water

The relative effects of biotic and abiotic factors on the recruitment of freshwater mussels (*Margaritifera laevis*)

Keita Kawajiri, Nobuo Ishiyama, Kazuki Miura, Akira Terui, Masanao Sueyoshi and Futoshi Nakamura

Supplementary Materials:

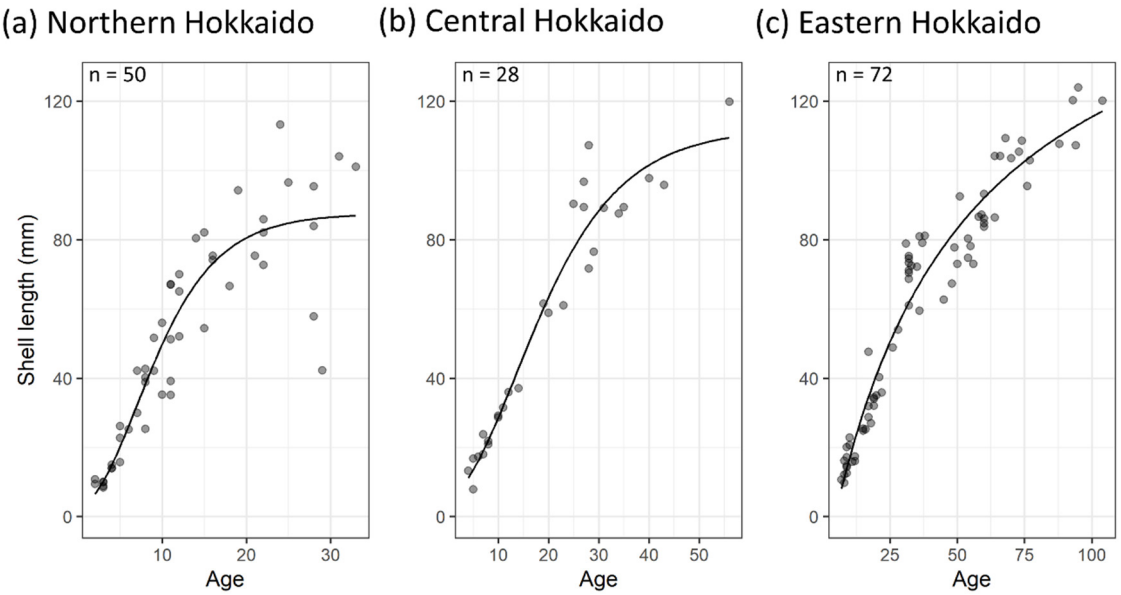

Figure S1. Relationships between shell length and age in the three regions. The plots represent the observed values. The solid lines represent the values predicted by the linear models that used the Gompertz function (a, b) and hyperbolic function (c) based on the results of the estimations of four nonlinear growth models (Table S2).

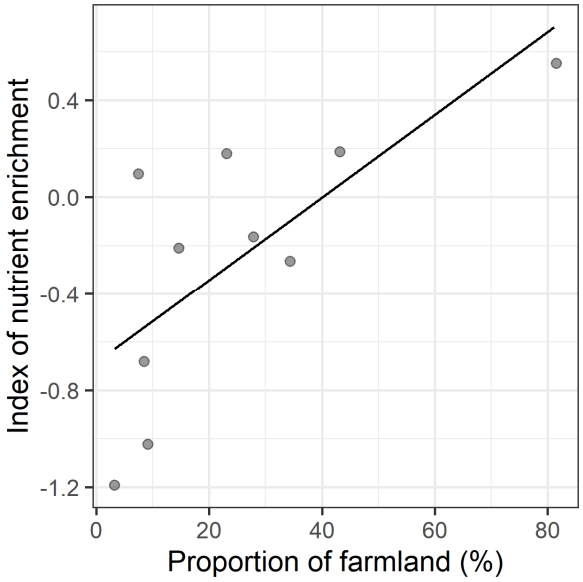

Figure S2. Relationship between the index of nutrient enrichment and proportion of farmland. The plots represent the observed values. The solid line represents the values predicted by the model. R^2: 0.521.

Analysis method： We used a general linear model (GLMs; n=10) with Gaussian error to examine how land-use modifications affected the index of nutrient enrichment. We treated the index of nutrient enrichment as a response variable and the proportion of farmland as an explanatory variable.

Table S1. Abiotic and biotic factors used in the statistical analysis. The values represent the average [standard deviation] at each site.

Stream	Mussel abundance (ind. 1.35 m^{-2})	Surface water width (m)	Water depth (cm)	Proportion of fine sediment (%)	Summer maximum water temperature (℃)	Index of nutrient enrichment	Host fish density (ind. m^{-2})	Proportion of farmland (%)
A	149.63 [123.61]	4.50 [1.27]	32.25 [14.78]	34.44 [8.83]	25.13	-0.31	0.36	31.15
B	87.90 [82.83]	6.58 [1.01]	26.13 [18.60]	27.31 [20.49]	19.85	0.54	0.19	44.41
C	75.31 [37.63]	5.91 [1.45]	32.57 [10.78]	28.01 [9.44]	21.86	-0.38	0.17	11.34
D	35.31 [7.57]	8.82 [1.04]	39.57 [11.42]	9.09 [4.58]	23.58	0.25	0.13	14.28
E	59.01 [24.41]	9.67 [3.15]	34.20 [6.15]	13.88 [8.93]	22.91	0.51	0.06	23.16
F	20.25 [9.55]	5.88 [0.14]	21.60 [3.53]	9.53 [3.51]	16.84	-0.94	0.30	3.11
G	12.35 [14.45]	9.77 [2.17]	26.23 [4.85]	15.94 [4.80]	25.42	-0.79	0.15	9.03
H	15.56 [17.81]	3.03 [0.69]	18.55 [4.03]	19.13 [4.81]	21.38	-0.46	0.56	50.69
I	94.44 [103.19]	8.73 [2.19]	29.90 [3.54]	14.93 [5.87]	19.85	-0.91	0.53	9.14
J	96.30 [4.19]	8.59 [0.65]	36.60 [1.84]	20.09 [1.64]	18.05	2.57	0.02	80.93

Table S2. Host fish density in the study streams (A-J) from 2005 to 2016.

Year	A	B	C	D	E	F	G	H	I	J
2005	NA	NA	NA	NA	0.10	0.37	NA	NA	NA	NA
2006	0.16	0.05	0.12	0.27	NA	NA	0.19	0.78	0.16	0.00
2007	NA	NA	NA	NA	0.52	0.65	NA	NA	NA	NA
2008	0.39	0.03	0.33	0.46	NA	NA	0.38	0.50	0.91	0.02
2009	NA	NA	NA	NA	0.36	0.59	NA	NA	NA	NA
2010	0.07	0.03	0.21	0.30	NA	NA	0.21	0.28	0.49	0.04
2011	NA	NA	NA	NA	0.01	0.31	NA	NA	NA	NA
2012	0.03	0.13	0.12	0.39	NA	NA	0.09	0.11	0.38	0.01
2013	NA	NA	NA	NA	0.02	0.04	NA	NA	NA	NA
2014	0.09	0.02	0.07	0.08	NA	NA	0.03	NA	0.60	0.00
2015	NA	NA	NA	NA	NA	NA	NA	1.11	NA	NA
2016	0.02	0.10	0.03	0.29	0.11	0.19	0.13	NA	0.60	NA

Density unit: ind. m^{-2}

Table S3. Results of preliminary analysis (GLMMs) for selecting explanatory variables from the host fish density and the index of nutrient enrichment. We used the proportion of juvenile mussels as a response variable and stream ID as a random effect.

Model	Log (host fish density)	Log (host fish density)^2	Index of nutrient enrichment	(Index of nutrient enrichment)^2	Intercept	AIC
1	-4.31	-4.20	-	-	-2.39	180.5
2	-	-	0.54	-	-2.61	182.6
3	-0.16	-	-	-	-2.58	183.6
4	-	-	0.41	-0.17	-2.60	184.6

Table S4. Results of the estimations of four nonlinear growth models in the three regions.

Northern Hokkaido	**Bertalanffy**	**Gompertz***	**Hyperbolic**	**Logistic**
L_∞	96.95	87.58	136.12	85.06
k	0.01	0.19	0.07	0.29
t_0	1.87	-	1.92	-
a	-	3.78	-	8.98
RSS	7686	7219	7686	7228
Central Hokkaido	**Bertalanffy**	**Gompertz***	**Hyperbolic**	**Logistic**
L_∞	136.20	112.19	205.00	104.73
k	0.04	0.09	0.03	0.14
t_0	2.72	-	2.89	-
a	-	3.27	-	17.27
RSS	1912	1747	1974	1809
Eastern Hokkaido	**Bertalanffy**	**Gompertz**	**Hyperbolic***	**Logistic**
L_∞	127.43	109.94	178.02	103.33
k	0.02	0.05	0.02	0.08
t_0	3.67	-	4.52	-
a	-	2.84	-	27.52
RSS	4591	5426	4454	6626

* The best fitting models.

Table S5. Results from the GLMs examining the abiotic factors affecting the host fish density in ascending order of AICc. The top two models with the lowest AICc are shown. Bold variables that were included in all ΔAICc < 2 models were considered influential variables.

Model	Depth	Fine sediment	Maximum water temperature	Index of nutrient enrichment	Intercept	AICc	ΔAICc
1	-	-	-	**-0.32**	-0.81	12.9	0.0
2	-	0.18	-	-0.38	-0.81	15.1	2.2