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4 **Contents of polyunsaturated fatty acids essential for fish nutrition in zoobenthos species**

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24 **Abstract:** Content of eicosapentaenoic acid (EPA, 20:5n-3) and docosahexaenoic acid (DHA,
25 22:6n-3) and the n-3/n-6 ratio are important indicators of nutritive value of aquatic invertebrates
26 as food for fish. We studied fatty acid (FA) content and composition of 68 zoobenthic species.
27 Benthic invertebrates differed significantly in their contents of EPA and DHA and n-3/n-6 ratios.
28 The most valuable food for fish were Insecta, especially Ephemeroptera and Trichoptera,
29 Gammaridae, and Turbellaria (*Dendrocaelopsis* sp.). The invertebrates of low food quality for
30 fish were Hirudinea, Mollusca, Oligochaeta, Bryozoa (*Plumatella emarginata*), and Coleoptera
31 (*Dytiscus lapponicus*). Our data suggest that the recent and ongoing global replacement of native
32 species, mainly Insecta, by invaders, mostly represented by Mollusca, Crustacea, Polychaeta,
33 Oligochaeta, Bryozoa, and Hirudinea, probably will reduce the nutritive value of food sources
34 for benthivorous fish. In addition, some of the taxa studied have peculiar FAs, which may be
35 useful as their markers in trophic webs. Thus, 20:1n-13, 20:2n-6, 22:5n-3, and 22:6n-3 are likely
36 to be considered markers of Mollusca, Hirudinea, Turbellaria, and Gammaridae, respectively, for
37 tracing food webs in freshwater ecosystems.

38 **Key words:** fatty acids, invertebrates, invasion, fish, food quality.

39

40 Different algal taxa (Bacillariophyta, Chlorophyta, Cryptophyta, etc.) and various groups
41 of bacteria (gram-positive, gram-negative, SO₄-reducing etc.) have unique fatty acids (FAs)
42 (Napolitano 1999, Gugger et al. 2002, Dijkman and Kromkamp 2006, Petkov and Garcia 2007,
43 Kelly and Scheibling 2012). These FAs are widely used as biochemical markers of trophic
44 interactions in aquatic ecosystems (Whiles et al. 2010, Kelly and Scheibling 2012, Makhutova et
45 al. 2012, Galloway et al. 2015). In contrast, contents and compositions of polyunsaturated FAs
46 (PUFAs) in animals are mainly considered to reflect PUFA content and composition of their
47 food. Experimental evidence supports the importance of diet in determining PUFA content in
48 consumers (Weers et al. 1997, Brett et al. 2006, Torres-Ruiz et al. 2010). However, genetically
49 predetermined metabolism also appears to play an important role in FA profiles of animals
50 (Kraffe et al. 2008, Lau et al. 2012).

51 Phylogenetic position of the zoobenthic species and their feeding strategy are important
52 determinants of FA profiles of invertebrates (Makhutova et al. 2011). Benthic invertebrates are a
53 major food source for many fish (Zuev et al. 2011, Nunn et al. 2012). Fish need food with a
54 certain FA composition to achieve high rates of growth and reproduction and to optimize
55 immune functioning (Ruyter et al. 2000, Arts and Kohler 2009, Tocher 2010, Jobling 2015). The
56 absolute concentrations and the ratio of n-3/n-6 PUFA are essential for all vertebrates and
57 probably for nearly all invertebrates, but the optimal ratios are not known for most organisms,
58 although they probably are species specific (Ahlgren et al. 2009). The 2 most important PUFAs
59 in vertebrates are eicosapentaenoic acid (EPA, 20:5n-3) and docosahexaenoic acid (DHA, 22:6n-
60 3) (Arts and Kohler 2009, Ahlgren et al. 2009, Gladyshev et al. 2013). “The n-3/n-6 ratio is
61 lowest and rather stable within species of herbivorous–omnivorous fish, intermediate in
62 carnivorous–piscivorous fish, and highest and highly variable in carnivorous–benthivorous fish”

63 (Ahlgren et al. 2009, p. 163). Variability up to 128-fold has been reported in EPA and DHA
64 levels across fish species (Gribble et al. 2016).

65 Benthic invertebrates with high EPA and DHA contents and high n-3/n-6 ratios are
66 regarded as food of high nutritional quality for fish (Ahlgren et al. 2009). Phylogeny is thought
67 to be an important determinant of EPA and DHA content and n-3/n-6 ratio in benthic
68 invertebrates (Makhutova et al. 2011). Thus, different taxonomic groups of zoobenthos have
69 different food quality for fish. In many aquatic ecosystems, dominant native species of
70 zoobenthos are being replaced by invaders that often belong to other taxonomic groups (Krisp
71 and Maier 2005, Gumuliauskaitė and Arbačiauskas 2008, Karatayev et al. 2009). Such
72 replacement probably changes the nutritional value of food sources for fish. Knowledge of the
73 content of essential FAs in benthic invertebrates will help to predict changes of food quality for
74 fish of zoobenthic communities under invasions. Thus, the goal of our work was to examine
75 nutritional value in terms of contents of metabolically important FAs, EPA, and DHA and the n-
76 3/n-6 ratio of benthic invertebrates inhabiting different aquatic ecosystems. An additional goal of
77 our study was to find FAs that could be used as biochemical markers of different taxonomic
78 groups of benthic invertebrates for tracing of food webs in aquatic ecosystems.

79

80 **METHODS**

81 FA compositions of 68 species of benthic invertebrates were analyzed. Invertebrates were
82 collected in 247 samples (Table S1) from 8 rivers: the Yenisei, Angara, Kacha, Mana, Bugach,
83 Birusa, Nizhnaya Buiba, and Oya Rivers; 12 lakes: Lakes Karovoe, Oyskoe, Svetloe, Tsirkovoe,
84 Bolshoi Kharbei, Zhabronogovoe, Andreevskoe, Anikino, Pleshchevo, Shira, Shunet, and Belo;
85 2 reservoirs: the Bugach and Rybinskoe Reservoirs; and 1 reservoir cooler (Table 1).

86 The samples were collected from 2004 to 2014 in different periods of year because of
87 seasonality in occurrence and dominance of the species (Table S1). Each sample consisted of 1–
88 20 individuals of various sizes. Most specimens were adult or larval stages. Animals were
89 sampled from littoral of rivers with a Surber-type kick-bottom sampler or a handle net. Animals
90 were sampled from reservoirs and lakes with a handle blade net (Zinchenko et al. 2014).
91 Immediately after sorting, the live animals were placed in beakers with settled tap water or
92 filtered (pore size = 80 μm) ambient water for 24 h to empty their guts. The animals' body
93 surfaces were gently wiped with filter paper, and the animals were weighed and placed in a
94 chloroform:methanol mixture (2:1, volume/volume [v/v]) and kept at $-20\text{ }^{\circ}\text{C}$ until further
95 analysis.

96 The methods of lipid extraction, transesterification (methylation) of the lipid extracts, and
97 purification of methyl esters were described by Christie (2003). Briefly, lipids from the samples
98 were extracted with chloroform:methanol (2:1, v/v) 3 times simultaneously with mechanical
99 homogenization of the tissues with glass beads. Before extraction, a definite volume of an
100 internal standard solution (a solution of free 19:0 in chloroform, 0.5 mg/mL; Sigma-Aldrich, St
101 Louis, Missouri) was added to the samples. The volume of the internal standard solution added
102 to the samples depended on the lipid content and mass of the samples and corresponded to 1
103 mL/g of wet mass of animal tissue. The combined lipid extracts were filtered, dried by passing
104 through an anhydrous Na_2SO_4 layer, and evaporated at 35°C . FA methyl esters (FAMES) were
105 prepared in a mixture of methanol:sulfuric acid (20:1, v/v) at 90°C for 2 h as previously
106 described (Makhutova et al. 2012). FAMES were analyzed on a gas chromatograph equipped
107 with a mass spectrometer detector (model 6890/5975C; Agilent Technologies, Santa Clara,
108 California) and a 30-m-long \times 0.25-mm internal diameter HP-FFAP capillary column (Agilent

109 Technologies, Santa Clara, California). The column temperature program was as follows: from
110 100 to 190°C at 3°C/min, 5 min isothermally, then to 230°C at 10°C/min, and 20 min
111 isothermally. Other instrument conditions were as described elsewhere (Gladyshev et al. 2014).
112 FAME peaks were identified by their mass spectrum compared to those in a database (NIST-
113 2005, Gaithersburg, Maryland) and to those of available authentic standards (Sigma-Aldrich).
114 Positions of double bonds in monoenoic acids were determined by gas chromatography-mass
115 spectrometry (GC-MS) of dimethyl disulfide adducts of FAs (Christie 2003). GC-MS of
116 dimethylloxazoline derivatives of FAs was used to determine the double-bond positions in the
117 polyenoic acids (Carrido and Medina 2002).

118

119 **Statistical analyses**

120 Means and standard errors (SEs) and 1-way analysis of variance (ANOVA) with Tukey's
121 Honestly Significant Difference (HSD) post hoc tests were calculated conventionally (Campbell
122 1967, Brown 2005). Single-linkage cluster analysis was conducted based on Euclidean distances
123 (Legendre and Legendre 1998). The data points in the cluster analyses were percentages of FAs
124 in each individual of each species (247 samples). FA levels (% total) were used as the axes of
125 multidimensional hyperspace. Thereby, 33 quantitatively prominent (>0.1%) FAs were included
126 and formed a 33-dimensional hyperspace. All calculations were carried out using STATISTICA
127 software (version 9.0; StatSoft, Tulsa, Oklahoma).

128

129 **RESULTS**

130 Trichoptera had high percentages of markers for green algae (16:3n-3 and 16:4n-3)
131 (Table 2). Ephemeroptera and Odonata had high percentages of markers for bacteria, including

132 cyanobacteria (18:1n-7) (Table 2). The other bacterial markers (i15:0, ai15:0, 15:0, i17:0, 17:0)
133 were typical of Oligochaeta (Table 2) and *Plumatella emarginata* (Bryozoa) (Table 3). *Dytiscus*
134 *lapponicus* (Coleoptera), Gammaridae, and Plecoptera contained high %18:1n-9 (Tables 2, 3).
135 High levels of oleic acid and especially high levels of the ratio of 2 monoenoic acids, 18:1n-
136 9/18:1n-7, which are markers of carnivory, were characteristic of *D. lapponicus* (Table 3),
137 Gammaridae, and Plecoptera (Table 2). Ratio values were 5.8, 4.5, 4.4, respectively. Plecoptera
138 and *Sialis sordida* (Megaloptera) had high %18:3n-3, a marker for green algae and cyanobacteria
139 (Tables 2, 3). *Dytiscus lapponicus* and Diptera had high %18:2n-6, also a marker of green algae
140 and cyanobacteria (Table 2, 3). Hirudinea, Mollusca, and Oligochaeta had high percentages of
141 isomers of 20:1, but different isomers were predominant in different taxa (Table 2). In Mollusca,
142 20:1n-11 and 20:1n-13 were predominant, whereas Hirudinea and Oligochaeta had mainly
143 20:1n-9. Hirudinea contained a significantly high percentage of the long-chain dienoic FA,
144 20:2n-6 (Table 2), whereas Insecta and *Dendrocaelopsis* sp. (Turbellaria) had negligible
145 percentages of this acid (Tables 2, 3). Mollusca, Oligochaeta, and Gammaridae had a
146 considerable %20:2n-6, but it was 2 to 3× lower than in Hirudinea (Table 2). The main
147 characteristic of the members of Insecta studied (Trichoptera, Ephemeroptera, Diptera,
148 Plecoptera, Odonata, and *S. sordida*) was the absence or negligible percentage of long-chain
149 polyunsaturated FAs with 22 C atoms (Tables 2, 3). However, *D. lapponicus* was an exception
150 and contained a high %DHA (Table 3). Among animals studied, Gammaridae had the highest
151 %DHA (Table 2). High %DHA also was present in some species of Mollusca, *P. emarginata*,
152 and *Dendrocaelopsis* sp. (Table 2, 3). *Dendrocaelopsis* sp. had the highest %22:5n-3, but
153 Mollusca also had a high percentage of this FA (Tables 2, 3). The %EPA was high in all animals,
154 especially in Ephemeroptera, Plecoptera, and Gammaridae (Tables 2, 3).

Добавлено примечание ([PS1]): Is this in Tables 2,3?
Oleic acid is 18:1n-9 and it is in Tables 2 and 3.

155 The highest total content of FAs, 68.8 mg/g of wet mass, and content of EPA, 9.6 mg/g
156 wet mass were found in *Ceraclea excisa* (Trichoptera), and the lowest contents, 1.7 and 0.2 mg/g
157 of wet mass, respectively, were found in *P. emarginata* (Table S1). A high content of DHA, was
158 found in Gammaridae, bivalve mollusks (*Dreissena polymorpha* and *Dreissena bugensis*) and in
159 *Dendrocaelopsis* sp. (Table S1). In most species studied, the content of n-3 PUFAs was higher
160 than the content of n-6 PUFAs (Table S1). The highest n-3/n-6 ratio was found in *Caenis* gr.
161 *pseudorivulorum* (Ephemeroptera) and the lowest in *Glossosoma* sp. (Trichoptera) (Table S1).
162 On average, high %EPA and %DHA and high n-3/n-6 ratios were present in Ephemeroptera,
163 Trichoptera, Gammaridae, and *Dendrocaelopsis* sp., whereas low %EPA and %DHA and low
164 ratios were found in *P. emarginata*, Oligochaeta, Mollusca, Hirudinea, and *D. lapponicus* (Table
165 S1).

166 FA composition differed significantly among taxa (Fig. 1). FA composition of species of
167 Oligochaeta, Hirudinea, and gastropod mollusks (*Anisus acronicus* and *Lymnaea ovata*) differed
168 from that of all other taxa, and this group formed a separate cluster (Fig. 1). Species of
169 Gammaridae formed a distinct cluster, as did most of species of Insecta (Fig. 1). Within the
170 cluster of Insecta, species of Ephemeroptera and Plecoptera tended to form separate clusters (Fig.
171 1). Trichoptera and Diptera were more variable than the other taxa and had scattered positions in
172 the dendrogram (Fig. 1).

173 The maximum %EPA+DHA content of Insecta was higher than that of Gammaridae, but
174 the medians were similar (Fig. 2). Mollusca had the lowest median and maximum %EPA+DHA
175 content (Fig. 2). Percent EPA+DHA of Oligochaeta was close to those of Mollusca, whereas
176 median and maximum %EPA+DHA of miscellaneous taxa was higher than those of Mollusca
177 and Oligochaeta but lower than those of Insecta and Gammaridae (Fig. 2). Nevertheless,

178 minimum values of %EPA+DHA of all taxa overlapped (Fig. 2). Thus, all taxa, including
179 Insecta, have species with comparatively low %EPA+DHA.

180 Insecta had the highest EPA content, and showed higher variability in EPA content than
181 the other taxa (Fig. 3). Gammaridae had the highest DHA content, followed by bivalve mollusks
182 (*D. polymorpha* and *D. bugensis*, the 2 upper points in polygon A in Fig. 3) and *Dendrocaelopsis*
183 sp. (the upper point in polygon C in Fig. 3). In the 2-dimensional space, polygons for
184 Gammaridae and Insecta did not overlap, whereas polygons for Insecta, Oligochaeta, gastropod
185 mollusks, and miscellaneous taxa overlapped nearly completely (Fig. 3).

186

187 **DISCUSSION**

188 In general, EPA and DHA contents and n-3/n-6 ratios overlapped among Insecta,
189 Gammaridae, Oligochaeta, Mollusca, Hirudinea, Turbellaria, and Bryozoa. Most taxa had high
190 variability in n-3/n-6 ratios and EPA or DHA contents. However, many species of several taxa
191 (e.g., Insecta, Gammaridae) were rich in EPA or DHA, whereas species in other taxa had
192 relatively low EPA and DHA contents (Fig. 3). These results suggest that the demand for various
193 PUFAs differs among particular taxa. Benthic invertebrates feeding selectively consume food
194 containing FAs that are essential for a certain species to thrive in various environmental
195 conditions. For example, Insecta did not have demand for DHA, whereas Gammaridae required
196 this acid in significant quantities even when both taxa inhabited the same aquatic ecosystem.
197 Thus, a relationship may exist between the n-3/n-6 ratio and EPA and DHA contents and the
198 taxonomic position of benthic invertebrates.

199 EPA and DHA contents and the n-3/n-6 ratio are major parameters of food quality for
200 fish (Arts and Kohler 2009, Ahlgren et al. 2009). Benthivorous fish have higher demand for n-3

201 PUFA content and n-3/n-6 ratio than do herbivorous and piscivorous fish (Ahlgren et al. 2009).
202 On the basis of n-3 PUFA content and the n-3/n-6 ratio, the most valuable foods for fish were
203 Insecta, especially Ephemeroptera and Trichoptera. Species of Gammaridae were also valuable
204 food sources for fish. Gammaridae had high contents of both important PUFAs, EPA and DHA,
205 whereas Insecta had negligible DHA content. *Dendrocaelopsis* sp. also appeared to be very
206 valuable food for fish. Turbellaria are not usually found in fish gut contents, but they are soft-
207 bodied and may not be distinguishable in gut contents. Some authors have supposed that fish do
208 indeed consume Turbellaria (planarian) in freshwater streams (Dumont et al. 2014, Manenti and
209 Bianchi 2014). The invertebrates of low food quality for fish were Hirudinea, Mollusca,
210 Oligochaeta, *P. emarginata*, and *D. lapponicus*.

211 The differences among invertebrate taxa in nutritional value for fish suggest that changes
212 in species composition of the zoobenthic community could result in changes in food quality for
213 benthivorous fish. Such changes might arise from processes, such as climate change,
214 anthropogenic pollution, eutrophication, and invasions. Invasions of new species in aquatic
215 ecosystems, regardless of the ways and reasons for the invasions, have an important effect on
216 community structure and composition (Karataev et al. 2008, 2009). A particularly notable effect
217 on the benthos is restructuring of benthic communities and extinction of native species (Molloy
218 et al. 1997, Burlakova et al. 2000). Karataev et al. (2009, p. 2009) found that “freshwater
219 macroinvertebrate invaders in North America and Europe are not a random selection of species,
220 and are overrepresented by molluscs and crustaceans”, followed by Polychaeta, Oligochaeta,
221 Bryozoa, and Hirudinea, “while taxa richness of native communities are dominated by insects”.
222 This finding is in good agreement with other studies (e.g., Arbačiauskas et al. 2011).

223 According to our data, replacement of insects by invaders probably will reduce

224 nutritional value of food sources for benthivorous fish. However, among taxa of low nutritive
225 value, some species, e.g., *D. bugensis*, do have comparatively high EPA or DHA content. In turn,
226 among taxa of high nutritive value, such as Insecta, some species have very low EPA and DHA
227 content, e.g., *Orthocladius thienemanni* (Diptera:Chironomidae). Therefore, estimation of
228 changes of nutritive value of zoobenthos for fish in a given ecosystem requires data on FA
229 content of invaders vs inhabitants of this ecosystem. For instance, in the Yenisei River, invasive
230 *Eulimnogammarus viridis* (Gammaridae) is causing extinction of native species of Trichoptera
231 and Diptera (Gladyshev and Moskvicheva 2002). Trichoptera, according to our data, are the most
232 valuable food for benthivorous fish. However, *Eulimnogammarus viridis* has higher DHA and
233 similar EPA content and n-3/n-6 ratio compared to the native species of Trichoptera
234 (*Potamophilax latipennis* and *Apatania crymophila*) and Diptera (*Prodiamesa olivacea*) from the
235 Yenisei River (Sushchik et al. 2003). Thus, invasion of *Eulimnogammarus viridis* the Yenisei
236 River did not change significantly or might have improved nutritional value of zoobenthos for
237 fish in terms of essential FAs. However, although essential, PUFAs are not complete indicators
238 of nutritive value. According to another indicator of nutritive value, content of essential amino
239 acids, *Eulimnogammarus viridis* was significantly poorer food than the dominating species of
240 Insecta from the Yenisei River (Kolmakova et al. 2013), and their invasion probably had
241 negative ecological outcomes (Gladyshev and Moskvicheva 2002). Thus, in terms of average
242 PUFA content, especially EPA and n-3/n-6 ratio of the studied taxa, invasions by Mollusca,
243 Crustacea, Oligochaeta, Bryozoa, and Hirudinea are expected to reduce food quality of
244 zoobenthos for fish compared to that of native Insecta.

245 We studied only species inhabiting water bodies in cold and temperate regions, so our
246 results may not be applicable to other climatic zones. In addition, Cyanophyta, Bacillariophyta,

247 and Chlorophyta dominated phytoplankton and phyto­benthos of the aquatic ecosystems studied
248 (Table 1). In aquatic ecosystems where other algae taxa predominate, the same benthic
249 invertebrate taxa probably would have different FA content and composition, including essential
250 EPA and DHA, than reported in our study.

251 Lists of FA markers of different taxonomic groups of plankton and benthic invertebrates
252 have been published (Tolomeev et al. 2010, Makhutova et al. 2013). According to FA markers,
253 Trichoptera and Diptera consumed green algae, diatoms, and cyanobacteria, whereas
254 Ephemeroptera preferred bacteria and diatoms. One of the main food sources of Oligochaeta was
255 detritus enriched with bacteria. Diptera also consumed bacteria. High levels of oleic acid and
256 especially high levels of the 18:1n-9/18:1n-7 ratio are used as markers of carnivory (Cripps and
257 Atkinson 2000, Brett et al. 2009). Gammaridae, Coleoptera, and Plecoptera had high levels of
258 oleic acid and the 18:1n-9/18:1n-7 ratio, so they probably had animals in their diets. Plecoptera,
259 Coleoptera, and Megaloptera consumed green algae and cyanobacteria. Carnivorous Insecta
260 probably obtained markers of green algae and cyanobacteria through trophic chains. Our data are
261 in good agreement with data of other studies (e.g., Sushchik et al. 2003, Füreder et al. 2003,
262 Makhutova et al. 2011, Mirzajani et al. 2011, Inoda 2012).

263 Some taxa had peculiar FAs that are thought to be useful as markers in trophic webs.
264 Mollusca had high %20:1n-13 and 20:1n-11, whereas the other animals did not contain 20:1n-13.
265 High levels of 20:1n-13 in mollusks have been reported by other authors (e.g., Kawashima and
266 Ohnishi 2004, Zhukova 2007, Saito and Hashimoto 2010, Kharlamenko et al. 2011), but its role
267 in metabolism is not clear. Mollusks are thought to biosynthesize 20:1n-13 from 18:1n-13 by
268 elongation, whereas 18:1n-13 is derived from 18:0 by the $\Delta 5$ desaturase, which is common in
269 bivalves (Zhukova 1991, Saito and Osako 2007). The main characteristic of Hirudinea in our

270 study was a high percentage of long-chain dienoic FA 20:2n-6, but other information on FA
271 content of free-living Hirudinea is not available in the literature. *Dendrocaelopsis* sp. had very
272 high 22:5n-3 content. Makhutova et al. (2009) also reported high 22:5n-3 content and extremely
273 high 22:5n-3/22:6n-3 ratios (2–10), which is unusual for most aquatic animals, in Turbellaria.
274 Gammaridae had the highest %22:6n-3. High percentages of this FA have reported for other
275 species of amphipods than those in our study (Kolanowski et al. 2007, Lahdes et al. 2010). High
276 % DHA was found in Gammaridae and Mollusca. Among Mollusca, only dreissenids
277 accumulated DHA and many other long-chain PUFAs. The sum of %22:4n-6, 22:5n-6, and
278 22:5n-3 in Mollusca was 2× higher than %DHA, whereas Gammaridae mostly accumulated
279 DHA. *Dytiscus lapponicus* also had comparatively high %DHA. This carnivorous insect was
280 sampled only in one ecosystem. According to our observations, *D. lapponicus* consumed
281 gammarids and obtained DHA from the prey. Thus, in some cases DHA could be considered as
282 the marker of Gammaridae. We also think that 20:1n-13, 20:2n-6, 22:5n-3 can be used as
283 markers of Mollusca, Hirudinea, and Turbellaria, respectively, for tracing of food webs in
284 freshwater ecosystems.

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526 **FIGURE CAPTIONS**

527 **Fig. 1.** Dendrogram of single linkage cluster analysis of fatty acid (FA) composition (% of total
 528 FA) for the zoobenthic species. Trichoptera: tcn = *Ceratopsyche nevae*, trs = *Rhyacophila*
 529 *sibirica*, tgs = *Goera sajanensis*, tle = Leptoceridae, tce = *Ceraclea excisa*, tac =
 530 *Apatania crymophila*, tsp = *Sericostoma personatum*, top = *Oligoplectrodes potanini*, tao
 531 = *Agrypnia obsoleta*, tp = *Pseudostenophylax* sp., tl = Limnephilidae, tpp = *Psychomyia*
 532 *pusilla*, tpl = *Potamophylax latipennis*, tg = *Glossosoma* sp.; Ephemeroptera: epl =
 533 *Potamanthus luteus*, eej = *Ecdyonurus (A.) joernensis*, eeo = *Ephemera orientalis*, erl =
 534 *Rhithrogena gr. lepnevae*, eep = *Epeorus pellucidus*, eh = Heptageniidae, eei =
 535 *Ephemerella (T.) ignita*, ee = *Ecdyonurus* sp., een = *Ephoron nigridorsum*, ecp = *Caenis*
 536 *gr. pseudorivulorum*, esa = *Ephemera sachalinensis*, ees = *Ephemerella (T.) setigera*, erg
 537 = *Rhithrogena (C.) grandifolia*; Diptera: dhf = *Hexatoma (H.) fuscipennis*, dmp =
 538 *Microtendipes pedellus*, dsc = *Stictochironomus crassiforceps*, dot = *Orthocladius*
 539 *thienemanni*, dc = *Chironomus plumosus*, ddn = *Dicrotendipes nervosus*, dpo =
 540 *Prodiamesa olivacea*, dcp = *Chironomus piger*, dt = Tipulidae; Plecoptera: pa = *Agnatina*
 541 sp., pio = *Isoptera obscura*, paa = *Arcynopteryx* sp., psp = *Skwala pusilla*, pbd = *Diura*
 542 *bicaudata*, ppf = *Paragnetina flavotincta*, pnc = *Nemoura cinerea*, pin = *Isogenus*
 543 *nubecula*; Odonata: oo = *Ophiogomphus* sp., oa = Anisoptera; Megaloptera: mss = *Sialis*
 544 *sordida*; Coleoptera: cdl = *Dytiscus lapponicus*; Gammaridae: ggl = *Gammarus lacustris*,
 545 ggf = *Gmelinoides fasciatus*, gev = *Eulimnogammarus viridis*, gls = *Gammarus lacustris*
 546 saltwater, gpq = *Pallasea quadrispinosa*, gg = *Gammarus* sp., gpv = *Pallasea viridis*, ggp
 547 = *Gammarus pulex*; Mollusca: mdp = *Dreissena polymorpha*, mdb = *Dreissena bugensis*,
 548 mlo = *Lymnaea ovata*, maa = *Anisus acronicus*, mpa = *Pisidium amnicum*; Hirudinea: ho

Добавлено примечание ([PS3]): Comments on fig
 Is there a scale showing similarity associated with the
 cluster analysis

549 = *Herpobdella octocolata*, hs = *Helobdella stagnalis*; Oligochaeta: ott = *Tubifex tubifex*,
 550 oim = *Isochaetides michaelsoni*, osf = *Spirosperma ferox*, osh = *Stylodrilus herringianus*;
 551 Turbellaria: tud = *Dendrocaelopsis* sp.; Bryozoa: bpe = *Plumatella emarginata*.

552 Linkage axis: arbitrary Units

553 Fig. 2. Box and whisker plot showing contents of eicosapentaenoic acid (EPA) +
 554 docosaheptaenoic acid (DHA) in zoobenthos. Squares in boxes show medians, box ends
 555 are quartiles, and whiskers show minima and maxima. Number of species (*n*): Insecta, *n*
 556 = 48; Gammaridae, *n* = 8; Oligochaeta, *n* = 4; Mollusca, *n* = 5; miscellaneous (Hirudinea,
 557 Turbellaria, and Bryozoa), *n* = 4.

558 Fig. 3. Two-dimensional plot of eicosapentaenoic acid (EPA) vs docosaheptaenoic acid (DHA)
 559 content of zoobenthos species. Polygons enclose all points representing species within
 560 groups: A = Mollusca (*n* = 5), B = Gammaridae (*n* = 8), C = miscellaneous species (*n* =
 561 4), D = Insecta (*n* = 48), and E = Oligochaeta (*n* = 4). WM = wet mass.

562

Добавлено примечание ([PS4]): Comments on fig
 y-axis title and units needed
 please remove the upper and right borders from around
 panel
 key to symbols not needed
 please remove dotted horizontal lines
 tick marks go outside axes

Добавлено примечание ([PS5]): comments on fig
 y-axis and x-axis units should be formatted "(mg/g WM)"

563 Table 1. Physical, chemical, and biological characteristics of **water bodies** studied. A = surface area, z_{av} = mean depth, z_{max} =
 564 maximum depth, S = Secchi depth, M = mineralization, L = length, Q = mean discharge, v = mean current velocity, Cya =
 565 Cyanobacteria, Chl = Chlorophyta, Bac = Bacillariophyta, Eug = Euglenophyta, Chry = Chrysophyta, Cry = Cryptophyta, Din =
 566 Dinophyta, Desm = Desmidiaceae, Xan = Xanthophyta, n.d. = no data.

Region, water body	Location	A (km ²)	z_{av} (m)	z_{max} (m)	S (m)	pH	M (mg/L)	L (km)	Q (m ³ /s)	v (m/s)	Phytoplankton	Phytobenthos
Krasnoyarsk territory												
Bugach Reservoir ^{a-c}	56°03' N 92°43' E	0.32	2	7	1	9.0	325				Cya Bac Chl Eug	Cya Chl Bac
Ergaki Mountains												
Lake Karovoe ^{d,e}	52°49' N 93°21' E	0.09	n.d.	7	7	7.9	~10				Chry	Cya Bac
Lake Oyskoe ^{d,e}	52°50' N 93°14' E	0.52	8.3	21	3–5	7.7	17				Bac Desm	Chl Desm
Lake Svetloe ^d	52°48' N 93°25' E	0.48	n.d.	24	6–12	7.6	14				Din Chry Bac	Cya Bac Eug Chl
Lake Tsirkovoe ^{f,g}	52°52' N 93°14' E	0.02	n.d.	15	n.d.	8.5	8				Chry Xan Cya	n.d.
Bolshezemelskaya tundra												
Lake Bolshoi Kharbei ^{h-j}	67°35' N 62°53' E	21.3	4.6	18.5	2.7	6.4	~20				Bac Cya	n.d.
Lake Zhabronogovoe ^{f,i}	67°36' N 62°54' E	0.04	n.d.	n.d.	n.d.	7.6	~20				n.d.	n.d.
Tyumen area												
Lake Andreevskoe ^{k,l}	57°03' N 65°45' E	16.2	1.5	2.4	0.4–1	7.0	~100–200				Cya Chl Bac	n.d.

FWS MS 15-157

Lake Anikino ^l	56°06'N 69°25'E	0.33	1.5	2	0.5–0.8	7.6	~900–1100		Cya Chl Bac	n.d.	
Reservoir-cooler ^l	57°09'N 65°38' E	0.13	n.d.	n.d.	0.4–0.6	6.8	~200–400		Cya Chl Bac	n.d.	
Yaroslavl area											
Lake Pleshcheevo ^{m,n}	56°44'N 38°48'E	51.5	11.2	24.3	1.1–4.3	n.d.	~300		Cya Din Bac	Bac Cya	
Rybinskoe Reservoir ^{o-s}	58°03'N 38°17'E	4550	5.6	30.4	0.9–1.5	7.8	~200		Cya Bac	Chl Bac	
Khakasia											
Lake Shira ^{b,t,u}	54°30'N 90°14'E	34.5	11.2	23.3	3.5	8.5	~16000		Cya	Bac Chl Cya	
Lake Shunet ^{b,t}	54°36'N 90°20'E	0.47	n.d.	6.2	2	8.3	~18000		Cya Bac	n.d.	
Lake Belo ^{v,w}	54°40'N 90°05'E	75	n.d.	48	n.d.	9.6	~12000		Bac Cya Chl	Cya Chl	
Krasnoyarsk territory											
Yenisei River ^x	55°58'N 92°44'E							4803	20164	1–2	Bac Chl
	55°57'N 92°35'E										
	56°23'N 93°36'E										
Angara River ^{y,z}	58°23'N 97°26'E							1779	1902	2–3	Bac Chl Cry
Kacha River ^x	56°04'N 92°49'E							103	4.3	1–2	Bac Chl
Mana River ^x	55°55'N 92°27'E							533	93	1–2	Bac Chl
Bugach River ^{aa}	56°03'N 92°43'E							24	n.d.	n.d.	n.d.
Birusa River ^{aa}	55°55'N 91°58'E							58	4.6	n.d.	n.d.
Ergaki Mountains											

Oya River ^{aa}	52°50'N 93°14'E	254	37.5	n.d.	n.d.
Nizhnaya Buiba River	52°48'N 93°17'E	n.d.	n.d.	n.d.	n.d.

567 ^aMakhutova et al. 2003; ^bGladyshev et al. 2015a; ^cE. S. Kravchuk, personal communication; ^dAnishchenko et al. 2015; ^eGlushchenko
568 et al. 2009; ^fONM, unpublished data; ^gE. A. Ivanova, personal communication; ^hGladyshev et al. 2011; ⁱFefilova et al. 2013; ^jFefilova
569 et al. 2012; ^kValeeva and Sannikova 1994; ^lTAS, personal communication; ^mButorin and Skljarenko 1989; ⁿZubishina, unpublished
570 data; ^oMakhutova et al. 2012; ^pMeteeva and Devyatkin 2005; ^qLitvinov et al. 2001; ^rBylinkina 2001; ^sKorneva 2015; ^tTolomeev et al.
571 2010; ^uGorbaneva et al. 2006; ^vGuseva et al. 2012; ^wMakeeva and Naumenko 2015; ^xGladyshev et al. 2015b; ^yKuzmin et al. 2014; ^zL.
572 A. Glushchenko, personal communication; ^{aa}SPS, personal communication

573 Table 2. Mean (\pm SE) % of the total levels of prominent fatty acids (FAs) of taxa with several species sampled (Table S1). * = sum of
 574 16:1n-7 and 16:1n-9, Σ = sum of isomers. Tukey's Honestly Significant Difference (HSD) post hoc tests were calculated for FAs
 575 marked by letters. Values in rows labeled with the same letter are not significantly different ($p < 0.05$).

FA	Trichoptera	Ephemeroptera	Diptera	Plecoptera	Odonata	Gammaridae	Mollusca	Hirudinea	Oligochaeta
12:0	1.9 \pm 0.74	0.7 \pm 0.16	1.2 \pm 0.35	1.2 \pm 0.23	0.5 \pm 0.07	0.5 \pm 0.19	1.2 \pm 0.74	0.8 \pm 0.08	2.4 \pm 0.46
14:0	2.5 \pm 0.30 ^{ab}	2.5 \pm 0.38 ^{ab}	4.0 \pm 0.63 ^b	1.0 \pm 0.16 ^a	1.1 \pm 0.53 ^{ab}	1.7 \pm 0.31 ^{ac}	2.1 \pm 0.34 ^{ab}	1.4 \pm 0.53 ^{ab}	3.6 \pm 0.58 ^{ab}
Σ 14:1	1.7 \pm 0.41 ^a	0.2 \pm 0.03 ^b	0.5 \pm 0.21 ^b	0.3 \pm 0.11 ^b	0.3 \pm 0.25 ^{ab}	0.1 \pm 0.02 ^b	0.1 \pm 0.12 ^b	0.4 \pm 0.22 ^{ab}	1.6 \pm 0.34 ^{ab}
i15:0	0.3 \pm 0.06 ^a	0.5 \pm 0.09 ^a	1.1 \pm 0.26 ^a	0.2 \pm 0.04 ^a	0.3 \pm 0.06 ^a	0.3 \pm 0.04 ^a	0.4 \pm 0.16 ^a	0.4 \pm 0.03 ^a	4.0 \pm 1.17 ^b
ai15:0	0.1 \pm 0.02 ^a	0.5 \pm 0.09 ^a	0.6 \pm 0.18 ^a	0.0 \pm 0.01 ^a	0.1 \pm 0.01 ^a	0.1 \pm 0.03 ^a	0.2 \pm 0.11 ^a	0.1 \pm 0.01 ^a	2.1 \pm 0.88 ^b
15:0	0.4 \pm 0.08 ^{ab}	0.5 \pm 0.07 ^{ab}	0.8 \pm 0.20 ^b	0.2 \pm 0.03 ^a	0.3 \pm 0.12 ^{ab}	0.3 \pm 0.05 ^{ab}	0.8 \pm 0.35 ^b	0.4 \pm 0.08 ^{ab}	0.8 \pm 0.07 ^{ab}
16:0	16.6 \pm 0.66 ^{ab}	19.2 \pm 0.87 ^a	18.2 \pm 0.99 ^{ab}	12.6 \pm 0.53 ^{cd}	15.7 \pm 0.33 ^{ac}	14.7 \pm 0.80 ^{bc}	17.3 \pm 1.25 ^{ab}	8.6 \pm 1.23 ^{cd}	8.3 \pm 0.42 ^d
16:1*	10.7 \pm 1.25 ^{ab}	12.8 \pm 0.70 ^a	12.7 \pm 1.63 ^a	6.1 \pm 1.13 ^b	5.8 \pm 1.96 ^{ab}	6.7 \pm 0.90 ^b	7.6 \pm 1.46 ^{ab}	7.8 \pm 1.70 ^{ab}	6.3 \pm 0.93 ^{ab}
i17:0	0.2 \pm 0.03 ^a	0.3 \pm 0.03 ^{ab}	0.3 \pm 0.04 ^{ab}	0.3 \pm 0.04 ^{ab}	0.6 \pm 0.13 ^{abd}	0.4 \pm 0.04 ^{ab}	1.0 \pm 0.34 ^d	0.8 \pm 0.19 ^{bd}	1.8 \pm 0.10 ^c
16:2n-4	1.5 \pm 0.26 ^a	1.4 \pm 0.20 ^a	1.3 \pm 0.35 ^a	0.7 \pm 0.16 ^a	0.5 \pm 0.36 ^a	0.5 \pm 0.16 ^a	0.4 \pm 0.19 ^a	0.3 \pm 0.14 ^a	0.5 \pm 0.17 ^a
17:0	0.6 \pm 0.08 ^a	0.8 \pm 0.10 ^a	1.0 \pm 0.15 ^{ab}	0.9 \pm 0.11 ^{ab}	1.6 \pm 0.60 ^{ab}	0.6 \pm 0.09 ^a	1.1 \pm 0.35 ^{ab}	0.9 \pm 0.17 ^{ab}	1.7 \pm 0.14 ^b
16:3n-4	0.9 \pm 0.32	0.6 \pm 0.10	0.5 \pm 0.21	0.3 \pm 0.09	0.2 \pm 0.19	0.3 \pm 0.13	0.4 \pm 0.24	0.1 \pm 0.05	0.3 \pm 0.18
16:3n-3	1.3 \pm 0.26 ^a	0.2 \pm 0.07 ^b	0.4 \pm 0.25 ^b	0.2 \pm 0.03 ^b	0.4 \pm 0.35 ^{ab}	0.1 \pm 0.05 ^b	0.2 \pm 0.10 ^b	0.4 \pm 0.00 ^{ab}	0.1 \pm 0.08 ^b
16:4n-3	2.6 \pm 0.73 ^a	0.2 \pm 0.06 ^b	0.3 \pm 0.17 ^b	0.2 \pm 0.09 ^b	0.4 \pm 0.36 ^{ab}	0.1 \pm 0.06 ^b	0.2 \pm 0.11 ^b	0.1 \pm 0.11 ^{ab}	0.2 \pm 0.09 ^{ab}

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16:4n-1	0.8 ± 0.24	0.3 ± 0.08	0.3 ± 0.13	0.5 ± 0.21	0.2 ± 0.22	0.3 ± 0.14	0.2 ± 0.11	0.0 ± 0.05	0.4 ± 0.22
18:0	5.4 ± 0.52 ^{ac}	5.7 ± 0.35 ^{ac}	6.2 ± 0.67 ^{ac}	7.6 ± 0.91 ^a	13.9 ± 7.49 ^b	3.2 ± 0.43 ^c	6.5 ± 1.29 ^{ac}	6.6 ± 1.11 ^{abc}	7.2 ± 0.97 ^{abc}
18:1n-9	14.7 ± 1.39 ^{ae}	9.0 ± 0.74 ^{bcd}	9.2 ± 0.56 ^{bcd}	18.8 ± 1.32 ^{ae}	14.4 ± 1.27 ^{abce}	19.6 ± 1.62 ^e	4.8 ± 0.64 ^{cd}	9.7 ± 1.81 ^{abcd}	2.8 ± 0.32 ^d
18:1n-7	2.7 ± 0.35 ^a	9.1 ± 0.64 ^c	4.5 ± 0.54 ^{ad}	4.3 ± 0.50 ^{ad}	10.5 ± 1.47 ^c	4.4 ± 0.28 ^{ad}	5.6 ± 1.28 ^d	7.6 ± 0.61 ^{cd}	7.4 ± 0.39 ^{cd}
18:2n-6	6.1 ± 1.26 ^{abc}	3.6 ± 0.48 ^{ac}	9.0 ± 1.21 ^b	6.6 ± 1.14 ^{abc}	5.3 ± 0.79 ^{abc}	5.1 ± 0.79 ^{abc}	3.1 ± 0.55 ^c	3.6 ± 0.11 ^{abc}	2.6 ± 1.23 ^c
18:3n-3	8.7 ± 1.24 ^{ab}	5.2 ± 0.63 ^{ac}	3.8 ± 0.67 ^c	10.3 ± 1.10 ^b	4.6 ± 2.59 ^{abc}	3.0 ± 0.43 ^c	3.7 ± 0.31 ^c	3.7 ± 0.12 ^{abc}	1.2 ± 0.38 ^c
18:4n-3	2.1 ± 0.28	2.7 ± 0.90	1.5 ± 0.37	2.1 ± 0.43	0.8 ± 0.76	1.2 ± 0.22	1.4 ± 0.63	0.8 ± 0.14	0.3 ± 0.12
20:0	0.7 ± 0.11 ^{ab}	0.5 ± 0.04 ^{ac}	1.1 ± 0.32 ^c	1.4 ± 0.21 ^b	2.4 ± 1.58 ^{abc}	0.3 ± 0.06 ^a	0.2 ± 0.10 ^{ac}	0.4 ± 0.16 ^{acd}	0.4 ± 0.06 ^{acd}
Σ20:1	0.3 ± 0.06 ^a	0.1 ± 0.02 ^a	0.2 ± 0.10 ^a	0.3 ± 0.02 ^a	0.3 ± 0.35 ^{ab}	1.2 ± 0.16 ^b	6.6 ± 0.69 ^c	6.9 ± 0.09 ^c	6.0 ± 0.25 ^c
20:2n-6	0.1 ± 0.02 ^a	0.1 ± 0.02 ^a	0.0 ± 0.01 ^a	0.1 ± 0.02 ^a	0.3 ± 0.28 ^{ab}	1.2 ± 0.14 ^{bd}	1.6 ± 0.54 ^d	4.6 ± 0.01 ^c	1.8 ± 0.21 ^d
20:4n-6	1.2 ± 0.23 ^a	1.8 ± 0.37 ^a	2.0 ± 0.37 ^a	1.8 ± 0.31 ^a	2.7 ± 0.05 ^{ab}	4.5 ± 0.76 ^b	5.2 ± 1.15 ^b	7.3 ± 2.43 ^b	5.5 ± 1.42 ^b
20:4n-3	0.2 ± 0.03 ^a	0.2 ± 0.02 ^{ab}	0.3 ± 0.04 ^{ab}	0.2 ± 0.04 ^{ab}	0.1 ± 0.13 ^{ab}	0.3 ± 0.04 ^{ab}	0.4 ± 0.09 ^b	0.3 ± 0.08 ^{ab}	0.3 ± 0.04 ^{ab}
20:5n-3	10.5 ± 1.10 ^a	16.4 ± 1.07 ^b	11.8 ± 1.80 ^{ab}	16.6 ± 1.98 ^{ab}	10.9 ± 2.97 ^{ab}	16.2 ± 1.13 ^{ab}	9.9 ± 1.07 ^{ab}	15.1 ± 2.38 ^{ab}	11.2 ± 2.45 ^{ab}
22:0	0.5 ± 0.11 ^a	0.8 ± 0.08 ^{ab}	0.6 ± 0.22 ^a	0.9 ± 0.19 ^{ab}	2.0 ± 1.44 ^b	0.3 ± 0.06 ^a	0.4 ± 0.29 ^a	0.8 ± 0.07 ^{ab}	0.9 ± 0.21 ^{ab}
22:2n-6	0.0 ± 0.00 ^a	0.0 ± 0.00 ^a	0.0 ± 0.00 ^a	0.0 ± 0.00 ^a	0.0 ± 0.00 ^a	0.0 ± 0.00 ^a	1.6 ± 0.71 ^b	0.3 ± 0.15 ^a	0.0 ± 0.05 ^a
22:4n-6	0.0 ± 0.00 ^a	0.0 ± 0.00 ^a	0.0 ± 0.01 ^a	0.0 ± 0.01 ^a	0.0 ± 0.00 ^{ac}	0.1 ± 0.02 ^{ac}	1.8 ± 0.76 ^b	0.6 ± 0.35 ^{ac}	1.0 ± 0.10 ^{bc}
22:5n-6	0.1 ± 0.05 ^a	0.0 ± 0.00 ^a	0.0 ± 0.02 ^a	0.1 ± 0.07 ^a	0.0 ± 0.04 ^{ab}	0.6 ± 0.11 ^{ab}	1.3 ± 0.75 ^b	0.1 ± 0.03 ^{ab}	0.5 ± 0.39 ^{ab}
22:5n-3	0.1 ± 0.02 ^a	0.0 ± 0.00 ^a	0.1 ± 0.05 ^a	0.1 ± 0.06 ^a	0.2 ± 0.17 ^{ac}	1.4 ± 0.14 ^d	3.6 ± 0.62 ^b	0.7 ± 0.37 ^{acd}	1.3 ± 0.24 ^{cd}
22:6n-3	0.3 ± 0.08 ^a	0.1 ± 0.02 ^a	0.2 ± 0.09 ^a	0.2 ± 0.06 ^a	0.4 ± 0.38 ^{ab}	6.5 ± 1.08 ^c	3.2 ± 1.28 ^b	0.5 ± 0.36 ^{ab}	0.6 ± 0.17 ^{ab}

577 Table 3. Mean (\pm SE) % of total prominent fatty acids (FAs) of taxa with single species sampled.

578 * = sum of 16:1n-7 and 16:1n-9, Σ = sum of isomers. tr. = trace, n.d. = not detected.

FA	Turbellaria	Bryozoa	Megaloptera	Coleoptera
	<i>Dendrocaelopsis</i> sp.	<i>Plumatella emarginata</i>	<i>Sialis sordida</i>	<i>Dytiscus lapponicus</i>
12:0	0.3 \pm 0.15	1.6 \pm 0.09	0.9 \pm 0.70	0.2 \pm 0.05
14:0	2.3 \pm 0.31	2.7 \pm 0.15	1.5 \pm 0.05	1.7 \pm 0.31
Σ 14:1	0.3 \pm 0.09	0.5 \pm 0.16	0.1 \pm 0.08	tr.
i15:0	0.4 \pm 0.04	1.8 \pm 0.04	0.5 \pm 0.03	0.2 \pm 0.03
ai15:0	0.2 \pm 0.04	0.3 \pm 0.03	0.1 \pm 0.03	0.1 \pm 0.01
15:0	0.4 \pm 0.10	1.7 \pm 0.09	0.3 \pm 0.01	0.3 \pm 0.04
16:0	16.1 \pm 1.05	21.1 \pm 1.22	18.8 \pm 2.95	13.3 \pm 1.03
16:1*	8.3 \pm 0.77	10.0 \pm 0.26	15.3 \pm 7.46	5.2 \pm 0.51
i17:0	0.2 \pm 0.03	1.1 \pm 0.07	0.1 \pm 0.03	0.3 \pm 0.02
16:2n-4	1.1 \pm 0.16	0.4 \pm 0.03	0.9 \pm 0.55	0.3 \pm 0.05
17:0	0.6 \pm 0.09	2.2 \pm 0.20	0.4 \pm 0.19	0.7 \pm 0.04
16:3n-4	0.8 \pm 0.11	0.2 \pm 0.03	0.1 \pm 0.03	0.2 \pm 0.03
16:3n-3	1.1 \pm 0.39	n.d.	n.d.	tr.
16:4n-3	0.6 \pm 0.24	0.1 \pm 0.05	n.d.	n.d.
16:4n-1	0.7 \pm 0.19	tr.	n.d.	n.d.
18:0	4.6 \pm 0.44	5.1 \pm 0.42	4.6 \pm 2.36	6.0 \pm 0.15
18:1n-9	16.1 \pm 1.49	7.3 \pm 0.72	13.4 \pm 0.90	23.1 \pm 0.38
18:1n-7	7.6 \pm 0.68	4.4 \pm 0.23	7.1 \pm 0.55	4.0 \pm 0.27
18:2n-6	2.7 \pm 0.31	2.3 \pm 0.15	5.2 \pm 0.54	13.5 \pm 0.46
18:3n-3	5.5 \pm 1.19	2.8 \pm 0.15	9.9 \pm 1.21	3.5 \pm 0.13
18:4n-3	1.4 \pm 0.13	0.9 \pm 0.05	1.5 \pm 0.39	1.8 \pm 0.23
20:0	0.4 \pm 0.04	0.3 \pm 0.06	0.9 \pm 0.62	0.9 \pm 0.02

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Σ20:1	0.6 ± 0.13	2.1 ± 0.12	0.1 ± 0.08	0.7 ± 0.05
20:2n-6	0.4 ± 0.05	2.2 ± 0.21	0.1 ± 0.00	0.7 ± 0.05
20:4n-6	0.6 ± 0.09	2.7 ± 0.13	2.4 ± 0.83	4.8 ± 0.20
20:4n-3	0.3 ± 0.02	0.8 ± 0.08	0.2 ± 0.08	0.8 ± 0.15
20:5n-3	10.0 ± 1.02	9.6 ± 0.74	10.6 ± 2.96	10.6 ± 0.73
22:0	0.5 ± 0.07	0.6 ± 0.07	0.9 ± 0.64	0.3 ± 0.02
22:2n-6	n.d.	n.d.	n.d.	n.d.
22:4n-6	0.9 ± 0.14	0.4 ± 0.13	n.d.	tr.
22:5n-6	0.1 ± 0.02	1.0 ± 0.11	n.d.	0.5 ± 0.10
22:5n-3	8.8 ± 1.17	1.1 ± 0.13	n.d.	0.3 ± 0.06
22:6n-3	1.9 ± 0.40	3.5 ± 0.48	0.1 ± 0.12	2.8 ± 0.43