOB140 (*P. caudatum*). 10. Bolshiye Koty village: BBK196 (*P. bursaria*), BBK197 (*P. caudatum*, *P. bursaria*), BBK200 (*P. caudatum*).

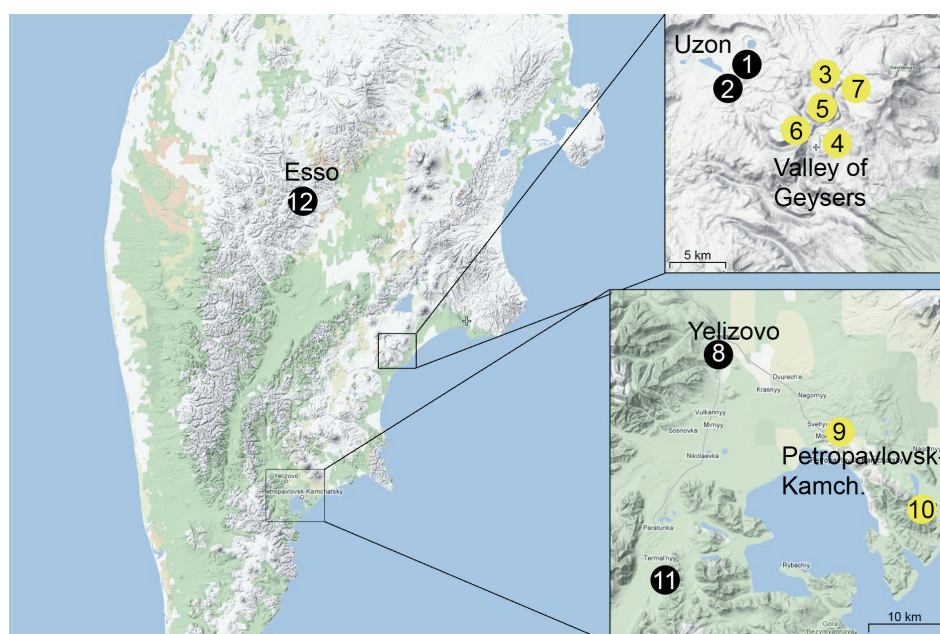


Fig. 2. Map of Kamchatka peninsula with collecting sites of the *P. aurelia* species (yellow circles) and other species of *Paramaecium* (black circles) marked by numerals. Letters (as KUZ etc) designate particular samples. 1. KUZ 32 (*P. putrinum*), KUZ 44 (*P. putrinum*), KUZ 47 (*P. putrinum*, *P. caudatum*), KUZ 70 (*P. putrinum*), KUZ 75 (*P. putrinum*), KUZ 76 (*P. putrinum*), KUZ 79 (*P. putrinum*), KUZ 80 (*P. putrinum*), KUZ 81 (*P. putrinum*), KUZ 85 (*P. putrinum*, *P. caudatum*). 2. KUZ 62 (*P. putrinum*), KUZ 95 (*P. putrinum*, *P. caudatum*), KUZ 96 (*P. putrinum*, *P. caudatum*), KUZ 100 (*P. putrinum*), KUZ 101 (*P. putrinum*). 3. KVG 108 (*P. aurelia* spp., *P. caudatum*), KVG 109 (*P. aurelia* spp.), KVG 110 (*P. aurelia* spp., *P. caudatum*), KVG 111 (*P. aurelia* spp., *P. caudatum*). 4. KVG 125 (*P. aurelia* spp.). 5. KVG 127 (*P. aurelia* spp.), KVG 128 (*P. aurelia* spp.), KVG 129 (*P. aurelia* spp.). 6. KVG 133 (*P. aurelia* spp.). 7. KVG 140 (*P. aurelia* spp., *P. caudatum*), KVG 141 (*P. aurelia* spp.), KVG 142 (*P. aurelia* spp.), KVG 143 (*P. aurelia* spp., *P. caudatum*). 8. KE 168 (*P. putrinum*), KE 171 (*P. caudatum*). 9. KPK 175 (*P. aurelia* spp., *P. caudatum*). 10. KCH 180 (*P. caudatum*), KCH 182 (*P. aurelia* spp.), KCH 183 (*P. aurelia* spp.). 11. KCH 186 (*P. multimicronucleatum*). 12. KES 196 (*P. bursaria*, *P. caudatum*), KES 198 (*P. caudatum*), KES 206 (*P. caudatum*).

this species. The presence of *P. primaurelia* was recorded earlier on the Kamchatka peninsula by DAGGETT (1978, data in POTEKHIN *et al.* 2010) but without designation of the sampling site. The species is cosmopolitan among other species of the *P. aurelia* complex (SONNEBORN 1975) and recorded in Russia in cold, moderate and warm zones (POTEKHIN *et al.* 2010).

P. biaurelia was found in Tulun, Irkutsk region (three strains TRB 99-3, TRB 99-8, and TRB 99-22, it occurred with *P. primaurelia* in the same sample); the vicinity of Lake Baikal (strains BL 26-10, BBR 178-8, together with *P. dodecaurelia*); Bolshiye Koty, in a small river near Baikal Lake (strain BBK 196-1); in the Buriatia region (strain ZB 98-1, together with *P. dodecaurelia*). *P. biaurelia* is considered a cosmopolitan species by SONNEBORN (1975), in Russia it has been found before in cold and moderate zones (data in POTEKHIN *et al.* 2010), also in Siberia and the Russian Far East, confirmed at present.

New stands of *P. dodecaurelia* were recorded in Cheboksary in the European part of Russia (strains ChD 5-1, ChD 8-2, ChD 8-16, ChD 10-1), and other stands located in Asian Russia, i.e. Novosibirsk (strain NRB 217-3); the vicinity of Lake Baikal (strains BL 15-11, BL 15-12); Buriatia (strains ZB 67-1, ZB 67-5); Kamchatka, Petropavlovsk Kamchatski (strain KPK 175-4, KPK 175-11, KPK 175-13, KPK 156-7); Kamchatka, Lake Chalkatyrskoye (strains KCH 182-1, KCH 183-6), and Kamchatka, Nalychevo peninsula, Nalychevo Lake (KNN 128-13). Previously this species was recorded in Russia in Yaroslavl and Vologda regions and in Eastern Siberia (PRZYBOŚ *et al.* 2008; POTEKHIN *et al.* 2010). The species is distributed in the Palearctic, North America (USA), and Hawaii (PRZYBOŚ *et al.* 2008). Its intra-specific differentiation revealed by molecular markers will be described in the next paper (PRZYBOŚ *et al.* 2012).

The present paper brings new data on the occurrence of species of the *P. aurelia* complex in Russia, in some cases extending the range of species in Russia, but still most of its large territory remains unstudied (unsampled).

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