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# Pathoecology of the town of Yeniseisk in Western Siberia from the 17th and 18th centuries

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A B S T R A C T

This article examines the prevalence and range of parasitic diseases based on soil sediment samples found in the town of Yeniseisk located in western Siberia.

These soil samples were taken from the sacral surface of 14 individuals buried at the cemetery of the Epiphany Cathedral dating back to the 17th century, and 15 samples of toilet contents taken from an 18th century mansion. It was found that *Diphyllobothrium* sp. eggs prevailed in the samples taken from the sacral surface. They were found in 64.3% of cases. At the same time, the prevalence of diphyllobothriasis does not depend on gender. *Ascaris lumbricoides* eggs were found in 1 individual, or 7.14% of the entire sample. However, *Ascaris lumbricoides* eggs prevailed in the toilet content of samples collected from the Yeniseisk manision. They were found in 14 of 15 samples (93.3%), while *Taenia* sp. eggs were found in 1 sample (6.7%).

Having examined the results within a historical context, we conclude that the high prevalence of Diphyllobothriasis in the Yeniseisk population, responsible for establishing this burial ground, was caused by consumption of raw fish or poorly cooked fish and persisted, owing to a relative stability of dietary habits dating back to the Pomors, who were the first Russian settlers in the region in the 17th century, as well as a tradition of eating fish adopted from the indigenous population of the Siberian North. Both traditions were probably adapted to Northern conditions and were considered, in particular, as antiscorbutic. Taenia sp. cestode eggs detected in the content of one toilet sample is indicative of having consumed contaminated, insufficiently boiled or roasted, raw beef and/or pork. The diet of the Russians who settled in Yeniseisk during the 18th century was probably more diverse and included a sufficient amount of beef and/or pork. The minimal prevalence of ascariasis in Yeniseisk in the 17th century, as identified by the present study, might reflect relatively satisfactory sanitary conditions based on the small initial population. However, as the population and its density grew during the 18th century, it is likely that the sanitary conditions deteriorated, possibly aggravated by frequent floods.

## 1. Introduction

Detection and identification of eggs of intestinal parasites in archaeological material and interpretation of the obtained data within a wide historical context allow us to reconstruct different aspects of the life of ancient people, including, for example, their nutrition and migration habits (Le Bailly and Bouchet, 2013; Reinhard, 1992; Mitchell, 2013; Reinhard and Vaughn, 1992; Araujo et al., 2008). It is also very important to determine the environmental, i.e., cultural, biotic, and abiotic, factors that could affect the incidence of parasitic diseases among ancient populations (Martinson et al., 2003; Morrow et al., 2016).

In particular, the urban environment, which was formed in the north of Siberia when the Russians settled there, created favorable conditions for the spread of parasites. High population density, which is a characteristic of the urban environment, and the concentration of economic activity within a small urban area contributed to the accumulation of a large amount of waste, leading to deteriorating sanitary conditions, including the breeding of a number of parasites in this particular town (King and Henderson, 2014; Shin et al., 2011; Kim et al., 2016).

Some studies have recently reported on parasitic diseases among different groups of the Siberian population. However, Russians who settled in both western and eastern Siberia in the 17th to the 20th centuries have been poorly studied (Slepchenko and Reinhard, 2018). Therefore, our study aimed to determine the prevalence of parasitic diseases, as well as identify and evaluate possible biotic, abiotic and cultural factors that may have contributed to the spread of parasites in

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**Fig. 1.** Location of the town of Yeniseisk, Russian Federation.

the Russian population living in the town of Yeniseisk (Fig. 1).

## 2. Material and methods

Archaeoparasitological research was based on soil samples obtained during archaeological excavations of the earliest burials at the Epiphany Cathedral in Yeniseisk, dating back to the early 17th century (Fig. 2), and during excavations of a toilet found around a nearby Yeniseisk mansion dating back to the first quarter of the 18th century (Fig. 3). Soil samples were taken from the sacral surface of 14 burials for archaeoparasitological analyses, and control samples were collected from the heads of the skeletons to verify if there was some sort of contamination (Fig. 4).

The content of the toilet pit consisted of layered sediments 0.9 m thick of a peat-like and relatively homogeneous structure with fragmented inclusions of dry grass, possibly hay, and large wooden pieces. We divided the entire mass into fifteen 6-cm segments and took samples from top to bottom. Each sample was put into a sterile plastic bag and labeled (Fig. 5).

In the lab environment, trisodium phosphate solution 0.5% ($Na_3PO_4$) was added to dry soil samples from 8 to 30 g and placed in an 800 ml beaker (Callen and Cameron, 1960). Beakers with samples were covered with absorbent paper, and the supernatant was drained one week later. The precipitate was run through a sieve with 200 μm mesh. The samples were separated into centrifuge tubes. The precipitate was collected by repeated centrifugation for 7 min (1500 rpm). Subsequently, glycerin was added to the samples. Twenty microslides were prepared for each sample, as recommended by standard methods (Araújo et al., 1998). AxioSkop 40 and MicMed 2 var. 2 under 80x and 400x magnification microscopes were used for examination. AxioVision 4.6 and Scope Photo 3.0 were used for measurement.

Sex determination and age details of the buried from which samples were taken came from a previous report on the results of excavations at the Epiphany Cathedral Cemetary (Matveev, 2019; Galuhin, 2019).

## 3. Results

Three types of intestinal parasite eggs were found during examination of the samples taken from the graves at the Epiphany Cathedral Cemetery and from the toilet pit found on the grounds surrounding the 17th century mansion (Table 1).

The eggs of the first type are oval-shaped, light brown, with a “cap” (Fig. 6 a,b). A small knob is opposite the cap on the other side of the egg. The average egg diameter is 66.4 μm × 42.6 μm. Taking into account these morphological traits, we can infer that the eggs belong to the genus *Diphyllobothrium* sp. (Ash and Orihel, 2007). This type of helminth egg was found in soil samples from the burials of 9 individuals, which accounts for 64.3% of the total number of the buried people under consideration. At the same time, these helminth eggs were discovered in 5 of 7 female (71.4%) and in 4 of 5 (80%) male individuals.

Except for *Diphyllobothrium* sp. eggs, 1 soil sample from among the 14 samples from burial No. 94 (7.14%) contained brown oval-shaped eggs with a thick tuberous surface and amorphous contents (Fig. 6 c,d). The eggs are 92.3 × 42.6 μm in size. Based on the morphology of the eggs found, we can conclude that they belong to *Ascaris lumbricoides* genus. The morphology of surface and size of eggs also indicates that the eggs were unfertilized (Ash and Orihel, 2007). A large number of *Ascaris lumbricoides* eggs with the same morphology as those from burial No. 94 were found in 14 of 15 (93.3%) organic layers taken from the toilet at the 18th century mansion.

Eggs of the third type are light brown and spherical; they have a thick angular striated shell (Fig. 6 e, f). The average egg diameter is 35.3 μm × 30.7 μm. Such morphological traits suggest that these eggs belong to *Taenia* sp. genus (Ash and Orihel, 2007).

The control samples collected from the heads of the skeletons taken during excavations at burials of the Epiphany Cathedral Cemetary and those gathered outside the mansion were free of eggs.

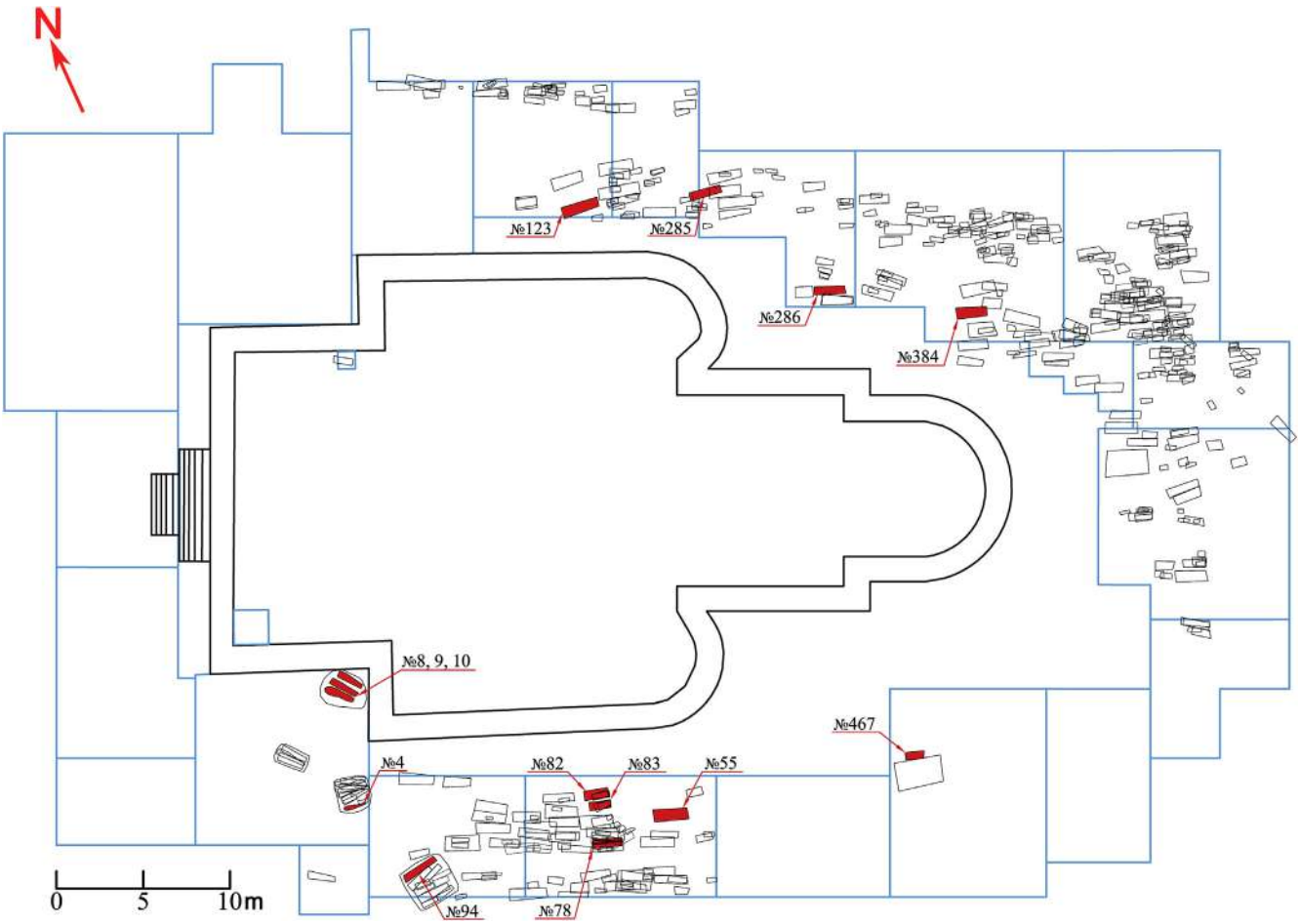


**Fig. 2.** The plan for the excavation of the burial ground of the Epiphany Cathedral. Distribution of burials on the archaeological site the Epiphany Cathedral. The red color marked burials dating back to the early 17th century. (For interpretation of the references to color in this figure legend, the reader is referred to the Web version of this article.)

## 4. Discussion

### *4.1. Dietary habits and parasitic diseases*

The main reason for the high prevalence of diphyllobothriasis, both in early and in modern times, is the consumption of raw and/or undercooked fish (Le Bailly and Bouchet, 2013). Currently, a high prevalence of diphyllobothriasis, exceeding the incidence rates in the Russian Federation by more than 10 times, has been observed in the Krasnoyarsk Territory wherein the town of Yeniseisk is located. In this context, the most epidemiologically important species are *Diphyllobothrium dendriticum* and *Diphyllobothrium latum* (Dmitrieva et al., 2016). Owing morphological homogeneity and without analysis of ancient DNA too hard to determine the exact species of eggs we discovered during the study (either *Diphyllobothrium Latum* or *Diphyllobothrium dendriticum*) (Delyamure et al., 1985; Scholz et al., 2009). Therefore, we

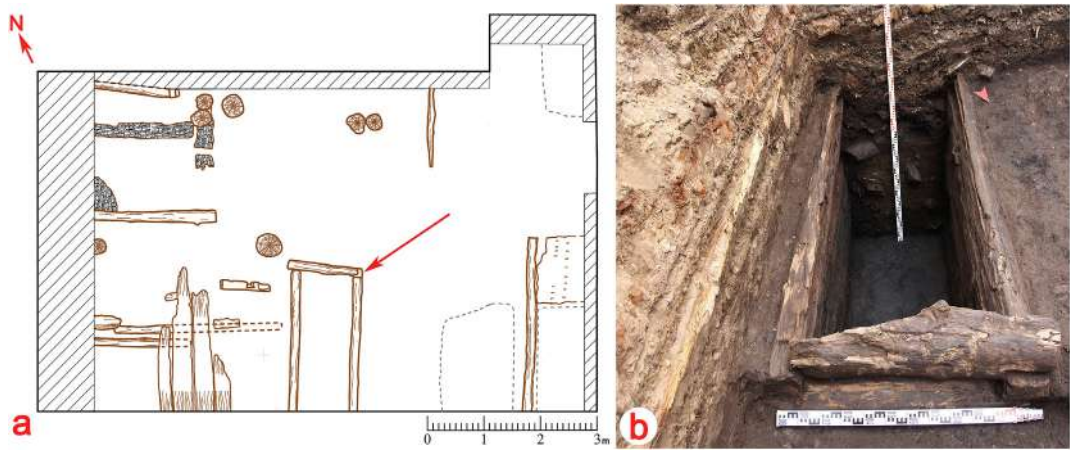


**Fig. 3.** The plan for the excavation of Yeniseisk mansion (a) and toilet (b) dating. back to the first quarter of the 18th century.

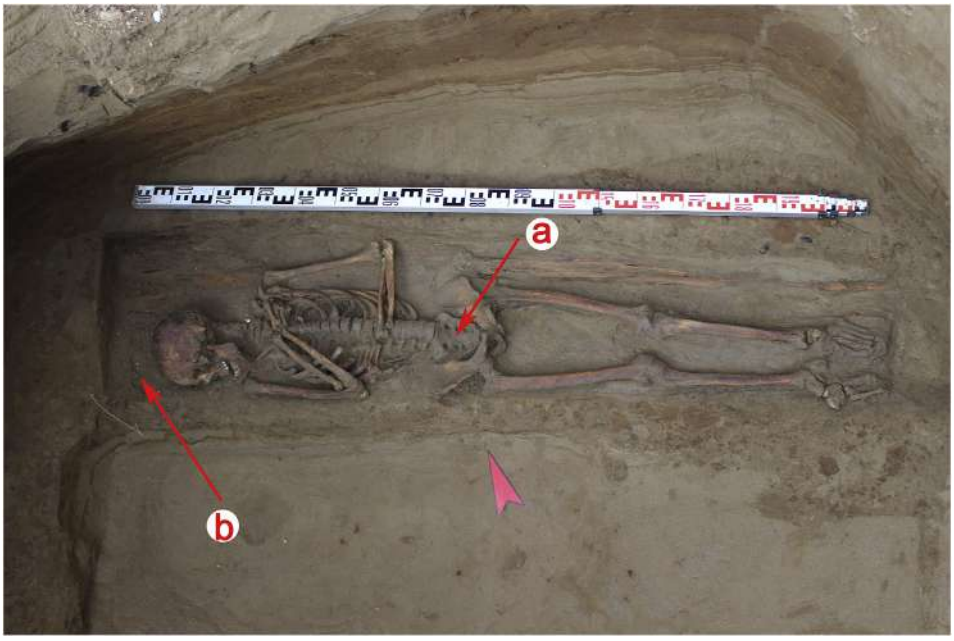


**Fig. 4.** Skeleton from Burial №10 at the Epiphany Cathedral in Yeniseisk. a. The place of sacral surface, where the soil sample was collected for the archaeoparasitological study. b. The place where the control soil sample was collected.

can only assert that the egg shells we discovered belong to the *Diphyllobothrium* cestode genus.

The high prevalence of the Diphyllobothrium cestodes we identified in the Russian population of Yeniseisk is not reflected in medical records or ethnographic and historical materials of the 17th through the 20th centuries. Nonetheless, a large amount of historical data are available for use in determining the probable causes of such high incidence of diphyllobothriasis in this specific population. As demonstrated by some historical studies, citizens of Yeniseisk, in particular, and of the Yenisei Territory, in general, primarily consisted of immigrants coming from the Russian North, namely from the northeastern part of European Russia and from northern and central Pomorie, in the second half of the 17th century (Aleksandrov, 1964). Siberia was initially settled by Russian Pomors, mainly along the territory of the West Siberian Far North, i.e., the territories inhabited by indigenous peoples of the Far North, such as Nenets, Khanty, Mansi, and Tungus. Pioneering explorers and first migrants to Siberia experienced difficulties in delivering food from Russia and had to adapt their dietary habits to local food resources, often adopting the dietary structure of the local population (Aleksandrov, 1981). At the same time, immigrants from Pomorie maintained their original traditions of eating fish used in Pomorie and Siberia until the 20th century. Fermentation is an example of a traditional way the Pomor cooked fish. S.V. Martynov describes fish fermentation in detail as follows: "… salted, spoiled and nasty smelling fish is the most widespread method. Local residents, in particular, women, eat this so-called "sour", or "fermented", fish with incomprehensible pleasure…. They find it more delicious, more healthy. … They cook it like this. They salt fish just a little bit because if you put more salt, it won't go sour. If the weather is warm, barrels with fish are kept in the sun. When the weather is cold, so fish cannot go sour, they bring it into the house and put it on the stove where it is kept for several days until it gets a sour taste and strong smell. In these conditions, it becomes completely soft, so you can easily remove the bones, and if the fish is well fermented, you just need to pull the tail slightly to completely remove the entire skeleton.…" (Martynov et al., 1905).

I.-G. Georgi presents one of the earliest observations of raw fish consumption by the first Russian settlers in Siberia. The author points out that Russian Cossacks lived in the cold northern and northeastern Siberian areas as poorly as the indigenous population. They ate wild plants and roots, raw meat and fish, often without bread and salt

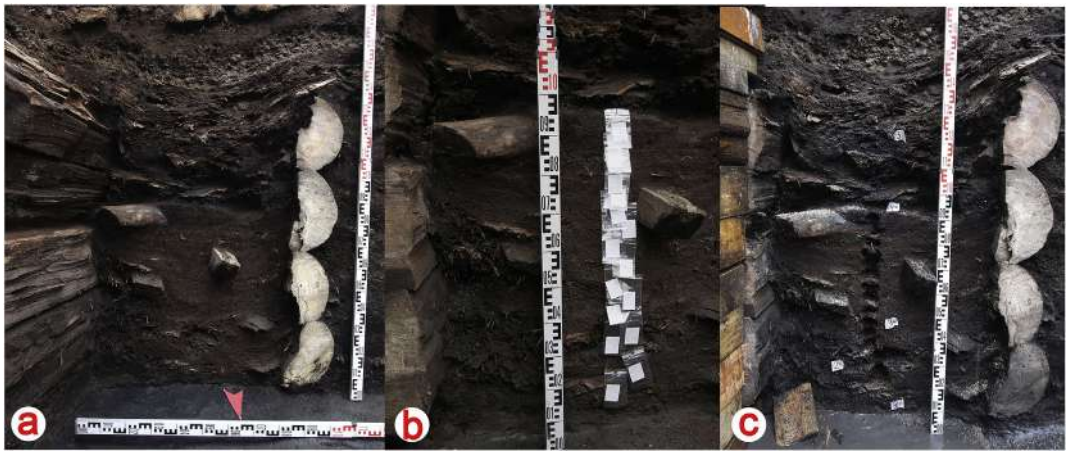


**Fig. 5.** Toilet sediment stratigraphy before (a,b) and after sampling (c).

**Table 1**
Ancient parasite species observed in the specimen from sacrum place of peoples buried of the cemetery of the Epiphany Cathedral and toilet layers.

| Sampling locations | Species of parasites | burial/Layer dating |
|---|---|---|
| The cemetery of the Epiphany Cathedral burial №4 | – | early XVII century |
| The cemetery of the Epiphany Cathedral burial №8 | – | early XVII century |
| The cemetery of the Epiphany Cathedral burial №9 | *Diphyllobothrium latum* | early XVII century |
| The cemetery of the Epiphany Cathedral burial №10 | *Diphyllobothrium latum* | early XVII century |
| The cemetery of the Epiphany Cathedral burial №55 | *Diphyllobothrium latum* | early XVII century |
| The cemetery of the Epiphany Cathedral burial №78 | *Diphyllobothrium latum* | early XVII century |
| The cemetery of the Epiphany Cathedral burial №82 | *Diphyllobothrium latum* | early XVII century |
| The cemetery of the Epiphany Cathedral burial №83 | *Diphyllobothrium latum* | early XVII century |
| The cemetery of the Epiphany Cathedral burial № 94 | *Ascaris lumbricoides* | early XVII century |
| The cemetery of the Epiphany Cathedral burial № 123 | - | early XVII century |
| The cemetery of the Epiphany Cathedral burial № 285 | *Diphyllobothrium latum* | early XVII century |
| The cemetery of the Epiphany Cathedral burial № 286 | - | early XVII century |
| The cemetery of the Epiphany Cathedral burial № 384 | *Diphyllobothrium latum* | early XVII century |
| The cemetery of the Epiphany Cathedral burial № 467 | *Diphyllobothrium latum* | early XVII century |
| Toilet, layer №1 | *Ascaris lumbricoides* | XVIII century |
| Toilet, layer №2 | *Ascaris lumbricoides* | XVIII century |
| Toilet, layer №3 | *Ascaris lumbricoides* | XVIII century |
| Toilet, layer №4 | *Ascaris lumbricoides*, *Taenia* sp. | XVIII century |
| Toilet, layer №5 | *Ascaris lumbricoides* | XVIII century |
| Toilet, layer №6 | *Ascaris lumbricoides* | XVIII century |
| Toilet, layer №7 | *Ascaris lumbricoides* | XVIII century |
| Toilet, layer №8 | *Ascaris lumbricoides* | XVIII century |
| Toilet, layer №9 | *Ascaris lumbricoides* | XVIII century |
| Toilet, layer №10 | *Ascaris lumbricoides* | XVIII century |
| Toilet, layer №11 | *Ascaris lumbricoides* | XVIII century |
| Toilet, layer №12 | *Ascaris lumbricoides* | XVIII century |
| Toilet, layer №13 | *Ascaris lumbricoides* | XVIII century |
| Toilet, layer №14 | – | XVIII century |
| Toilet, layer №15 | *Ascaris lumbricoides* | XVIII century |


**Fig. 6.** Egg suggestive of *Diphyllobothrium* sp. eggs (a, b), *Ascaris lumbricoides* eggs (c, d) and *Taenia* sp. eggs (e, f).

(Georgi, 1799). According to the author, among other reasons, eating raw fish resulted from the lack of firewood (Georgi, 1799). We suggest that this factor is relevant for the western Siberian tundra zone and was not relevant for residents Yeniseisk, which is located in a territory rich in Wood supplies.

I.S. Pestov presents detailed evidence of eating raw and fermented fish in Turukhansk Territory, which is located somewhat north of Yeniseisk. The author claims that the lifestyle of the residents of Turukhansk was very much like that of the "wild vagrant peoples, such as the Tungus, Samoyeds, and Ostiaks". He says that Russian residents of Turukhansk mainly ate raw, unsalted, frozen, and sometimes even live fish (Pestov, 1833).

According to M.A. Kastren, Russians with different socioeconomic status consumed raw fish for food and as an antiscorbutic agent, following the example of indigenous peoples. He writes in his book that "not only the Samoyeds, but even the Russians and Zyryans, became accustomed to eating raw fish and raw meat. I even met educated people who ate such food, especially frozen fish, which were thought to be excellent antiscorbutic prevention." (Kastren, 1860). Returning to the subject some pages later, the author comments on the way of life of those Russians who lived on the Yenisei River between Yeniseisk and Turukhansk as "little different from the natives during a fishing season… as soon as they drag out a net with fish, they split several live fish and immediately, like gulls, eat them without bread, or salt, or any seasoning. It is said that the consumption of raw fish protects against overwhelming scurvy" (Kastren, 1860). Later sources also cite the use raw fish as an example of an antiscorbutic agent. For instance, S.L. Chudnovskii reports as follows: "… Foreigners and Russians eat fresh raw fish, which, at the same time, is a good antiscorbutic remedy; besides, they eat frozen and dried fish" (Chudnovskii, 1885).

Therefore, the consumption of undercooked and/or raw fish caused the high prevalence of diphyllobothriasis among the Yeniseisk population. This way of consuming fermented or raw fish for food was, on the first hand, probably associated with relatively stable dietary habits originated from the Pomors, the first Russian settlers in the region, whose descendants formed the main part of the Yeniseisk population. On the other hand, the traditions of eating fish were adaptive in nature, serving, in particular, as an antiscorbutic agent, and the Russians adopted them, as such, from the indigenous population of the Siberian North.

The fact that no statistical differences in the prevalence of diphyllobothriasis were found between men and women suggests that the consumption of raw and/or undercooked fish probably did not depend on gender. This might be confirmed by ethnographic and historical literature as it does not refer to any differences in the fish consumption by men and women.

*Taenia* sp. eggs found in one of the toilet content samples represent an interesting case. Three types of taeniid cestodes can parasitize on humans. They are *Taenia saginata, Taenia solium,* and *Taenia asiatica*. The morphological difference among the eggs of these cestode species is hard to determine without using genetic analysis (Rausch, 1985). However, we might exclude *Taenia asiatica* cestodes from consideration as it is less likely that they could be a source of detected eggs since the habitat of this helminth is situated at a considerable distance from the town of Yeniseisk, e.g., in southern China, Korea, Thailand, Vietnam, and Indonesia (Eom et al., 2009). We suggest the two other types of cestodes (*Taenia saginata* and *Taenia solium*) to be the most probable sources of eggs found. The consumption of worm-infested beef and pork, which is confirmed by ethnographic literature regarding nutrition of the Russian population of Siberia, could lead to infection with these helminths (Aleksandrov, 1964; 81).

An analysis of zooarchaeological material discovered during archaeological excavations in Yeniseisk also revealed the predominance of cattle (86.8%) and pig bones (6.7%) among all animal bones (Klementiev and Lysenko, 2018). These domestic animals are also typical of most Russian towns and settlements in Siberia. For instance, a study of zooarchaeological materials obtained during excavations of the Russian settlements of Ananyino-1 and Iziuk-1, dating back to the 17th and 18th centuries, revealed that cattle dominated the landscape with bones of domestic bulls and cows of 50.7% and 50.6%, respectively (Yavsheva et al., 2008). According to the results of excavations, cattle bones amounted to 71% at the Tomsk Kremlin, and cow and bull bones amounted to 83% of all bones found at the Tobolsk Kremlin (Bachura et al., 2011). Excavations of the historical center of Irkutsk also revealed the predominance of cattle remains which added up to 90.1% in the soil layers of the 18th century (Isaev et al., 2001). Bones of domestic animals (cattle and pigs), which could be a source of infection with bovine tapeworm, were found during excavations in the Russian city of Mangazeia (existence time: 1601–1672) (Vizgalov et al., 2013). An analysis of animal bones discovered during excavations of the Russian towns of Berezovo and Staroturukhansk, located in the Taiga Zone, also demonstrated a predominance of cattle and pig bones (Vizgalov et al., 2013). Therefore, *Taenia saginata* and *Taenia solium* cestodes are the most probable sources of eggs that we found in the toilet content sample. The infection could be a result of eating contaminated, insufficiently boiled or roasted meat, or raw beef or pork (Vozianova, 2000).

It is interesting that no *Taenia saginata* and/or *Taenia solium* eggs were found in soil samples from the burials of the Epiphany Cathedral Cemetery, also containing a large number of *Diphyllobothrium* sp. eggs, and that eggs of the latter helminth were not found in the toilet content samples. This could be explained by the dietary regimes of different populations. In particular, fish that could be a source of infection with diphyllobothriasis was, probably, the most affordable food for the residents of Yeniseisk throughout the 17th and 18th centuries, especially for those at the poorest stratum of the population and the first settlers. The richer town residents and those who lived in the town later, in the 18th century, could probably afford to consume better quality fish, such as sturgeon, and eat beef and pork regularly. Therefore, it is possible that this difference in dietary regimes of ordinary residents of the town and first settlers, who are buried at the Epiphany Cathedral Cemetery, on the one hand, and the later population of Yeniseisk, including wealthy residents, who lived in the mansion where the toilet was situated, on the other hand, led to different parasitic diseases.

### *4.2. Parasitic diseases and the sanitary condition of Yeniseisk in the 18th century*

As demonstrated by our study, ascarid eggs were detected in the majority samples (except layers №4 and 14) taken from the toilet located at the 18th century mansion, indicating that the inhabitants of this house were infected with ascariasis. Ascarid eggs were also found in one individual buried at the Epiphany Cathedral Cemetery. A person becomes infected with ascariasis by the fecal-oral route. *Ascaris lumbricoides* eggs get into the organism of a new host if s/he eats contaminated vegetables, berries, fruits, or drinks unboiled water, which is less often the case (Vozianova). People involved in agriculture, horticulture, and gardening, especially if the soil is fertilized with contaminated human feces, are population segments which run the highest risk of infection (Vozianova, 2000; Shin et al., 2011; Kim et al., 2016).

Russians undoubtedly began to practice gardening as soon as they settled in Siberia. They cultivated onions, garlic, radish, carrots, cabbage, and turnips, i.e., the main vegetables consumed among Russians before they started to grow potatoes. For instance, a Census Book of Accommodation Houses compiled in Yeniseisk in the early 18th century contains information about the food which hostlers gave their guests. In particular, cabbage was noted everywhere as "food supplies". Based on these records, it is believed that traditional Russian products and dishes formed the basis of nutrition in the agricultural zone in the early 18th century (Aleksandrov, 1981). Vegetable gardening intensively developed in Siberia during the 18th century. A turnip was of special importance, and it was stocked for the whole year as the main vegetable

food crop. Peas, beans, cabbage, beetroots, and onions were cultivated in northern uyezds (Aleksandrov, 1964, 1981).

According to the later sources of the first third of the 19th century, we can see the results of horticulture. A list of plants grown in Yenisei province in 1830 includes potatoes, cabbage, onions, radishes, carrots, turnips, peas, beans, cucumbers, watermelons, and rutabaga (Stepanov, 1835). About Yeniseisk, M.F. Krivoshapkin writes that "… women are in charge of summer vegetable gardening. Almost every house in the town has a vegetable garden; the garden lands are fertilized for cucumbers, cabbage or tobacco, but no fertilizer is applied with other vegetables. The local economy is inevitably based on cabbage, beetroots, radishes, rutabaga, carrots, cucumbers, and potatoes" (Krivoshapkin, 1865). N.V. Latkin also describes vegetable gardening as women's responsibility: "… there are many vegetable gardens in the town, and mainly women take care of them; mostly potatoes, cabbage, cucumbers, onions, turnips, rutabaga, carrots, and beetroots are cultivated there" (Latkin, 1892). Therefore, ignoring sanitary standards when eating vegetables cultivated in the town gardens probably explains why its residents became infected with ascariasis. However, what led to the contamination of the garden soils with ascarid eggs remains unclear.

It has been argued in several studies that agricultural lands were contaminated with *Ascaris lumbricoides* eggs and eggs of other geohelminths because they were fertilized with human feces (Shin et al., 2011; Kim et al., 2016). However, historical and ethnographic literature on vegetable gardening in Siberia lacks information on fertilization of the gardens with human feces (Aleksandrov, 1964, 1981). Therefore, when talking about Siberia, we can discard this explanation.

After analyzing some historical documents, we tried to identify factors that could cause the spread of ascariasis among the population of Yeniseisk. We suggest that the contamination of Yeniseisk territory, in general, and the soil of vegetable gardens, in particular, was mainly caused by unsatisfactory sanitary conditions of the town. It had neither a sewage system nor centralized household waste disposal system, which was typical of many towns of that time, not only in Siberia (King and Henderson, 2014). Some authors highlight the poor sanitary condition of the town of Yeniseisk. It can be summarized with the words by historian A.I. Kytmanov who wrote that "one could hardly walk through Yeniseisk because of mud, and no one considered it necessary to clean the streets and courtyards. In spite of quite a lot of space, the buildings were built close to each other, which caused frequent fires… Cattle dung was everywhere…" (Kytmanov, 2016). Town officials worried about the poor sanitary condition of Yeniseisk. For example, to quote A.I. Kytmanov again, "… Mayor Dementiev made many efforts to improve the sanitary condition of the town. He ordered construction of ditches for water flow, pebble streets, and removal of dung; he was in his wheelhouse doing that" (Kytmanov, 2016).

Regular floods and inundations of Yeniseisk should be mentioned among the most important abiotic factors of contamination of the town, territory, and agricultural lands with geohelminths. Runoff must have washed toilet contents into vegetable gardens and urban areas. Many studies have reported on floods in Yeniseisk. For instance, several authors repeatedly mentioned the "low" position of Yeniseisk in terms of the river's encroachment line, associating it, consequently, with constant inundation of the town (Pestov, 1833; Stepanov, 1835; Latkin, 1892). M.F. Krivoshapkin witnessed a severe flood in 1857. He writes as follows: "… there were 11 similar floods over the past 60 years, namely in 1800, 1823, 1824, 1836, 1837, 1839, 1841, 1846, 1848, 1853, and 1857. The 1800 flood was the worst among them; it covered the entire town. Only elevated pieces of ground remained dry in 1846 and 1848" (Krivoshapkin, 1865).

The book "The Climate and Society in Siberia in the Little Ice Age" by V.S. Miglan enumerates only major floods in Yeniseisk starting from the 17th century. According to the table "Historical Data on Extreme Climatic Manifestations", more than 10 floods of the Angara River and the Yenisei River in its middle reaches occurred in the 18th century (Myglan, 2010).

Summarizing, we can conclude that the poor sanitary condition and constant inundation of Yeniseisk caused contamination of the town, in general, and its vegetable gardens, in particular, with ascarid eggs, thereby most likely causing the high incidence of ascariasis. Human feces were likely washed off the toilets, contaminating agricultural lands in and around the city, which was one of the main causes of ascariasis.

We can see reasons and factors which could lead to a high prevalence of ascariasis. At the same time, we found a minimal incidence of ascariasis in people buried at the Epiphany Cathedral Cemetery. This can likely be attributed to a small number of residents at the early stage of settlement in the 17th century, making sanitary conditions relatively satisfactory. Moreover, Yeniseisk is located in the northern latitudes and characterized by a rather harsh climate, which, probably, prevented rapid contamination of soil with parasites. We cannot exclude the possibility that the situation was aggravated in the 18th century amid the growth of population and its density, deterioration of sanitary conditions, and regular floods. However, data do not allow us to be conclusive, and, therefore, we have insufficient grounds to be certain about the leading role of floods in the spread of ascariasis in Yeniseisk. At the same time, we argue that this factor, along with the poor sanitary conditions of the town, should not be ignored.

## 5. Conclusion

Study of the incidence of parasitic diseases among the Russian urban population of the 17th and 18th centuries in Eastern Siberia allowed us to expand our knowledge of the sanitary conditions in Yeniseisk and dietary habits of its residents, as well as determine some possible cultural and abiotic factors resulting in the development of parasitoses. We argue that the combination of dietary habits of the first Russian settlers originating from the Pomorie of the European part of Russia and dietary habits of the indigenous peoples of Northern Siberia with their consumption of fermented and/or raw fish had a significant impact on the high incidence of diphyllobothriasis in the Russian population of Yeniseisk in the 17th century. The food consumed by Russian settlers in the 18th century was probably more varied and included a sufficient amount of beef and/or pork. The very low incidence of ascariasis in the Yeniseisk population of the 17th century can also be explained by a relatively satisfactory sanitary condition of the town in relation to its small population at the beginning of settlement. As the population and its density grew during the 18th century, however, sanitary conditions would have likely deteriorated, and the overall situation was aggravated by such abiotic factor as frequent floods.

It should be noted that our observations are only a working hypothesis, which, undoubtedly, requires further verification. It is certain that the accumulation and analysis of new materials, as well as an interdisciplinary approach to research, will allow us to reconstruct various aspects of the life of the Russian population of Siberia, as more concrete evidence surfaces.

## Declaration of competing interest

We have no conflict of interest with anyone.

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