Length-weight relationships of ten freshwater fish species from Abashiri River basin, eastern Hokkaido, Japan

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Running title: LWRs of 10 freshwater fishes in Hokkaido, Japan

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Abstract

Length-weight relationships (LWRs) were estimated for ten freshwater fish species such as a species of crucian carp, gin-buna, *Carassius langsdorffii* Temminck & Schlegel, 1846, lake minnow *Phynchocypris percnura* (Pallas, 1814), a species of stone loach *Barbatula toni* (Dybowski, 1869), Japanese smelt *Hypomesus nipponensis* McAllister, 1963, masu salmon *Oncorhynchus masou* (Brevoort, 1856), rainbow trout *O. mykiss* (Walbaum, 1792), whitespotted char *Salvelinus leucomaenis* (Pallas, 1814), ninespine stickleback *Pungitius pungitius* (Linnaeus, 1758), a species of sculpin, hana-kajika, *Cottus nozawae* Synder, 1911, and a species of goby *Rhinogobius* sp. OR. Specimens were collected once a month except snowy season from Abashiri River basin, eastern Hokkaido, between June 2007 to November 2011. Fish were captured by the electrofisher (Smith-Root, Model 12-b). The estimated allometric coefficient $b$ values ranged from 2.790 (ninespine stickleback) to 3.294 (the sculpin), and $r^2$ values ranged from 0.772 (lake minnow) to 0.994 (the goby). All the LWRs were highly significant, with $p < 0.001$. Besides, the study provides the first estimates of LWRs for the stone loach, Japanese smelt, masu salmon, whitespotted char, the sculpin, and the goby.

Key Words: Gin-buna, goby, lake minnow, LWRs, ninespine stickleback, sculpin, stone loach, trout
Introduction

Length-weight relationships (LWRs) are commonly used as a fundamental tool for estimating weight and biomass of the species under studies, where weighing fish in the field is often impossible to provide sufficient precision for LWR estimates (Froese 2006; Roul et al. 2018). LWRs are also important for morphological comparisons between different species in the same taxon and populations from a different geographical area (Herath et al. 2014; Panda et al. 2016; Pathak and Serajuddin 2015; Roul et al. 2017a, 2017b, 2018).

In the Abashiri River basin in Hokkaido, several freshwater fishes inhabit. However, the species' primary biological parameters, such as LWRs, have not been studied or poorly studied. Hence the present study aimed to provide the first estimates of LWRs for a species of stone loach *Barbatula toni* (Dybowski, 1869), Japanese smelt *Hypomesus nipponensis* McAllister, 1963, masu salmon *Oncorhynchus masou* (Brevoort, 1856), whitespotted char *Salvelinus leucomaenis* (Pallas, 1814), a species of sculpin, hana-kajika, *Cottus nozawae* Synder, 1911, and a species of goby *Rhinogobius* sp. OR. In addition, this study aimed to provide a new estimate of LWRs for alien rainbow trout *Oncorhynchus mykiss* (Walbaum, 1792) exploited in eastern Hokkaido, Japan, and new estimates of LWRs for lake minnow *Phychoxypris percnura* (Pallas, 1814) and ninespine stickleback *Pungitius pungitius* (Linnaeus, 1758) inhabiting in Asia.

Materials and methods

Fish were collected once a month except snowy season between June 2007 to November 2011, from Abashiri River basin (i.e., Abashiri River, Horokama-hashirihashi stream, Kemichappu River, Chimikeppu River, and Tsubetsu River, Lat. 43° 28′–44° 01′ N; Lon. 143° 48′–144° 16′ E). All fishes were captured by the electrofisher (Smith-Root, Model 12-b). Fish were measured after being anesthetized by the clove oil on the field (Anderson et al. 1997). Crucian carp, lake minnow, Japanese smelt, and Salmonid fishes were measured by fork length (FL),
other fish were measured by total length (TL) using a fish measuring board and scale with 0.1 cm accuracy. Total body weight (BW) was weighted by an electronic weighing balance with 0.1 g accuracy.

The length-weight relationships (LWRs) for all species were calculated using the equation,

\[ \log(BW) = \log(a) + b \log(FL or TL) \]

where BW is the total body weight (g), FL is the fork length (cm), TL is the total length (cm), \( \log(a) \) is the intercept related to body form and \( b \) is the co-efficient indicating allometric growth. The parameters of \( a \) and \( b \) were estimated by a simple linear regression after logarithmic transformation of length and weight data. Extreme outliers were removed from the regression analysis by performing a log-log plot of the length-weight pairs (Froese 2006). The 95% confidence interval (CI) of parameters \( a \) and \( b \), and co-efficient of determination (\( r^2 \)) were estimated.

**Results**

The details on length-weight relationships (LWRs) of all species are given in Table 1. All the LWRs showed highly significance levels (\( r^2 > 0.772, p < 0.001 \)). The allometric co-efficient \( b \) values ranged from 2.942 for whitespotted char to 3.294 for the sculpin, whereas the coefficient of determination (\( r^2 \)) values ranged from 0.772 for lake minnow to 0.994 for the goby.

**Discussion**

In addition to the fishes mentioned in the results, the following species were collected during the investigation: lampreys (especially ammocoetes larva), *Lethenteron reissneri* (Dybowski, 1869) and *L. camtschaticum* (Tilesius, 1811), and redfins, *Pseudaspius hakonensis* (Gunther, 1877) and *P. sachalinensis* (Nikolskii, 1889), these were difficult to identify in the field and were excluded from this study.

This study was the first report to determine LWRs of the stone loach, Japanese smelt, masu
salmon, whitespotted char, the sculpin, and the goby. These LWRs were not found in the FishBase (https://www.fishbase.se/search.php/ "last access 13 Jan, 2022") except for Russian sea-run form of masu salmon. However, Kato (1992) reported the LWR of whitespotted char in Japanese; the formula is $BW=0.01389SL^{3.0181}$, where SL is a standard length. Besides, Kato (1991) reported the LWR of subspecies of masu salmon, $O.\ masou\ ishikawai$ in Japanese; the formula is $BW=0.00220SL^{3.66}$. Both reports using SL are not directly comparable to this study's results using FL. On the other hand, there are some reports of the LWRs of alien rainbow trout in Europe and western Asia (Esmaeilli and Ebrahimi 2004; Erguden and Goksu 2008; Verreycken et al. 2011), but there is no report in eastern Asia. In addition, the LWRs for lake minnow and ninespine stickleback were studied at Lake Baikal in Russia (IGFA 2001) and Lake Superior in the USA(Devine 2002), respectively. These LWRs of this study were the first records in Asia. Furthermore, since the LWRs of gin-buna was recorded from only one individual (IGFA 2001), the results of this study enriched the database. As for the goby, its classification has not yet been determined, and according to Nakabo (2013), it is probably a species included in $Rhinogobius\ kurodai$ (Tanaka 1908), but $R.\ kurodai$ is not recognized as a valid species by Fishbase. These results that provide primary data for further biological research will be useful for fishery conservation in the Abashiri River basin.

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References


IGFA (2001) Database of IGFA angling records until 2001. IGFA, Fort Lauderdale, USA.


Table 1. LWRs parameters for 10 freshwater fish species collected from Abashiri River basin, eastern Hokkaido, Japan.

<table>
<thead>
<tr>
<th>Family</th>
<th>Species</th>
<th>n</th>
<th>Fork length range (cm)</th>
<th>Total length range (cm)</th>
<th>Weight range (g)</th>
<th>a</th>
<th>95% CIa</th>
<th>b</th>
<th>95% Cib</th>
<th>r²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cyprinidae</td>
<td>Carassius langsdorfi Temminck &amp; Schlegel, 1846</td>
<td>764</td>
<td>2.1-29.7</td>
<td>22.4-410.0</td>
<td>0.0213</td>
<td>0.0176-0.0258</td>
<td>2.9353</td>
<td>2.8713-2.9991</td>
<td>0.915</td>
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<td></td>
<td>Phynchocypris percnura (Pallas, 1814)</td>
<td>58</td>
<td>5.3-9.7</td>
<td>1.6-13.5</td>
<td>0.0139</td>
<td>0.0058-0.0334</td>
<td>2.9953</td>
<td>2.5685-3.4221</td>
<td>0.772</td>
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<tr>
<td>Balitoridae</td>
<td>Barbatula toni (Dybowski, 1869)</td>
<td>4,611</td>
<td>2.0-19.8</td>
<td>0.1-121.0</td>
<td>0.0076</td>
<td>0.0074-0.0079</td>
<td>2.9797</td>
<td>2.9635-2.9960</td>
<td>0.966</td>
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<td>Osmeridae</td>
<td>Hypomesus nipponensis McAllister, 1963</td>
<td>13</td>
<td>5.3-10.9</td>
<td>0.9-7.4</td>
<td>0.0089</td>
<td>0.0012-0.0636</td>
<td>2.8731</td>
<td>2.0411-3.7051</td>
<td>0.789</td>
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<td>Salmonidae</td>
<td>Oncorhynchus masou (Brevoort, 1856)</td>
<td>8,208</td>
<td>1.9-21.9</td>
<td>0.1-161.5</td>
<td>0.0106</td>
<td>0.0103-0.0109</td>
<td>3.0397</td>
<td>3.0245-3.0550</td>
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<td>Oncorhynchus mykiss (Walbaum, 1792)</td>
<td>3,410</td>
<td>2.0-40.0</td>
<td>0.1-800.0</td>
<td>0.0117</td>
<td>0.0114-0.0120</td>
<td>2.9970</td>
<td>2.9854-3.0094</td>
<td>0.987</td>
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<td></td>
<td>Salvelinus leucomaenis (Pallas, 1814)</td>
<td>3,314</td>
<td>2.3-52.0</td>
<td>0.1-1700.0</td>
<td>0.0121</td>
<td>0.0117-0.0126</td>
<td>2.9424</td>
<td>2.9273-2.9558</td>
<td>0.978</td>
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<td>Gasterosteidae</td>
<td>Pungitius pungitius (Linnaeus, 1738)</td>
<td>9</td>
<td>3.0-6.8</td>
<td>0.2-3.0</td>
<td>0.0119</td>
<td>0.0028-0.0507</td>
<td>2.7901</td>
<td>2.0579-3.5222</td>
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<td>Cottidae</td>
<td>Cottus nozawae Synder, 1911</td>
<td>38</td>
<td>5.4-17.3</td>
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<td>0.0050-0.0099</td>
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<td>Gobiidae</td>
<td>Rhinogobius sp. OR</td>
<td>3</td>
<td>6.0-9.0</td>
<td>2.2-8.4</td>
<td>0.0063</td>
<td>0.0001-0.7084</td>
<td>3.2860</td>
<td>2.9194-3.6526</td>
<td>0.994</td>
<td></td>
</tr>
</tbody>
</table>

n = number of individuals studied, a = intercept of relationship, b = slope of relationship, CI = confidence interval, r² = co-efficient of determination.