ISSN 1995-4255, Contemporary Problems of Ecology, 2010, Vol. 3, No. 1, pp. 50–54. © Pleiades Publishing, Ltd., 2010.
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Community of Aquatic Insects in Forest-Steppe Lakes of Baraba (*South of West Siberia*)

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Abstract—This paper gives unique data on the ecology of aquatic insects inhabiting lakes in the Baraba forest-steppe region of West Siberia, where the lakeside zone is represented by thick reeds. It is shown that reeds, along with other lake biotopes, are an optimal habitat for many hydrobionts and especially for larvae of the orders Odonata and Diptera.

DOI: 10.1134/S199542551001008X

Key words: aquatic insects, population, reeds, West Siberian forest-steppe

Aquatic taxocenes are more difficult to study than land ones because the collection of hydrobiological material requires laborious techniques and cumbersome equipment. This is especially true for heavily overgrown parts of water bodies. The main benthic zones of lakes are: (1) the littoral zone—as a rule, the entire coastal zone occupied by helophytes, with subzones of hygrohelophytes (shoreline plants) and hygrophytes; (2) the sublittoral zone—the transition zone below the littoral, almost without helophytes; (3) the profundal zone—the central part of a lake, usually with no vegetation [1]. The littoral and partly the sublittoral lakes are characterized by good oxygen conditions, various substrates, and a great diversity of benthic (pelophilous, psammophilous, and lithophilic) and phytophilous communities. In view of the stratification of organism distributions among aquatic plants, this diversity becomes greater even at small depths [2]. This picture is typical of lakes where vegetation is more or less sparse and trophicity is thus favorable for the life of many organisms. Increasing anthropogenic eutrophication of water bodies causes their overgrowing, resulting in a considerable reduction in species richness and abundance [3–5]. The state of aquatic communities in lakes with natural dense beds of helophytes has been the subject of a few studies; the most significant of them is the monograph on the coastal zone of the Neva Bay of the Gulf of Finland written by researchers of the Zoological Institute of the Russian Academy of Sciences [6]. Forest-steppe lakes of the south of West Siberia are of interest as model objects for such studies. In the Chany–Baraba lake region with a total area of 117 thousand km^2, 4.9 thousand km^2 (4.2%) are occupied by 2500 lakes—the highest lake-to-land ratio in the south of West Siberia. In most of these lakes, the vegetative invasion is of the reed-border type. In addition, one of the most typical elements of the Baraba landscape is the so-called inundated plains—reed-filled water-covered and wet depressions. Thus, the total area of reed beds in this region is very large, which makes data on their biodiversity and biological productivity especially important. In many lakes, the littoral is dominated by reed with a small amount of bladderwort and hornweed, and the sublittoral is dominated by bladderwort and hornweed with a small amount of reed. In the littoral zone, reeds often form a continuous impassable border which extends a few tens or even hundreds of meters from the shore to the center of the lake. For most of such lakes the division of the benthal into the littoral and sublittoral is conditional because these zones are both shallow. In our region insect populations of reed beds have not been studied so far.

MATERIAL AND METHODS

The studies were performed from 2004 to 2006 (mid-May–late October) on drainage Lake Fadikha, a typical water body with reed beds in the Barabinsk region of the Baraba forest-steppe zone in the south of West Siberia. Populations of six groups of aquatic insects were studied: dipterans (Diptera), dragonflies (Odonata), mayflies (Ephemeroptera), caddis flies (Trichoptera), beetles (Coleoptera), and bugs (Heteroptera). For the analysis, dipterans were divided into two groups: (1) family Chironomidae; (2) all other dipterans without the family Chironomidae (below, we will call this group nonchironomid dipterans). A total of seven groups of aquatic insects (insects) were analyzed. The population was assessed by taxonomic composition, number, biomass, and domination structure.

The coastal shallow-water area (conditional littoral) of Lake Fadikha is represented by continuous reed beds interrupted by small mirrors of water covered with bladderwort, duckweed, and, sometimes, hornweed. A thick reed border (below, reeds) extends 60–80 m from the shoreline to the middle of the lake (average depth

0.4 m); the next zone is the sublittoral (conditional sublittoral) 100–200 m wide (average depth 0,7); the sublittoral is followed by open water (average depth 1–2 m) free of all types of aquatic macrophytes (profundal). The sublittoral zone consists of open water sites with islands of sparse reed; the aquatic vegetation (hygrophytes) of the sublittoral is represented by bladderwort and hornweed, with the latter dominating. The lake bottom is entirely covered with silts differing in mechanical composition and structure. The water temperature in the sublittoral zone is on average 3–5°C higher than that in reeds.

It should be noted that the common reed (*Phragmites australis* (Cav.)) has an ambiguous effect on hydrobionts. On the one hand, it is a biofilter, located on the boundary between land and aquatic ecosystems, which entraps and deposits biogenic elements and suspensions brought by flow. On the other hand, this plant releases toxic substances which can have an adverse effect on invertebrates and fishes. The decomposition of reed yields readily oxidizing products which create an oxygen deficiency in water. In addition, the reed beds produce shading and overtop hygrophytes [7]. Nevertheless, reed beds create a special microclimate favorable for the development of preimaginal stages of aquatic insects, in particular, due to smaller temperature fluctuations.

Quantitative record of invertebrates was made using a biocenometer and a dip net. A biocenometer is a metal frame of square section of side 25 cm and height 70–90 cm. The dip net was used for mowing (sweeping) over submerged vegetation; the sweep length and depth, distance from the shore, and net diameter were recorded. The studies were simultaneously performed in two biotopes—in the open sublittoral zone and in reeds. For three seasons at Lake Fadikha, 382 hydrobiological samples were taken: 202 in the sublittoral and 180 in reeds. The paper gives average data for three years.

According to the number and biomass, the study insects were grouped into three categories: dominants (no less than 25% of the total number/biomass), subdominants (no less than 10%) and other taxa, less than 10%.

RESULTS AND DISCUSSION

Population of aquatic insects. The limnophilic community in the sublittoral and in reeds is primarily represented by the following invertebrates: flies, dragonflies, mayflies, caddis flies, beetles, bugs, spiders, bloodsuckers, molluscs, and zooplankton. Most of the species are aquatic insects—almost 60% of all detected invertebrates. According to the literature data, this value is 55 to 63% [8–11]. Insects are dominated by amphibionts, which amount to 68% in number and 47% in mass of all insects. Among amphibionts, the most numerous are dipterans, or, more precisely, representatives of the family Chironomidae, which amount to 89% of the total number of Diptera.

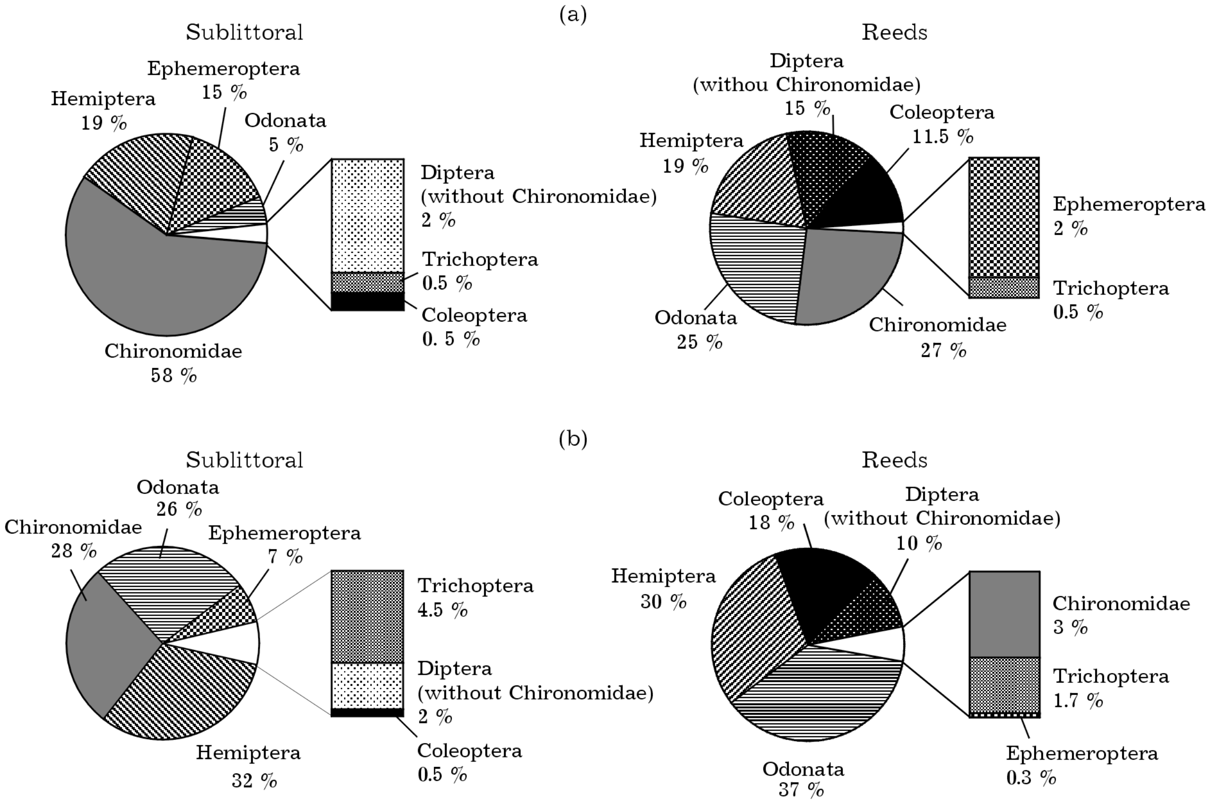
Let us examine the population structure of seven groups of insects in two biotopes of Lake Fadikha (see the figure). In the sublittoral, chironomids dominate in abundance, bugs and mayflies are subdominant in abundance, and the other taxa comprise dragonflies, nonchironomid dipterans, caddis flies, and beetles; bugs dominate in mass, chironomids and dragonflies are subdominant in mass, and the other taxa comprise mayflies, caddis flies, nonchironomid dipterans, and beetles. In reeds, chironomids and dragonflies dominate in abundance, bugs and nonchironomid dipterans are subdominant in abundance, and the other taxa are beetles, mayflies, and caddis flies; dragonflies and bugs dominate in mass, beetles are subdominant in mass, and the other taxa are nonchironomid dipterans, chironomids, caddis flies, and mayflies.

The two biotopes have the following features in common: (1) the mean total (raw) mass of insects per 1 m^2 in the sublittoral (1.7 g) is approximately equal to that in reeds (2 g); (2) the dominants include chironomids, the subdominants bugs, and the other taxa include beetles and caddis flies; (3) identical percentages of bugs (19%) and caddis flies (0.5%).

We note the following differences between the biotopes. The mean total population density of insects in the sublittoral (364 ind/m^2) is twice than that in reeds (196 ind/m^2). The numerical superiority in the sublittoral is due to chironomids (which are two times more abundant here than in reeds) and mayflies (which are five times more abundant than in reeds). The sublittoral taxa are absolutely dominated by chironomids, whereas in reeds, both chironomids and dragonflies are dominants; in the sublittoral, the latter are neither dominants nor subdominants. In reeds, the subdominants, together with bugs, are nonchironomid dipterans, unlike mayflies in the sublittoral. Among the other taxa in reeds, beetles rank first in abundance (an order of magnitude more abundant than in the sublittoral, where they are the least abundant), followed by mayflies and caddis flies.

Analysis of the seasonal dynamics of insect biomass revealed two peaks of biomass in the sublittoral: (1) late June, (2) mid-August–late October; and three peaks in reeds: (1) mid-July, (2) early August, (3) early October. These peaks account for the maximum concentration of older larval stages of amphibionts and imagoes of hydrobionts is necessary.

Because the greatest contrast in number was found for dragonflies, nonchironomid dipterans, mayflies, and beetles, we continued the study of the biotopic features of the sublittoral and reeds, as exemplified by the taxonomic structures and number of dragonflies and nonchironomid dipterans. Dragonflies deserve special attention because they play an important biocenotic role as obligate and numerous predators [12–15]. In ag-



Ratios of the number (a) and biomass (b) of aquatic insects in the sublittoral and in reeds of Lake Fadikha.

gregate, they accounted for about 12% of the others hydrobionts by number and 30% by mass.

Population of dragonfly larvae. At the lake and adjacent areas, 41 species of dragonflies were identified. Samples taken from the lake contained larvae of 18 species of dragonflies belonging to two suborders—Anisoptera (11 species) and Zygoptera (7 species). This difference in the number of species between imagoes and larvae is due to the specificity of the research object in its different habitats. The visibility and mobility of dragonfly imagoes allow counts to be performed over large areas, and this eliminates the aggregated distribution effect. The opposite situation occurs with larvae: the objects are counted almost blindly, and the employed sampling and analysis procedures are very laborious. Therefore, the accounting areas for larvae are two orders of magnitude smaller than those for imagoes. Analysis of nonuniformity in the spatial distribution of dragonfly larvae using various aggregation indices revealed nearly equal proportions of random and aggregated distributions.

In the sublittoral, 14 species (8 Anisoptera and 6 Zygoptera) were found, and in the reed border, also 14 species (9 Anisoptera and 5 Zygoptera) were found. In the sublittoral, *Lestes sponsa* (Hansemann, 1823), *Aeshna serrata* Hagen, 1856, *Leucorrinia dubia* (Vander Linden, 1825), and *Sympetrum danae* (Suelzer, 1776) were absent. The absence of *Lestes sponsa* in the sublittoral zone is not surprising since this species prefers shallow, saline, and heavily silted or overgrown water bodies. The absence of the other three species may be occasional (see below). In reeds, *Enallagma cyathigerum* (Charpentier, 1840), *Erythromma najas* (Hansemann, 1823), *Anax parthenope* Selys, 1839, and *Somatochlora flavomaculata* (Vander Linden, 1825) are absent. The absence of the first two species in reeds may be due to their specific environmental demands. They need oxygen and therefore live in parts of water bodies which are not heavily overgrown and are dominated by submerged vegetation (hornweed, bladderwort, pondweed, etc.). The absence of the other two species may also be occasional (see below). Ten species, characterized by wide environmental valence, appeared to be common for the sublittoral and reeds: four Zygoptera—*Sympecma paedisca* (Brauer, 1877), *Coenagrion armatum* (Charpentier, 1840), *C. lunulatum* (Charpentier, 1840), and *C. pulchellum* (Vander Linden, 1823) and six Anisoptera—*Leucorrhinia pectoralis* (Charpentier, 1825), *L. rubicunda* (Linnaeus, 1758), *Libellula quadrimaculata* Linnaeus, 1758, *Sympetrum flaveolum* (Linnaeus, 1758), *S. sanguineum* (Mueller, 1764), and *S. vulgatum* (Linnaeus, 1758).

A comparison of the number of dragonfly larvae in the studied biotopes showed that Odonata are 3.3 times more abundant in reeds than in the sublittoral, and of them Anisoptera were 1.7 times and Zygoptera 3.6 times more abundant in reeds than in the sublittoral. The ratio of the numbers of Anisoptera and Zygoptera is 1 : 6.4 in the sublittoral and 1 : 13.5 in reeds. Most likely, these ratios are not quite realistic. This large difference between Anisoptera and Zygoptera in the number of larvae is likely due to the specific distribution of representatives of each of the suborders in the water environment. Anisoptera larvae, unlike Zygoptera larvae, appear to show aggregated distribution more often than random; therefore they are rare and less abundant in samples. Generally, the number of Anisoptera larvae in a water body should not be much smaller than that of Zygoptera larvae because counts of imagoes provide evidence for approximately equal proportions of these suborders in nature.

Population of preimaginal stages of nonchironomid dipterans. The samples taken from the lake contained preimaginal stages (larvae, pupae, puparia) of 29 fly genera belonging to 14 families and three suborders: Long-horned (Nematocera), short-horned straight-seamed flies (Brachycera–Orthorrhapha), and short-horned circular-seamed flies (Brachycera–Cyclorrhapha). The long-horned flies belonged to seven families: Ceratopogonidae, Chaoboridae (with one genus *Chaoborus*), Culicidae, Cylindrotomidae, Dixidae, Limoniidae, and Tipulidae; the short-horned straight-seamed flies represented two families: Stratiomyidae and Tabanidae; and the short-horned circular-seamed flies represented five families: Ephydridae, Muscidae, Scathophagidae, Sciomyzidae, and Syrphidae. In the sublittoral, only five families from three suborders were found: long-horned flies—Ceratopogonidae, Chaoboridae, and Culicidae; short-horned straight-seamed flies—Stratiomyidae; and short-horned circular-seamed flies—Ephydridae. In reeds, all 14 families were noted.

A comparison of the number of nonchironomid dipterans in the biotopes studied shows that it is 3.6 times more abundant in reeds than in the sublittoral (as for dragonflies of the suborder Zygoptera). The ratios of the numbers of the suborders Nematocera, Brachycera—Orthorrhapha, and Brachycera–Cyclorrhapha in the sublittoral and in reeds are similar—66.8 : 1.5 : 1 and 11.2 : 1.6 : 1, respectively. Both biotopes are dominated by representatives of the suborder Nematocera, among which species of the genus *Chaoborus* absolutely dominated in number, but in reeds they are two times more abundant than in the sublittoral. Here these are the single permanent plankton insects which develop only in still and slow-flow water bodies with saline water. Long-horned flies are three times more abundant in reeds than in the sublittoral. Short-horned (both straight- and circular-seamed) flies are 16 times more abundant in reeds than in the sublittoral.

In both biotopes, Brachycera–Orthorrhapha are dominated by representatives of the family Stratiomyidae, which are two times more abundant in reeds than in the sublittoral. Brachycera–Cyclorrhapha are dominated by representatives of the families Syrphidae and Scathophagidae, noted only for reeds. Their larvae live in aquatic and semiaquatic environments; before pupation, they often leave the water habitat, move large distances, and pupate on coastal substrates.

CONCLUSIONS

Summarizing the data obtained at Lake Fadikha and comparing the biocenoses of the lake sublittoral and reed zones, it is possible to draw the following conclusions:

1. Reed beds are a special element of a hydrobiogeocenosis and an optimum habitat for most aquatic insects, especially for dragonfly larvae and flies (both for the family Chironomidae and for nonchironomid dipterans) in the given region.

2. In the sublittoral and in reeds there are similar complexes of aquatic insects which differ only in the degree of quantitative representation of their constituent taxa. The sublittoral is absolutely dominated by chironomids, and reeds are absolutely dominated by chironomids and dragonflies. The subdominants are bugs and mayflies in the sublittoral and bugs and nonchironomid dipterans in reeds. The category of other taxa in both biotopes includes beetles and caddis flies.

3. In reeds, unlike in the sublittoral, dragonflies and nonchironomid dipterans are so abundant that they move from the category of other taxa (in the sublittoral) to the higher-rank abundance categories: dragonflies to the dominant category, where they are equal in number to chironomids, and nonchironomid dipterans become subdominants and superior in number to mayflies.

4. The species composition of dragonfly larvae in the sublittoral and in reeds is very similar; the abundance of dragonfly larvae in reeds is 3.3 times greater than in the sublittoral zone.

5. The taxonomic composition of nonchironomid dipterans in the sublittoral is poorer (five families) than in reeds (14 families), and their abundance in reeds is 3.6 times higher than in the sublittoral zone.

We are grateful to A. Yu. Haritonov for help in the work and discussion of the results and to N. Yu. Ilyushchenkov for the participation in sample collection.

This work was supported by Russian Foundation for Basic Research nos. 08-04-00698a and 08-04-00725a.

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