MAYFLIES (EPHEMEROPTERA) OF THE WEST SIBERIAN LOWLAND AND OIL POLLUTION

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Mayflies were studied from 1989-1993 between 60°-68° N. latitude and 70°-78° E. longitude during a research program on the influence of oil pollution on aquatic organisms. The West-Siberian mayfly fauna combines species of quite diverse West-Palaearctic and East-Palaearctic faunas. The list of mayflies includes 22 species from 7 families. These are holarctic and circumarctic (4 species), transpalaearctic (10 species), 4 species spread across Europe and West Siberia, one species each in Scandinavia and Siberia and two species in East Palaearctic. The indicator significance of some species is discussed.

INTRODUCTION

The mayflies of the West Siberian Lowland have not been studied until now. Only a few papers (IOFFE, 1947; ROMANOVA, 1949) report the presence of mayflies in benthos and the food of fish. At the present time the intensive extraction of oil and gas in this area is accompanied by environmental change and pollution in significant degrees. The water-bodies accumulate, transport and change a great number of polluted substances and chemical analysis alone is not a sufficient method to estimate the state of the water quality. To determine conditions in aquatic ecosystems the examination of ecological parameters including faunistic characteristics is necessary. Our research in West Siberia is connected with the use of mayflies as indicator organisms of the water quality.

METHODS AND SAMPLING SITES

Mayflies were collected in two areas - in the centre and in the north of the West Siberian Lowland, from 1989-1993. Larvae were collected by net dip and Petersen dredge, imago were collected by net sweep.

The territory N 1 lies in the Khanty-Mansi Autonomous District of T'umen' Province, between 60°-63° N. lat. and 70°-76° E. long. in a subzone of middle and northern taiga (Fig. 1). Samples were taken from the tributaries of the middle part of the river Ob'; east of Surgut - at the rivers Lyamin, Pim (and its tributaries Mil'ton-yaun, Vachim), Vynga, Minchimkina, Bystrinka, Chyornaya, Mokhovaya, south of Surgut - at the river Bol'shoy Yugan and its small tributaries and to the north-east of Surgut - at the rivers Kotukhta, Nyucha-Kotukhta, Vat'egan (with its small tributaries) (Fig. 1). Most of these rivers are situated in fields of oil extraction and were polluted. Only Mil'ton-yaun, Kotukhta, Nyucha-Kotukhta and the upper part of Lyamin, Pim, Bystrinka, Vat'egan rivers were located outside the oil fields. Samples were taken in June-July 1989, June 1990, June and August 1991, June and August 1992 by E. Novikova and in August 1989 by N. Kluge.

The territory N 2 lies in Yamalo-Nenets Autonomous District of T'umen' Province, between 66°-68° N. lat. and 76°-78° E. long. (Fig. 1) in a subzone of forest-tundra and tundra below and above the polar circle. Samples were taken from western tributaries of the river Pur, the rivers Evoyakha, Syagoikhadutte, Khadutte and their tributaries, and some nameless lakes. These water bodies are situated in gas fields, where extensive drilling is done. Samples were taken in August 1993 by N. Kluge.

Chemical analyses of river water from territory N 1 were done in the laboratories of Sankt-Petersburg («Nevsk-geologia» *et al.*) and from Surgut («Surgutneftegaz») by standard methods.

RESULTS AND DISCUSSION

Hydrochemical characteristics

Clean rivers in the territory N 1 had the following hydrochemical characteristics:
pH 6.2-6.5; concentration of dissolved oxygen (in summer) 4.9-7.5 mg/l and 70-100% of saturation; Fe = 0.03-3.0 mg/l; Mg = 1.2-4.8 mg/l; Ca = 4-12 mg/l; Na+K = 1.2-40.0 mg/l; Cu<0.005 mg/l; NH_4^+= 0.2-0.6 mg/l; NO_3^-= 0-0.5 mg/l; NO_2^-= 0-0.1 mg/l; HCO_3^-= 12-183 mg/l; CO_3^{2-}= 0 mg/l; Cl^-=1.5-6 mg/l; SO_4^{2-}= 6-8 mg/l; total phosphate 0.005 mg/l or more; surface-active substances 0-0.04 mg/l; oil 0.5-0.16 mg/l; total mineralisation 60-220 mg/l. Water was brownish and had high parameters of BOD (biochemical oxygen demand) and COD (chemical oxygen demand by bichromate of potassium), because it contained a lot of natural dissolved organic substances [COD = 20-25 mg

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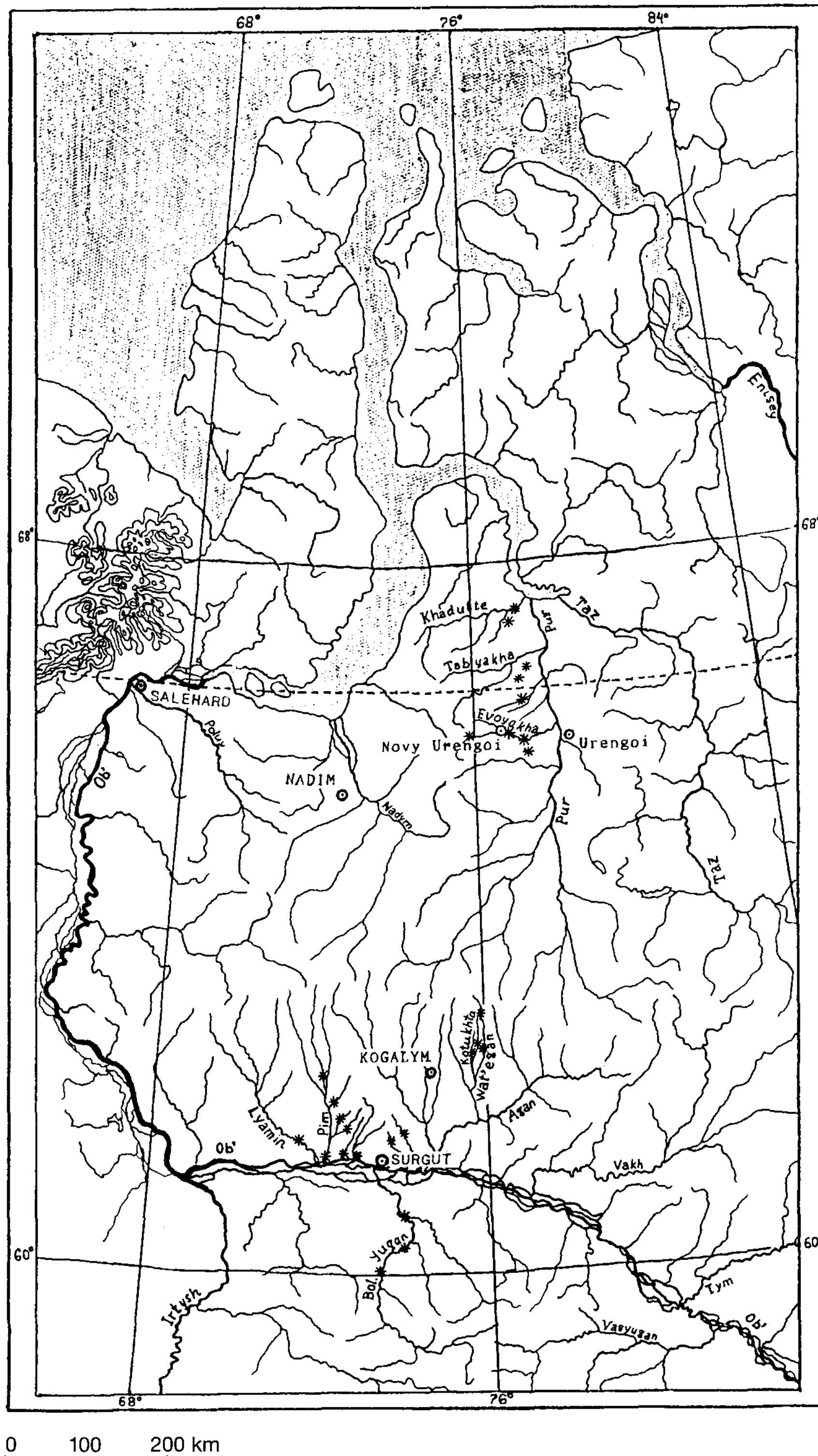

Fig. 1. Map of the area sampled in the West Siberian Lowland from 1989-1993. The stars represent sampling sites.

O_2/l, BOD (5 days) = 2.0-2.2 mg O_2/l]. The temperature of water was 8-20°C.
It should be noted that the unpolluted surface water of the territory N 1 has a naturally high content of oil-derived hydrocarbons. The concentration of natural oil substances was 0.05-0.16 mg/l in the water of unpolluted rivers, but it was from 0.07-0.80 to 3-4 mg/l in the water of polluted rivers. Therefore, it was not possible to separate human oil pollution from natural pollution in oil concentrations from 0.07 to 0.16 mg/l. There also is a problem in finding and identifying the large number of chemical organic substances (more than 200), which are used in the extraction of oil and gas (there are stabilizers, inhibitors, de-emulsifiers, solvents, modifiers, bactericides etc.), many of which are known to be toxic. The toxicity of these substances was not studied, and the correlation between concentrations of this group of substances and oil hydrocarbons is unknown. Most likely such correlation is absent. Perhaps, the total amount of pollutants of this group correlates approximately with COD and BOD. COD was 30-40 mg O_2/l or more in polluted water, BOD was 3-4 mg O_2/l in the same cases.

Geographical distribution of West Siberian mayflies

Twenty-two species of mayflies were found in the study areas of the West Siberian Lowland (Table 1). Most of them are widely distributed: 3 of these species are holarctic, 10 species are transpalaearctic.
The ranges of several species were determined during our investigation:
Baetis macani is known from the arctic zone of Europe and North America; it is also found in the Lena delta. This species was very common in the tundra lakes of Northern West Siberia (territory N 2), thus it must be concluded that it is a circumarctic species.
Siphlonurus aestivalis, Cloeon inscriptum, Arthroplea congener, Leptophlebia vespertina and *L. marginata*, which were known as European species (formerly only a single specimen of *S. aestivalis* was reported from Altai), are also distributed and common in the West Siberian Lowland. *C. inscriptum* was recently collected by N. Kluge in Chita Province, so it can be a transpalaearctic species.
Leptophlebia (Paraleptophlebia) strandii was known from Scandinavia and (under the name *L. lunata*) from East Siberia and the Far East; it is widely distributed and very common in the West Siberian Lowland.
Cloeon (Intercloeon) spiniventre, which was known from Altai, East Siberia and the Far East, and was reported as a single specimen from the east of Northern Urals, is found to be common in the tundra lakes of North Western Siberia.
Metreplecton macronyx nom. nud. (KLUGE, 1996, in press) is another species distributed from Western Siberia to the Far East and absent in Europe.

Characteristics of biotopes and biotopical distribution

The West Siberian Lowland is a large flat area, without any rocky ground; a thicklayer of sand underlies a thin layer of soil. Because of this, those mayfly species whose larvae are adapted for life in streams with stony bottoms can not inhabit this great lowland. Thus for many rheophilous mayflies the West Siberian Lowland plays a role of boundary, dividing the West-Palaearctic zoogeographical sector from the East-Siberian subregion of the Amphipacific zoo-geographical sector.
The second cause for the absence of rheophilous mayflies is a long period of anaerobic conditions in the water, lasting almost 6 months when the water bodies are covered by ice. Well-known species poverty of bentofauna in middle Ob' and its tributaries (IOFFE, 1947; ROMANOVA, 1949) depends on winter anaerobic conditions.
River Ob' in its middle part (near Surgut) is a large river with a sandy bottom. In contrast to other examined rivers, mayflies have not been found here. The species poverty of this river and its tributaries (IOFFE, 1947; ROMANOVA, 1949) is likely a result of winter anaerobic conditions.
The big rivers in territories N 1 and N 2 are similar in their mayfly fauna. These are the rivers Khadutte, Syagoikhadutte, Evoyakha, Lyamin, Pim, Bol'shoy Yugan, Vat'egan. These are flatland rivers with current rates 0.1-1

Table 1. List of species found in the West Siberian Lowland. Eu - Europe without Scandinavia; Sc - Scandinavia; WS - the examined territory of Western Siberia; ES - Eastern Siberia and Far East; NA - North America.

Species	Geographical distribution					Territories:		
	Eu	Sc	WS	ES	NA	N 1 rivers	N 2 rivers	N 2 lakes
Siphlonurus (Siphlurella) alternatus Say, 1924	+	+	+	+	+	+		
S. (Siphlonurus) aestivalis Eaton, 1903	+	+	+			+		
Parameletus ? chelifer Bengtsson, 1908		+	+	?+	?+	+		
Metretopus borealis (Eaton, 1871)		+	+	+	+	+	+	
Metreplecton macronyx Kluge, nom. nud.			+	+		+	+	
Baetis (Baetis) fuscatus (Linnaeus, 1761)	+	+	+	+		+		
B. (B.) vernus Curtis, 1834	+	+	+	+		+	+	
B. (B.) macani Kimmins, 1937		+	+	+	+			+
Cloeon (Procloeon) bifidum (Bengtsson, 1912) [incl. *C.(P.) ornatum* (Tshernova, 1928)]	+	+	+	+	+	+	+	
C. (Procloeon) pennulatum (Eaton, 1885)	+	+	+	+	+	+		
C. (Cloeon) inscriptum Bengtsson, 1914	+	+	+	+		+		
C. (Intercloeon) spiniventre Kluge et Novikova, 1992			+	+				+
Heptagenia (Kageronia) fuscogrisea (Retzius, 1783)	+	+	+	+		+	+	
H. (Heptagenia) flava Rostock, 1878	+	+	+	+		+	+	
H. (H.) sulphurea sulphurea (Muller, 1776)	+	+	+	+		+		
Arthroplea congener Bengtsson, 1908	+	+	+			+		
Ephemerella ignita (Poda, 1961)	+	+	+	+		+		
Caenis rivulorum Eaton, 1884	+	+	+	+		+	+	
Brachycercus harrisella Curtis, 1834	+	+	+	+		+	+	
Leptophlebia (L.) vespertina (Linnaeus, 1758)	+	+	+			+		
L. (L.) marginata (Linnaeus, 1767)	+	+	+			+	+	
L. (Paraleptophlebia) strandii Eaton, 1901 [= *L. (P.) lunata* Tshernova, 1852]		+	+	+		+	+	

m/sec, with sandy bottom, sometimes with snags and silt, mainly without vegetation or with limited vegetation close to banks and in bays. Bottom fauna is poor, being concentrated mainly in vegetation and on snags. Mayfly fauna of these rivers includes widely distributed species - *Baetis vernus, Metretopus borealis, Cloeon (Procloeon) bifidum, Heptagenia fuscogrisea, Heptagenia flava, Caenis rivulorum, Brachycercus harrisella* and others.

Small streams examined in both territories (Mil'ton-yaun, Vachim, Minchimkina, Chornaya, Mokhovaya, Kotukhta, Nyucha-Kotukhta, and others) had silt or sandy bottoms and often dense vegetation and thick layers of plant fragments and detritus. The density of some mayfly species - such as *Baetis vernus, Arthroplea congener, Heptagenia fuscogrisea, Caenis rivulorum, Leptophlebia marginata, L. (Paraleptophlebia) strandii* and others - can be high. Only *Caenis rivulorum* and *Baetis vernus* were found on the bottom covered by water moss in some small streams.

Numerous larvae of *Siphlonurus alternatus* and *S. aestivalis* were found in shallow warm puddles, pools, small currentless creeks and former river-beds which were joined to rivers at flood-time. The highest numbers of *Siphlonurus* larvae of (300-500 specimens per m^2) were registered in pools near the Vat'egan river at the end of June 1992. *Leptophlebia marginata, Arthroplea congener, Heptagenia* *fuscogrisea, Caenis rivulorum* and a single specimen of *Parameletus? chelifer* were found in the same places.

There was an unusual kind of biotope found, consisting of pebbles or stony bottoms. Such biotopes were artificial and near bridges and industrial construction. Only one natural stony biotope was found on a small tributary of the Bol'shoy Yugan river. The complex of *Baetis vernus, B. fuscatus* and *Heptagenia sulphurea* is characteristic of such biotopes.

Several tundra lakes have been examined in the territory N 2. Lakes which have a peat bottom and brown water, lack mayfly fauna. Lakes of another kind, with sandy bottoms and light water, are inhabited by *Baetis macani*. The larvae of this species were found only in lakes and never in the running waters of channels and streams flowing out of these lakes (in these running waters *B. macani* is replaced by *B. vernus*). Larvae of *Cloeon* (*Intercloeon*) *spiniventre* and *B. macani* are present in lakes which have dense macrophyte growth near the shore.

Influence of pollution caused by oil and gas extraction

The saprobic status of rivers in the N 1 territory were determined by using saprobic coefficients of many species of zoobenthos, zooplankton and phytoplankton and the biotic index of Woodiwiss; all indexes had a good inter-corelation. The saprobic indices of PANTLE & BUCK (1955), SLADECEC (1973), «GERMAN STANDARD METHODS» (1990), the biotic index by WOODIWISS (1964) and others (GUHL, 1987; MAKRUSHIN, 1974) were used.

In polluted waters the majority of mayfly species are less abundant than in unpolluted waters, or disappear completely. However, the larvae of *Baetis vernus* were found in streams with heavy oil pollution (α-mesosaprobic condition) and in such streams the density of *B. vernus* can increase, as competition with other species is diminished. *Baetis vernus* and single specimens of *Caenis rivulorum, Siphlonurus alternatus* and *Heptagenia fuscogrisea* were found under α-meso-β-mesosaprobic conditions.

Most of the mayfly species were found in β-meso-, oligo- and xenosaprobic rivers. Ten to sixteen species of mayflies were recorded in rivers with xenosaprobic and oligosaprobic conditions. In rivers with β-mesosaprobic conditions, the number of species was 2-3 times less.

In contrast to *B. vernus*, the related species *B. macani* is sensitive to pollution. In tundra lakes *B. macani* can be used as an indicator of xenosaprobic conditions more successfully than *C.* (*I.*) *spiniventre*, as *B. macani* is able to inhabit all clean lakes with sandy bottom, while *C.* (*I.*) *spiniventre* also needs the presence of dense vegetation, which is absent in many lakes. In the examined lakes, on the banks of which drilling for gas is being done or has been done in the past, larvae of *B. macani* have not been found. At the same time in these polluted lakes other hydrobionts are present. Otherwise, *B. macani* was present in 9 lakes and only absent in 3 lakes without traces of drilling, indicating the influence of drilling and gas extraction on this species. However, we need more and more intensive studies to evaluate this human impact on the tundrial fauna.

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