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Ixodid ticks in St. Petersburg: a possible threat to public health

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Abstract. Seasonal field investigations of the distribution and abundance of four ixodid tick species in the urban area of St. Petersburg and of their host species – small, medium-sized, and large vertebrates – were carried out in 2006–2010. A total of 27 sites in this area were studied. Stable populations of ixodid ticks were present in forests near the Morskaya railway station, in the Lake Razliv region, the Northern and Southern cemeteries, and the Rzhevskij and Nevskij forest parks. These areas are most dangerous for people. The largest number of the ticks *Ixodes persulcatus* in St. Petersburg was 18 adults per 1 dragging hour (in the forest near Lake Razliv).

Key words: ixodid ticks, urban areas, *Ixodes persulcatus*, *Ixodes ricinus*, *Ixodes apronophorus*, *Ixodes trianguliceps*.

INTRODUCTION

Traditionally, areas that are home to many small and medium-sized mammals and birds – hosts of ixodid ticks – have been reported as sources of ixodid tick-borne encephalitis and ixodid tick-borne borreliosis, the Q-fever, and a number of other tick-borne diseases in St. Petersburg and its surroundings (Antykova et al., 2006). In such areas more than 10 000 tick bites are recorded annually. More than 70 persons get diagnosed with tick-borne encephalitis and more than 300, with tick-borne borreliosis in St. Petersburg every year. In such cases the mortality rate has been reported as 1.5%. Needless to say that only a small part of cases get reported while considerably more patients may suffer without seeking medical treatment.

Recently, borreliosis in urban centres and dissemination of ixodid ticks on the territories of urban and semi-urban parks have received considerable attention (Daniel & Černý, 1990; Gern et al., 1997; Junttila et al., 1999; Romanenko, 2002; Ephremova & Yakovich, 2009). The most recent observations on ixodid ticks in St. Petersburg (former Leningrad) date back to the 1980s (Vershynsky et al., 1988; Smyslova et al., 1989). As a result of more than 20 years of monitoring the distribution of ixodid ticks and nidus of tick-borne encephalitis in St. Petersburg two ixodid tick species were reported: the forest tick *Ixodes persulcatus* (Sch., 1930) and the taiga tick *Ixodes ricinus* (L., 1758) (Vershynsky et al., 1988). It was

concluded that the distribution of both species follows an uneven mosaic pattern, leading to a wide variation in the degree of a potential danger of acquiring tick-borne encephalitis in the areas mentioned above. In particular, such areas as Petrodvortsovy, Krasnosel′skij, Pushkinskij, Kolpinskij, and Nevskij districts were characterized by a low abundance of ticks. The authors reported an absence of permanent populations of ticks in those areas, and suggested that findings of imagoes were a consequence of nymphs carried over by birds. On the contrary, the numbers of ticks were high in Primorskij and Vyborgskij districts (more than 11 adults per 1 dragging hour). The total number of specimens of ticks per 1 hectare reported during different years was 30 to 400 (Vershynsky et al., 1972, 1988; Vansulin & Malakhov, 1974; Vansulin et al., 1981; Smyslova et al., 1989). Uneven patterns in the distribution of ticks can be attributed to factors such as extermination of forests and road-building activities (Vershynsky et al., 1988).

However, these studies cannot be considered flawless with regard to the methods used. For example, no data on larvae and nymphs of *I. ricinus* and *I. persulcatus* and types of the nest type of parasitism of *Ixodes apronophorus* (Sch., 1930) and *Ixodes trianguliceps* (Birula, 1895) were collected; such data can be obtained only by catching small mammals, who are the main hosts of ticks (Daniel & Černý, 1990). Only Vansulin et al. (1981), using trapping methods in the territory of the Kurortnyj district, mentioned small mammals with almost no findings of ticks themselves on those mammals.

Taking into account recent trends of expanding city boundaries as well as substitution of wetlands and former landfills and horticultural lands by forests, additional studies on the distribution patterns of ixodid ticks and their hosts (small mammals) within the city of St. Petersburg are long overdue.

MATERIALS AND METHODS

During the period of 2006–2010 (May to September of each year), ixodid ticks were sampled in different areas of St. Petersburg by researchers of the Zoological Institute of the Russian Academy of Sciences. A total of 27 sites of this area frequently visited by residents of the city were studied (Fig. 1). The sites included the forest near Lake Razliv (1), near the Morskaya railway station (2), near the Northern (3) and Southern (4) cemeteries, forest parks (Rzhevskij (5), Udel′nyj (6), Untolovskij (7), Shuvalovskij (8), Shungerovskij (9), Sosnovskij (10), and Nevskij (11)), parks (Ekateringofskij (12), Forestry Academy (LTA park) (13), Pavlovskij (14), Aleksandrino (15), Sosnovaya Polyana (16), Botanical Garden BIN RAS (17)), territories of cemeteries (Crematorium (18), Okhtinskoe (19), Porokhovskoe (20), Konovievskoe (21), Krasnenkoe (22), Victims of January the 9th (23), Volkhovskoe (24), Smolenskoe (25), Serafimovskoe (26), and Bogoslovskoe (27)).

The forests near Lake Razliv and around the Southern cemetery and Nevskij forest park are large areas of deciduous forests located on the periphery of the city, which maintain contact with natural forests (or are part of them), with a predominance of birch and alder. These areas were characterized by a low

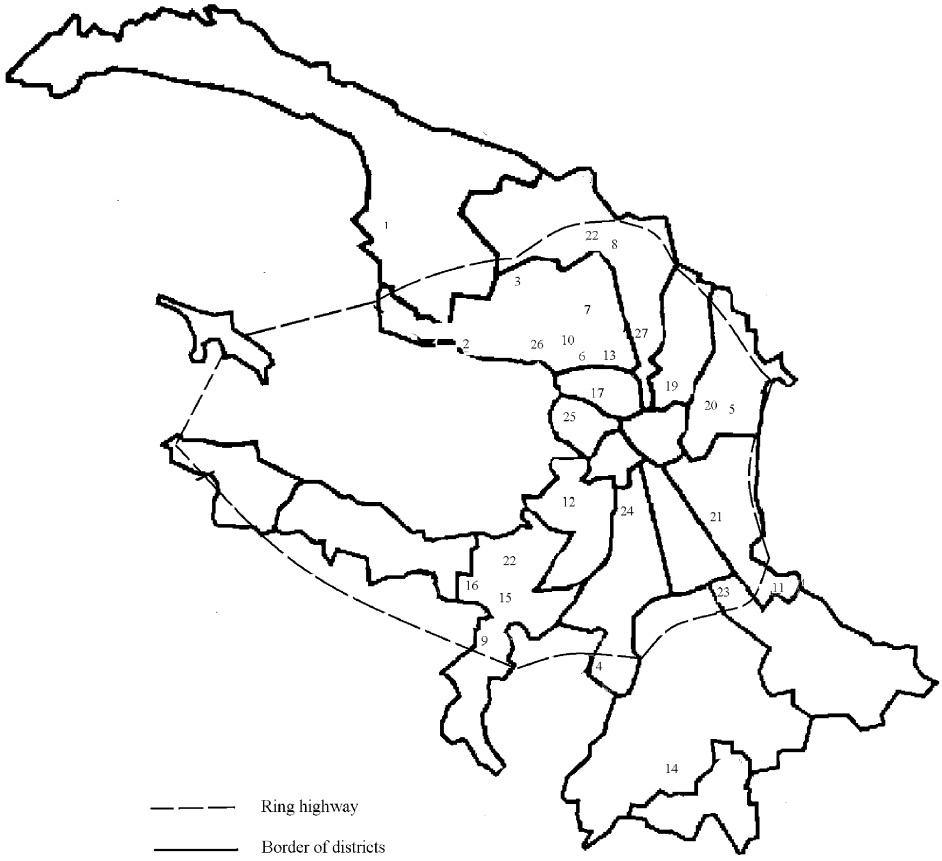

Fig. 1. Scheme of St. Petersburg with studied areas. *Forests*: (1) near Lake Razliv; (2) around the Morskaya railway station; (3) around the Northern cemetery; (4) around the Southern cemetery; *forest parks*: (5) Rzhevskij, (6) Udel′nyj, (7) Untolovskij, (8) Shuvalovskij, (9) Shungerovskij, (10) Sosnovskij, and (11) Nevskij; *parks*: (12) Ekateringofskij, (13) Forestry Academy (LTA park), (14) Pavlovskij, (15) Aleksandrino, (16) Sosnovaya Polyana, (17) Botanical Garden BIN RAS; *territories of cemeteries*: (18) Crematorium, (19) Okhtinskoe, (20) Porokhovskoe, (21) Konovievskoe, (22) Krasnenkoe, (23) Victims of January the 9th, (24) Volkhovskoe, (25) Smolenskoe, (26) Serafimovskoe, and (27) Bogoslovskoe.

anthropogenic pressure and a direct contact with large forest tracts, being thus favourable habitats for medium-sized and large wild mammals. Seven species of small mammals may inhabit these sites.

The forests near the Morskaya railway station and around the Northern cemetery, Shungerovskij and Rzhevskij forest parks, and the Pavlovskij park are extensive forest areas with abundant vegetation. These areas cannot be considered as favourable habitats for ticks (pine forests, deciduous wetland forests). However, some ties with natural (primary) forests remained even after the construction of the ring highway. These areas have moderate habitation conditions for medium-

sized and large wild mammals. Five to seven species of small mammals may inhabit these sites.

The areas of the Udel′nyj and Untolovskij forest parks and the Sosnovaya Polyana park are close to the city's quarters or surrounded by them (maintaining ties with forests in some cases). Scarce populations of large and medium-sized mammals – hosts of ticks *I. persulcatus* and *I. ricinus* – are typical for this type of habitat. Three to four species of small mammals may live here.

City parks (Aleksandrino, Sosnovskij, Forestry Academy, Ekateringofskij, and Botanical Garden) and cemeteries are quite small with lean vegetation surrounded by blocks of houses. The natural soil layer is severely damaged. The grass cover is subject to regular trampling. Medium-sized and large wild mammals are absent here. In most of these areas one species of small mammals is present.

The two methods used in the present study to collect ixodid ticks are those frequently applied in parasitology. Adult ticks *I. persulcatus* and *I. ricinus* were collected from vegetation from the end of April to mid-June (we do not describe isolated instances of collecting *I. ricinus* in August and September). The ticks were caught by dragging a 1-m^2 cotton cloth through the vegetation. Ticks of immature phases were collected from small mammals captured with Gero traps. A sequence of 100 traps was used in each case for two days. The traps were checked twice a day: in the morning and in the evening. Small mammals were caught during summer and in the first half of autumn.

Immature specimens of *I. persulcatus* and *I. ricinus* and all stages of *I. apronophorus* and *I. trianguliceps* were mounted on microslides in Faure–Berlese solution. Adult *I. persulcatus* and *I. ricinus* were determined with dissecting microscope. For the identification of the tick species we used the key by Filippova (1977).

For the purposes of the study, the following indicators were applied: the number of adult ticks per 1 dragging hour and the number of tick larvae, nymphs, or imagoes (of *I. apronophorus* and *I. trianguliceps*) per each mammal (the indicator of abundance). As an indicator of the abundance of small mammals, the number of animals per 100 traps per day was used. During all five years of the study, a total of 290 dragging hours were spent and 727 imagoes of ixodid ticks were caught. Small mammals belonging to 13 species (2183 specimens in total) were trapped in different areas of St. Petersburg during 10 800 trapping days.

RESULTS AND DISCUSSION

As mentioned above, larvae and nymphs of ixodid ticks were collected from small mammals. All captured animals belonged to 13 species. The bank vole *Myodes glareolus* Schreber, 1780, the common shrew *Sorex araneus* L., 1758, and the field mouse *Apodemus agrarius* Pall., 1771, made up the majority of the caught animals. It should be noted that different sites had different lists of host species. For instance, the territories at the boundary of the city were dominated by bank

vole and common shrew. In different years voles can contribute up to 89% and common shrews up to 63% of the total population of hosts. In areas located closer to the centre of the city the field mouse dominated accounting for up to 100% of the total host population. The remaining species were encountered much less frequently, and some of them were represented by single animals only (northern birch mouse *Sicista betulina* Pall., 1778, yellow-necked mouse *Apodemus flavicollis* Melchior, 1834).

In the samples collected *I. persulcatus* clearly dominated. Adult ticks were found in nine sites only (Table 1). The greatest numbers of them were observed in the secondary small-leaved forests in the north-western part of the city near Lake Razliv (18.4 adults per 1 dragging hour). Additionally, smaller numbers of this species were observed in the forest near the Southern cemetery (12.4 adults per 1 dragging hour) and in the Nevskij forest park (10.6 adults per 1 dragging hour). A chracteristic feature of these areas was a direct contact with large forest tracts and reduced anthropogenic pressure. Hence, the likelihood of medium-sized and large wild mammals using those areas as their habitats is high. Smaller numbers of ticks (up to 5 adults per 1 dragging hour) were observed in the Northern cemetery, the forest located close to the Morskaya railway station, and in the Rzhevskij forest park. These areas lost direct connection to large forest tracts after the construction of the ring highway. It should be mentioned that the number of ticks outside the ring highway was significantly higher than inside it (at $p < 0.05$).

The smallest numbers of adult ticks (no more than 1 adult per 1 dragging hour) were collected on the territories of the Shungerovskij and Untolovskij forest parks as well as in the Pavlovskij park.

Table 1. Localities where adult ticks were collected and the abundance of *I. persulcatus* and *I. ricinus* collected from vegetation (number of adults per 1 dragging hour) in St. Petersburg in 2006–2010*

Locality (numbers as in 'Materials and Methods')	Geographical coordinates		Abundance of ticks	
	Latitude, E	Longitude, N	*I. persulcatus*	*I. ricinus*
Forest near Lake Razliv (1)	60.0696	29.975	18.40 ± 5.60	0.05 ± 0.01
Forest near Southern cemetery (4)	59.7668	30.2083	12.40 ± 3.80	0.13 ± 0.02
Nevskij forest park (11)	59.8321	30.5666	10.60 ± 4.20	0.00 ± 0.00
Rzhevskij forest park (5)	59.9814	30.5094	3.44 ± 1.72	0.00 ± 0.00
Forest near Morskaya railway station (2)	60.0027	30.0705	4.84 ± 1.53	0.00 ± 0.00
Forest near Northern cemetery (3)	60.0578	30.2695	4.36 ± 1.56	0.00 ± 0.00
Pavlovskij park (14)	59.6933	30.4333	0.48 ± 0.92	0.00 ± 0.00
Shungerovskij forest park (9)	59.8518	30.0479	0.33 ± 0.09	0.00 ± 0.00
Untolovskij forest park (7)	60.0408	30.1913	0.15 ± 0.01	0.15 ± 0.03

* Only sites where adult ticks were found are listed.

The Shungerovskij and Untolovskij forest parks have a direct relationship with forests surrounding the city; however, because of the vegetation type they cannot be considered as favourable habitats for tick populations. The Pavlovskij park is surrounded by buildings of the residential area. This prevents the inflow of large hosts from outside, needed to maintain the population (dogs and hedgehogs being most frequent). In areas surrounded by urban development (urban parks and cemeteries) not a single adult specimen of *I. persulcatus* and *I. ricinus* was detected. This can be explained by the lack of appropriate conditions for ticks: no large or medium-sized mammals, small territory, rare tree and shrub vegetation, damaged upper layer of soil.

The largest numbers of larvae and nymphs were detected in the Nevskij forest park, in the Southern cemetery, and in the forest near Lake Razliv (Table 2). In general, there were many adults as well as a large number of immature stages of *I. persulcatus*.

In most cases, larvae and nymphs of *I. persulcatus* were found on bank voles (Fig. 2). Common and pygmy (*Sorex minutus* L., 1766) shrews and the minor forest mouse *Apodemus uralensis* Pall., 1811 play a significant role in the feeding of this tick: it was not found on other species of small mammals. This can be explained both by small numbers of other species of small mammals and by the fact that field mice do not usually live in habitats typical for *I. persulcatus*.

Adult *I. ricinus* were extremely scarce in our samples, which is consistent with the data reported earlier (Vershynsky et al., 1988). Individuals of *I. ricinus* were found in the areas of the Northern and Southern cemeteries, in the forest near Lake Razliv, the forest near the Morskaya railway station, and in the Shungerovskij and Untolovskij forest parks (Table 1). Larvae and nymphs of *I. ricinus* were rare in our samples (Table 2) and primarily found in paws of the bank vole and minor forest mouse (Fig. 1).

Larvae, nymphs, and adult *I. apronophorus* and *I. trianguliceps* were collected only from small mammals. The largest population of *I. trianguliceps* was observed in the Udel′nyj park (Table 2). It was not found in the Shuvalovskij forest park, in the Aleksandrino, Ekateringofskij, and LTA parks, the Botanical Garden, and the cemeteries. This tick mainly has as hosts field mouse, common shrew, and bank vole (Fig. 2). The important role of field mice in the feeding of *I. trianguliceps* can be explained by a considerable number of this species in the Udel′nyj forest park.

Ixodes apronophorus was found in the Untolovskij and Nevskij forest parks and the forest near the Northern cemetery. These areas are located near small rivers. The largest population of this species was observed in the Untolovskij forest park (Table 2). This species is common in habitats with high humidity and close to water bodies (Filippova, 1977). Therefore, this fact may explain the small number of the samples in which this tick was found. Most specimens of *I. apronophorus* had bank voles as a host (Fig. 2), with only a fraction of the population missing the tick altogether.

Table 2. Abundance of ticks collected from small mammals (number of individuals per 1 host) in different localities in St. Petersburg*

Site**	Species and development stage of ticks									
	I. persulcatus		*I. ricinus*		*I. trianguliceps*			*I. apronophorus*		
	Larva	Nymph	Larva	Nymph	Larva	Nymph	Adult	Larva	Nymph	Adult
1	1.15±0.90	0.02±0.02	0.20±0.20	0.00±0.00	0.08±0.06	0.17±0.11	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00
11	0.53±0.48	0.00±0.00	0.00±0.00	0.00±0.00	0.45±0.21	0.05±0.04	0.00±0.00	0.01±0.01	0.00±0.00	0.00±0.00
4	0.58±0.45	0.01±0.01	0.01±0.01	0.00±0.00	0.01±0.01	0.04±0.02	0.01±0.01	0.01±0.01	0.00±0.00	0.00±0.00
2	0.05±0.03	0.04±0.04	0.00±0.00	0.00±0.00	0.02±0.02	0.14±0.09	0.02±0.02	0.00±0.00	0.00±0.00	0.00±0.00
14	0.05±0.03	0.00±0.00	0.01±0.01	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00
5	0.10±0.07	0.02±0.02	0.00±0.00	0.00±0.00	2.21±1.32	0.34±0.16	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00
3	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.22±0.12	0.06±0.04	0.00±0.00	0.02±0.02	0.01±0.01	0.00±0.00
9	0.00±0.00	0.04±0.04	0.00±0.00	0.00±0.00	0.02±0.02	0.15±0.09	0.02±0.02	0.00±0.00	0.00±0.00	0.00±0.00
6	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	1.86±0.03	0.29±0.15	0.03±0.03	0.00±0.00	0.00±0.00	0.00±0.00
16	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.15±0.09	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00
7	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.25±0.12	0.17±0.08	0.05±0.03	0.62±0.18	0.07±0.04	0.02±0.02

* Only sites where ticks were found are listed.
** See Fig. 1 for sites.

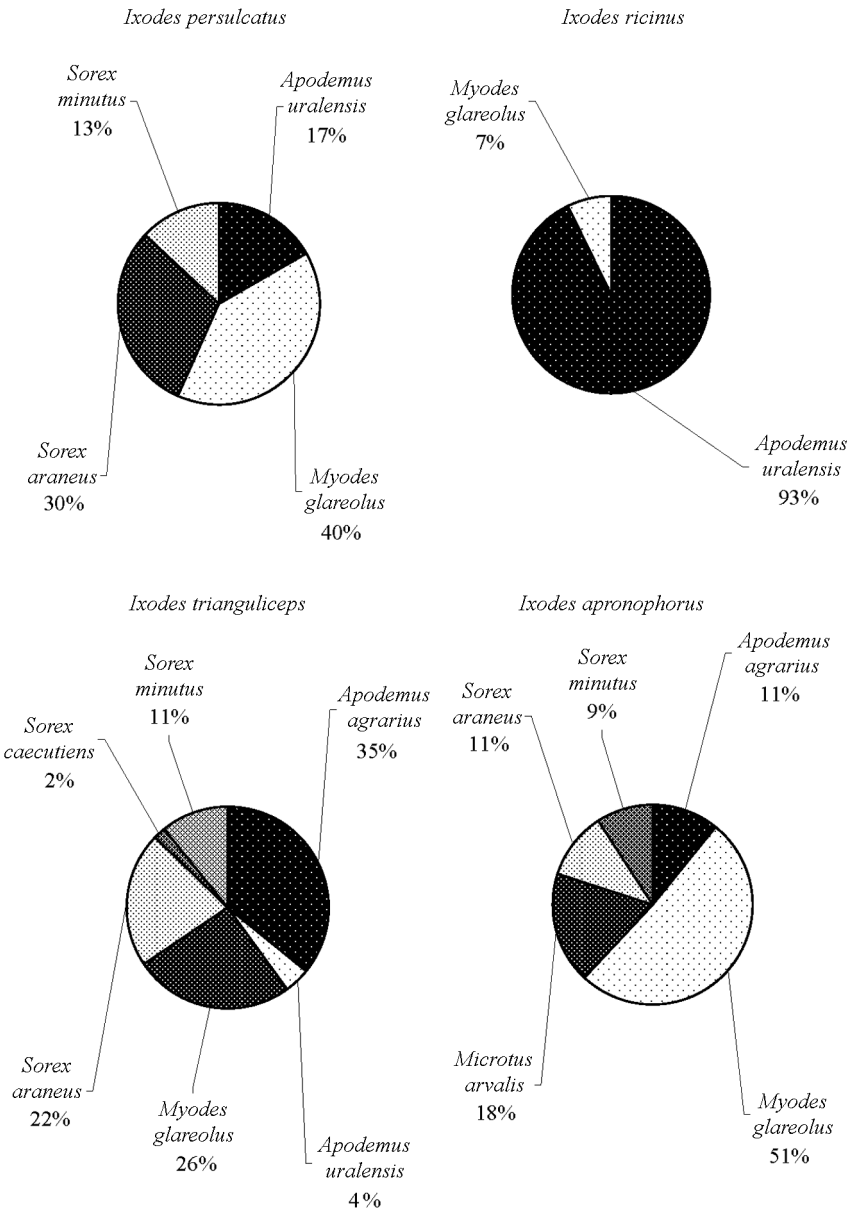

Fig. 2. Contribution of different species of small mammals in feeding ixodid ticks.

Based on the data collected and analysed, we suggest four different types of ixodid ticks' habitats:

I. Large areas of deciduous forests (sites 1, 4, 11 on the map) located on the periphery of the city outside of the ring highway that maintain contact with natural forests (or are part of them), with a predominance of birch and alder. These areas are characterized by a low anthropogenic pressure. These areas

were a favourable habitat for medium-sized and large wild mammals. This type favours populations of *I. persulcatus* and *I. ricinus*. The number of taiga ticks in these areas was more than 5 adults per 1 dragging hour.

II. Extensive forest areas with abundant vegetation, which cannot be considered as favourable habitats for ticks (pine forests, wetland forests). However, some ties with natural (primary) forests remained even after the construction of roads (sites 2, 3, 5, 9, 14). The number of taiga ticks in these areas did not exceed 5 adults per 1 dragging hour.

III. Parks close to the city's quarters or surrounded by them and maintaining ties with forests in some cases (sites 6, 7, 16). Large and medium-sized mammals – hosts of ticks *I. persulcatus* and *I. ricinus* – are not typical for this type of habitat. We suppose that in most cases the ticks found had been carried there by birds or feral dogs. We found only *I. apronophorus* and *I. trianguliceps* on small mammals in such parks. All stages of development of these ticks can feed only on small mammals.

IV. City parks and cemeteries with no findings of ixodid ticks. As examples of this type of habitat, such parks as Aleksandrino, Sosnovskij, Forestry Academy, Ekateringofskij, and Botanical Garden can be given (sites 8, 10, 12, 13, 15, 17–27). These areas are quite small with lean vegetation surrounded by blocks of urban areas. The natural soil layer is severely damaged. The grass cover is subject to regular trampling. Woody vegetation was mainly represented by artificial plantings. City parks and cemeteries cannot be considered as a favourable habitat for ticks either.

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Puugid Peterburis – võimalik oht rahva tervisele

Kirill A. Tretyakov, Sergey G. Medvedev ja Maria A. Apanaskevich

Aastail 2006–2010 viidi Peterburi piiresse jäävail aladel läbi välitööd puukide leviku ja arvukuse ning nende peremeesliikide – väikeste, keskmiste ja suurte imetajate – väljaselgitamiseks. Kokku uuriti läbi 27 piirkonda. Püsivad puugipopulatsioonid esinesid Morskaja raudteejaama ja Razlivi järve piirkonnas, Põhja- ning Lõuna-kalmistul ja Rževski ning Nevski metsapargis. Suurim laanepuugi arvukus oli Razlivi järve ääres. Need alad on puhkajatele ohtlikemad.