ISSN 1995-0829, Inland Water Biology, 2018, Vol. 11, No. 1, pp. 42–45. © Pleiades Publishing, Ltd., 2018.
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ZOOPLANKTON, ZOOBENTHOS AND ZOOPERIPHYTON

American rotifer *Kellicottia bostoniensis* (Rousselet, 1908) (Rotifera: Brachionidae) in the Kama Reservoir (Kama River, Russia)

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Received December 15, 2016

Abstract—The American rotifer *Kellicottia bostoniensis* (Rousselet, 1908) was first recorded in the Kama Reservoir (Kama River, Middle Volga basin) in 2012. The species was found in over 70% of the samples; its maximum abundance was 2000 ind./m^3. This alien species co-existed with closely related native species *K. longispina* (Kellicott). This is the easternmost location (56°–57° E) for *K. bostoniensis* in the Volga River basin and in Europe.

Keywords: Volga basin, Kama Reservoir, *Kellicottia bostoniensis*, new findings, species biology
DOI: 10.1134/S199508291801008X

INTRODUCTION

Kellicottia bostoniensis (Rousselet, 1908) is a North American species that penetrated in Europe in the first half of the 20th century. By the turn of the century, it became a common species in the rivers and lakes of Northern Europe [10, 12, 15, 16]. In the new century, *K. bostoniensis* began to actively spread to the east; it was recorded in the Ohre River (the basin of the Elbe River, Czech Republic) [13], and it was recently found in the old channel of the Sozh River (the Dnieper River basin) in Belarus [3].

In Russia, *K. bostoniensis* was first recorded in 2000 in lakes of the Karelian Isthmus [5]. Later, it spread widely in the rivers and lakes of the Upper and Middle Volga basin, Lake Onega, and Lake Ladoga and its tributaries [2, 17, 18]. In 2005–2012, *K. bostoniensis* was found in the reservoirs of the Upper Volga (Ivankovo, Uglich, and Sheksna reservoirs) [14]. In the basin of the Volga River, the rotifer spread, reaching 61° N in the north (lakes of the basins of the rivers Kema and Andoma), 55° N in the south (lakes of the basins of the Oka and Pra rivers), and 45° E in the east (the Kerzhenets River and the basin of the Cheboksary Reservoir) [18]. Therefore, *K. bostoniensis* has not been found to the east of 45° E.

Our goal was to describe ecology of the new species *K. bostoniensis* in the Kama Reservoir (the Kama River, Middle Volga basin).

MATERIALS AND METHODS

The material was collected during the regular monitoring of the Kama Reservoir conducted by the Perm Branch of the State Research Institute for Lake and River Fisheries (2012–2016) and in the expedition of the Institute for Biology of Inland Waters, Russian Academy of Sciences, in the Volga and Kama rivers in August, 2016. Total zooplankton samples (from the bottom to the water surface) were collected in 25 sections of the reservoirs with two or three sites in each (Fig. 1). We studied a deep-water zone (>6 m) along the flooded riverbed of the Kama River and its tributaries and a shallow-water zone (<3 m) along the right and left shores of the reservoir. Samples were taken by a small Juday net with an opening diameter of 120 mm and a mesh size 105–120 μm. The samples were fixed with 4% formalin. In the laboratory, rotifers were counted in the Bogorov chamber under LOMO MSP-2, Olympus SZ-51, and Stereo Discovery-V12 (Carl Zeiss) microscopes. We measured body and spine lengths of *K. bostoniensis* under an MBI-15 microscope with an ocular micrometer (LOMO).

The Kama (or Perm or Upper Kama) reservoir is the first step of the cascade in the Kama River, which was filled in 1954. The Votkinsk and Lower Kama reservoirs are located downstream. The area of the Kama reservoir is 1915 km^2, the mean depth is 6.4 m (the maximum depth is 30 m), and the water-exchange coefficient is 4.4 year^{-1} [8]. The length of the reservoir from the dam near Perm to the transient region in the mouth of the Vishera River, including the curvature of the reaches, is 350 km; the

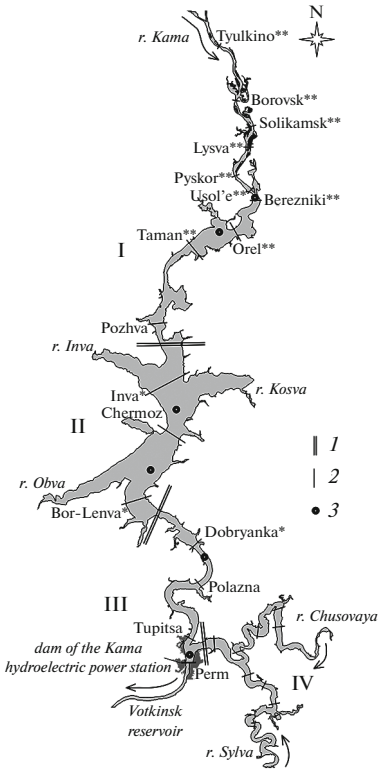

Fig. 1. Map of Kama reservoir from Matarzin [4]: location of hydrobiological sections of the State Research Institute of Lake and River Fisheries and sampling sites of the Institute for Biology of Inland Waters, Russian Academy of Sciences: (I) upper, (II) central, and (III) lower regions of Kama reach and (IV) Chusovskii reach. (*1*) Region boundaries; (*2*) sections of the State Research Institute of Lake and River Fisheries; and (*3*) sampling sites of the Institute for Biology of Inland Waters, Russian Academy of Sciences. *Solitary findings of *K. bostoniensis*. **Multiple findings of *K. bostoniensis*.

mean width is 5.5 km; and the maximum width is 13.5 km [4]. The reservoir regulates the seasonal river flow. Fluctuations of the water level during the year reach 7.5 m [8].

As follows from the map [4], there are two large reaches in the reservoir: the main (Kama) and regional (Chusovskii) reaches, with five hydrographic regions (Fig. 1). The regions of the Kama reach differ considerably in their morphometry. The upper region is an alternation of wide (to 9 km) and narrow (1.5–2.5 km) canals, the central region is a vast lakelike part of the reservoir, and the lower region is a deep-water and narrow area with steep banks.

The Kama reservoir is characterized by a considerable heterogeneity of the water chemical composition. The total mineralization varies from 40 to over 1000 mg/L, with the domination of sodium chloride water [1]. The lowest water mineralization (<350 mg/L) was registered in the upper region of the Kama reach near the transient region and in its lower region above the mouth of the Chusovaya River; the largest water mineralization was recorded near the towns of Solikamsk and Berezniki.

RESULTS

Alien species *K. bostoniensis* was first recorded in the autumn zooplankton samples collected in the Upper Kama reach in 2012. The new species coexisted with the local rotifer *K. longispina* (Kellicott), which was common in this reservoir [6, 7]. In the upper regions of the Kama reach, *K. bostoniensis* was found in all sample sites at a water temperature of 10–12°C, except for the lower region (Pozhva section) (Table 1). *K. bostoniensis* was found in 77% of the samples. Its abundance ranged from 20 to 2000 ind./m^3 (on average, 388 ± 85 ind./m^3). Rare individuals of *K. bostoniensis* (20 ind./m^3) were registered in the central region of the Kama reach close to the mouth of the Inva River (Inva section) at the right bank of the reservoir. In its lower region and Chusovskii reach, *K. bostoniensis* did not occur. In the samples of 2012, the body length with spines varied from 277 to 400 μm, on average 323 ± 8 μm (measurements of 23 individuals). The population included females with parthenogenetic eggs.

Zooplankton samples were not collected in autumn of 2013–2014. In the summer of 2014, at a water temperature of 17–25°C, rare individuals (60–90 ind./m^3) of *K. bostoniensis* were recorded in the upper (Pyskor section) and, for the first time, in the lower part (Dobryanka section) of the Kama reach.

In the autumn of 2015, in the upper part of the Kama reach, at a water temperature of 10–13°C, *K. bostoniensis* was distributed widely and was present in ~90% of the samples at a density of 72–627 ind./m^3 (on average, 228 ± 71 ind./m^3). It was rare in the central region. It was absent in the lower region of the Kama reach and in the Chusovskii reach of the reservoir. *K. bostoniensis* was not found in the Kama Reservoir in August 2016 at a high water temperature (26–30°C).

Therefore, *K. bostoniensis* is spread throughout the Kama reach of the reservoir. It was more frequently found in the upper region, where it was the most abundant (Fig. 1). This rotifer occurred in areas with different depths (1–15 m) in the Kama River, in the mouths of large tributaries of the Inva River, and in the open inshore waters of the reservoir (Table 1). The contribution of *K. bostoniensis* to the total zooplankton abundance was not high (1–3%), which is similar to the contribution of the native rotifer species *K. longispina* (Table 2). However, in some of the sites, the contribution of *K. bostoniensis* was more significant, especially in the autumn, when the total zooplankton abundance decreased. For example, in September 2012, in the flooded area of the Kama River of the upper region of the Kama Reach (Tyulkino and Borovsk sections), the share of *K. bostoniensis* reached 20–30% of the zooplankton abundance.

Table 1. Characteristics of the habitats of *Kellicottia bostoniensis* in the Kama Reservoir in 2012–2016

Sample sites, coordinates, N; E	Depth, m (T,°C)	Water transparency, m (pH)	Sample sites, coordinates, N; E	Depth, m (T,°C)	Water transparency, m (pH)
Tyulkino, 59°49′; 56°31′			Dobryanka, 58°28′; 56°22′		
R	6.0 (10)	1.0	LB**	2 (11)	1.2 (8.2)
Borovsk, 59°43′; 56°37′			Pyskor, 58°08′; 56°21′		
RB	1.0	1.0	RB	1.2 (12)	0.8 (8.5)
R	5.5 (11)	1.1	R	7–11 (12)	1.0–1.5 (7.4)
LB	1.0	1.0	LB	1–1.8 (11)	1.2 (7.4)
Solikamsk, 59°36′; 56°41′			Orel, 59°19′; 56°31′		
RB	1.0	1.0	RB	1.5 (12)	1.4 (7.6)
R	8.0 (11)	1.4	R*	8–10 (11–12)	1.2–1.7 (7.6)
LB	3.0	1.2	LB	1–2 (11–13)	1.3 (7.6)
Lysva, 59°35′; 56°39′			Taman, 59°17′; 56°22′		
RB	1.2	1.0	RB	1–2 (12)	1.0 (7.7)
R	6.5 (12)	1.2	R*	9–12 (12–13)	1.4 (7.7)
LB	1.2	1.2	LB	1.5 (12)	1.2 (7.8)
Usol'e, 59°26′; 56°41′			Berezniki, 59°24′; 56°42′		
R*	8 (11)	1.5	R*	7.5 (11)	1.5 (8.4)
LB	1.8	1.5	LB	1.2	1.8
Bor-Lenva, 58°60′; 56°09′			Inva, 58°47′; 56°15′		
R**	15 (11)	1.5 (7.5)	RB*	1.5 (13)	0.9 (8.4)

R, riverbed of the Kama River; RB and LB, right and left banks of the reservoir, respectively; and T, water temperature. Water color: * 25 mg Pt/L; ** 40 mg Pt/L.

DISCUSSION

Most of the habitats of *K. bostoniensis* are located in rivers and lakes [3, 10, 12, 13, 15, 16]. In the large reservoirs of the Volga basin, it appeared only after 2004 [14]. In the European part of Russia, this alien species occurs in over 40 water bodies of the basins of the Caspian and Baltic seas at 55°–61° N and 29°–44° E [18]. Findings of the rotifer in the Kama Reservoir have significantly expanded the range of the species to the east (to 56°–57° E). Nowadays it is the easternmost location of the rotifer in the Volga basin and Europe.

K. bostoniensis has a capacity for high ecological plasticity, which enables it to colonize water bodies differing in trophic status, water salinity, color, and pH [18]. Previously, *K. bostoniensis* was recorded only in deep-water areas of the Volga reservoirs [14]. However, in the Kama reservoir, the species was found equally frequently at depths of >5 and <3 m (Table 1). Inshore, the rotifer is commonly more abundant than offshore at deep sites [17]. In Russia, *K. bostoniensis* occurs in a wider range of water color (30–680 mg Pt/L) when compared to other European countries [18]. In the Kama Reservoir, the rotifer occurs in waters with color of 25–40 mg Pt/L, which is close to the lower threshold of the parameter for this species.

The rotifer reached high abundances at water temperatures in the range 5–20°C [18]. In Russian reservoirs, the peak of *K. bostoniensis* abundance usually occurs in July [18]; in Scandinavian lakes, the rotifer attained maximum abundance in August [9]. In the Kama Reservoir, the rotifer was the most abundant in

Table 2. Abundance of rotifers of the genus *Kellicottia* and total number of rotifers and zooplankton (Cladocera, Copepoda, and Rotifera) in the upper region of the Kama reach of the Kama Reservoir in 2012 and 2015.

Taxa	2012 (30)	2015 (9)
Kellicottia bostoniensis	$\frac{388 \pm 85}{1}$	$\frac{228 \pm 71}{3}$
K. longispina	$\frac{1472 \pm 891}{4}$	$\frac{80 \pm 36}{1}$
Rotifera	$\frac{19824 \pm 8598}{58}$	$\frac{2122 \pm 665}{28}$
Total zooplankton	$\frac{34046 \pm 13706}{100}$	$\frac{7617 \pm 2711}{100}$

Above the line is the average abundance ±SE, ind./m^3; under the line is the percent of the total abundanece, %. The number of samples are given in parentheses.

the autumn (September) at a water temperature of 10–12°C. In the summer, at 20–25°C, it was rare; in August 2016, at 26–30°C, it was absent in the plankton samples. Presumably, high temperatures (>20°C) negatively affect *K. bostoniensis* development.

In the upper part of the Kama reach, *K. bostoniensis* cooccurred with *K. longispina* in >70% of the samples; in 10–18% of the samples, only one of these species was present. In the central and lower regions of the Kama reach, *K. longispina* dominated over *K. bostoniensis*. The average and maximum abundances of the alien rotifer in the Kama Reservoir were low and similar to those recorded in the Ivankovo Reservoir (Upper Volga) [14] but significantly lower than in the rivers and lakes [17, 18].

K. bostoniensis in the Kama reservoir is distinguished by a large body length (280–400 μm). It is similar to the representatives of this species from the Volga reservoirs and Valdai lakes [14, 17], and its sizes are close to the sizes of this species from the lakes of Scandinavia and North America [9, 11].

CONCLUSIONS

K. bostoniensis was first recorded in the upper reaches of the Kama reservoir in the autumn of 2012. This species was found in over 70% of the samples. By 2015, it had spread throughout the Kama reach. It was most abundant in the upper region in autumn at water temperatures in the range 10–12°C. In the Chusovskii reach of the reservoir, this species was absent. This alien rotifer was equally frequently found inshore, where its maximum abundance reached 2×10^3 ind./m^3. It coexisted with a local closely related species *K. longispina*. Kama reservoir is the fourth reservoir in the cascade of the Volga River where *K. bostoniensis* was recorded. It is currently the easternmost point (56°–57° E) in the basin of the Volga River and Europe.

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Translated by I. Feniova