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FIRST CONTRIBUTION OF PALEOPARASITOLOGY TO THE STUDY OF COPROLITES FROM THE NEOLITHIC SITE SERTEYA II (NW RUSSIA)

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Highlights:

- Paleoparasitological analyses were performed on Neolithic coprolites from Russia.
- Four taxa of gastrointestinal parasites were detected in coprolites.
- The parasitic assemblage allows to define a canine origin of the material.
- This is the second record of parasites from coprolites in this region.
- The results allow discussing the human/animal relationship during the Neolithic.

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Abstract:

Paleoparasitological analysis was performed on a set of ten coprolites recovered during excavations of the Neolithic site Serteya II (NW Russia). Eggs of four gastrointestinal parasite taxa were identified, namely the fish tapeworm genus *Diphyllobothrium*, the giant kidney worm *Dioctophyma renale*, and two trematode taxa, including the liver lancet fluke genus *Dicrocoelium*. The diversity of parasites enables us to discuss the biological origin of the studied material, which can be attributed to carnivores, probably to canids. This is only the second record of ancient parasites in this part of the world for the Neolithic period and our results are consistent with those from the first study. They contribute to highlighting relationships between humans and animals, and show how environments and human activities can induce parasite transmission.

Key Words: Parasite; Dog; *Diphyllobothrium*; *Dioctophyma renale*; *Dicrocoelium*; *Alaria*.

1. Introduction

Paleoparasitology aims to detect the remains of ancient parasites, especially eggs produced by adult gastrointestinal worms. The study of parasites in archaeological contexts can answer various questions related to the health and living habits of past individuals and populations, notably regarding paleodiet, hygiene, or the management of organic matter (Dittmar et al., 2012; Le Bailly and Araujo, 2016). Among the material propitious to paleoparasitological analysis, coprolites, i.e., mineralized or desiccated faecal matter, of human or animal origin are regularly tested (Appelt et al., 2014). This is not the first time that such material is studied, as several coprolites excavated from various Neolithic sites in Eurasia have already

undergone paleoparasitological analysis. This was the case for the Swiss site of Arbon-Bleiche 3 (Le Bailly et al., 2003), the French sites of Chalain 3, 4 and 19 (Dommelier-Espejo and Pétrequin, 2016), or for the Central European part of Russia (Savinetsky and Khrustalev, 2013).

During excavations of the Neolithic site Serteya II (NW Russia), large amounts of coprolites were discovered, accompanied by cultural remains that date to the 3rd millennium BC. An exploratory analysis was conducted to assess parasite diversity in these samples in order to define the biological origin of the material, and, more generally, to enhance our knowledge of human/animal relationships, and the distribution and importance of parasitism in prehistoric Eastern Europe.

2. Material and methods

2.1. The site of Serteya II and sampled material

The site of Serteya II (55°38’22-21’’N / 31°31’24-51’’E) is located in the Serteya valley, tributary of the Western Dvina in North Western Russia (Figure 1).

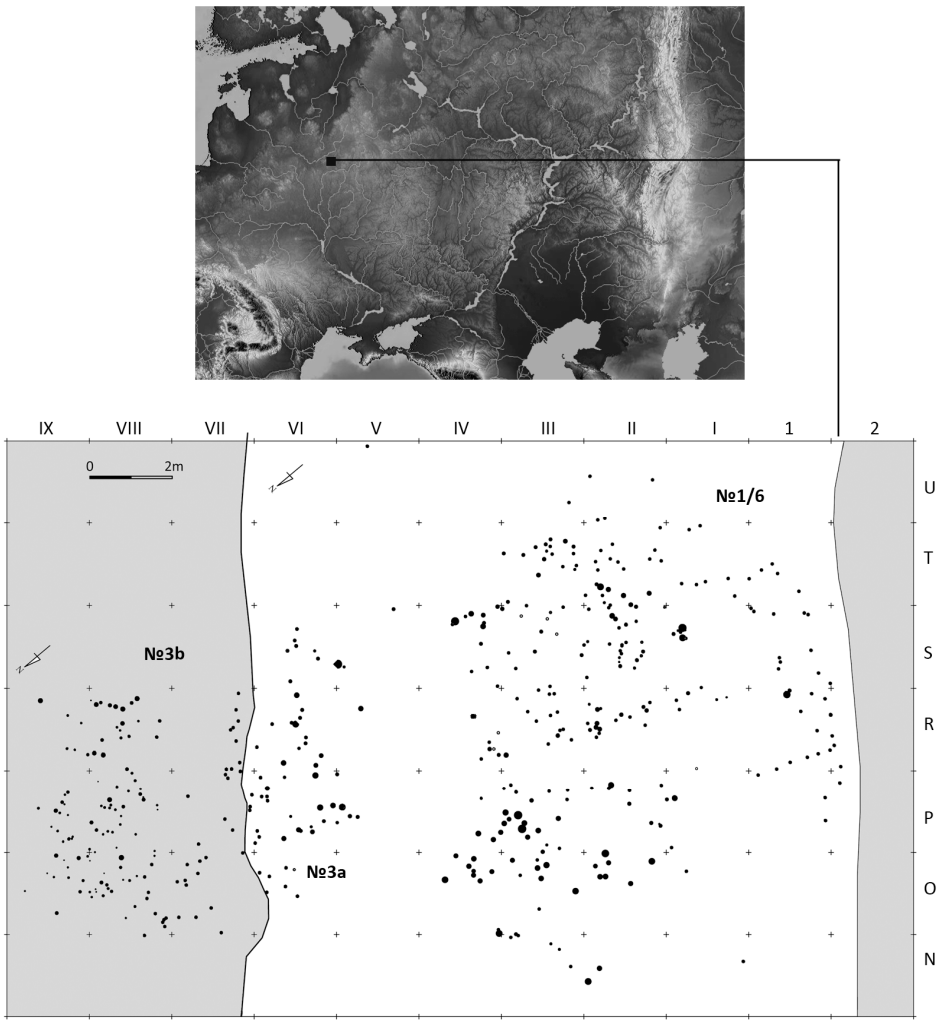

Figure 1: Above: Location of the site of Serteya II (Russia); below: Map of the excavation area of Serteya II , with location of the post holes of dwellings N°3a, 3b et 1/6. The white area corresponds to the underwater excavated zone (Photo A. Mazurkevich/E. Dolbunova).

The strong archaeological potential of the valley has been known since the 1960s, and the region was occupied by past populations periodically between the Palaeolithic and the Middle Ages (Kulkova et al., 2001; Mazurkevich et al., 2018). Studied firstly in 1970s and later from 2008, the Serteya II site is an archaeological multi-layered complex with several settlements and relicts of the area occupation since the Mesolithic up to the Middle Ages. The core zone of the site located within drainage channel and its shores revealed several late

Neolithic pile-dwelling constructions from the 3rd millennium BC. The layer with pile-dwelling constructions within coarse detritus gyttja was excavated using underwater and wetland archaeological methods (Dolukhanov and Miklyayev, 1986; Mazurkevich et al., 2017; Mazurkevich and Dolbunova, 2011). Until now, at least six pile-dwellings were recognised, attributed to the Zhizhistskaya Culture, between ca. 2900 cal. BC and ca. 2000 cal. BC (Mazurkevich and Dolbunova, 2011). The constructions were established most probably on a marshy shore or on the post-lake plains of an exposed lake bottom (Kittel et al., 2018). Archaeological remains (lithic, ceramic, faunal, various organic artefacts and ecofacts) are exceptionally preserved at Serteya II, allowing for a comprehensive approach to the study of cultural influences and the complex settlement dynamics in the valley. In fact, valley populations maintained a livelihood based on gathering, fishing and hunting despite contacts with agro-pastoral populations (Mazurkevich et al., 2018). The inhabitants' diet was dominated by hunting and fishing (Sablin and Syromyatnikova, 2009), elk (43.5% of large mammal bones) and pike (52% of fish remains) (Kulkova et al., 2015; Maigrot, 2014) were within the main species. During excavations, a large amount of coprolites were found, especially in archaeological structure Nb. 3b with 243 pieces (Figure 1), which can be attributed to middle-second half of the 3rd millennium BC. At first sight, these faeces were attributed to boars and it was presumed that boars were kept on the settlement, and fed with fish before being slaughtered (Mazurkevich et al., 2010).

2.2. Egg extraction method

A first set of twelve samples, corresponding to ten coprolites, were proceed for paleoparasitological analysis. Coprolites were first measured and weighed. They measure

between 3.6 to 7.2 cm in length (average 5.8 ± 1.47 cm) for 1.6 to 2.8 cm in width (average 2.5 ± 0.46 cm), with masses varying between 1.5 to 6 g (Figure 2).

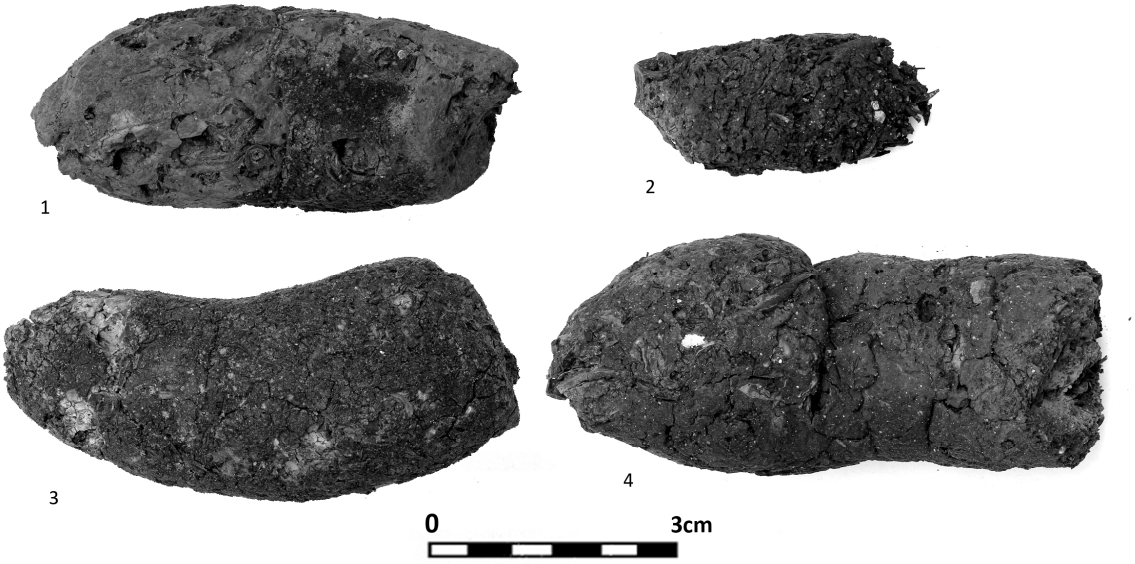

Figure 2: Photos of four coprolites founded on the site of Serteya II: 1 – SII15 1459, 2 - SII15 276, 3 - SII15 1367, 4 - SII15 1495 (numbers recorded during excavations, photos: Yolaine Maigrot).

In two cases (#C1 and #C5), samples were pulverulent and provided sediment associated to the initial coprolite. Sediment samples were treated as single samples and labelled #C1bis and #C5bis (Table I). The sizes, as well as the shapes of the coprolites, are consistent with an omnivorous or carnivorous origin, and could correspond to humans, suids or canids (Chame, 2003). They were then prepared following the standard RHM protocol (Rehydration-Homogenization-Microsieveing) used in Besancon (France) to extract and concentrate gastrointestinal parasite markers (Dufour and Le Bailly, 2013). This protocol has been shown as reliable and appropriate for coprolite analysis, and was used as part of a qualitative

approach of the parasite remains (Camacho et al., 2018). Depending on the initial weight of the material, between 1 and 5 grams of each coprolite were placed for one week in a solution of 0.5% tri-sodium phosphate (TSP) and 5% glycerinated water (Table 1). Samples were then crushed in a mortar and placed in an ultrasound bath for one minute (50-60 Hz). Finally, the sediments were filtered in a column of sieves with 315, 160, 50 and 25 µm meshes. The last 2 screenings were placed in 4 ml tubes with water, and drops of 10% formalin solution were added to each tube to avoid fungi or algae proliferation. Ten slides from the 25 µm and 50 µm fractions were observed under a light microscope (Leica DM2000 LED), and all parasite markers were counted. Photos and measurements of the parasite eggs were also taken using a digital camera (Leica ICC50 HD) coupled to the microscope. After analysis, all samples are stored in a refrigerate room (2-4°C), and are available in the Chrono-environment laboratory (Besancon, France).

During RHM extraction, the macroscopic content of the coprolites was screened, and a number of fragments of fish scales, fish bones, vertebrae and bone splinters were observed. The size of the coprolites and the contents observed during the sieving and microscopic reading phase tend to attribute them to a carnivorous/piscivorous mammal.

In addition, the rarity of pollen grains observed during microscopic analyses is characteristic of a carnivorous origin (E. Gauthier, palynologist, pers. comm.).

3. Results

Nine coprolites (90%) tested positive to the presence of gastrointestinal parasites, and only one gave negative results (i.e., sample #C8). Eggs from four taxa were retrieved in the samples. The number of counted eggs of each taxon is reported in Table 1.

Both sediment samples (#C1bis and #C5bis) gave lower parasite diversity and egg number than the coprolites from which they were obtained. In case of this preliminary qualitative study, egg number will be not considered and the results from the sediment samples will be then integrated to the results of the coprolites with which they are associated.

Coprolites	Laboratory n°	Weight (g)	*Diphyllobothrium* sp.	*Dioctophyma renale*	*Alaria alata*	*Dicrocoelium* sp.
SII14 – TII	C1	1.5	16113	0	0	2
SII14 – TII	C1bis	5	122	0	0	0
SII14 – P2	C2	5	0	0	1	0
SII14 – УII 1	C3	6	15	0	0	0
SII14 – УII 2	C4	2.8	10	1	2	0
SII14 – УII 3	C5	5	4	1	1	0
SII14 – УII 3	C5bis	5	1	1	0	0
SII15 – У18	C6	3.6	193	0	0	0
SII15 276	C7	3.9	0	1	0	0
SII15 1367	C8	16.4	0	0	0	0
SII15 1459	C9	12.7	4956	1	25	0
SII15 1495	C10	15	0	0	19	0

Table 1: Results of the paleoparasitological analyses on the Neolithic site of Serteya II, with the total number of counted eggs. Greyed out samples correspond to pulverulent coprolites, which left sediment. The associated coprolites and sediment were both analysed.

3.1. Cestoda

One taxon belongs to the Cestoda class, and corresponds to the fish tapeworm genus *Diphyllobothrium*. Eggs are ovoid, operculated with a smooth thin eggshell, and present a small knob at the opposite side of the operculum. The average size is about 61 ± 3.1 µm in

length and 44 ± 3.6 µm in width (Figure 3A). The heteroxenous life cycle includes two successive intermediate hosts, first a fresh water copepod, then a fish. Infection occurs when fish-eating mammals ingest raw, undercooked, or insufficiently smoked or salty fish (Ash and Orihel, 2007; Soulsby, 1982; Taylor et al., 2007). The parasite can cause nausea, abdominal pain, diarrhoea and appetite disorder for the definitive host, sometimes accompanied by anaemia. The adult worm can be up to 12 meters in length, and the possible cohabitation of several worms within the same host intestine can explain the important egg concentrations in some samples (Table 1). Fish tapeworm is very common in dogs and human, and its presence in pigs is exceptional (Euzéby, 2008; Taylor et al., 2007).

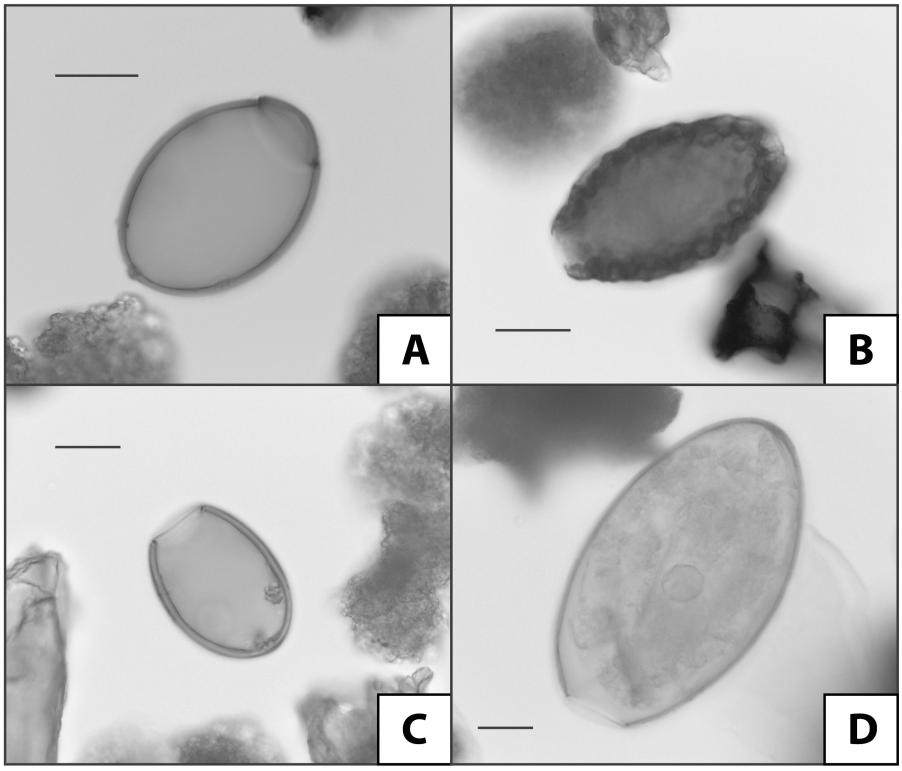

Figure 3: Photos of parasite eggs retrieved on the Serteya II site. A: *Diphyllobothrium*; B: *Dioctophyma renale*; C: *Dicrocoelium*; D: *Alaria alata*. Scale bar: 20 µm (Photo: Céline Maicher).

3.2. Trematoda

Two of the retrieved taxa belong to the Trematoda class. The first corresponds to the lancet liver fluke, genus *Dicrocoelium*. The operculated eggs present a typical asymmetric ovoid shape with a thick shell, and the average size of the eggs is 46.8 ± 0.6 µm in length and 31.5 ± 2.6 µm in width (Figure 3C). The lancet liver fluke is a cosmopolitan parasite that can evolve on wet or dry ground. Its life cycle is heteroxenous, and includes two intermediate hosts (a terrestrial gastropod and an ant). The presence of parasite larvae in the ant's nervous system induces a change in the ant's behaviour and leads to its ingestion and the infection of the final herbivorous host. The pathology develops two forms: a chronic form (which can affect sheep, goats and cattle), which is not specific, with weight loss and diarrhoea; and an acute form (only present in sheep), which is more severe (Taylor et al., 2007). The lancet liver fluke mainly infects herbivorous sheep, but also cattle and goats to a lesser extent. Experimental analyses prove that *Dicrocoelium*, especially *D. dendriticum*, is host generalist (Beck et al., 2014). In North America, where it was introduced from Europe (Le Bailly and Bouchet, 2010), it is commonly found in elk populations. However, in this part of the globe, *D. dendriticum* corresponds to an invasive species and is less prevalent in elk populations in the Russian central plain (Paridon et al., 2017). It has also been occasionally noted in boars, and never in dogs (Euzéby, 2008; Taylor et al., 2007). Only a few cases are reported in humans, and most of these correspond to a false parasitosis, resulting from the consumption of the liver of an infected animal or infected ants (Euzéby, 2008). The eggs of the second trematode taxon

are operculated ellipsoids with an average size of about 113.5 ± 4 µm in length and 79 ± 12.8 µm in width (n=10) (Figure 3D). Egg size and morphology are consistent with the species *Alaria alata*. This species is common in Eastern Europe today. It can infect humans, felids, mustelids and other wild carnivorous, but it is predominant in canids, especially dogs and foxes (Taylor et al., 2007). Canids can be infected after the ingestion of the intermediate host in the parasite lifecycle, i.e., frogs or tadpoles (Euzéby, 2008).

3.3. Nematoda

The last taxon belongs to the Nematoda phylum, and is identified as the giant kidney worm, *Dioctophyma renale*. This uncommon parasite produces ovoid-shaped eggs with two polar plugs, a thick and characteristic shell presenting polygonal depressions (Nozais et al., 1996). The average size of the recovered eggs was 67.4 ± 5.9 µm in length, and 39.3 ± 1.2 µm in width (n=5) (Figure 3B). The heteroxenous life cycle of *Dioctophyma* includes one intermediate host, an oligochaete annelid, often of the genus *Lumbriculus*. A paratenic host, corresponding to freshwater fish (Cyprinidae or Siluridae), or frogs of the *Rana* genus, can integrate the parasite lifecycle. The definitive host becomes infected after the ingestion of the intermediate host, but more often after the consumption of the paratenic hosts. Eggs are produced by adult worms located in the kidney of the definitive host and are evacuated during urination. The giant kidney worm is currently commonly found in the urinary systems of carnivore mammals such as canids, felids and mustelids (Measures, 2008). However, during the past decade, it has been observed in the abdominal cavity of harbour seals, rats and capuchin monkeys (Hoffman et al., 2004; Ishizaki et al., 2010; Tokiwa et al., 2011). Humans may also be infected even though such mentions are much more sporadic (Li et al., 2010) since they correspond to an accidental definitive host (Acha and Szyfres, 2005; Li et al., 2010). Clinical signs of dioctophymiasis are mainly due to the presence of the worm in the

kidneys and can lead to haematuria, pyuria, renal colic and dysuria (Soulsby, 1982; Taylor et al., 2007).

4. Discussion

Since the 1990s, several paleoparasitological investigations have contributed to our knowledge of parasites in ancient Eastern Europe (Slepchenko and Reinhard, 2018). However, very few analyses have focused on the Neolithic period. In 1996, Engovatova and Khrustalev published an article on the study of three sites from the Upper Volga basin, Zamostje 1, Zamostje 2 and Vojmezhnoe. Among them, the sole study comparable to the present work is the analysis performed on the site of Zamostje 2 (Engovatova and Khrustalev, 1996). The site is dated between the Late Mesolithic (7000-6600 cal. BC) and the Middle Neolithic (4900-4300 cal. BC) and is characterized by a significant fishery industry (Lozovski and Lozovskaya, 2016), marked by the presence of a very large number of archaeological and faunal remains. Although the taxonomic diversity of fish declines over time, the site is still characterized by an economy based on fishing (Clemente-Conte et al., 2016). During the analysis of 35 coprolite samples, four gastrointestinal parasite eggs were retrieved, namely *Diphyllobothrium* sp., *Opistorchis felineus*, *Alaria alata* and eggs of the Capillaridae family. In addition, in 2013, Savinetsky & Khrustalev published a synthesis of their work in paleoparasitology, and evoked the presence of two *Dioctophyma renale* eggs in a sample from Zamostje 2, with no details of the archaeological layer or period concerned (Savinetsky and Khrustalev, 2013). *Diphyllobothrium* is often mentioned during the Neolithic period in Western Europe and has been retrieved from many archaeological sites, mainly on lakeside settlements in Switzerland, France, Germany and Austria (Le Bailly and Bouchet, 2013). Its frequency varies depending on the cultures and the proportion of fishing in the local diet

(Bouchet et al., 1995; Dommelier-Espejo and Pétrequin, 2016; Le Bailly, 2011; Le Bailly et al., 2005). Recent research also tends to demonstrate that fish tapeworm prevalence can vary depending on the social organization in the site itself (Maicher et al., 2019). The pathoecology of the fish tapeworm is clearly related to freshwater hydric systems (lakes or rivers), and develops in populations where fish and fishing play a role in the diet and economy. The lancet liver fluke was retrieved from ten lacustrine sites in Western Europe, around the lakes of Federsee, Bodensee, Zurich, Neuchatel and Chalain (Dommelier-Espejo and Pétrequin, 2016; Le Bailly and Bouchet, 2010; Maicher et al., 2019). The oldest mention of this parasite comes from the Pleistocene site of Tautavel (south-western France), and is dated to around 550 000 BP (Jouy-Avantin et al., 1999). Finally the giant kidney worm, *Dioctophyma renale,* was retrieved twice from the Neolithic period, in coprolites from the Swiss site of Arbon-Bleiche 3 (Le Bailly et al., 2003), and in the Russian Late Mesolithic-Middle Neolithic site of Zamostje 2 (Savinetsky and Khrustalev, 2013).

Owing to the diversity of the recovered parasites, it is possible to discuss the biological origin of the studied coprolites. As all the coprolites were taken from same occupation layer and present similar shapes, it is likely that they share the same biological origin. The presence of a number of bone splinters and the scarcity of pollen grains in the coprolites suggest a carnivorous origin. The parasitic assemblage, in particular *Alaria alata*, but also *Diphyllobothrium* and *Dioctophyma*, corresponds to a probable canid origin. Among the faunal remains retrieved on the site, both dog and fox bones were identified (Mazurkevich et al., 2020). However, fox bones were present in small proportion, which suggests an on-site butchering of foxes for furs. It is so unlikely that foxes were present on the site, but just hunted for their furs. Also, location of the studied coprolites, nearby and within (under) a dwelling or household construction/platform, testify to species living close to human. All these statements point toward a dog origin of the coprolites. Moreover, the presence of fish-

eating related parasites in the coprolites (*Dioctophyma renale* and *Alaria alata*) suggests that dogs were probably fed with fishes. The feeding of dogs with fish remains (heads in this case) was recently proposed in the case study of dog coprolites retrieved from the Neolithic site of Črnelnik in Slovenia (Tolar and Galik, 2019). The consequence on the health status of dogs cannot be documented in our studies, as pathogenicity varies between individuals and may have varied throughout time. However, some parasites, such as the giant kidney worm, are known today to be potentially lethal (Ash and Orihel, 2007).

As seen above (section 3.3), *Dioctophyma* is rare in archaeological contexts, with only two mentions in Switzerland. Nevertheless, this is the second time that it has been found in Western Russia during the Neolithic period, also in probable dog coprolites (Savinetsky and Khrustalev, 2013). *Alaria alata* is also mentioned for the second time in archaeological samples, in a region which correspond today to an endemic area of this parasite (Taylor et al 2007). The presence of *Dicrocoelium* eggs probably indicates the accidental consumption of the raw offal of an infected wild or domesticated herbivore during population movement, or the intentional feeding of dogs by humans on the site. The coprological analysis demonstrates that the coprolites from Serteya II are very probably of dog origin. This could suggest dog breeding for consumption or other activities, as the faunistic collections include fragments of domestic dogs.

5. Conclusion

The analysis on several coprolites provides new paleoparasitological evidence in prehistoric Russia, and also raises questions concerning the human/dog relationship during the Neolithic. More coprolites need to be analysed to confirm these hypotheses. A new set of samples, coprolites and samples from the occupation layers, were recently collected from several

occupation areas — central part of the pile-dwelling 3 and residential area of the shore zone in order to address further questions about human-animal relationships in the 4th-3rd millennium BC. These samples are stored at The State Hermitage Museum in St. Petersburg and will be analysed shortly.

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Litterature cited:

Acha, P.N., Szyfres, B., 2005. Zoonoses et maladies transmissibles communes à l'homme et aux animaux, third ed. OMS, Paris.

Appelt, S., Armougom, F., Le Bailly, M., Robert, C., Drancourt, M., 2014. Polyphasic Analysis of a Middle Ages Coprolite Microbiota, Belgium. PLOS ONE 9, 1–8. https://doi.org/10.1371/journal.pone.0088376.

Ash, L.R., Orihel, T.C., 2007. Ash & Orihel's atlas of human parasitology. ASCP Press, Chicago.

Beck, M.A., Goater, C.P., Colwell, D.D., van Paridon, B.J., 2014. Fluke abundance versus host age for an invasive trematode (Dicrocoelium dendriticum) of sympatric elk and beef cattle in southeastern Alberta, Canada. Int. J. Parasitol. Parasites Wildl. 3, 263–268. https://doi.org/10.1016/j.ijppaw.2014.08.003.

Bouchet, F., Pétrequin, P., Paicheler, J.-C., Dommelier, S., 1995. Première approche paléoparasitologique du site Néolithique de Chalain (Jura, France). Bull Soc Path Ex 88, 265–268.

Camacho, M., Araujo, A., Morrow, J., Buikstra J., Reinhard K. 2018. Recovering parasites from mummies and corpolites: an epidemiological approach. Parasites & Vectors 11:248, 1-17. https://doi.org/10.1186/s13071-018-2729-4.

Chame, M., 2003. Terrestrial mammal feces: a morphometric summary and description. Mem. Inst. Oswaldo Cruz 98, 71–94. https://doi.org/10.1590/S0074-02762003000900014.

Clemente-Conte, I., Lozovski, V.M., Gassiot Ballbe, rmengol, Mazurkevich, A., Lozovskaya, O., 2016. Prehistoric fish traps and fishing structures from Zamostje 2, Russian European Plain: Archaeological and ethnographic contexts, in: Wild Harvest: Plants in the Hominin and Pre-Agrarian Human Worlds. Oxbow Books, Oxford, pp. 253–272.

Dittmar, K., Araújo, A., Reinhard, K., 2012. The Study of Parasites Through Time: Archaeoparasitology and Paleoparasitology, in: Gauer, A. (Ed), A Companion to Paleopathology. Blackwell Publishing, Oxford UK, pp. 170–190.

Dolukhanov, P.M., Miklyayev, A.M., 1986. Prehistoric lacustrine pile dwelling in the North-Western part of the USSR. Fennosc. Archaeol. III 3, 81–89.

Dommelier-Espejo, S., Pétrequin, P., 2016. Analyses paléoparasitologiques à Clairvaux et à Chalain, in: Clairvaux et Le “Néolithique Moyen Bourguignon,” Les Cahiers de La MSHE Ledoux. Presses Universitaires de Franche-Comté, pp. 1175–1192.

Dufour, B., Le Bailly, M., 2013. Testing new parasite egg extraction methods in paleoparasitology and an attempt at quantification. Int. J. Paleopathol. 3, 199–203. https://doi.org/10.1016/j.ijpp.2013.03.008.

Engovatova, A.V., Khrustalev, A., 1996. Coprolites from stone age sites of Podmoskovye. Tver. Sb. 2, 148–154.

Euzéby, J., 2008. Grand dictionnaire illustré de parasitologie médicale et vétérinaire, Tec and Doc. ed. Lavoisier, Paris.

Hoffman, V., Nolan, T.J., Schoelkopf, R., 2004. First Report of the Giant Kidney Worm (Dioctophyme renale) in a Harbor Seal (Phoca vitulina). J. Parasitol. 90, 659–660. https://doi.org/10.1645/GE-198R.

Ishizaki, M.N., Imbeloni, A.A., Muniz, J.A.P.C., Scalercio, S.R.R. de A., Benigno, R.N.M., Pereira, W.L.A., Cunha Lacreta Junior, A.C., 2010. Dioctophyma renale (Goeze, 1782) in the abdominal cavity of a capuchin monkey (Cebus apella), Brazil. Vet. Parasitol. 173, 340–343. https://doi.org/10.1016/j.vetpar.2010.07.003.

Jouy-Avantin, F., Combes, C., (de), H.L., Miskovsky, J.-C., Moné, H., 1999. Helminth Eggs in Animal Coprolites from a Middle Pleistocene Site in Europe. J. Parasitol. 85, 376–379. https://doi.org/10.2307/3285652.

Kittel, P., Mazurkevich, A., Dolbunova, E., Kazakov, E., Mroczkowska, A., Pavlovskaia, E., Piech, W., Płóciennik, M., Sikora, J., Teltevskaya, Y., Wieckowska-Lüth, M., 2018. Palaeoenvironmental reconstructions for the Neolithic pile-dwelling Serteya II site case study, Western Russia. Acta Geogr. Lodz. 107, 191–213.

Kulkova, M., Mazurkevich, A., Dolbunova, E., Regert, M., Mazuy, A., Nesterov, E., Sinai, M., 2015. Late Neolithic Subsistence Strategy and Reservoir Effects in 14C Dating of Artifacts at the Pile-Dwelling Site Serteya II (NW Russia). Radiocarbon 57, 611–623. https://doi.org/10.2458/azu_rc.57.18427.

Kulkova, M., Mazurkevich, A., Dolukhanov, Pavel., 2001. Chronology and paleoclimate of prehistoric sites in western Dvina-Lovat' area of north-western Russia. Geochronometria 20, 87–94.

Le Bailly, M., 2011. Les parasites dans les lacs nord alpins au Néolithique (3900-2900 BC), et nouvelles données dans la détection des paléoantigènes de Protozoa. Editions Universitaires Européennes, Sarrebruck.

Le Bailly, M., Araujo, A., 2016. Past intestinal parasites. Microbiol Spectr. 4, 143–152. https://doi.org/10.1128/microbiolspec.PoH-0013-2015.

Le Bailly, M., Bouchet, F., 2013. Diphyllobothrium in the past: Review and new records. Int. J. Paleopathol. 3, 182–187. https://doi.org/10.1016/j.ijpp.2013.05.004.

Le Bailly, M., Bouchet, F., 2010. Ancient dicrocoeliosis: Occurrence, distribution and migration. Acta Trop. 115, 175–180. https://doi.org/10.1016/j.actatropica.2010.03.004.

Le Bailly, M., Leuzinger, U., Bouchet, F., 2003. Dioctophymidae Eggs in Coprolites From Neolithic Site of Arbon–Bleiche 3 (Switzerland). J. Parasitol. 89, 1073–1076. https://doi.org/10.1645/GE-3202RN.

Le Bailly, M., Leuzinger, U., Schlichtherle, H., Bouchet, F., 2005. Diphyllobothrium: Neolithic Parasite? J. Parasitol. 91, 957–959. https://doi.org/10.1645/GE-3456RN.1

Li, G., Liu, C., Li, F., Zhou, M., Liu, X., Niu, Y., 2010. Fatal Bilateral Dioctophymatosis. J. Parasitol. 96, 1152–1154. https://doi.org/10.1645/GE-2132.1.

Lozovski V., Lozovskaya O. 2016. New Evidence of the Fishing Economy of Stone Age Waterlogged Sites in Central and North- Western Russia: The Example of Zamostje 2. In: Pirjo Uino, Kerkko Nordqvist (eds.), New sites, New methods. " Proceedings of the Finnish-Russian Archaeological Symposium, Helsinki. The Finnish Antiquarian Societty, Iskok. 21, 85-100.

Maicher, C., Bleicher, N., Le Bailly, M., 2019. Spatializing data in paleoparasitology: Application to the study of the Neolithic lakeside settlement of Zürich-Parkhaus-

Opéra, Switzerland. The Holocene 29, 1198–1205. https://doi.org/10.1177/0959683619838046.

Maigrot, Y., 2014. Bone tools from Neolithic settlement Serteya II (Smolensk region, Russia), in: Mazurkevich A., Polkovnikova M., Dolbunova E. (Eds.), Archaeology of Lake Settlements IV – II Mill. BC: Chronology of Cultures, Environment and Palaeoclimatic Rhythms. Presented at the Archaeology of lake settlements IV – II mill. BC: chronology of cultures, environment and palaeoclimatic rhythms, Saint-Petersburg, pp. 214–220.

Mazurkevich, A., 2016. Северо-Западной археологической экспедиции Государственного Эрмитажа о раскопках и подводных исследованиях памятника Сертея II в 2015 году (Rapport de fouilles archéologiques). Musée de l'Hermitage, Saint-Petersburg.

Mazurkevich, A., Dolbunova, E., 2011. Underwater Investigations in Northwest Russia: lacustrine archaeology of Neolithic pile dwellings, in: Submerged Prehistory. Oxbow Books, pp. 158–172.

Mazurkevich, A., Dolbunova, E., Kittel, P., Fassbinder, J.W.E., Maigrot, Y., Mroczkowska, A., Płóciennik, M., Sikora, J., Słowiński, M., Sablin, M., Shirobkov, I., 2017. Multi-disciplinary research on the Neolithic pile-dwelling Serteya II site (Western Russia) and the landscape reconstruction, in: Nie Tylko Krzemienie – Not Only Flints. Instytut Archeologii Uniwersytetu Łódzkiego, Łódzka Fundacja Badań Naukowych, Stowarzyszenie Naukowe Archeologów Polskich Oddział w Łodzi, Łódź, pp. 103–128.

Mazurkevich, A., Dolbunova, E., Maigrot, Y., Hook, D., 2010. The results of underwater excavations at Serteya II, and research into pile-dwellings in northwest Russia. Archaeologia Baltica 14, 47–64.

Mazurkevich, A., Dolbunova, E., Zaitseva, G., Kulkova, M., 2018. Chronological timeframes of cultural changes in the Dnepr-Dvina region (7th to 3rd millennium BC). Doc. Praehist. 44, 162–175. https://doi.org/10.4312/dp.44.10.

Mazurkevich, A., Sablin, M., Dolbunova, E., Kittel, P., Maigrot, Y., Kazakov, E. 2020. Landscape, seasonality and natural resources use in the 3rd millennium BC by pile-dwelling communities (NW Russia). In: Settling waterscapes in Europe. The Archaeology of Neolithic and Bronze-Age pile-dwellings. OSPA 1: 17 -36.

Measures, L.N., 2008. Dioctophymatosis, in: Samuel, W.M., Pybus, M.J., Kocan, A.A. (Eds.), Parasitic Diseases of Wild Mammals. Iowa State University Press, pp. 357–364.

Nozais, J.-P., Datry, A., Danis, M., 1996. Traité de parasitologie médicale. Pradel, Paris, France.

Paridon, B.J. van, Gilleard, J.S., Colwell, D.D., Goater, C.P., 2017. Life Cycle, Host Utilization, and Ecological Fitting for Invasive Lancet Liver Fluke, Dicrocoelium dendriticum, Emerging in Southern Alberta, Canada. J. Parasitol. 103, 207–212. https://doi.org/10.1645/16-140.

Sablin, M., Syromyatnikova, E.V., 2009. Animal Remains from Neolithic Sites in Northwestern Russia, in: The East European Plain on the Eve of Agriculture. Oxford: Archaeopress, Oxford, pp. 153–158.

Savinetsky, A.B., Khrustalev, A.V., 2013. Paleoparasitological investigations in Mongolia, Middle Asia and Russia. Int. J. Paleopathol. 3, 176–181. https://doi.org/10.1016/j.ijpp.2013.09.004.

Slepchenko, S., Reinhard, K., 2018. Paleoparasitology and pathoecology in Russia: Investigations and perspectives. Int. J. Paleopathol. 22, 39–44. https://doi.org/10.1016/j.ijpp.2018.03.005.

Soulsby, E.J.L., 1982. Helminths, Arthropods and Protozoa of domesticated animals. 1982, 7th ed. Baillière Tindall, London.

Taylor, M.A., Coop, R.L., Wall, R., 2007. Veterinary parasitology, third ed. Blackwell Pub., Oxford, UK.

Tokiwa, T., Harunari, T., Tanikawa, T., Akao, N., Ohta, N., 2011. Dioctophyme renale (Nematoda: Dioctophymatoidea) in the abdominal cavity of Rattus norvegicus in Japan. Parasitol. Int. 60, 324–326. https://doi.org/10.1016/j.parint.2011.03.003.

Tolar, T., Galik, A., 2019. A Study of Dog Coprolite from Late Neolithic Pile-Dwelling Site in Slovenia. Archaeol. Discov. 20–29. https://doi.org/10.4236/ad.2019.71002.