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Mayfly biodiversity (Insecta, Ephemeroptera) of the Russian Far East

Биоразнообразие подёнок (Insecta, Ephemeroptera) российского Дальнего Востока

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Ключевые слова: подёнки, фауна, Дальний Восток, Россия.

Abstract. The mayfly fauna of the Russian Far East currently includes 176 species from 39 genera and 18 families (i.e. 70 % of the total number of species known in Russia). The greatest diversity of mayflies is recorded from the southern part of the Russian Far East, including the basins of the Ussuri River, Amur, and the Sea of Japan. Species with Palaearchearctic ranges represent 43 % of the mayfly fauna of the Russian Far East. Mayfly species composition of the Russian Far East is similar to surrounding territories of Japan and Korea.

Резюме. Фауна подёнок Дальнего Востока России представлена 176 видами из 39 родов и 18 семейств, что составляет около 70 % фауны подёнок России и около 4 % мировой фауны. Анализ распространения подёнок по регионам Дальнего Востока России на уровне видов показал, что наиболее богатыми регионами в видовом отношении являются бассейны рек Уссури (119 видов) и Амур (121 вид), где сконцентрировано соответственно 67 % и 69 % дальневосточной фауны подёнок. Фауна подёнок бассейна Японского моря включает в настоящее время 100 видов, острова Сахалин — 61, Курильского архипелага — 40, Охотского моря — 62, бассейна озера Ханка — 75, водотоков Камчатки — 28 и Чукотки — 17 видов. Среди 176 видов дальневосточной фауны подёнок 36 видов встречаются только на Дальнем Востоке России.

Показан различный удельный вес семейств в той или иной стране. Так, представители семейства Behningiidae отмечены только на территории Дальнего Востока России, где они составляют 14 % от мировой фауны. В Японии, Корее и Китае отсутствуют представители семейств Ametropodidae и Acanthametropodidae. Наибольшее видовое разнообразие представителей семейств Potamanthidae, Ephemeridae и Neoephemeridae отмечено в Китае, Palingeniidae и Isonychiidae — на Дальнем Востоке России, Polymitarcyidae — в Японии, Heptageniidae, Ametropodidae, Ameletidae, Siphlonuridae и Baetidae — в Канаде. При этом отмечено, что, при различии числа видов в России и Канаде практически в два раза, удельный вес ряда семейств довольно близок. Это относится к таким семействам как Potamanthidae, Neoephemeridae, Metretopodidae, Acanthametropodidae, Oligoneuridae, Caenidae.

Наибольшее сходство видового состава подёнок Дальнего Востока России с прилегающими территориями отмечено для Японии и Кореи.

В биогеографическом отношении в фауне подёнок доминируют палеархеарктические виды, составляющие более 43 % фауны подёнок Дальнего Востока России. Наиболее обильны по числу видов с палеархеарктическим и восточно-палеарктическим типами ареалов водотоки бассейнов рек Уссури, Амура и Японского моря.

Introduction

Biological diversity presents balance between formation and extinction of species over the course of the development of a biosphere. There are three basic levels of the conservation and study of biological diversity: population/genetics, species and ecosystem. When developing strategy to conserve biological diversity, the species level is the most convenient to work, considering a species as a set of populations. A fourth level is biogeocenosis, which is between the species and ecosystem levels. Biogeocenoses, that is, communities of organisms, form ecosystems. Thus, conservation of biological diversity on the ecosystem level leads to conservation of the biogenesis of an ecosystem, the ecosystem's species and their populations, i.e., all levels of the organization of biological diversity are addressed.

The Russian Far East occupies an area of 3,016 million square kilometers and extends from Wrangel Island (71° N) in the south to Khasan Lake (42° N) and from Dezhnev Cape (170° W) in the west to the Stanovoi Range (120° E). Sakhalin Island and the Kuril Archipelago also belong to the Far East. In the territory covered by the Far Eastern region, there are more than 940 thousand rivers, which account for approximately 30 % of all Russian rivers. The main river of the region is one of the largest rivers of the world — the Amur River, the basin of which occupies more than half of the Far Eastern region. Regarding the water

discharge volume, the Amur River is only surpassed by the Yenisei, Lena and Ob rivers. The main tributaries in the territory of the Far East are the Zeya (1242 km), Ussuri (897 km), Amgun (723 km), Selemdza (647 km), Bureya (623 km), Bikin (560 km, tributary of the Ussuri River) and Tunguska (544 km) Rivers. The second most significant river of the Far East is the Anadyr River — the largest river in the northeast part of Russia, which extends 1170 km. There are more than 470 thousand rivers at least 100 km in length in the Russian Far East, and there are approximately 460 thousand rivers at least 10 km long.

Currently, more than 2 million living organisms have been discovered, that at a synonymy average level in 20 % allows the establishments to consider as the described about 1.868 million species, of which 1.450 million are terraneous organisms and 318 thousand are aquatic organisms [Reaka-Kudla, 1997; Adrianov, 2003; Adrianov, Tarasov, 2006]. Among aquatic species, 90 % (274 thousand) are found in the sea, and approximately 10 % are found in freshwater (approximately 40 thousand). The mayfly fauna of the world includes approximately 4.5 thousand species (insecta.bio.pu.ru/z/Eph-spp/Contents.htm). In Russia, there are approximately 250 species [Tshernova et al., 1986; Kluge, 1997], and the Russian Far East is home to 176 species [Tiunova, 2008a]. Thus, the Far Eastern mayfly fauna represents 0.4 % of all freshwater organisms of the World and approximately 70 % of Russian mayfly fauna.

The level of scrutiny of mayflies in the Russian Far East has not been sufficiently in depth. Detailed information is available for higher taxa (families) that are already included in determinants [Tshernova et al., 1986; Kluge, 1997]. However, even in these books, only attribute tables for genera are given for some families (for example, Ameletidae, Siphlonuridae, Isonychiidae), and data on species composition are absent because of a low level of scrutiny [Kluge, 1997]. Therefore, it was practically impossible to estimate a saturation species of typical biotopes of river ecosystems of different regions of the Russian Far East in the absence of species lists of local faunas. Therefore, since 1987, the author has surveyed more than 300 rivers and streams across all of the territories of the southern part of the Russian Far East (Fig. 1). These data provide the chance to investigate the taxonomy of mayfly fauna in the Russian Far East and its individual regions [Kocharina et al., 2003; Tiunova et al., 2003; Tiunova, Potikha, 2005; Tiunova, Tiunov, 2007, 2010; Tiunova, 2009; Tiunova, Gorovaya, 2011].

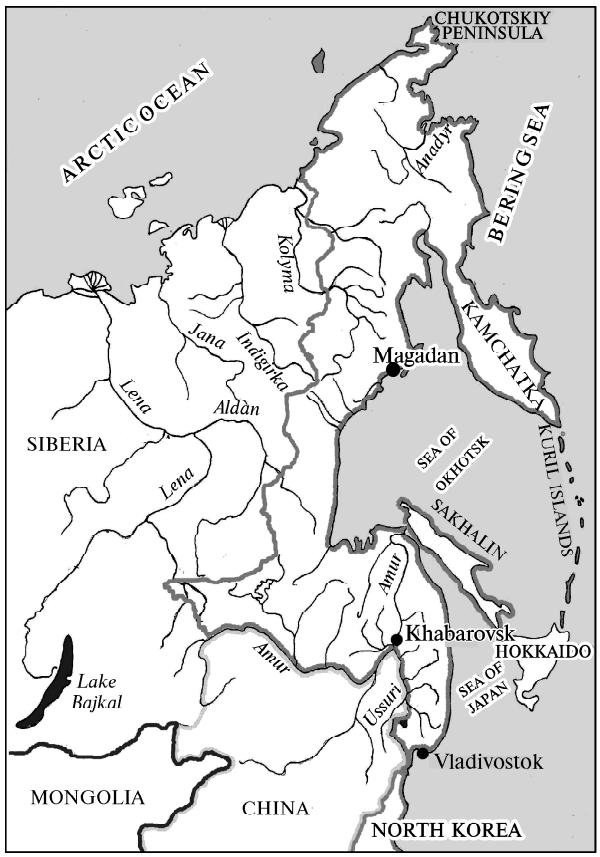

Fig. 1. Map of study area in the Far East of Russia.

Рис. 1. Карта-схема обследованной территории Дальнего Востока России.

Results and discussion

The mayfly fauna of the Russian Far East currently includes 176 species from 39 genera and 18 families (Table 1), or 70 % of the total number of species known in Russia [Tshernova et al., 1986; Kluge, 1997; Tiunova, 2007a, 2008a], despite of the fact that the area of the Far East of Russia is only 18 % of the country's total. The greatest diversity of mayflies is recorded from the southern part of the Russian Far East, including the basis of the Ussuri River, Amur, and the Sea of Japan [Tiunova, 2008a].

The Ussuri River is one of the biggest tributaries of the Amur River, running for 897 km. From a point of confluence with the Sungacha River up to its mouth, the Ussuri River forms the boundary with China. We surveyed the basic tributaries of the Ussuri River, large rivers and its tributaries including Bolshaya Ussurka (440 km), Bikin (560 km), Khor (453 km), and a series of smaller streams (Kabarga, Malinovka, Shivki, Kiya, and others). In its basin, 119 species are found, that is about 67 % of the entire mayfly fauna of the Far East of Russia. The faunal list of mayflies includes 85 species for the Ussuri River, 72 for the Bolshaya Ussurka River, 77 for the Bikin River, and 63 species for the Khor River [Tiunova, 1995a, 2007a, 2008a; Tiunova et al., 1997].

Another region equally rich in mayfly diversity is the Amur River basin up to the border with the Chitinskaya oblast. Here, 121 species, or 69 % of the Russian Far East mayfly fauna, are found. Our investigation followed the largest tributaries of the Amur River, the Anui, Gur, Yai, Amgun', Bureya, Zeya, Arkhara, Bolshoi Ol'doi, Amasar, Bira, and Bidzhan, and included streams of the Evreiskaya Avtonomnaya Ob-

Table 1. List of mayflies (Ephemeroptera) of the Russian Far East and their distribution patterns
Таблица 1. Список подёнок (Ephemeroptera) Дальнего Востока России и типы их ареалов

Species	Distribution
Potamanthidae	
1. *Potamanthus formosus* Eaton, 1892	EAci
2. *P. luteus oriens* Bae et McCafferty, 1991	EP
3. *Rhoenanthus coreanus* Yoon et Bae, 1985	EAc
Ephemeridae	
4. *Ephemera japonica* McLachlan, 1875	EAci
5. *E. orientalis* McLachlan, 1875	EP
6. *E. sachalinensis* Matsumura, 1911	EP
7. *E. shengmi* Hsu, 1937	EAc
8. *E. strigata* Eaton, 1892	EAci
9. *E. transbajkalica* Tshernova, 1973	EP
Polymitarcyidae	
10. *Ephoron shigae* (Takahasi, 1924)	EAci
11. *E. nigridorsum* (Tshernova, 1934)	TP
Palingeniidae	
12. *Anagenesia paradoxa* Buldovsky, 1935	EAc
13. *Chankagenesia natans* Buldovsky, 1935	EAc
14. *Ch. sibirica* McLachlan, 1872	EAc
Behningiidae	
15. *Behningia tshernovae* Edmunds et Traver, 1959	EAc
16. *Protobehningia asiatica* Tshernova et Bajkova, 1960	EAc
Heptageniidae	
17. *Cinygma lyriformis* (McDunnough, 1924)	AP
18. *Cinygmula autumnalis* Tiunova et Gorovaya, 2012	EAc
19. *Cinygmula brunnea* Tiunova, 1990	EAc
20. *C. cava* Ulmer, 1927	EP
21. *C. irina* Tshernova et Belov, 1982	EAc
22. *C. hirasana* Imanishi, 1935	EAci
23. *C. kurenzovi* (Bajkova, 1965)	EP
24. *C. levanidovi* Tshernova et Belov, 1982	EAc
25. *C. malaisei* Ulmer, 1927	EP
26. *C. putoranica* Kluge, 1980	EP
27. *C. sapporensis* (Matsumura, 1904)	EP
28. *C. unicolorata* Tshernova, 1979	EP
29. *Cinygmula* sp.	EAc
30. *Ecdyonurus abracadabrus* Kluge, 1983	EP
31. *E. aspersus* Kluge, 1980	EP
32. *E. aurarius* Kluge, 1983	EP
33. *E. dracon* Kluge, 1983	EAc
34. *E. bajkovae* Kluge, 1986	EAc
35. *E. inversus* Kluge, 1980	EP
36. *E. fragilis* Tiunova, 2006	EAc
37. *E. joernensis* Bengtsson, 1909	TP
38. *E. kibunensis* Imanishi, 1936	EAci

Table 1. (continuation)
Таблица 1. (продолжение)

Species	Distribution
39. *Ecdyonurus levis* (Navas, 1912)	EP
40. *E. scalaris* Kluge, 1983	EAc
41. *E. simplicioides* (McDunnough, 1924)	AP
42. *E. rubromaculatus* You, Wu, Gui et Hsu, 1981	EAc
43. *E. yoshidae* Takahashi, 1924	EAci
44. *E. vicinus* (Demoulin, 1964)	EP
45. *Epeorus anatolii* Sinitshenkova, 1981	EP
46. *E. ermolenkoi* Tshernova, 1981	EAi
47. *E. frolenkoi* Sinitshenkova, 1981	EAi
48. *E. gornostajevi* Tshernova, 1981	EAc
49. *E. latifolium* Ueno, 1928	EAi
50. *E. ninae* Kluge, 1995	EP
51. *E. pellucidus* (Brodsky, 1930)	EP
52. *E. rubeus* Tiunova, 1991	EAc
53. *E.* (*Iron*) *aesculus* Imanishi, 1934	EAci
54. *E.*(*I.*) *alexandri* Kluge et Tiunova, 1989	EP
55. *E.* (*I.*) *maculatus* (Tshernova, 1949)	EP
56. *E.* (*I.*) *uenoi* (Matsumura, 1933)	EAi
57. *Heptagenia chinense* Ulmer, 1919	EAc
58. *H. flava* Rostock, 1878	TP
59. *H. guranica* Belov, 1981	EAc
60. *H. orbiticola* Kluge, 1987	TP
61. *H. sulphurea* (Müller, 1776)	TP
62. *Rhithrogena bajkovae* Sowa, 1973	EP
63. *R. klugei* Tiunova, 2010	EP
64. *R. lepnevae* Brodsky, 1930	EP
65. *R. sibirica* Brodsky, 1930	EP
Ametropodidae	
66. *Ametropus fragilis* Albarda, 1878	TP
Metretopodidae	
67. *Metreplecton macronyx* Kluge, 1996	EP
68. *Metretopus borealis* (Eaton, 1871)	CB
69. *M. tertius* Tiunova, 1995	EAci
Acanthametropodidae	
70. *Acanthametropus nikolskyi* Tshernova, 1948	EP
Isonychiidae	
71. *Isonychia concoloria* Tiunova et al., 2004	EAc
72. *I. crassiuscula* Tiunova et al., 2004	EAc
73. *I. ignota* (Walker, 1853)	TP
74. *I. ivani* Tiunova et Gorovaya, 2010	EAc
75. *I. ussurica ussurica* Bajkova, 1970	EP
76. *I. ussurica sibirica* Tiunova et al., 2004	EP
77. *I. vshivkovae* Tiunova et al., 2004	EAc
78. *I. sexpetala* Tiunova et al., 2004	EAc
79. *I.* gr. *japonica*	EAc

Table 1. (continuation)
Таблица 1. (продолжение)

Species	Distribution
Ameletidae	
80. *Ameletus camtschaticus* Ulmer, 1927	EP
81. *A. cedrensis* Sinitshenkova, 1977	EAc
82. *A. costalis* (Matsumura, 1931)	EAci
83. *A. inopinatus inopinatus* Eaton, 1871	TP
84. *A. inopinatus labiatus* Sinitshenkova, 1981	EP
85. *A. montanus montanus* Imanishi, 1930	EP
86. *A. montanus arlecchino* Kluge, 2007	EP
87. *A. montanus rossicus* Kluge, 2007	EAc
88. *Metreletus micus* (Bajkova, 1976)	EAc
89. *M. omelkoi* Tiunova, 2012	EAc
Siphlonuridae	
90. *Siphlonurus alternatus* Say, 1824	TP
91. *S. immanis* Kluge, 1985	EP
92. *S. chankae* Tshernova, 1952	EP
93. *S. lacustris* (Eaton, 1870)	TP
94. *S. zhelochovtsevi* Tshernova, 1952	EP
95. *S. palaearcticus* (Tshernova, 1949)	EP
96. *Parameletus arcuatus* Tiunova, 2008	EAc
97. *P. ensiformis* Tiunova, 2008	EAc
98. *P. chelifer* Bengtsson, 1908	CB
99. *P. minor* (Bengtsson, 1909)	TP
Baetidae	
100. *Baetis* (*Nigrobaetis*) *acinaciger* Kluge, 1983	EAc
101. *B.* (*N.*) *bacillus* Kluge, 1983	EP
102. *B.* (*Labiobaetis*) *atrebatinus* Eaton, 1870	TP
103. *B.* (*L.*) *tricolor* Tshernova, 1928	TP
104. *B.* (*Baetis*) *bicaudatus* Dodds, 1923	AP
105. *B.* (*B.*) *feles* Kluge, 1980	EAc
106. *B.* (*B.*) *fuscatus* L., 1761	TP
107. *B.* (*B.*) *macani* Kimmins, 1957	CB
108. *B.* (*B.*) *pseudothermicus* Kluge, 1983	EP
109. *B.* (*B.*) *silvaticus* Kluge, 1983	EAc
110. *B.* (*B.*) *thermicus* Ueno, 1928	EAi
111. *B.* (*B.*) *ussuricus* Kluge, 1983	EP
112. *B.* (*B.*) *ursinus ursinus* Kazlauskas, 1963	EP
113. *B.* (*B.*) *vernus* Curtis, 1834	TP
114. *B.* (*Acentrella*) *gnom* (Kluge, 1983)	EP
115. *B.* (*A.*) *fenestratus* (Kazlauskas, 1963)	EP
116. *B.* (*A.*) *diptera* Kluge et Novikova, 2011	EP
117. *B.* (*A.*) *sibiricus* (Kazlauskas, 1963)	EP
118. *B.* (*Baetiella*) *tuberculatus* (Kazlauskas, 1963)	EP
119. *Cloeon* (*Cloeon*) *dipterum* L., 1761	TP
120. *C.* (*Centroptilum*) *kazlauskasi* (Kluge, 1983)	EAci
121. *Cloeon* (*Centroptilum*) sp.1	EAc

Table 1. (continuation)
Таблица 1. (продолжение)

Species	Distribution
122. *Cloeon* (*Procloeon*) *albisternum* (Novikova, 1986)	EAc
123. *C.* (*P.*) *maritimum* (Kluge, 1983)	EAc
124. *C.* (*P.*) *pennulatum* (Eaton, 1870)	TP
125. *C.* (*P.*) *pulchrum*? (Eaton, 1885)	TP
126. *C.* (*Similicloeon*) *simile* Eaton, 1870	TP
127. *Baetopus* (*B.*) *wartensis* Keffermüller, 1960	TP
128. *B.* (*Raptobaetopus*) *tenellus* (Albarda, 1878)	TP
Oligoneuriidae	
129. *Oligoneuriella pallida* (Hagen, 1855)	TP
Leptophlebiidae	
130. *Choroterpes* (*Euthraulus*) *altioculus* Kluge, 1984	EP
131. *Leptophlebia* (*Neoleptophlebia*) *chocolata* (Imanishi, 1937)	EP
132. *L.* (*P.*) *curvata* Ulmer, 1927	EAc
133. *L.* (*N.*) *vladivostokica* (Kluge, 1982)	EAc
134. *L.* (*Paraleptophlebia*) *strandii* Eaton, 1901	TP
Ephemerellidae	
135. *Amurella gracilis* Tshernova, 1952	EAc
136. *Drunella aculea* Allen, 1971	EAc
137. *D. basalis* (Imanishi, 1937)	EAi
138. *D. cryptomeria* (Imanishi, 1937)	EP
139. *D. lepnevae* Tshernova, 1949	EP
140. *D. sachalinensis* (Matsumura, 1931)	EAi
141. *D. solida* Bajkova, 1980	EAc
142. *D. triacantha* Tshernova, 1949	EP
143. *D. trispina* (Uéno,1928)	EAi
144. *Ephacerella longicaudata* (Uéno, 1928)	EAci
145. *Ephemerella aurivillii* Bengtsson, 1908	TP
146. *E. dentata* Bajkova, 1967	EP
147. *E. kozhovi* Bajkova, 1967	EP
148. *E. mucronata* (Bengtsson, 1909)	CB
149. *Cincticostella levanidovae* Tshernova, 1952	EAci
150. *C. tshernovae* Bajkova, 1962	EAc
151. *C. okumai* (Gose, 1980)	EAi
152. *C. nigra* (Uéno, 1928)	EAi
153. *Serratella ignita* (Poda, 1761)	TP
154. *S. setigera* (Bajkova, 1967)	EP
155. *S. thymalli* (Tshernova, 1952)	EP
156. *S. zapekinae* Bajkova, 1967	EP
157. *Torleya mikhaili* Tiunova, 1995	EAc
158. *T. padunica* Kazlauskas, 1963	EP
159. *Uracanthella lenoki* (Tshernova, 1952)	EP
160. *U. punctisetae* (Matsumura, 1931)	EP
Neoephemeridae	
161. *Potamanthellus chinensis* (Hsu, 1935)	EAc

Table 1. (continuation)
Таблица 1. (продолжение)

Species	Distribution
Caenidae	
162. *B. corniger* Kluge, 1991	EP
163. *B. harisella* Curtis, 1834	TP
164. *B. minutus* Tshernova, 1952	TP
165. *B. tubulatus* Tshernova, 1952	EAc
167. *Caenis amurensis* Kluge, 1987	EAc
168. *C. cornuta* (Tshernova, 1952)	EAc
169. *C. horaria* (L., 1758)	TP
170. *C. lactea* (Burmeister, 1839)	TP
171. *C. maculata* (Tshernova, 1952)	EAc
172. *C. miliaria* (Tshernova, 19520	EP
173. *C. macronyx* Kluge, 1987	EAc
174. *C. pseudorivulorum* Keffermüller, 1960	TP
175. *C. pustula* Tiunova, 1999	EAc
176. *C. rivulorum* Eaton, 1884	TP

A — Amphipacific, C — Circum-Boreal, TP — Transpalaearctic, EP — East-Palaearctic, EAc — East-Asian continental, EAi — East-Asian island, EAci — East-Asian continental-island.

last' and Amurskaya Oblast' along a line from the cities of Khabarovsk to Chita. Among 121 mayfly species inhabiting the Amur River basin, 54 species are found in its basic channel [Tiunova, 2008a], 68 species in Bureya River [Tiunova, Tiunov, 2007], 66 species in Zeya River [Tiunova, 2008b; Tiunova, Tiunov, 2010], and 76 species of the Low Amur and its left-bank tributaries [Tiunova, Gorovaya, 2011].

The streams draining into the basin of the Sea of Japan are highly variable, both in length and in hydrological parameters. This area includes streams of the northern and eastern parts of the Sikhote-Alin mountain system and the southeastern spurs of the Black Mountains. We investigated large rivers such as the Tumnin, Razdolnaya, Malinovka, Milogradovka, Samarga, Botchi, Avvakumovka, Serebryanka, and about 30 streams of a moderately cold-water type, each with a length of about 50 km. The majority of these streams are important as so-called salmon rivers, where salmon not only spawn, but fry feed and grow until migration to the ocean [Tiunova et al., 2008; Teslenko et al., 2010]. The mayfly fauna of streams of the Sea of Japan basin now includes 100 species. The checklist of mayflies of the Sikhote-Alin mountain system totals 65 species [Tiunova, Poticha, 2005], the southeastern spur of the Black Mountains — 82 species [Tiunova et al., 2003; Tiunova, 2006].

The water bodies of Lake Khanka are also highly variable, including foothill sections of streams with moderately cold water and flat sections with moderately warm to warm watercourses. Lake Khanka is the largest freshwater reservoir in the Russian Far East. It is 95 km long and covers a surface area of 4070 km^2, with prevailing depths of 1–3 m, reaching a maximum depth of 10.6 m. We studied the Komissarovka, Ilistaya, Nesterovka, Poperechnaya, Malinovka, Kiselevka, and Mel'gunovka rivers, as well as Lake Khanka. These investigations resulted in a list of the mayflies of Lake Khanka basin totaling 75 species [Tiunova, 2007a, 2008a], and only 11 species are found actually in Lake Khanka.

Our studies of coastal rivers along the Okhotsk Sea were carried out in 1998–2000. The material was collected in the rivers Marikan, Okhota, Bulginka, Kuhtui, Ul'ya, Aldoma, Chelasin, Maya, Uika, Lantar', Til, Uda, Iski and others. The author also studied mayfly material collected in Taui River Basin [Arefina et al., 2003]. The mayfly list of the Okhotsk Sea basin now includes 62 species.

The likewise species-rich region of Sakhalin Island includes watercourses and reservoirs in which 60 species have now been found [Tiunova 2007b]. From 1979 to 2004, have been surveyed the rivers and streams of Sakhalin Island from Kriljon Cape in the south up to Schmidt Peninsula in the north. Five species: *Ephemera japonica*, *Epeorus ermolenkoi*, *E. frolenkoi*, *Baetis thermicus* and *Cincticostella nigra* are insular species, occurring in the South of the Russian Far East.

The mayfly fauna of the Kuril Islands now totals 40 species, among which eight are typical island species [Tiunova 1995b, 2007a]. The rivers and streams of islands Kunashir, Shikotan, Zelenyi, Iturup, Urup, Onekotan, Macanrushi, Paramushir and Shumshu have been surveyed.

The streams of the Kamchatka peninsula (28 species) and Chukotka (17 species) have the smallest number of mayfly species [Levanidova, 1972, 1982; Zasypkina et al., 1996; Ishiwata et al., 2000]. Despite of the low diversity of mayfly species along the streams of Chukotka this area is of significant interest for faunistic research as it is a part of the ancient Bering land bridge, the location of migration routes between Asia and North America. A prominent feature of the Chukotka mayfly fauna is the prevailing presence of common species. All mayflies have a wide distribution, and the fauna does not contain endemic forms. This is different to the mayfly fauna known for the basins river Ussuri and Amur. This difference is probably connected with an insufficient level of investigation, as even on Kamchatka, with its poor freshwater fauna, 28 species are now registered, which is 60 % more than on Chukotka.

The majority of mayfly families are well represented in each region of the Russian Far East, except for Chukotka, Kamchatka and Kuril Islands. The family distributions in various regions and river basins has shown that there are at least four levels of diversity (Fig. 2): 6–7 families (Chukotka, Kamchatka and Kuril Islands), 9–10 families (Sakhalin Island and sea of Okhotsk basin), 12–14 families (sea of Japan basin and Khanka Lake) and 16–17 families (basins of Ussuri River and Amur River). Thus, mayfly diversity at the family level in a southern part of the Far East is more than twice that of the northern part.

Table 2. Mayfly fauna composition of the Far East of Russia
Таблица 2. Состав фауны подёнок Дальнего Востока России

Family	Chukotka	Kamchatka	Kuril Islands	Sakhalin Island	Sea of Okhotsk basin	Khanka Lake basin	Sea of Japan basin	Ussuri River basin	Amur River basin	Far East of Russia
Potamanthidae	0	0	0	0	0	1	2	3	2	3
Ephemeridae	0	0	2	5	1	3	3	5	5	6
Polymitarcyidae	0	0	0	0	0	1	1	1	2	2
Palingeniidae	0	0	0	0	0	1	0	0	3	3
Behningiidae	0	0	0	0	0	1	0	1	1	2
Heptageniidae	5	9	12	19	23	20	32	31	32	49
Ametropodidae	0	0	0	0	0	0	0	0	1	1
Metretopodidae	1	1	0	1	2	0	0	2	3	3
Acanthametropodidae	0	0	0	0	0	0	0	1	1	1
Isonychiidae	0	0	0	1	0	4	4	5	5	9
Ameletidae	2	2	2	2	4	1	7	3	3	10
Siphlonuridae	2	3	1	1	6	4	4	9	7	10
Baetidae	4	6	11	15	10	11	20	25	20	30
Oligoneuriidae	0	0	0	0	0	0	1	1	1	1
Leptophlebiidae	0	1	1	3	2	1	3	3	2	5
Ephemerellidae	3	6	11	13	13	19	20	19	19	26
Neoephemeridae	0	0	0	0	0	1	1	1	0	1
Caenidae	0	0	0	1	1	7	2	9	14	14
Total:	17	28	40	61	62	75	100	119	121	176
%	10	16	23	35	36	43	57	68	69	

Analysis of mayfy distribution at species level in regions and river basins of the Russian Far East (Table 2) has shown that there are five levels of diversity: approximately 20 species (Chukotka), approximately 40 species (Kamchatka and Kuril Islands), approximately 80 species (Sakhalin Island, Sea of Okhotsk basin, basin of Khanka Lake), approximately 100–110 species (Sea of Japan basin), and more than 110 species (basins of Ussuri River and Amur River). Note that the species diversity of the southern areas of the Far East (Ussuri River basin) is seven times greater that in the northern regions (Chukotka); the number of species increases from the north to the south to a degree more than the number of families.

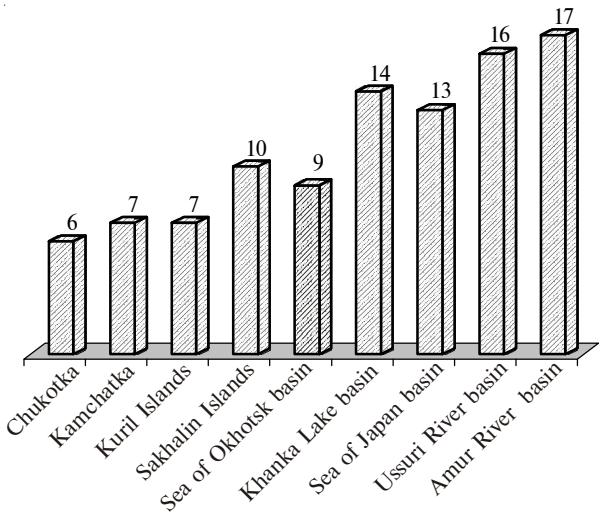

Fig. 2. Distribution of mayfly families on regions of the Far East of Russia.

Рис. 2. Распределение семейств подёнок по регионам Дальнего Востока России.

The relative densities of families in different countries should be noted (Table 3). Representatives of the family Behningiidae were noted only in territories in the Russian Far East, where 14 % of the world's mayflies live. In Japan, Korea and China, there are no representatives of the Ametropodidae and Acanthametropodidae families. The greatest species diversity of representatives of the Potamanthidae, Ephemeridae and Neoephemeridae families was observed in China; of Palingeniidae and Isonychiidae, in the Russian Far East; of Polymitarcyidae, in Japan; and of Heptageniidae, Ametropodidae, Ameletidae, Siphlonuridae and Baetidae, in Canada.

Two times larger similarities is marked between the mayfly fauna of the Russian Far East and the faunas of Korea and Japan. According to data from Bae and Yoon [1997] and others [Bae at al., 1998; Bae, Liu, 1999; Hwang, Bae, 2001] there are 81 species reported in Korean rivers, among which 67 species also inhabit the southern rivers of the Russian Far East. According to Ishiwata [2001], there are 140 species found in Japan, amongst which 44 species are also present in the rivers of the Russian Far East.

Table 3. Number of mayfly species of the Far East of Russia and other countries
Таблица 3. Число видов подёнок на Дальнем Востоке России и других странах

Family	Russia[1]	Far East Russia[2]	Japan[3]	Korea[4]	China[5]	Canada[6]	Total[7]
Potamanthidae	3 (7.5)	3 (7.5)	2 (5.0)	1 (2.5)	12 (30)	4 9 (10)	40
Ephemeridae	9 (6.4)	6 (4.3)	5 (3.6)	4 (2.9)	33 (23.6)	9 (6.4)	140
Polymitarcyidae	3 (3.0)	2 (2.0)	4 (4.0)	1 (1.0)	2 (2.0)	3 (3.0)	100
Palingeniidae	5 (14.3)	3 (8.6)	0	0	1 (2.9)	1 (2.9)	35
Behningiidae	2 (28.6)	1 (14.3)	0	0	0	0	7
Heptageniidae	49 (6.5)	49 (6.5)	42 (5.6)	24 (3.2)	59 (7.9)	82 (10.9)	750
Ametropodidae	1 (16.7)	1 (16.7)	0	0	0	2 (33.3)	6
Metretopodidae	4 (28.6)	3 (21.4)	0	1 (7.1)	0	3 (21.4)	14
Acanthametropodidae	1 (50)	1 (50)	0	0	0	1 (50)	2
Isonychiidae	9 (18.0)	9 (18.0)	4 (8.0)	2 (4.0)	6 (12.0)	6 (12.0)	50
Ameletidae	12 (17.1)	10 (14.3)	7 (10.0)	2 (2.9)	3 (4.3)	23 (32.9)	70
Siphlonuridae	10 (11.1)	10 (11.1)	4 (4.4)	3 (3.3)	3 (3.3)	20 (22.2)	90
Baetidae	53 (6.2)	30 (3.5)	38 (4.5)	15 (1.8)	45 (5.3)	74 (8.7)	850
Oligoneuriidae	3 (5.0)	1 (1.7)	1 (1.7)	0	2 (3.3)	1 (1.7)	60
Leptophlebiidae	12 (0.8)	6 (0.4)	9 (0.6)	2 (0.1)	24 (1.6)	26 (1.7)	1500
Ephemerellidae	26 (8.7)	26 (8.7)	25 (8.3)	16 (5.3)	43 (14.3)	47 (15.7)	300
Neoephemeridae	3 (37.5)	1 (12.5)	0	1 (12.5)	2 (25.0)	1 (12.5)	8
Caenidae	18 (7.8)	14 (6.1)	3 (1.3)	4 (1.7)	12 (5.2)	15 (6.5)	230
Total:	223 (5.0)	176 (3.9)	140 (3.1)	76 (1.7)	250 (5.5)	326 (7.2)	4500

In brackets the percent from the general number is given. Source of data: [1] on: Kluge, 1997; [2] on: Tiunova, 2008a; [3] on: Ishiwata, 2001; [4] on: Bae, Yoon, 1997; [5] on: famu.org/mayfly/china/checklist.html; [6] on: famu.org/mayfly/index.php; [7] on: insecta.bio.pu.ru/z/Eph-spp/Contents.htm.

Table 4. Biogeographical composition of mayfly fauna of the Far East of Russia
Таблица 4. Биогеографический состав фауны подёнок Дальнего Востока России

Distribution	Chukotka	Kamchatka	Kuril Islands	Sakhalin Island	Sea of Okhotsk basin	Sea of Japan basin	Khanka Lake basin	Ussuri River basin	Amur River basin	Far East of Russia
East-Asian	6 (1)	7 (2)	37 (15)	27 (16)	11 (7)	34 (34)	32 (24)	34 (40)	30 (36)	43 (75)
East-Palaearctic	53 (9)	46 (13)	40 (16)	45 (27)	60 (37)	46 (46)	45 (34)	44 (53)	44 (52)	35 (61)
Transpalaearctic	18 (3)	25 (7)	18 (7)	22 (13)	23 (14)	15 (15)	19 (14)	18 (22)	22 (26)	17 (30)
Amphipacific	6 (1)	4 (1)	2,5 (1)	3 (2)	2 (1)	3 (3)	1 (1)	2 (2)	3 (3)	2 (3)
Circum-Boreal	18 (3)	18 (5)	2,5 (1)	3 (2)	5 (3)	1 (1)	3 (2)	2 (2)	2 (2)	2 (5)
Number of species in region	17	28	40	60	62	100	75	119	121	174

Upper lines — the percent from the general number species in respective region is given %; in brackets — number of species in respective region.

Biogeographical composition

As for biogeography, the mayfly fauna of the Russian Far East includes mainly East Asian and East Palaearctic species, which account about 77 % of the species composition (Table 3). Mayflies with East-Asian and East Palaearctic types of distribution are most common in the basins of the Ussuri and Amur rivers, as well as in the Sea of Japan.

Among the regions investigated, species with East-Asian distribution are most richly represented in streams of the Kuril Islands (37 %), Sea of Japan (34 %) and the Ussuri River basin (34 %). It is no wonder that the maximum numbers of endemic insular mayfly species are found on the Kuril Islands. Species with East-Palaearctic distribution prevail in streams of the Sea of Okhotsk (60 %), Chukotka Peninsula (56 %) and Kamchatka Peninsula (48 %). Mayflies with Trans-Palaearctic dis-

tribution are most abundant on Kamchatka Peninsula (26 %) and Sea of Okhotsk basin (23 %). Species with extensive distributions — the Amphipacific and Circum-Boreal types — comprise the greatest percentage on Chukotka (18 %) and Kamchatka Peninsula (19 %).

Conclusion

The mayfly fauna of the Far East of Russia is presented with 176 species from 39 genera and 19 families, representing about 70 % of the mayfly fauna of Russia and about 4 % of the world fauna. Among 176 mayfly species of the fauna of Far East 36 species are found only in the Far East of Russia. The species richest regions are basins of the Ussuri and Amur Rivers, where 67 % and 69 % of the mayfly fauna of the Far East concentrated. East-Asian species dominate in the Far Eastern fauna presenting more than 43 % of mayfly fauna of Russian Far East. The greatest similarity in mayfly species composition of Russian Far East with Japan and Korea is found.

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