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Forest Insect Spectra in Late Holocene Deposits of the Lena Delta Terrace, North of the Actual Tree Line

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Summary: It was the first time that insects were sampled in the Late Holocene deposits of the Lena Delta. The insect fauna consists of taiga, aquatic and riparian, meadow, shrub, tundra and others species. There are many thermophilic species in different ecological groups of insects. Our findings suggest that about 3000 yr BP predominantly taiga or forest tundra with some steppe elements existed in closer distance to the Lena Delta head in contrast to today. The climate was warmer than it is now and relatively dry in this region.

Zusammenfassung: Erstmalig wurden Insekten in spät-holozänen Ablagerungen des Lena-Deltas untersucht. Die Insektenfauna besteht aus Taigaarten, aquatischen Arten und Uferbewohnern, sowie aus Wiesen-, Strauch-, Tundra- und anderen Arten. Es wurden viele thermophile Arten in unterschiedlichen ökologischen Gruppen beobachtet. Unsere Beobachtungen deuten darauf hin, dass ca. 3000 Jahre vor heute in der näheren Umgebung des Lena-Deltas eine Taiga- oder Waldtundra-Vegetation mit einigen Steppe-Elementen vorherrschte. Das Klima war wärmer als heute und relativ trocken.

INTRODUCTION AND STUDY AREA

During the studies of the joint Russian-German "Lena 2000" expedition to the Lena Delta head, a small island called Arga-Bilir-Aryta, located between Samoylov and Kurungnakh-Sise Islands was investigated (Fig. 1). Current floods do not affect the highest island areas of up to 10 m. In the southwestern area of the island, its height reaches 7-8 m and this part of the island surface is also free of driftwood, indicating that no flooding of the surface occurs during the high water level in the river. Here, at 72° 21.713' N and 126° 19.588'E, the island's surface presents a sandy site with slightly pronounced initial frost cracks. The protective vegetation cover comprises 60-70 % being represented by shrub willow and herbs. In the washout scarp 7 m high, the deposits were outstripped and samples were collected to determine the age and to investigate entomofauna contained in the sediments.

METHODS

Radiocarbon dating of the plant remains was undertaken at the Laboratory of Geochronology of the St. Petersburg State University. Two datings were made. In order to obtain the remains of insects, the following three samples from the section were screened: Bkh -B2, Bkh -B1 and Bkh -B3. The sediment volume screened for each sample comprised about 60 kilograms of sand, silt and plant remains. Insects were extracted from the obtained enriched sediment and studied using a light microscope.

RESULTS AND DISCUSSION

The washout scarp of up to 7 m in height is composed of sands interbedded with silt and a great number of interlayers of plant detritus (mainly herb fibers and plant seeds). The section is presented in Figure 2. Beneath the soil horizon, a 0.2 m thick, fine-grained quartz sand bed alternate with thin interlayers of silty sand and plant remains. The stratification is undulated and sometimes cross-bedded. The horizontal section displays poorly pronounced indications of the current ripples. The radiocarbon age determination using one of the plant detritus interlayers revealed the age of 540 ±60 yr BP (LU-4565). From this interlayer, sample B-3 was collected for the entomological studies. The sand is 0.9 m in thickness.

Gray silt and silty sand layers alternate with laminae of plant remains in the horizon below. The thickness of the clastic beds amounts to several centimeters. The plant remains occupy a volume of more than 60 % of the unit whose thickness is 1.7 m. Sample B-1 was collected from a height of 5.0 m from the middle of the layer.

In the visible washout scarp foot, fine- and coarse-grained quartz sand beds (20-50 cm thick) alternate with silt beds (10-15 cm thick), which contain quite a lot of plant detritus. The silt beds become thinner towards the section surface. The sands are finely and horizontally bedded. Plant detritus was sampled from the base of the layer and dated. Its radiocarbon age turned out to be equal to 3170 ±50 yr BP (LU-4609). Sample B-2 was also collected from here for entomological studies. Below, there is a talus reworked by melt water.

We shall now consider the complexes of insects from the section. From sample Bkh–2, 97 remains of insects were obtained, which correspond to 68 real individuals. 42 species of insects were determined belonging to 11 families of beetles and one ant family. The distribution of the ecological groups is presented in Figure 2; a list of species is given in Table 1. In addition to the remains of insects, larch seeds were found in the sample.

Insects of the taiga group comprise 9 % of the complex. They include three insect species:
(1) Ground beetle *Dromius quadraticollis* is a small beetle with thin chitinous covers. It only lives on trees, hunting small invertebrates and moving along the trunk and branches. The beetles' way of life and their frail structure explain the few

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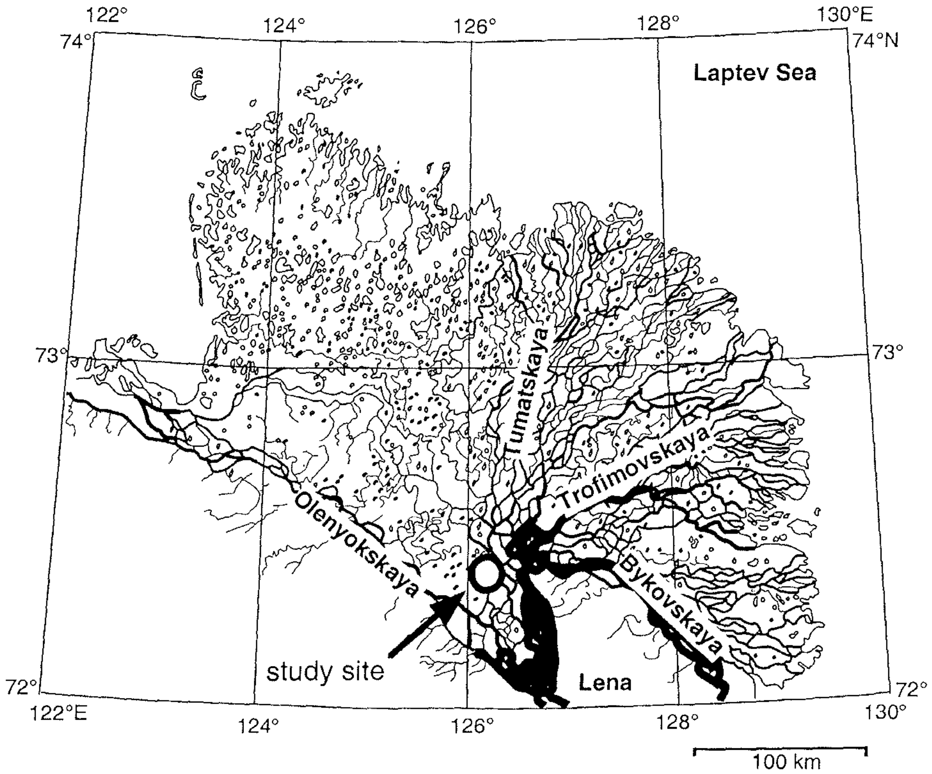

Fig. 1: Location of the investigated site of Arga-Bilir-Aryta Island in the Lena Delta.

Abb. 1: Lage des untersuchten Profils auf der Insel Arga-Bilir-Aryta im Lena-Delta.

chances they have to be preserved in the fossil state. In any case, this is the first finding in NE Siberia.

(3) The carrion beetle *Phosphuga atrata* is a widespread beetle in the forest zone, one of the most common species in the temperate belt of Russia. It can be observed more often in damp places under the bark of fallen trees.

(3) Tree ants *Camponotus herculeanus* are widespread over the entire forest zone. They make nests only in the fallen tree trunks. Ants *Camponotus* can be exported to the tundra zone with driftwood by the current of large rivers. Thus, in Tiksi Bay we observed the winged individuals of these insects, but they probably cannot become acclimatized due to too severe conditions. We have not found any normal nests with worker-ants. In our sample, the remains of both winged individuals and workers are presented indicating that they are probably of local origin.

Some insect species from the riparian group are also connected with the taiga zone. These are the dung beetles *Aegalia kamtschatica* inhabiting damp places and areas near waters on Kamchatka, Sakhalin, Primorye and in Japan. As can be seen, its current area is located much further south of the northern boundary of the taiga zone and quite far from the Lena Delta. Another riparian species is the weevil beetle *Lixus paraplecticus*. It is now spread in Europe (except for the north), Primorye and in the south and central Yakutia. It feeds on near-water umbellate *Oenanthe* and *Sium*. In the tundra, these umbellate (*Apiaceae*) plants are not encountered at all (in general, the family of *Apiaceae* is not typical of the tundra), while in the case of the weevil beetle *Lixus paraplecticus*, we deal with a narrow food specialization since its food plants are poisonous.

The other ecological groups also have species , which do not inhabit the tundra at present. In the group of shrubs, this is the leaf beetle *Phratora vulgatissima*, feeding on willow, which is not beyond the northern taiga limits. In the group of meadows, it is the weevil beetle *Sitona lineellus* feeding on legumes. It penetrates the north only to the south of Chukotka. Such species of the mesic tundra group like the ground beetle *Blethisa catenaria, Diacheila polita*, are encountered in the southern shrub tundra and also in the forest tundra and northern taiga.

All insects belong to current species, whose ecology and spreading are known. During the entomological analysis, we subdivided the insects conventionally into several ecological groups. This is done for convenience and illustration purpose, which does not mean an obligatory clarity and non-ambiguity. Thus, the group of tundra meso-hygrophilous species includes insects, which can be observed in the tundra, in the northern taiga and even in the mountain regions of South Siberia. We should note that due to its relatively young age tundra biota contain very few true tundra specialized species. Only some insect species' distribution is restricted to the tundra zone, but they also have close relatives from a number of taiga or steppe inhabitants.

Among the fossil species there are intra-zonal species, for example, from the number of riparian insects. It is typical that they have extensive areals covering several biogeographical zones, but other typical features are also observed. Most riparian species are not observed today north of the northern forest boundary. In the Pleistocene tundra-steppes, the composition of the coastal fauna is also restricted. In addition, the quantitative fraction of the remains of aquatic and riparian insects in the taiga fossil complexes is much higher than in the fossil complexes of the treeless landscapes. NAZAROV (1984) was the first to pay attention to this phenomenon. By the example of

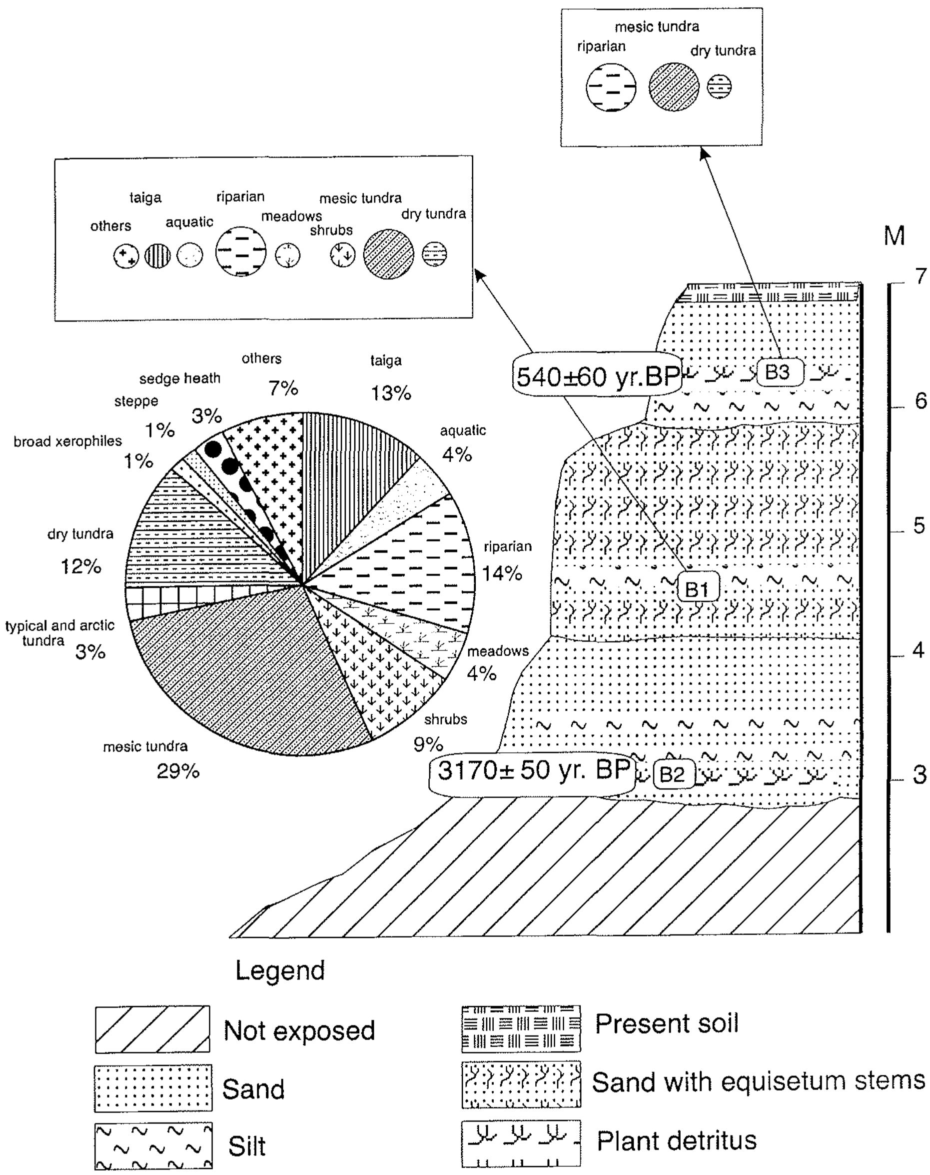

Fig. 2: Section of the first alluvial terrace of Arga-Bilir-Aryta Island and distribution of the ecological groups of insects.

Abb. 2: Profil der ersten alluvialen Terrasse auf der Insel Arga-Bilir-Aryta und Verteilung ökologischer Gruppen der identifizierten Insekten.

the Belorussian quaternary entomofaunas, it was called a "bank barrier". Under taiga conditions, the burial contains predominantly the insects inhabiting either the water body itself or very close to it. The taiga species proper have fewer chances to be in the burial. The existence of a bank barrier is attributed to the fact that in the forest zone, the coastal vegetation is more developed and the surface discharge of plant detritus with the insect remains is restricted. A forest does not experience such catastrophic floods, which are common in the treeless landscapes and that probably presents the main way for the insects to get to the burial. The presence of a bank barrier can also account for a large quantity of hygrophilous tundra insects, which are usually present in the fossil forest complexes. As in the taiga these species occupy the coldest swampy areas being often observed along the banks of lakes and rivers. Thus, the indications of the taiga fossil fauna of insects include (i) the presence of species that are directly or indirectly connected with tree vegetation (bark beetles, ants, etc.); (ii) the presence of species whose areas are not beyond the forest zone; (iii) a large fraction of aquatic and riparian species.

It is more likely that the insects inhabited the taiga with a vertical zonality, in which such thermophillous species as *Lixus paraplecticus* and species typical of the forest tundra and northern taiga could co-exist. We admit the presence of an extensive drift area from which the insect remains could be exported. Moreover, we admit also a possibility of a restricted redeposition of material from the Pleistocene sediments as the species from the group of typical and arctic tundra (3 %) and a group of steppe insects (1 %) were found in the complex evidently contradicting the taiga look of fauna. All this is possible under the dynamic conditions of the river delta. But it is difficult to assume that the entire forest complex consisting of the representatives of different ecological groups was transferred from the forest and redeposited in the delta. In particular, the forest fauna representatives showed the best preservation in the sample.

The insects of the sedge heath group comprising 3 % in the complex could occupy some segments with special extremely xerotic conditions within the taiga zone. One of such segments

	part of body							
	h	p	le	re	lre	o	n	ecol
Sample Bkh-B1								
Ord. Coleoptera								
Fam. Carabidae								
Diacheila polita Fald.	0	0	0	2	0	0	2	mt
Bembidion (Peryphus) umiatense Lindrt.	0	0	0	1	0	0	1	ri
Bembidion (Peryphus) petrosum Gebl.	0	0	0	1	0	0	1	ri
Pterostichus (Cryobius) brevicornis (Kirby)	0	2	0	0	0	0	2	mt
Curtonotus alpinus Payk.	0	1	1	0	0	0	2	dt
Fam. Dytiscidae								
Hydroporus acutangulus ? Thoms.	0	0	0	1	0	0	1	aq
Agabus moestus (Curt.)	1	1	0	1	0	0	1	aq
Agabus ? lapponicus (Thoms.)	0	0	0	0	0	1	1	aq
Fam. Staphylinidae								
Olophrum consimile Gyll.	0	0	0	1	0	0	1	mt
Staphylininae gen.indet.	0	0	1	0	0	0	1	oth
Fam. Elateridae								
Hypnoidus hyperboreus Gyll.	0	1	0	0	0	0	1	me
Fam. Coccinelidae								
Scymnus sp.	0	0	1	0	0	0	1	ri
Fam. Curculionidae								
Lepyrus cf. nordenskjoeldi Faust	0	0	0	0	0	1	1	sh
Dorytomus rufulus amplipennis Tourn.	0	1	0	0	0	0	1	sh
Tournotaris bimaculatus F.	0	0	0	0	0	1	1	ri
Ord. Hymenoptera								
Fam. Formicidae								
Camponotus herculeanus L.	0	0	0	0	0	1	1	ta
total number of specimens							18	
Sample Bkh-B3								
Ord. Coleoptera								
Fam. Carabidae								
Bembidion (Peryphus) sp.	0	0	1	0	0	0	1	ri
Bembidion (Plataphus) sp.	0	0	1	0	0	0	1	ri
Pterostichus (Cryobius) brevicornis (Kirby)	0	0	2	1	2	0	5	mt
P. (Lyperopherus) sublaevis Sahlb.	0	0	0	1	0	0	1	dt
Agonum sp.	0	0	1	0	0	0	1	ri
Trichocellus mannerheimi Sahlb.	0	0	0	1	0	0	1	dt
Fam. Staphylinidae								
Olophrum consimile Gyll.	0	0	0	1	0	0	1	mt
Fam. Curculionidae								
Tournotaris bimaculatus F.	0	0	0	0	0	1	1	ri
total number of specimens							12	

	part of body							
	h	p	le	re	lre	o	n	ecol
Sample Bkh-B2s								
Ord. Coleoptera								
Fam. Carabidae								
Carabus sp.	1	0	0	0	0	0	1	oth
Pelophila borealis Payk.	0	0	1	0	0	0	1	mt
Nebria frigida Sahlb.	0	0	1	1	0	0	1	ri
Blethisa catenaria Brown.	0	0	0	0	0	1	1	mt
Diacheila polita Fald.	0	1	0	2	0	0	2	mt
Bembidion (Peryphus) sp.	0	0	1	0	0	0	1	ri
Bembidion (Plataphus) sp.	0	0	0	1	0	0	1	ri
Pterostichus (Cryobius) brevicornis (Kirby)	0	1	0	1	1	0	2	mt
Pterostichus (Cryobius) spp.	0	0	1	2	3	0	5	mt
P. (Stereocerus) haematopus Dej.	0	0	0	1	0	0	1	dt
P. (Lyperopherus) sublaevis Sahlb.	0	1	1	1	0	0	2	dt
Agonum sp.	0	0	1	1	0	0	1	ri
Curtonotus alpinus Payk.	0	1	2	0	0	0	2	dt
Amara glacialis Mnnh.	0	0	1	0	0	0	1	dt
Dromius quadraticollis Mor.?	0	0	0	1	0	0	1	ta
Fam. Dytiscidae								
Hydroporus acutangulus ? Thoms.	0	0	1	0	0	0	1	aq
Agabus sp.	0	1	0	0	0	4	2	aq
Fam. Silphidae								
Phosphuga atrata L.	0	0	0	1	0	0	1	ta
Fam. Staphylinidae								
Olophrum consimile Gyll.	0	0	5	0	0	0	5	mt
Deliphrum sp.	0	0	0	1	0	0	1	oth
Tachinus arcticus Motsch.	0	1	0	3	0	0	3	mt
Fam. Scarabaeidae								
Aegalia kamtschatica Motsch.	0	0	0	2	0	0	2	ri
Aphodius sp.	0	0	1	0	0	0	1	ks
Fam. Byrrhidae								
Morychus viridis Kuzm.et Korot.	0	0	2	0	0	0	2	ss
Fam. Melyridae								
Collops obscuricornis Motsch. ?	1	0	0	0	0	0	1	st
Fam. Elateridae								
Hypnoidus hyperboreus Gyll.	0	1	0	0	0	0	1	me
Fam. Coccinelidae								
Coccinelidae gen indet.	0	0	0	0	0	1	1	oth
Fam. Chrysomelidae								
Chrysomela blaisdelli Van Dyke	0	0	1	0	0	0	1	sh
Gastrolina peltoidea Gebl.	0	0	0	2	0	0	2	sh
Gonioctena affinis Gyll.	0	0	0	0	0	1	1	sh
Gastrophysa viridula Deg.	0	0	0	1	0	0	1	me
Phratora vulgatissima L.	0	0	2	0	0	1	2	sh
Fam. Curculionidae								
Phyllobius viridiaeris Laich.	0	0	1	0	0	0	1	me
Sitona borealis Korot.	0	0	0	1	0	0	1	dt
Sitona lineellus Bonsd.	0	0	1	1	0	0	1	me
Lepyrus sp.	0	0	0	0	0	2	1	sh
Hypera ornata Cap.	0	0	0	1	0	0	1	dt
Lixus paraplecticus L.	1	0	0	0	0	0	1	ri
Tournotaris bimaculatus F.	0	3	0	0	0	3	3	ri
Grypus mannerheimi Faust	0	0	0	2	0	0	2	ri
Isochnus arcticus Korot.	0	0	1	1	0	0	2	tt
Ord. Hymenoptera								
Fam. Formicidae								
Camponotus herculeanus L.	0	0	0	0	0	16	4	ta
total number of specimens							68	

Tab. 1: List of identified insect species. h: head pronotum, le: left elytron, re: right elytron, lre: left and right elytrons, o: others, n: abundance; ecol: ecology, ta: taiga, ag: aquatic, ri: riparian, me: meadows, mt: mesic tundra, dt: dry tundra, tt: typical and arctic tundra, ks: broad xerophiles, st: steppe, ms: meadow-steppe, ss: sedge heath

Tab. 1: Liste der identifizierten Insektenarten.

is located at the Lena Delta head at the Belaya Skala station of Tit-Ary Island 50 km upstream. In two other samples collected higher in the section, the insect remains are few. In sample BKh-B1 (at a height of 5.0 m), the remains of 18 individuals of insects of common tundra species, except for single remains of taiga ant *Camponotus herculeanus,* were found. We cannot, on the basis of only single remains, talk about the existence of taiga conditions, as the possibility of its redeposition from the lower layers cannot be excluded. In sample BKh-B3, collected from a height of 6 m, the remains of 12 individuals were detected belonging to the species that can inhabit this locality at the present time. The sample was collected 0.1 m below the sampling place and its radiocarbon age was 540 ±60 years.

CONCLUSIONS

The investigated section consists of three units. The lower unit (4.2-2.8 m interval) is characterized by an abundance of plant detritus, sand and silt layers which were deposited under river floodplain conditions with weak current energy The age of this stage of the mouth development is around 3000 years. The middle unit of 2.8-1.1 m in thickness and characterized by plant remains was probably formed in a bay or an estuary. Only the upper unit (1.1-0.2 m) shows alluvial features. Lamination is undulated and cross-bedded pointing to higher fluvial current energy during sediment formation. This basin development stage began around 550 years ago. All three identified sediment units accumulated sufficiently fast. The time of the breaks between the accumulation of these deposits was characterized by the stages of river entrenchment at a depressed erosion basis. The breaks were probably caused by the level changes of the river and the receiving water body.

There are no well preserved insect samples from Holocene of Northern Yakutia. Only several samples from Bykovsky peninsula, Alazea River, Krestovka River were studied (KISELEV 1976, 1981, KUZMINA 1986, KUZNETSOVA at al 1999). These samples include tundra, shrubs, water, riparian, forest and few steppe species. The same Holocene insect samples were studied from Chukotka (BOYARSKAYA & KISELEV 1980, BOYARSKAYA at al. 1983). But Late Holocene insects with radiocar-bon date we had taken for the first time.

Paleobotanic data (megafossil tree, pollen and diatoms) from the location of Dolgoe Ozero, a lake near the Lena Delta, reflect the change of forest to tundra conditions at 3500 radiocarbon yr BP (LAING at al. 1999, MACDONALD at al. 2000, PISARIC at al. 2001). We suppose locality changes of the tree line in the Lena Delta region in the time interval 3500-3000 yr. The obtained data of entomological studies allow the hypothesis that around 3000 years ago, the forests (most likely larch forests) even if they did not exist in this area near the Lena Delta head, must have been very close to it. They advanced northward along the Lena River valley. The geological structure of the section does not provide any evidence that the forest existed right on the island. However, the spectra of insects in the floodplain deposits and a better preservation of exactly the representatives of forest entomofauna allow this suggestion.

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