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Archaeoparasitological data and pathoecology of the town of Mangazeya in Western Siberia in the 17th century

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ABSTRACT

In 2002–2003 years, excavations were conducted in the town of Mangazeya, one of the northernmost Russian settlements in Western Siberia. Herein, we report data on the incidence and range of intestinal parasites discovered in samples taken from the occupation layer of Mangazeya and human and animal coprolites.

Among the eggs found, *Diphyllobothrium* sp. and *Opisthorchis felineus* eggs predominate. They were discovered in most of the examined samples. Considering the obtained results in a historical context, it can be concluded that the most frequent parasitoses in humans and dogs were associated with the consumption of raw fish. Consumption of poorly cooked and/or raw fish most likely derived from relatively stable dietary habits of the first Russian settlers in the region. The clinical problem can also be explained by the adaptation of the settlers to the conditions of the Far North where raw fish was served as an antiscorbutic agent. *Taenia* sp. eggs found in samples of toilet contents probably indicate that the fish-based diet was supplemented by beef and/or pork.

Our analysis also revealed eggs of two geohelminth species, *Ascaris lumbricoides* and *Trichuris trichiura,* in human coprolites and samples of toilet contents. Eggs of these geohelminths don`t reach the invasive stage at the latitude of Mangazeya. Nevertheless, we cannot exclude that local secondary foci of these invasions could have formed under certain conditions leading to infestations in the town.

This study made it possible to supplement, confirm, and reconstruct, in some detail, certain aspects of the economic activities conducted by the inhabitants of Mangazeya. For example, the high incidence of diphyllobothriasis and opisthorchiasis in dogs gives evidence that raw fish was an integral part of their diet. The discovery of *Oxyuris equi* eggs in a sample from the occupation layer confirms that the population of Mangazeya kept horses. The discovery of *Alaria alata* and *Capillariidae* sp. eggs in dog coprolites and samples from the occupation layer allows us to partly determine possible risk factors for some parasitoses in humans.

We took the pathoecological approach in this study, as particularly suitable for this kind of research, and, for the first time, it allowed us to outline the urban environment that appeared in the Far North of Western Siberia in the 17th century.

1. Introduction

Large towns appeared in the Western Siberian territory close to the Arctic Circle when the Russian population arrived there in the 17th century (Vershinin, 2018). However, much historical evidence suggests that Russian influence had been spreading over the northern lands of Western Siberia since the 11th–12th centuries, both through military campaigns and, indirectly, through trade (Vershinin, 2018).

Mangazeya is the first Russian town beyond the Arctic Circle in Siberia (Fig. 1). It was founded in 1601 on the Taz River to supply furs to the state treasury. The town was situated in the forest-tundra permafrost zone where it was impossible to plow. Nevertheless, its inhabitants, immigrants from the European part of Russia, strove to conduct traditional economic activities. Animal husbandry served as the foundation

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for this activity. They raised cows, pigs, some sheep, and hens for food. However, the meat of wild and domestic reindeer, poultry and fish were important sources of protein food. The residents of Mangazeya kept horses, raised dogs for hunting and transport, and cats to protect grain reserves from rodents (Kosincev and Lobanova, 2005). The town existed for just over 70 years. It experienced periods of rapid rise, prosperity and decline, and it was abandoned in 1672. The people moved to their Turukhansk wintering place (later, Staroturukhansk) situated on the Turukhan River, a left tributary of the Yenisei River.

The occupation layer of the site was frozen which explains why various organic materials, including micro-remains of animals, were well preserved. Archaeoparasitological studies of materials from the excavations of Mangazeya started in 2002–2003. Some of the results were published in 2013. A study of 4 dog coprolites and 2 samples from the occupation layer revealed the presence of *Opisthorchis felineus*, *Diphyllobothrium latum*, *Trichuris trichiura*, *Toxocara canis,* and *Fasciola hepatica* eggs (Kosincev et al., 2004; Istoricheskaya ekologiia…, 2013). However, we should take these results with a grain of salt because the authors didn't specify what technique they used to process the coprolites and samples from the occupation layer, and they didn't introduce any metric or morphological data concerning the found helminth eggs. The authors just mentioned that dog coprolites and the occupation layer, on the whole, were highly infected with helminth eggs, mainly opisthorchiasis, but they didn't offer any significant archaeological interpretation (Istoricheskaya ekologiia…, 2013). The lack of archaeoparasitological information prompted us to repeat the study, applying a proven methodology to a larger number of samples from the occupation layer and dog and human coprolites obtained during the excavations at the town of Mangazeya.

This study aims to determine the parasitic range of the town of Mangazeya, the cultural and natural factors that contributed to the spread of parasites there and those factors that hindered it. We outline the range of possible ways used by the urban Russian population to adapt to the harsh conditions of the Far North of Western Siberia. Finally, we consider our results in the context of parasitological data obtained at other archaeological sites of Western Siberia.

2. Materials and methods

Sample collection was carried out immediately during the excavations at the town of Mangazeya, taking care to prevent contamination, using, for example, individual tools and packaging material for each sample. Visually good preservation of organic material served as the criterion for sampling. The samples were taken from stratigraphic layers which were dated both according to the archaeological artifacts found in them and by the dendrochronological dating of wood samples (Vizgalov and Parkhimovich, 2008). Soil samples collected outside the territory of the archaeological excavations were used as a control sample. All samples were dried, packed in sealed plastic bags, and labeled. They were stored in the Museum at the Institute of Plant and Animal Ecology in Yekaterinburg. In 2017, the samples were transported to Tyumen Scientific Center for further work. The samples were further processed according to the repeatedly described standard scheme using a 0.5% solution of trisodium phosphate (Na_3PO_4). We use sedimentation technique to process the samples (Callen and Cameron, 1960; Slepchenko et al., 2020). The mass of samples of the occupation layer, as well as human and dog coprolites, varied from 1.0 to 100 g, depending on impurities, such as fragments of wood chips, sand, wool, or seeds. At least 20 microscope slides were prepared for each sample. Microscopic examination was carried out using AxioSkop 40 and MicMed 2, v.2. with 100 and 400 times magnification. AxioVision 4.6 and Scope Photo 3.0 were used to carry out the measurements.

In total, the examination covered 52 samples of the occupation layer and human and dog coprolites from the archaeological layers belonging to the first third of the 17th century, i.e., the earliest chronological period of the town's existence (Fig. 2). All samples were divided into three groups in laboratory conditions:

1. Samples of feces from a toilet. Three samples (No. 30, 35, 46) were obtained directly from the layer where the toilet was, around Building No. 16B, Mansion 3.
2. Human coprolites (17 samples)
3. Dog coprolites (15 samples)
4. Samples of the occupation layer that visually contained remains of human or dog coprolites or coprolites of other animals (20 samples).

Samples containing seeds of cloudberries and/or other berries were considered to be human coprolites. Samples containing fragments of bones, scales, and wool were considered to be dog coprolites.

It should be noted that the largest number of samples containing remains of human and dog coprolites were associated with the layers located next to wooden sidewalks of the "streets" or those located along the walls of houses (Fig. 2).

3. Results

The study of 52 samples obtained from the town of Mangazeya revealed eggs of six types of intestinal parasites (Fig. 3).

Fig. 1. Location of the town of Mangazeya, Western Siberia in the 17th century.

Fig. 2. The plan for the excavation of the town of Mangazeya. Localization of discovered coprolites.

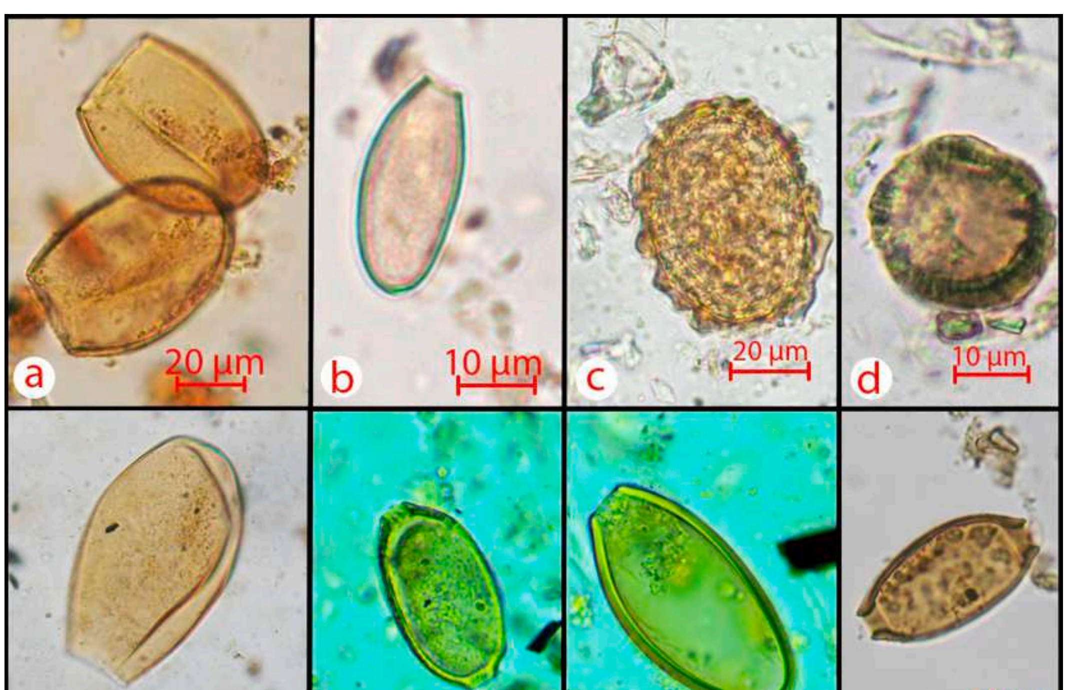

Fig. 3. Egg suggestive of *Diphyllobothrium* sp. (a), *Opisthorchis felineus* egg (b), *Ascaris lumbricoides* egg (c), and *Taenia* sp. eggs (d), *Alaria alata* (e), *Capillariidae* sp. (f), *Oxyuris equi* (g), *Trichuris trichiura* (h).

Oval-shaped light brown eggs with a "cap" (Fig. 3a) were discovered in 48 samples of the occupation layer and human and dog coprolites. A small knob can be seen opposite the cap on the other side of an egg. The average eggs is 67.4–72.8 in length and from 43.3 to 48.1 μm. Taking into account the above-mentioned morphological traits, we infer that the eggs belong to the genus *Diphyllobothrium* sp. (Ash and Orihel, 2007).

Eggs of this helminth were found in all dog coprolites (100%). As to the human coprolites and samples of toilet contents, and only one sample did not contain the eggs of this helminth (94%). The contamination of the occupation layer with *Diphyllobothrium* sp. eggs was up to 85%.

The morphological features of the following type of eggs resemble *Opisthorchis felineus* (Fig. 3b). They are oval-shaped, with a light yellow shell, an operculum, a weakly pronounced fold where the operculum is attached, and a shell-like pin on the opposite pole of an egg. Eggs size ranges from 32.5 to 33.7 in length and from 18.2 −18.7 μm (Ash and Orihel, 2007). Eggs of this helminth were found in 16 samples (Table 1). In particular, *Opisthorchis felineus* eggs were discovered in 2 samples of human coprolites in samples of toilet contents (12%) and in 5 samples of dog coprolites (33%). The contamination of the occupation layer was 45%.

Two samples (12%), a sample of toilet contents and a human coprolite sample, revealed brown oval-shaped eggs with a thick tuberous surface and amorphous contents. Egg size is from 90.1 to 94.5 in length and from 41.7 to 43.2 μm. Considering the morphology of the discovered eggs, we can argue that they belong to the intestinal parasite *Ascaris lumbricoides* (Fig. 3c). The tuberous shell also indicates that the eggs were infertile (Ash and Orihel, 2007).

Eggs of another type are light brown and spherical, and they have a thick angular striated shell. The average egg diameter is 34.2–42.7 in length and from 30.9 to 31.3 μm. These morphological traits let us suggest that these eggs belong to the *Taenia* sp. genus (Fig. 3d) (Ash and Orihel, 2007). Eggs with such morphological traits were found in 3 (18%) human coprolites.

Three human coprolites, samples of toilet contents (18%) and 3 samples from the occupation layer containing fragments of coprolites (15%) revealed elongated barrel-shaped eggs with a thick wall and a double outline. The contents and characteristic mucoid plugs at the poles of all eggs were absent. Egg size was 61.9–62.3 in length and from 24.6 to 25.2 μm. Considering these morphological and morphometric features and the circumstances of the finding, i.e., the fact that the feces from the toilet and coprolites belong to humans, we suggest that these are eggs of *Trichuris trichiura* (Fig. 3h) (Ash and Orihel, 2007).

Other eggs (n = 3) found in one sample (5%) of the occupation layer are also barrel-shaped with two polar plugs symmetrically located at both ends of the eggs. They have a two-layer shell and dimensions of 56.6–57.4 in length and from 25.3 to 25.8 μm. Nevertheless, the sizes of the found eggs and a pronounced reticulation of the outer shell let us suggest that these eggs belong to the *Capillariidae* family (Fig. 3f). We decided not to identify their species affiliation because eggs within the *Capillariidae* family are morphologically similar and extremely diverse (Ash and Orihel, 2007; Le Bailly et al., 2014).

One asymmetric egg sized 79.3 in length × 41.4 μm in width was found in one sample taken from the occupation layer (5%). One of its edges is more convex, and another one is flattened; the surface is smooth (Kassai, 1999; Dufour et al., 2015). Based on its typical morphology, we concluded that it belongs to *Oxyuris equi* (Fig. 3g).

The eggs we discovered in 2 dog coprolites (13%) are oval-shaped and have a light brown shell. Moreover, they don't have a shell-like pin on the opposite end and are characterized by rather large sizes of 106.3–119.9 in length and from 59.1 to 65.7 μm in width. Taking into account these morphological data and the fact that the eggs were found in dog coprolites, we assume that they belong to the trematodes of *Alaria alata* species (Fig. 3e) (Cherepanov et al., 2002).

The control sample, which was collected from the mainland part of the excavation site, was free of eggs.

4. Discussion

Not many archaeological sites have been investigated by the archaeoparasitological method in the territory of Russia and in Western Siberia (Slepchenko and Reinhard, 2018). All available archaeoparasitological materials related to Western Siberia can be divided into two groups: data obtained during studies at burial grounds and materials from settlements. Both groups of investigated archaeological sites are distinguished by the fact that they were established by the "pre-Russian" population of the northern part of Western Siberia. Burial materials are dated from the Early Middle Ages (7th–13th centuries) (Nakhodka Bay II, Zeleny Yar) (Slepchenko et al., 2019a, Slepchenko et al., 2019b) until the 17th - first part of the 20th centuries (Kikki-Akki, Vesakoiakha II-IV, Niamboito I) (Slepchenko and Ivanov, 2015; Slepchenko et al., 2016).

Archaeoparasitological studies of occupation layers of West Siberian settlements are even rarer. Materials from Nadym Gorodok have been studied and published for the present time (Slepchenko et al., 2019a, 2019b, 2019c). It was a settlement built by the indigenous population of Western Siberia, who lived in the town from the 12th to early 18th centuries (Sivkova et al., 2018; Slepchenko et al., 2019a, 2019b, 2019c). We can also mention a single study of a presumable dog coprolite found at the settlement of Yarte VI located in the Yamal Peninsula and dated back to the 10th-11th centuries (Slepchenko and Reinhard, 2018).

All of the above-mentioned archaeological sites were established by the indigenous population of the northern part of Western Siberia. They are distinguished by a similar range of parasite eggs found there. It should be noted that the archaeoparasitological range at all sites under consideration includes "fish" biohelminths (*Diphyllobothrium* sp., *Opisthorchis felineus*). At the same time, geohelminths are completely absent. Such an abundance of eggs of "fish" parasites suggests that the dietary regime of the Russian population of the town of Mangazeya resembled that of the indigenous peoples of the northern part of Western Siberia. Moreover, it was more akin to the dietary regime practiced by Nenet fishermen who built the Niamboito burial ground than to that of Nenet reindeer herders from the Vesakoiakha II-IV burial ground (Slepchenko et al., 2016).

It is well known that the main reason for the high incidence of diphyllobothriasis and opisthorchiasis is the consumption of raw and/or poorly cooked fish. This is true, both for ancient and modern times. The

Table 1
Parasite species found in samples and % of samples with eggs from the total number of samples.

	Diphyllobothrium sp.	*Opisthorchis felineus*	*Taenia* sp.	*Ascaris lumbricoides*	*Trichuris trichiura*	*Alaria alata*	*Capillariidae*	*Oxyuris equi*
Human coprolites	16/17 (94%)	2/17 (12%)	3/17 (18%)	2/17(12%)	3/17(18%)	0	0	0
Dog coprolites	15/15 (100%)	5/15 (33%)	0	0	0	2/15 (13%)		
Samples of the occupation layer that visually contained remains of human or dog coprolites or coprolites of other animals	17/20 (85%)	9/20 (45%)	0	0	3/20(15%)	–	1/20(5%)	1/20 (5%)
The control sample	0	0	0	0	0	0	0	0

permanent population of Mangazeya had to adapt their dietary regime to local food resources. This probably happened because Mangazeya was difficult to reach, and ships with food periodically capsized in the Gulf of Ob. That is why Russians borrowed some dietary habits of the local population (Aleksandrov, 1981). Fish was consumed in frozen (*stroganina*) and sun-dried (*yukola*) forms. Apparently, it was sometimes the only food resource that the inhabitants of Mangazeya enjoyed in sufficient quantities.

In point of fact, historical sources evidence that the Russian population of Turukhansk consumed raw and fermented fish. This town was founded by people who originated from Mangazeya after the latter had been abandoned in the 1670s. For example, I.S. Pestov mentions that the lifestyle of the residents of Turukhansk was not very different from that of "wild nomadic peoples, such as Tungus, Samoyeds, and Ostyaks". He notes that Russian residents of Turukhansk mostly ate raw frozen fish without salt. Sometimes, they even ate live fish (Pestov, 1833). Other researchers also mention that raw fish was eaten in the northern territories of Siberia. In particular, they note that both Russians and the indigenous population of the Siberian north consumed it to prevent and treat scurvy (lack of vitamin C) (Georgi, 1799; Chudnovskij, 1885). A similar dietary regime was observed among the population of the town of Yeniseisk (Eastern Siberia) in the 17th century (Slepchenko et al., 2020).

The excavations in Mangazeya demonstrated its occupation layer to be replete with fish bones and scales, a fact which additionally confirms that fish was an important food resource. According to ichthyological analysis, the remains belong to 9 fish species, in particular, the *Coregonidae* subfamily, including sturgeon, nelma, ide, crucian carp, Siberian roach, burbot, and common perch (Kosincev et al., 2004; Istoricheskaya ekologiya..., 2013). If consumed raw, all the above-mentioned fish species, except for sturgeon, could have been a potential source of infection with diphyllobothriasis. Fish species of the *Coregonidae* subfamily (broad whitefish, muksun, humpback whitefish, and peled) could be a source of infection with *Diphyllobothrium dendriticum*. Consumption of poorly cooked perch, pike, and burbot could lead to human infestation with *Diphyllobothrium latum* (Serdyukov, 1979).

Based on the parasitological range and the abundance of fish bones in the occupation layer of Mangazeya, we assume that fishing was an important and, possibly, dominant branch of the economy of the town's inhabitants. This assumption is confirmed by the excavated materials. Many wooden floats, fishing sinkers, fishing net needles, hooks, fishing lures, fish spears, and wooden knives for removing scales were found in the occupation layer of the town (Belov et al., 1981; Vizgalov and Parkhimovich, 2008). A few historical documents (customs books) contain data on a large number of commercial fishing tackle entering the Mangazeya market in 1633 and 1635 (Belov et al., 1981).

It should be noted that the researchers who conducted excavations of Mangazeya assume that the fish was consumed by the population of the town and used to feed sled and hunting dogs. This assumption was confirmed by the discovery of *Diphyllobothrium* sp. and *Opisthorchis felineus* eggs in all dog coprolites. This is also confirmed by 17th century historical documents on the Russian population of the northern part of Western Siberia and by ethnographic materials on indigenous peoples of Western Siberia who fed dogs with fish (Vizgalov and Parkhimovich, 2008). The results of our research confirm that assumption, too.

Interestingly, no natural foci of *Opisthorchis felineus* were found in the Taz River where Mangazeya was located. Nevertheless, eggs of this trematode were found in human and dog coprolites. The highest water temperature in the Taz River is $+15\,^{\circ}C$ in summer. These conditions are unsuitable for *Codiella inflate* and *Bithynia tentaculata* mollusks, which are the first intermediate hosts of the helminth. Therefore, the life cycle of *O. filineus* is hindered by natural factors (Be'er, 2005; Slepchenko, 2020). Reasoning from this fact, we can conclude that the population of Mangazeya couldn't be infected with this helminth if eating raw fish caught in the Taz River.

Even though Mangazeya was located outside the endemic focus of opisthorchiasis, the incidence of infection in the population of the town can be explained by its history. According to historical sources, Mangazeya was founded by Russian Cossacks headed by Duke Miron Shakhovskii. It happened in 1601 after they had already left the Siberian towns of Tobolsk and Berezovo (Vershinin, 2018). Moreover, the population came to the newly founded town mainly from settlements located in the Ob-Irtysh basin, which is hyperendemic for opisthorchiasis (Be'er, 2005). In this context, opisthorchiasis serves both as a marker of raw fish consumption and a marker of migration.

Along with eggs of "fish" parasites, the archaeoparasitological analysis of materials from the occupation layer of Mangazeya revealed *Taenia* sp. eggs. The infection is transmitted by, for example, eating contaminated meat of pigs, cattle, or reindeer brains. It is well known that humans can be infected with three types of cestodes: *Taenia saginata*, *Taenia solium,* and *Taenia asiatica*. Morphologically, they are very similar, and it is difficult to distinguish the eggs of these cestodes without conducting a genetic analysis (Rausch, 1985). However, we can exclude *Taenia asiatica* from this list because its distribution area, such as southern China, Korea, Thailand, Vietnam, or Indonesia, is geographically very far from where Mangazeya was located (Eom et al., 2009).

Two other cestode species, *Taenia saginata* and *Taenia solium*, can be considered as sources of eggs discovered in the feces of people who lived in Mangazeya. They could be infected with these helminths by eating contaminated cattle meat and pork. According to the results of excavations, the residents of Mangazeya ate meat of these animals. In particular, 8573 ungulate bones were gathered during the excavations of Mangazeya. We consider them to be kitchen remains. Among them, pig bones accounted for 42%, and cattle bones accounted for 15%. Bones of piglets and calves were found, too, which speaks to the presence of local livestock (authors' data). Moreover, it is known that cattle meat and pork were also brought to the town as food supplies from other territories (Vizgalov and Parkhimovich, 2008).

One can be infected with *Taenia saginata* cestode if eating the brains of infected reindeer. The helminth progresses to the invasive stage in the brain meninges of reindeer. At the same time, eating reindeer meat, even raw reindeer meat, is safe because *Taenia saginata* does not develop in their muscle tissues (Kirichek et al., 1984; Konyaev et al., 2017).

Reindeer bones excavated in Mangazeya accounted for 40% of the kitchen remains of ungulates. This suggests that the inhabitants of the town ate domestic reindeer meat bought from the local indigenous population and/or hunted reindeer. However, no ethnographic or historical data indicate that Russians consumed reindeer brains. Therefore, we doubt that reindeer could be a source of infestation of the Russian population of Mangazeya with teniarinchiasis. Nevertheless, the indigenous population that periodically lived in the town and its outskirts could have become infected with teniarinchiasis precisely by eating raw reindeer brains (Slepchenko et al., 2016). Therefore, it is likely that consumption of infected pork or cattle meat was the main reason for teniarinhosis and/or teniasis in the Russian population of the town of Mangazeya.

Eggs of two geohelminth species, in particular *Ascaris lumbricoides* and *Trichuris trichiura*, were found in human coprolites and samples of toilet contents. This finding means that the inhabitants of Mangazeya were infected with ascariasis and trichuriasis. Taking this discovery into account, we can conclude that the parasitological range of Mangazeya radically differs from that of other northern West Siberian sites populated by indigenous peoples. At the same time, the combination of geohelminths (*Ascaris lumbricoides* and *Trichuris trichiura*) brings the parasitological range of Mangazeya closer to European towns where the incidence of ascariasis and trichuriasis was quite high (Bartošová et al., 2011; King and Henderson, 2014).

It is commonly known that these helminthiases are transmitted through the fecal-oral route. This means that the eggs of geohelminths get into the host's body if s/he eats contaminated food or, less often, drinks unboiled water (Vozianova, 2000). People who do gardening and farming are among the most at-risk groups, especially if they fertilize the soil with non-neutralized human feces (Vozianova, 2000; Shin et al., 2011). However, this idea becomes irrelevant for the territories near the Arctic Circle because it is almost impossible to plow the land. Besides, natural conditions, such as short summer, cold soil, and permafrost, prevent the maturation of geohelminths in the soil. Taking these considerations into account, we suggest that almost all cases of ascariasis and trichuriasis in Mangazeya were imported. On the one hand, the population that founded Mangazeya and the people who visited it for various reasons might already have been infected with the helminthiases under consideration. On the other hand, contaminated vegetables and fruits that were delivered to Mangazeya from other Russian towns could be the cause of infection. For example, archaeological excavations revealed plum and cherry kernels in the occupation layer (Korona, 2010). According to the data of 1633 and 1635 customs books, prunes and garlic were imported to Mangazeya, among other things (Vizgalov and Parkhimovich, 2008).

At the same time, we cannot hold that it was completely impossible to get infected in the town. Local secondary foci of the above-mentioned invasions could be formed in Mangazeya if the population, or a part of it, didn't observe personal hygiene. In particular, the eggs of geohelminths could develop to the invasive stage in warm huts or sheds where pigs were raised and cattle were kept. A failure to observe personal hygiene, especially by those who were constantly involved in livestock management, could well have led to infestation with geohelminths directly in Mangazeya.

Eggs of the *Capillariide* family were found in one of the samples of the occupation layer, along with *Diphyllobothrium* sp. and *Opisthorchis felineus* eggs. Humans, dogs, cats, and other animals, such as rodents, could be infected with them. Indeed, evidence suggests cases of pseudoparasitism of this helminth in humans who could be infected by eating the meat of wild animals (Le Bailly et al., 2014). Dogs from Mangazeya infected with capillariasis could also be the source of the eggs found. It is well known that cats and rodents can be infected with capillariasis, too. Evidence leaves little doubt that cats and rodents were in Mangazeya (Vizgalov and Parkhimovich, 2008).

Alaria alata eggs found in some dog coprolites are not unique findings in the northern part of Western Siberia. Earlier, *Alaria alata* eggs were found in five dog coprolites taken from layers of the 17th-18th centuries in a study of the occupation layer and coprolites obtained at Nadym Gorodok, a settlement where the indigenous peoples of Siberia lived in the 12th-18th centuries (Sivkova et al., 2018; Slepchenko et al., 2019a, 2019b, 2019c). Based on the development cycle of *Alaria alata* (Akbaev et al., 1998), we can assume that sled and hunting dogs could become infected by eating the first intermediate hosts, such as frogs and tadpoles, from the surrounding water bodies, or by eating meat of reservoir hosts, such as sable, weasel, marten, and other mustelids, remaining after being skinned.

Alariasis (metacercariasis) is a parasitosis caused by *Alaria* sp. trematodes. It occurs quite rarely in humans and is associated with the consumption of poorly cooked meat like that of frogs or wild boars (Möhl et al., 2009). No available ethnographic or historical evidence supports that the Russian population ate the intermediate and reservoir hosts of *Alaria alata.* However, we can't discard helminthiasis caused by *Alaria* sp. as a risk factor for the inhabitants of Mangazeya.

Oxyuris equi eggs were also found in one sample of the occupation layer. This nematode is a parasite with a direct life cycle. It lives in the large intestine of horses and donkeys (Akbaev et al., 1998; Dufour et al., 2015). The bones of the latter were not found in Mangazeya, while horse bones were found in the occupation layer of the town everywhere. A small number of horses were kept and used in the household in all Russian towns in the north of Western Siberia (Vizgalov and Lobanova, 2017). *Oxyuris equi* is harmless to humans, but it could be relatively dangerous for horses kept in Mangazeya, which could cause complications, e.g., proctitis (Akbaev et al., 1998) and potentially cause the death of an animal, in turn damaging economic activities.

A previous study revealed *Fasciola hepatica* eggs in one sample of the occupation layer of Mangazeya (Istoricheskaya ekologiya…, 2013). Within our study, we were unable to confirm or refute their presence in the samples of the occupation layer and coprolites under consideration. It is possible that the sample of the occupation layer, analyzed in the previous study, had an admixture of manure of cattle or small ruminants. In this case, we would find *Fasciola hepatica* eggs. Indeed, our study did reveal one *Oxyuris equi* egg, along with *Opisthorchis felineus*, *Diphyllobothrium* sp., and *Trichuris trichiura* eggs, in one of the samples of the occupation layer, suggesting that the occupation layers might contain manure of herbivores.

We didn't find *Toxocara canis* eggs in either of the dog coprolites under consideration. Nevertheless, the results of previous research don't let us discard the possibility that dogs in Mangazeya suffered from this nematodiasis.

5. Conclusion

The urban environment, which first appeared in the Far North of Western Siberia in the 17th century, became a new factor affording ground for the spread of parasites among humans. The high population density and concentration of economic activity in a limited area, not very typical of the Far North of Western Siberia, probably led to deteriorating sanitary conditions and increased contamination with parasites in urban areas. The territory faced parasites that were not typical for it (*Ascaris lumbricoides*, *Trichuris trichiura*). Moreover, conditions for the development of those parasites appeared in the Far North.

At the same time, the population of the first Russian settlements in the northern part of Western Siberia couldn't stay unchanged. The settlers had to adapt their habits and dietary regime to the natural conditions of the Far North. They ate poorly cooked and/or raw fish because it was a relatively stable food tradition dating back to the time of the first Russian settlers. Moreover, they ate raw fish as an antiscorbutic agent as a way of adapting to the conditions of the Far North. This dietary habit was likely to have been partially adopted by the Russian first settlers from the indigenous population of the Far North of Western Siberia.

Archaeoparasitological data on other types of human and animal parasites were, for the first time, discovered during the study of samples taken from the town of Mangazeya. These data make it possible to supplement, confirm, and reconstruct some details and aspects of the economic activities conducted by the inhabitants of Mangazeya. Further elaboration on this promising topic based on the pathoecological approach will make it possible to determine cultural and natural adaptive factors that contributed to the spread of parasitoses, or hindered it, in the towns founded by Russian pathfinders, settlements, and places where the indigenous peoples of the northern part of Western Siberia lived.

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