

Appendix S1

When giant amphibians rule the river: Community trophic structure of Japanese giant salamander ecosystems

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Ecology

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Table S1. List of species groups found in the river community. Sample size corresponds to the number of tissue samples collected for stable isotope analysis. “Aquatic insects” includes species from different taxa (see ‘Sampling’ section in Materials and methods).

Groups	Scientific name	Family	Sample size (<i>n</i>)	Tissue sampled
Japanese giant salamander	<i>Andrias japonicus</i>	Cryptobranchidae	160	Tail muscle
Alevins	Various fish species		25	Muscle
Dark chub	<i>Nipponocypris temminckii</i>	Xenocypridae	26	Muscle
Lizard goby	<i>Rhinogobius flumineus</i>	Gobiidae	21	Muscle
Gudgeons	<i>Pungtungia</i> sp.	Gobionidae	13	Muscle
Chinese minnow	<i>Rhynchocypris oxycephala</i>	Leuciscidae	37	Muscle
Catfish	<i>Liobagrus reinii</i>	Amblycipitidae	5	Muscle
Turtles	<i>Mauremys</i> sp.	Geomydidae	14	Claw tip
Frogs	<i>Buergeria buergeri</i>	Rhacophoridae	36	Interdigital membrane
Tadpoles	<i>Buergeria buergeri</i>	Rhacophoridae	6	Tail membrane
Freshwater crabs	<i>Geothelphusa dehaani</i>	Potamidae	38	Muscle
Prawns	<i>Palaemon paucidens</i>	Palaemonidae	30	Muscle
Aquatic insects	Various species		404	Whole body
Gastropods	<i>Semisulcospira</i> spp.	Semisulcospiridae	36	Muscle

Table S2. Reference materials used for stable isotope analysis in both Belgium and Japan. Japanese analyses were standardized against reference materials from the Center for Ecological Research (Kyoto University) and the Institute of Biogeosciences, JAMSTEC (Tayasu et al., 2011). In addition to these standards, tissues from a single fish individual were analysed in both laboratories as a cross-lab control to check consistency between datasets.

Location	Reference Material	$\delta^{15}\text{N}$ (‰)	$\delta^{13}\text{C}$ (‰)	Source
Belgium	Ammonium sulphate (IAEA-N2)	20.3 ± 0.2	–	IAEA, Vienna
	Sucrose (IAEA C-6)	–	-10.8 ± 0.5	IAEA, Vienna
	Glycine (internal standard)	2.3 ± 0.3	-47.5 ± 0.3	LETIS Lab, Liège
Japan	L-Alanine (CERKU-02)	22.71 ± 0.06	-19.04 ± 0.04	CER Kyoto Univ. / BioGeos, JAMSTEC
	L-Threonine (CERKU-5)	-2.88 ± 0.01	-9.45 ± 0.05	CER Kyoto Univ. / BioGeos, JAMSTEC
	Alanine (internal standard)	1.79 ± 0.2	-19.9 ± 0.2	Shoko Science Co., Ltd

Reference

Tayasu, I., R. Hirasawa, N. O. Ogawa, N. Ohkouchi and K. Yamada 2011. "New Organic Reference Materials for Carbon- and Nitrogen-Stable Isotope Ratio Measurements Provided by Center for Ecological Research, Kyoto University, and Institute of Biogeosciences, Japan Agency for Marine-Earth Science and Technology." *Limnology* 12: 261–266.

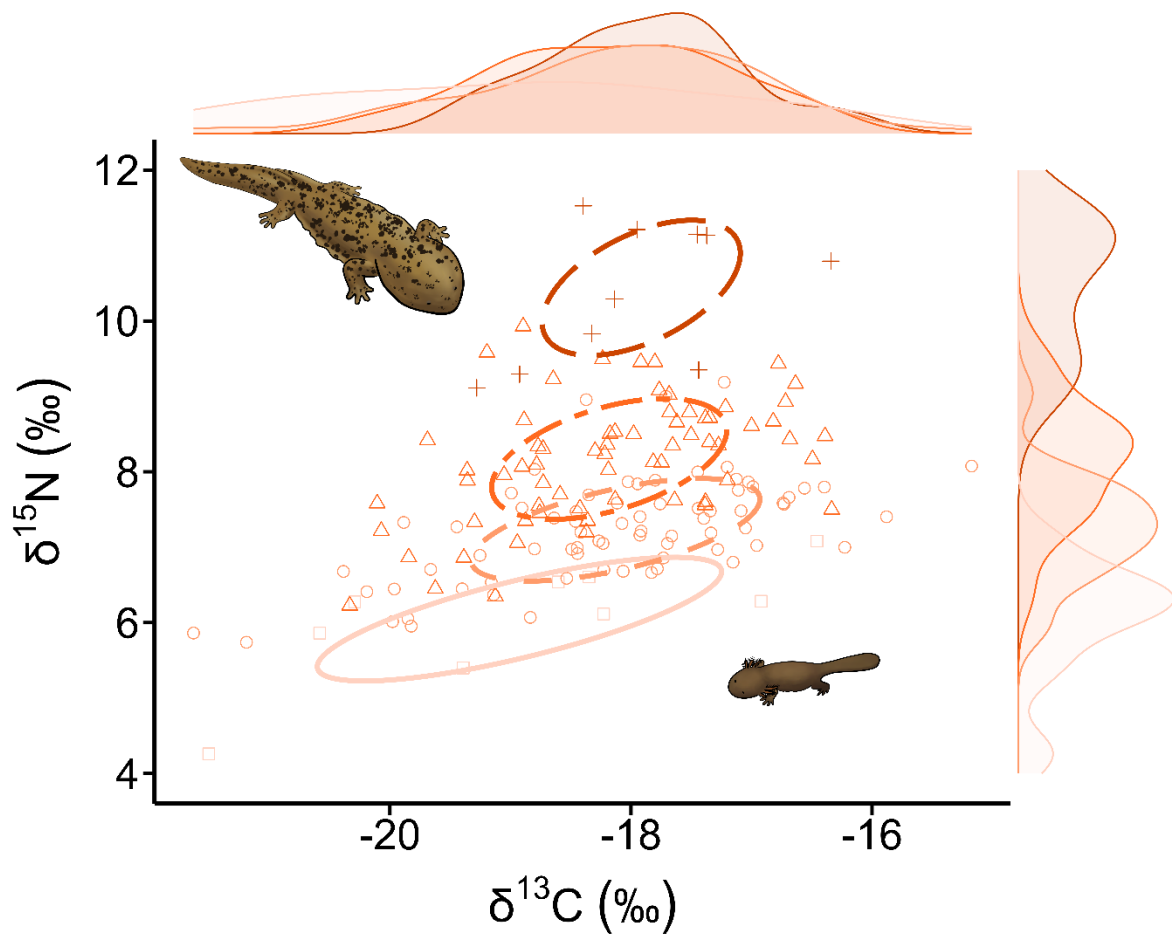


Figure S1. Stable isotope bi-plot illustrating the isotopic niche of the four Japanese giant salamanders (JGS) size groups with density plots. The lines correspond to the standard ellipse area (SEA_C) of each size group. JGS group 1 (4–16.7 cm) : solid light pink ellipse with square points; JGS group 2 (16.8–41.5 cm): dashed light salmon orange ellipse with circular points; JGS group 3 (41.6–52.7 cm): twodash bright orange ellipse with triangular points; JGS group 4 (52.8–67.3 cm): longdash dark brick red ellipse with cross points. Illustrations created by Juliette Vallin.

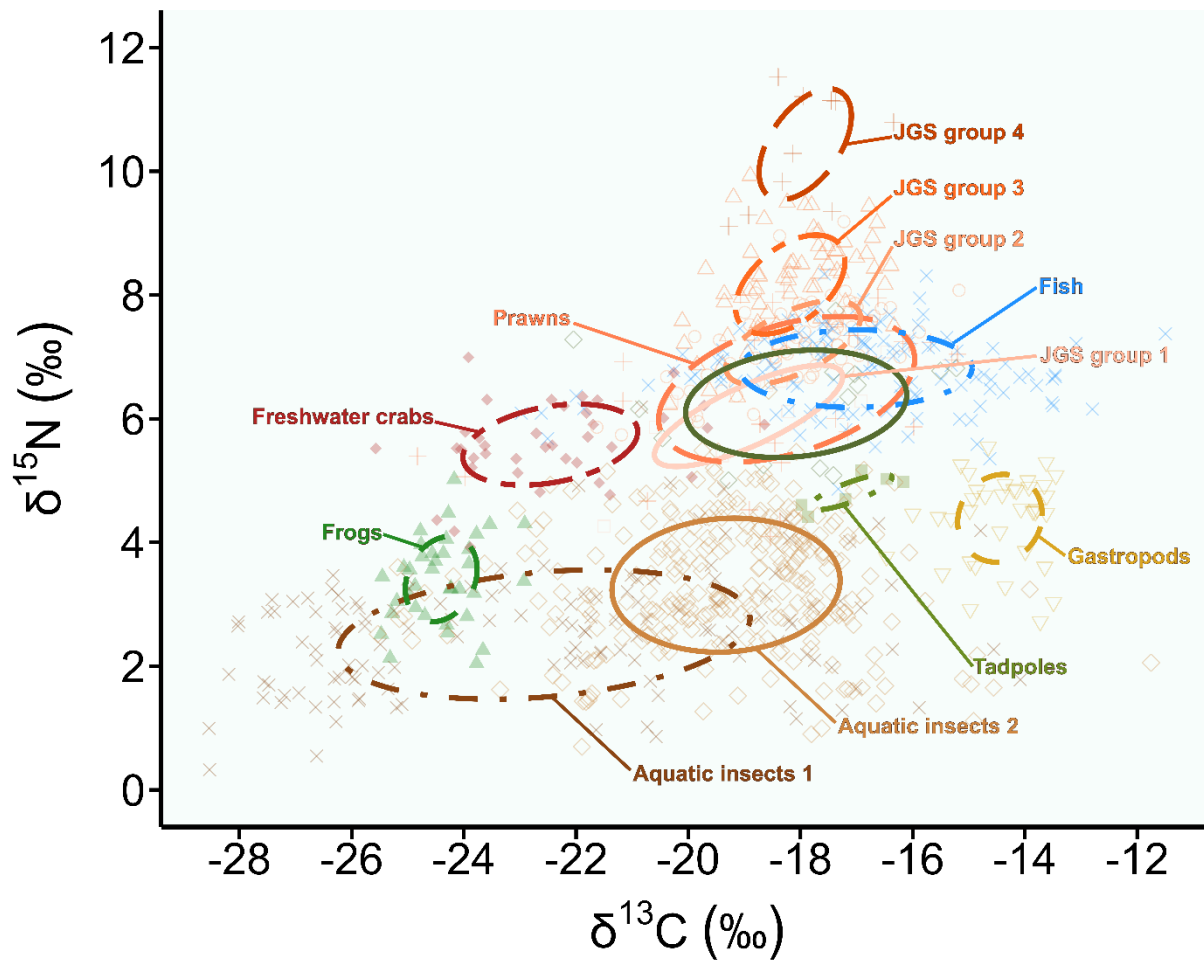


Figure S2. Stable isotope bi-plot (carbon and nitrogen) illustrating the isotopic niches of consumers (ellipses) within the food web dominated by Japanese giant salamanders where the aquatic insects group was subdivided into two groups based on their $\delta^{13}\text{C}$ values. The two insect subsets did not show isotopic overlap with Japanese giant salamanders.

Table S3. Different estimates and metrics of the isotopic niche of consumers of the food web dominated by Japanese giant salamanders. $\delta^{13}\text{C}$ (‰) and $\delta^{15}\text{N}$ (‰) are given as mean $\pm$ SD, SEA = standard ellipse area, SEA_C = SEA corrected for sample size, SEA_B = Bayesian modes of SEA with 95% credible intervals (CI95), TA = Total area of the convex Hull.

Group	$\delta^{13}\text{C}$ (‰)	$\delta^{15}\text{N}$ (‰)	SEA	SEA _C	SEA _B (CI95)	TA
Giant salamanders						
Group 1	-18.9 ± 1.7	6.0 ± 0.8	2.77	3.16	2.80 (1.50 – 6.22)	4.78
Group 2	-18.1 ± 1.2	7.2 ± 0.7	2.05	2.08	2.05 (1.63 – 2.58)	10.81
Group 3	-18.2 ± 1.0	8.2 ± 0.8	2.16	2.19	2.15 (1.69 – 2.74)	9.82
Group 4	-17.9 ± 0.8	10.4 ± 0.9	1.99	2.21	1.91 (1.05 – 3.72)	2.21
Fish						
Alevins	-17.9 ± 2.5	6.2 ± 0.3	2.03	2.12	1.96 (1.34 – 2.99)	6.1
Dark chubs	-18.5 ± 1.1	7.1 ± 0.5	1.1	1.15	1.11 (0.75 – 1.66)	3.46
Lizard gobies	-15.2 ± 1.0	6.5 ± 0.7	2.08	2.19	2.01 (1.30 – 3.17)	5.66
Gudgeons	-14.5 ± 2.3	6.7 ± 0.4	2.87	3.13	2.72 (1.54 – 4.93)	5.3
Chinese minnows	-17.3 ± 1.1	7.2 ± 0.5	1.52	1.56	1.50 (1.08 – 2.09)	5.26
Catfish	-16.8 ± 0.6	6.7 ± 0.5	0.19	0.26	0.47 (0.19 – 1.39)	0.22
Turtles						
Turtles	-18.1 ± 2.0	6.2 ± 0.9	5.31	5.75	5.01 (2.94 – 8.89)	11.73
Frogs						
Frogs	-24.4 ± 0.6	3.4 ± 0.7	1.35	1.39	1.32 (0.95 – 1.86)	5.42
Tadpoles						
Tadpoles	-17.1 ± 0.7	4.8 ± 0.3	0.38	0.48	0.43 (0.18 – 1.12)	0.51
Freshwater crabs						
Freshwater crabs	-22.5 ± 1.6	5.6 ± 0.7	3.04	3.13	2.98 (2.18 – 4.18)	13.03
Prawns						
Prawns	-18.2 ± 2.3	6.5 ± 1.2	7.69	7.96	7.51 (5.24 – 10.95)	21.69
Aquatic insects						
Aquatic insects	-20.5 ± 3.1	3.1 ± 1.1	10.73	10.76	10.73 (9.72 – 11.82)	83.54
Gastropods						
Gastropods	-14.4 ± 0.8	4.4 ± 0.7	1.67	1.72	1.63 (1.19 – 2.31)	5.86

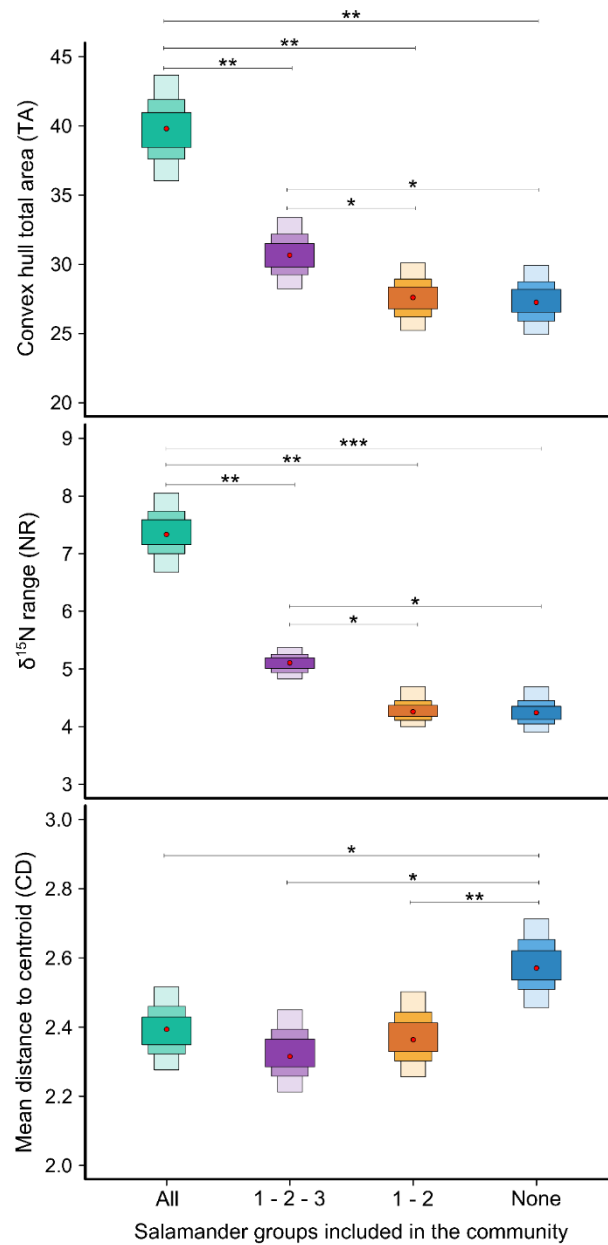


Figure S3. Results of Bayesian estimation for three of Layman's metrics — TA (total convex hull area), NR ($\delta^{15}\text{N}$ range), and CD (mean distance to centroid) — computed for the same community assemblage under four different scenarios of Japanese giant salamander inclusion. From left to right: community including all Japanese giant salamanders, community excluding the largest Japanese giant salamanders (group 4), community including only smaller Japanese giant salamanders (groups 1 and 2), and community without Japanese giant salamanders. Red dots represent the posterior modes. Horizontal bars with asterisks denote robustness in differences in metric values between groups: *: < 0.05; **: < 0.01; ***: < 0.001.

Table S4. Layman’s metrics estimated using a Bayesian approach for four community assemblages (All = community including all Japanese giant salamanders, 1 – 2 – 3 = community excluding the largest Japanese giant salamanders (group 4), 1 – 2 = community including only smaller Japanese giant salamanders (groups 1 and 2), and None = community without Japanese giant salamanders), and for each species present in the community. Metrics include: CR = $\delta^{13}\text{C}$ range; NR = $\delta^{15}\text{N}$ range; TA = total area of the convex hull; CD = mean distance to centroid; NND = mean nearest neighbor distance; SDNND = standard deviation of nearest neighbor distance. Results for community assemblages are presented as modes with 95% credible intervals in parentheses. The subscript ‘b’ indicates that the value (mean) has been generated via bootstrapping.

	CR	NR	CD	NND	SDNND	TA
Communities						
All	10.04 (9.56 – 10.59)	7.35 (6.69 – 8.05)	2.39 (2.28 – 2.52)	1.27 (1.13 – 1.40)	1.02 (0.87 – 1.17)	39.70 (36 – 43.64)
1 – 2 – 3	10.08 (9.56 – 10.58)	4.26 (3.99 – 4.69)	2.37 (2.25 – 2.50)	1.27 (1.07 – 1.37)	1.02 (0.88 – 1.20)	27.55 (25.21 – 30.08)
1 – 2	10.04 (9.55 – 10.60)	5.10 (4.83 – 5.38)	2.31 (2.21 – 2.45)	1.20 (1.06 – 1.34)	1.01 (0.86 – 1.17)	30.67 (28.22 – 33.36)
None	10.04 (9.56 – 10.57)	4.24 (3.89 – 4.68)	2.58 (2.46 – 2.71)	1.37 (1.20 – 1.53)	1.08 (0.91 – 1.24)	27.37 (24.92 – 29.92)
Species						
Giant salamanders						
Group 1 _b	4.37	2.19	1.42	2.04	1.34	10.20
Group 2 _b	3.51	2.00	1.08	1.61	0.96	8.61
Group 3 _b	2.81	2.36	1.04	1.54	0.82	7.99
Group 4 _b	2.24	2.14	0.99	1.39	0.83	6.89
Fish						
Alevins _b	6.76	0.78	1.85	2.68	2.08	13.85
Dark chubs _b	2.95	1.26	0.93	1.34	0.83	6.69
Lizard gobies _b	2.72	1.86	0.98	1.42	0.80	7.21
Gudgeons _b	6.29	1.04	1.69	2.41	1.94	13.11
Chinese minnows _b	2.98	1.37	0.92	1.36	0.79	7.13
Catfish	1.49	1.20	0.53	0.36	0.42	0.22
Turtles _b	5.40	2.28	1.72	2.45	1.53	12.34
Frogs _b	1.83	1.99	0.77	1.15	0.59	5.99
Tadpoles	1.81	0.75	0.66	0.34	0.13	0.51
Freshwater crabs _b	4.41	0.87	10.43	1.35	2.00	1.18
Prawns _b	6.46	1.87	15.34	2.02	2.94	1.80
Aquatic insects _b	8.99	1.76	20.42	2.62	3.88	2.41
Gastropods _b	2.07	0.89	6.50	0.87	1.26	0.66

Table S5. Isotopic niche overlap based on SEAC (standard ellipse area corrected for sample size) between the following consumers: each group of salamanders (JGS 1 (group 1) to JGS 4 (group 4)), different fish species, turtles, and prawns.

Ellipse 1	Ellipse 2	SEAC1	SEAC2	Overlap	Overlap ellipse 1 on 2	Overlap ellipse 2 on 1
Intraspecific niche overlap among Japanese giant salamanders						
JGS 1	JGS 2	3.16	2.08	0.18	5.6%	8.5%
JGS 1	JGS 3	3.16	2.19	0	0.0%	0.0%
JGS 1	JGS 4	3.16	2.21	0	0.0%	0.0%
JGS 2	JGS 3	2.08	2.19	0.29	13.7%	12.9%
JGS 2	JGS 4	2.08	2.21	0	0.0%	0.0%
JGS 3	JGS 4	2.19	2.21	0	0.0%	0.0%
Niche overlap between giant salamanders and other consumers						
JGS 1	Alevins	3.16	2.11	1.11	35.2%	52.6%
JGS 1	Dark chubs	3.16	1.15	0	0.0%	0.0%
JGS 1	Lizard gobies	3.16	2.19	0	0.0%	0.0%
JGS 1	Gudgeons	3.16	3.13	0	0.0%	0.0%
JGS 1	Chinese minnows	3.16	1.56	0.1	3.1%	6.2%
JGS 1	Catfish	3.16	0.26	0	0.0%	0.0%
JGS 1	Turtles	3.16	5.75	2.51	79.4%	43.7%
JGS 1	Prawns	3.16	7.95	2.87	90.7%	36.0%
JGS 2	Alevins	2.08	2.11	0	0.0%	0.0%
JGS 2	Dark chubs	2.08	1.15	1.05	50.3%	91.1%
JGS 2	Lizard gobies	2.08	2.19	0	0.0%	0.0%
JGS 2	Gudgeons	2.08	3.13	0	0.0%	0.0%
JGS 2	Chinese minnows	2.08	1.56	0.81	38.9%	51.7%
JGS 2	Catfish	2.08	0.26	0	0.0%	0.0%
JGS 2	Turtles	2.08	5.75	0.74	35.6%	12.9%
JGS 2	Prawns	2.08	7.95	1.74	83.5%	21.8%
JGS 3	Alevins	2.19	2.11	0	0.0%	0.0%
JGS 3	Dark chubs	2.19	1.15	0.06	2.7%	5.2%
JGS 3	Lizard gobies	2.19	2.19	0	0.0%	0.0%
JGS 3	Gudgeons	2.19	3.13	0	0.0%	0.0%
JGS 3	Chinese minnows	2.19	1.56	0	0.0%	0.0%
JGS 3	Catfish	2.19	0.26	0	0.0%	0.0%

JGS 3	Turtles	2.19	5.75	0	0.0%	0.0%
JGS 3	Prawns	2.19	7.95	0.1	4.4%	1.2%
JGS 4	Alevins	2.21	2.11	0	0.0%	0.0%
JGS 4	Dark chubs	2.21	1.15	0	0.0%	0.0%
JGS 4	Lizard gobies	2.21	2.19	0	0.0%	0.0%
JGS 4	Gudgeons	2.21	3.13	0	0.0%	0.0%
JGS 4	Chinese minnows	2.21	1.56	0	0.0%	0.0%
JGS 4	Catfish	2.21	0.26	0	0.0%	0.0%
JGS 4	Turtles	2.21	5.75	0	0.0%	0.0%
JGS 4	Prawns	2.21	7.95	0	0.0%	0.0%

Interspecific niche overlap among other consumers

Turtles	Alevins	5.75	2.11	1.87	32.5%	88.3%
Turtles	Dark chubs	5.75	1.15	0.41	7.1%	35.5%
Turtles	Lizard gobies	5.75	2.19	0.08	1.4%	3.6%
Turtles	Gudgeons	5.75	3.13	0.29	5.1%	9.3%
Turtles	Chinese minnows	5.75	1.56	0.46	8.1%	29.7%
Turtles	Catfish	5.75	0.26	0.19	3.3%	72.6%
Turtles	Prawns	5.75	7.95	5.23	91.0%	65.7%
Prawns	Alevins	7.95	2.11	1.81	22.7%	85.4%
Prawns	Dark chubs	7.95	1.15	1.15	14.4%	100.0%
Prawns	Lizard gobies	7.95	2.19	0.04	0.5%	1.8%
Prawns	Gudgeons	7.95	3.13	0.43	5.4%	13.6%
Prawns	Chinese minnows	7.95	1.56	1.49	18.7%	95.1%
Prawns	Catfish	7.95	0.26	0.26	3.2%	100.0%

Niche overlap between fish species

Dark chub	Chinese minnows	1.15	1.56	0.37	32.1%	23.6%
Dark chub	Lizard gobies	1.15	2.19	0	0%	0%
Dark chub	Catfish	1.15	0.26	0	0%	0%
Dark chub	Gudgeons	1.15	3.13	0	0%	0%
Dark chub	Alevins	1.15	2.12	0	0%	0%
Chinese minnow	Lizard gobies	1.56	2.19	0	0%	0%
Chinese minnow	Catfish	1.56	0.26	0.03	1.7%	10.2%
Chinese minnow	Gudgeons	1.56	3.13	0.01	0.1%	0%
Chinese minnow	Alevins	1.56	2.12	0	0%	0%
Lizard goby	Catfish	2.19	0.26	0	0%	0%

Lizard goby	Gudgeons	2.19	3.13	1.31	60%	41.8%
Lizard goby	Alevins	2.19	2.12	0.23	10.5%	10.9%
Catfish	Gudgeons	0.26	3.13	0.1	37.2%	3.1%
Catfish	Alevins	0.26	2.12	0.05	19.2%	2.3%
Gudgeons	Alevins	3.13	2.12	0.01	0.3%	0.5%

Table S6. Modes (95% CI) estimates of trophic position (TP) and proportional contribution of terrestrial carbon sources (α) for each consumer of the community.

Species	TP	α
Giant salamanders		
Group 1	2.44 (2.00–3.24)	0.40 (0.26–0.55)
Group 2	2.77 (2.39–3.62)	0.37 (0.27–0.55)
Group 3	3.14 (2.68–4.06)	0.40 (0.29–0.56)
Group 4	4.05 (3.35–5.75)	0.46 (0.31–0.70)
Fish		
Alevins	2.39 (2.04–3.14)	0.33 (0.21–0.46)
Dark chub	2.80 (2.38–3.95)	0.39 (0.29–0.55)
Lizard goby	2.28 (1.90–2.93)	0.14 (0.04–0.25)
Gudgeons	2.33 (1.95–3.08)	0.10 (0.01–0.26)
Chinese minnow	2.72 (2.33–3.41)	0.30 (0.20–0.43)
Catfish	2.52 (2.03–3.35)	0.26 (0.13–0.40)
Turtles	2.42 (2.02–3.20)	0.33 (0.21–0.48)
Frogs	1.89 (1.66–2.33)	0.70 (0.65–0.77)
Tadpoles	1.83 (1.46–2.39)	0.22 (0.11–0.34)
Freshwater crabs	2.55 (2.20–3.32)	0.62 (0.54–0.75)
Prawns	2.53 (2.14–3.45)	0.35 (0.25–0.50)
Aquatic insects	1.42 (1.23–1.77)	0.41 (0.34–0.47)
Gastropods	1.50 (1.20–1.96)	0.01 (0.00–0.11)

Table S7. Pairwise comparison (% probability of difference) of isotopic niche width (SEA_B) among all consumer groups.

[illegible]

Table S8. Pairwise comparison (% probability of difference) of carbon range (CR) among all consumer groups.

[illegible]

Table S9. Pairwise comparison (% probability of difference) of nitrogen range (NR) among all consumer groups.

[illegible]

Table S10. Pairwise comparison (% probability of difference) of the mean nearest-neighbour distance (NND) among all consumer groups.

[illegible]

Table S11. Pairwise comparison (% probability of difference) of the trophic position (TP) among all consumer groups.

[illegible]

Table S12. Pairwise comparison (% probability of difference) of the contribution of terrestrial versus aquatic carbon sources (α) among all consumer groups.

[illegible]