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A Review of the Siberian Lamprey, *Lethenteron kessleri*, in Hokkaido, Japan

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Abstract

We have reviewed the data on Siberian lamprey *Lethenteron kessleri*, in Hokkaido, Japan. This species leads a nonparasitic and landlocked life.

L. kessleri is distinguished from *L. reissneri* by the presence of distinct posterial teeth, by the pointed supraoral lamina, by the larger eye diameter, and by the larger number of trunk myomeres. *L. kessleri* is distinguished from young of *L. japonicum* by the blunt cusps of infraoral lamina, by the smaller eye diameter and by the absence of metallic silver coloration.

We conclude that the Siberian lamprey is not a subspecies of the parasitic and anadromous Arctic lamprey *L. japonicum*, but is a different species. *L. matsubarai* should be synonymized with *L. kessleri*.

Up to the present, four species of the genus *Lethenteron* have been reported in Japan; *L.japonicum*, *L. kessleri*, *L. matsubarai* and *L. reissneri* (Sato, 1951; Miyadi et al., 1976; Vladykov and Kott, 1978). The Siberian lamprey, *L. kessleri*, is distributed in the area between the Ob River and the Anadyr River and in Sakhalin (Berg, 1931, 1948-1949). No specimens have been reported in Japan since Sato (1951) described the Siberian lamprey as new to Japan at the Shibichari River, except for a brief comment by Hieda (1984).

The life history of this species is not known (Berg, 1931, 1948-1949; Sato, 1951), and its taxonomic treatment varies: *Lampetra japonica kessleri*, (Berg, 1931, 1948-1949; Sato, 1951); *Lampetra* (*Lethenteron*) *japonica kessleri*, (Miyadi et al., 1976); *Entosphenus kessleri*, (Matsubara, 1955; Nakamura, 1963); and *Lampetra kessleri*, (Ichthyological Society of Japan, 1981).

We have studied many specimens identified as the Siberian lamprey and clarified some facts about its life history and distribution. We have given detailed description of the Siberian lamprey because the information reported by Berg (1931, 1948-1949), Sato (1951), and Hieda (1984) is sketchy. We have also compared the characters of the Siberian lamprey with those of *L. reissneri* and of the young of *L. japonicum*, and of the holotype of *L. matsubarai* Vladykov and Kott 1978.

Materials and methods

The scientific names of the lampreys, except for that of the Siberian lamprey, are those of Vladykov and Kott (1982). Terminology for the various types of teeth follows that of Vladykov and Follett (1967).

Measurments and counts were made on the left side of specimens preserved in 5% formalin and followed the procedures outlined in Vladykov and Follett (1965),

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except for the snout length, intestine diameter, and length of velar tentacles. All measurements were expressed as percentages of the branchial length of the specimen; the branchial length was also expressed as a percentage of total length. The following abbreviations were used: TL, total length, the distance from the anterior most oral fimbria to the end of the caudal fin; B_1-B_7, branchial length, the distance from the anterior edge of the first branchial opening to the posterior edge of the last branchial opening; O, eye diameter, the horizontal diameter of the eye; d, disc length, longitudinal diameter, measured with the disc closed; a-C, tail length, the distance from the posterior edge of the cloacal slit to the end of the caudal fin; Int, intestine diameter under the anterior insertion of the first dorsal fin; VC, length of the median velar tentacle; VF, length of the next tentacle to the median; and GP, length of urogenital papilla.

The specimens which had the catalogue number (HUMZ) were deposited in the Laboratory of Marine Zoology, Faculty of Fisheries, Hokkaido University. Data for the specimens used for measurements and counts are given in the following

Table 1. Proportional measurements of *L. kessleri*. Data show the mean values, confidence limit at 95%, and ranges (in parentheses)

	at metamorphosis		spawning season	
	♂	♀	♂	♀
TL, mm	138.8-184.3	139.7-183.7	120.8-160.0	112.2-178.6
B_1-B_7/TL	N=33 9.65±0.13 (8.85-10.58)	N=17 10.03±0.31 (9.16-11.31)	N=23 10.65±0.24 (9.53-11.87)	N=24 10.42±0.21 (9.52-11.43)
S/B_1-B_7	N=33 61.75±1.03 (55.43-67.31)	N=17 58.62±2.37 (52.72-68.52)	N=20 73.60±1.50 (67.40-79.40)	N=24 66.18±1.87 (59.36-74.81)
O/B_1-B_7	N=33 19.24±0.84 (15.48-25.00)	N=17 16.90±0.86 (13.37-19.75)	N=23 20.39±0.91 (15.38-24.46)	N=31 19.17±0.64 (16.31-24.03)
d/B_1-B_7	N=33 48.17±1.24 (42.86-57.06)	N=17 44.64±1.84 (38.51-52.00)	N=23 60.36±1.71 (52.11-67.45)	N=47 49.26±1.01 (41.13-59.85)
a-C/B_1-B_7	N=33 303.74±5.45 (260.13-340.99)	N=17 286.08±10.25 (249.74-314.29)	N=23 269.98±7.54 (231.25-300.0)	N=24 270.35±7.95 (233.33-310.95)
GP/B_1-B_7			N=23 19.00±2.83 (5.76-34.66)	
	♂+♀			
Int/B_1-B_7	N=36 3.12±0.32 (1.79-5.52)			
VC/B_1-B_7	N=20 3.98±0.45 (1.89±5.54)			
VF/B_1-B_7	N=20 4.57±0.49 (2.89-6.74)			

sequence : catalogue number, number of specimens, total length (mm), locality, date of collection.

L. kessleri, Siberian lamprey, specimens at metamorphosis (early maturity stage of Vladykov and Follett, 1965) : 9, 157.2-182.0, Toyosato, Atsuma River, 5, Oct. 1982 ; HUMZ 104603-104622, 148.0-183.7, Toyosato, Atsuma River, 8, Oct. 1982 ; 2, 158.0-176.2, Souma-bashi, Mukawa River, 4, Oct. 1982 ; HUMZ 104598, 104599 and 104602, 3, 164.9-169.9, Toyoshiro, Mukawa River, 5, Oct. 1982 ; HUMZ 104646, 104650, 104651, 104653 and 104654, 5, 168.2-184.3, Mukawa-bashi, Mukawa River, 5, Oct. 1982 ; HUMZ 104670 and 104671, 2, 138.8-139.7, Abira River, 7, Oct. 1982.

Mature specimens (spawning period of Vladykov and Follett, 1965) : HUMZ 104623-104645, 23, 120.8-160.0, Abira River, 4-6, May, 1983.

L. reissneri, far eastern brook lamprey, specimens of early maturity stage : HUMZ 104081-104150, 70, 136.1-202.5, Monbetsu River, 2, Oct. 1982 ; HUMZ 104395-104410, 16, 139.4-190.0, Monbetsu River, 6, Nov. 1982.

Specimens of spawning period : HUMZ 104420-104424, 5, 129.8-150.4, Hekiriji

Table 2. Proportional measurements of *L. reissneri*. Data show the mean values, confidence limit at 95%, and ranges (in parentheses)

	at metamorphosis		spawning season	
	♂	♀	♂	♀
TL, mm	136.1-177.3	151.5-202.5	110.8-153.8	129.8-157.4
B_1-B_7/TL	N=24 10.14±0.15 (9.53-11.30)	N=24 10.35±0.2 (9.64-11.62)	N=21 10.27±0.17 (9.63-11.03)	N=12 10.43±0.36 (9.56-11.48)
S/B_1-B_7	N=30 59.24±1.30 (52.78-66.0)	N=30 54.98±1.42 (48.73-63.75)	N=20 75.22±2.24 (66.89-84.93)	N=12 64.28±2.80 (57.76-71.63)
O/B_1-B_7	N=33 12.93±0.59 (9.20-16.67)	N=31 12.21±0.51 (9.76-15.66)	N=21 16.67±0.83 (13.51-21.03)	N=12 14.82±1.25 (11.41-19.70)
d/B_1-B_7	N=39 43.23±1.02 (37.16-48.08)	N=31 40.74±1.10 (36.04-47.09)	N=21 60.30±2.13 (51.35-69.18)	N=12 50.14±2.28 (41.61-55.32)
a-C/B_1-B_7	N=24 284.39±7.30 (224.29-312.43)	N=24 269.76±9.52 (222.60-313.53)	N=21 289.11±8.20 (253.10-312.50)	N=12 259.54±12.78 (219.46-288.65)
GP/B_1-B_7			N=21 39.15±5.67 (16.44-67.77)	
	♂+♀			
Int/B_1-B_7	N=41 1.86±0.19 (0.59-2.84)			
VC/B_1-B_7	N=14 4.44±0.59 (3.05-6.54)			
VF/B_1-B_7	N=15 5.08±0.57 (3.43-6.69)			

River, 19, May, 1982; HUMZ 104364-104387, 24, 110.8-157.4, Monbetsu River, 28, May, 1982.

L. japonicum, Arctic lamprey, specimens at metamorphosis (stage 6-7 of Youson and Potter, 1979): 4, Nibudani, Saru River, 4, Oct. 1982; HUMZ 104490-104494, 5, 148.6-168.2, Toyoshiro, Mukawa River, 5, Oct. 1982; HUMZ 104495-104505, 11, 168.6-215.0, Saru River, 24, Oct. 1983; HUMZ 104488 and 104487, 163.4-171.6, Ryukei River, 31, Oct. 1983.

Young specimens (young juvenile adult stage of Youson and Potter, 1979): HUMZ 104506-104510, 5, 168.2-228.4, Toufutsu lake, 22, Apr. 1980; HUMZ 104460-104482, 23, 152.8-214.5, Toufutsu lake, 28, Apr. 1982.

L. matsubarai, holotype: BC (the catalogue number of the Ichthyological Collection, the University of British Columbia, Canada) 77-71, 150.0, Shokotsu River, 1950-1952.

Results

Total length (*Tables 1, 2, 3*)

Metamorphosis of *L. kessleri* took place from July to September. Total length of metamorphosed individuals (early maturity stage of Vladykov and Follett, 1965)

Table 3. Proportional measurements of *L. japonicum*. Data show the mean values, confidence limit at 95%, and ranges (in parentheses)

	at metamorphosis	young
TL, mm	153.1-215	164.9-228.4
B_1-B_7/TL	N=22 9.03±0.12 (8.39-9.63)	N=23 9.29±0.15 (8.77-10.11)
S/B_1-B_7	N=12 67.83±2.73 (60.80-75.33)	N=20 77.32±2.00 (67.61-83.87)
O/B_1-B_7	N=22 24.58±1.57 (17.93-31.85)	N=23 28.17±1.14 (22.75-36.88)
d/B_1-B_7	N=22 53.78±1.62 (44.21-61.54)	N=23 66.35±1.48 (59.09-73.58)
a-C/B_1-B_7	N=22 325.89±6.70 (298.77-362.73)	N=23 316.38±7.56 (280.13-350.00)
Int/B_1-B_7		N=23 17.12±0.97 (13.56-21.43)
VC/B_1-B_7		N=23 6.85±0.48 (4.19-8.58)
VF/B_1-B_7		N=23 7.24±0.5 (5.81-9.23)

Table 4. Frequency distribution of trunk myomeres in *L. reissneri*, *L. kessleri*, and *L. japonicum*

	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77
L. reissneri	9	7	34	47	38	24	6	6	4												
L. kessleri									3	10	10	25*	27	20	17	6	5				
L. japonicum												2	6	11	16	13	13	9	5	4	2

* Holotype of *L. matsubarai*.

Table 5. Frequency distribution of teeth number of *L. japonicum* and *L. kessleri*

	Marginals																							
	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83
L. japonicum	1	2	2	5	5	3	3	7	10	3	10	2	4	4	2	2	3		2	1				3
L. kessleri	1		4	2	3	4	2	2	2	3*	2	1	2		3									

	Posterials										Infraoral cusps				
	16	17	18	19	20	21	22	23	24	25	6	7	8	9	10
L. japonicum	1	2	2	9	23	15	5	3				2	35	3	1
L. kessleri		2	3	9	7	2	1	4	1	2*	10*	2	14	4	

	Anterials																	
	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
L. japonicum	1		1	1	4	2	8	4	12	9	6	3	4	7		4	2	4
L. kessleri						2	1	3	3	3	5	3	4	2*	3	1		1

* Holotype of *L. matsubarai*.

ranged from 138.8 mm to 184.3 mm. In the spawning season, the range of total length did not differ from that of metamorphosed specimens.

Trunk myomeres (*Table 4*)

The number of trunk myomeres varied from 65 to 73 (mean 68.5). *L. reissneri* is distinguishable from *L. kessleri* by its low number. *L. kessleri* had fewer trunk myomeres than *L. japonicum*.

Dentition (*Table 5*)

According to figure 1 of pl. VI of Berg, 1931, *L. kessleri* has the following dentition: supraoral lamina bicuspid; three inner lateral teeth on each side of the disc, all bicuspid; posterial teeth unicuspid and forming a single row. This dentition is similar to that of the genus *Lethenteron* (Vladykov and Follett, 1967). The teeth were weakly cornified and blunt, except for the supraoral lamina cusps.

In *L. kessleri*, the teeth of the infraoral lamina were round and blunt, but those of *L. japonicum* were sharply pointed. *L. kessleri* and *L. japonicum* overlapped each other in the number of anterial, marginal, posterial and infraoral cusps. *L. reissneri* is easily distinguishable from *L. kessleri* by 1) poorly developed and almost indistinguishable posterials and marginals and 2) very blunt cusps on the infraoral lamina, supraoral lamina, and inner laterals.

Table 6. Comparison between *L. matsubarai* and *L. kessleri*. Data of *L. matsubarai* are cited from Vladykov and Kott (1978). Numbers in parentheses refer to means.

	L. matsubarai	*L. kessleri*
Size at maturity	Small	Small
No. of trunk myomeres	66-70	65-73
Feeding habits	Nonparasitic	Nonparasitic
Intestinal tract in metamorphosed specimens	Nonfunctional	Nonfunctional
Diameter of intestine	Less than 1 mm	Less than 1 mm
Eye diameter in % of B_1-B_7	17.1-23.3 (20.2)	15.4-24.5 (19.7)
Disc length in % of B_1-B_7	46.7-56.3 (52.0)	41.1-67.9 (52.9)
Velar tentacles	Short	Short
Teeth	Weakly cornified and pale yellow, with cusps blunt	Weakly cornified and pale yellow, with cusps blunt
Infraoral cusps	6	6-9
Dark pigmentation on caudal fin	Absent	Present or Absent

Body proportions (*Tables 1, 2, 3*)

L. reissneri and *L. kessleri* showed overlap in all body measurements. There was, however, an obvious tendency for the eye diameter of *L. kessleri* to be larger than in *L. reissneri*. Tail length had higher ratio in *L. kessleri* than in *L. reissneri* in both sexes at the early maturity stage, but relation was reversed in males at the spawning period. *L. japonicum* was larger than *L. kessleri* in all measurements.

Velar tentacles (*Tables 1, 2, 3*)

There were seven velar tentacles in all the *Lethenteron* species in Japan. The velar tentacles of *L. japonicum* showed a tendency to be longer than in *L. kessleri* and *L. reissneri*.

Intestine diameter (*Tables 1, 2, 3*)

The intestine of *L. kessleri*, as is the case with *L. reissneri*, was atrophied and thin even just after metamorphosis, but that of *L. japonicum* was functional and thick.

Urogenital papilla (*Tables 1, 2, 3*)

At the spawning season, the urogenital papilla of *L. kessleri* was longer than that of *L. reissneri*.

Sexual dimorphism (*Tables 1, 2, 3*)

L. kessleri males were larger than females in snout, disc, and tail length and eye diameter even at the early maturity stage. In the spawning season, snout and disc length had a higher ratio in both sexes, especially in males, than in the early maturity stage. The eye of females was larger than in the early maturity stage. The tail length was shorter in the spawning season, particularly in males, than in specimens at metamorphosis.

As is the case with other holarctic lamprey (Vladykov et al., 1982), the males had a higher dorsal fin and a well developed urogenital papilla in the spawning period, and the anal fin-like fold was well developed and the anterior edge of the

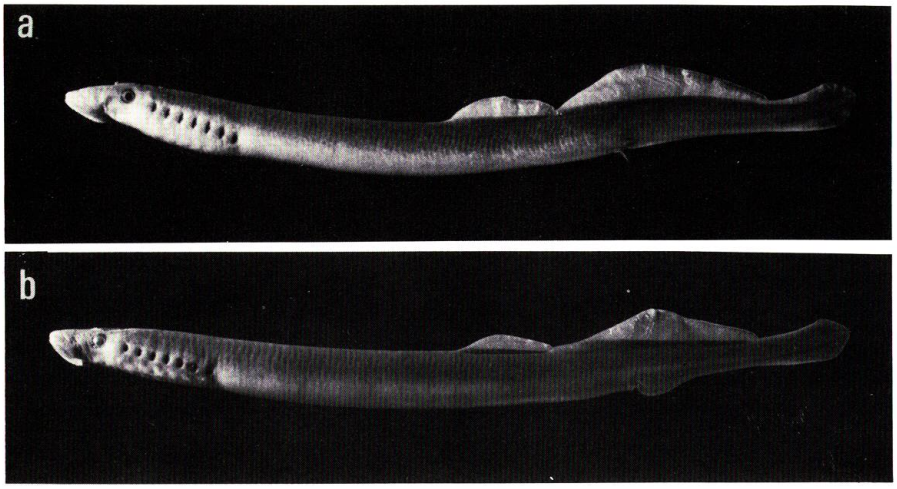

Fig. 1. Siberian lamprey *Lethenteron kessleri*. a : male, 176.2 mm TL, Abira River, 29, Apr. 1984. b : female, 180.9 mm TL, Shiraoi River, 30, Apr. 1984.

second dorsal swollen in the females (Fig. 1).

Coloration

In life, the usual color of *L. kessleri* was brownish on the back and sides, and whitish on the belly, but there was much color variation. The caudal fin was dark brown, but a few individuals had no pigmentation on the caudal membrane. There was no dark dot on the tip of the second dorsal. The young of *L. japonicum* exhibit metallic silver coloration. The young of *L. kessleri* were easily distinguishable from young of *L. japonicum* because the absence of this strong metallic silver coloration and of a dark dot on the tip of the second dorsal fin. In formalin, no marked change was present except for the disappearance of the metallic silver coloration.

Life history

L. kessleri leads a nonparasitic and landlocked life. This species was similar to *L. reissneri*, a typical nonparasitic and landlocked species of this genus, in the following characters : 1) nonfunctional intestine, 2) high values of G.S.I. even just after metamorphosis, and 3) mature length equal to or slightly shorter than that of the metamorphosed form.

Geographic distribution (*Fig. 2*)

Sato (1951) reported *L. kessleri* from the Shibichari River (old name of Shizunai River). We recognized the presence of this species in the Yuuchi River, Barou River, Toufutsu lake, Ichani River, Bettouga River, Saru River, Mukawa River, Abira River, Shiraoi River, and Assabu River. Hieda (1984) reported this species from the drainage of the Ishikari River. This species was allopatric with *L. reissneri* except in the Chitose River tributary of the Ishikari River. Extensive investigations are required in order to clarify the distribution of landlocked specimens of *Lethenteron*.

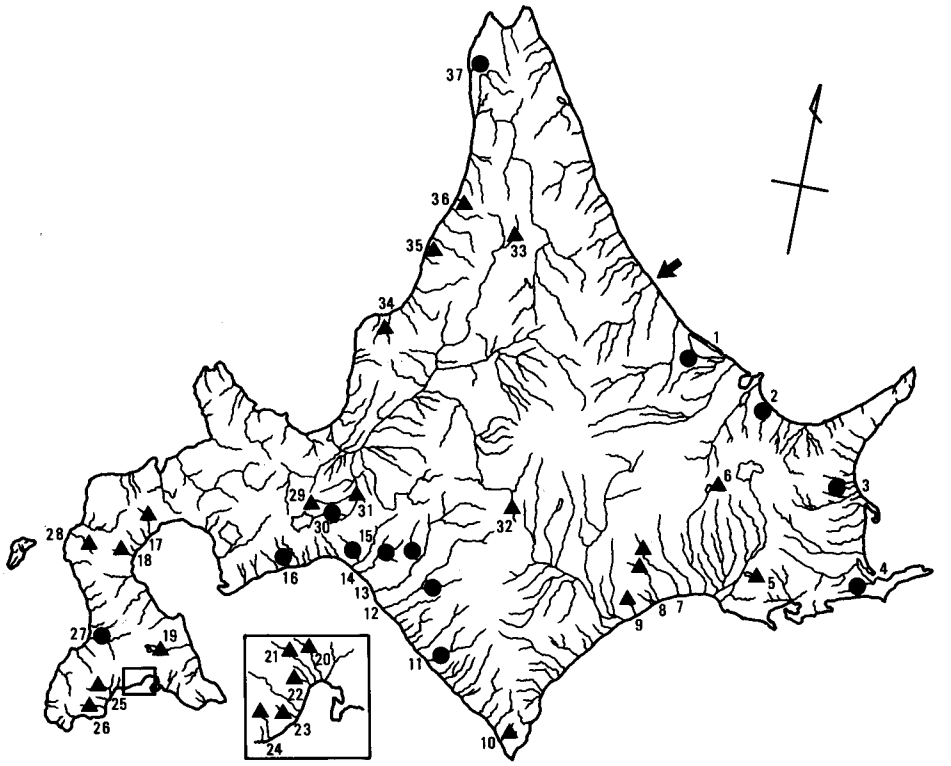

Fig. 2. Geographic distribution of landlocked and nonparasitic species of *Lethenteron* in Hokkaido. circle: *L. kessleri*. triangle: *L. reissneri*. Arrow indicates the Shokotsu River, which is the type locality of *L. matsubarai*.
1. Barou R.; 2. Toufutsu Lake; 3. Ichani R.; 4. Bettouga R.; 5. Touro Lake; 6. Hyotan pond; 7. Charo R.; 8. Onbetsu R.; 9. Atsunai R.; 10. Utabetsu R.; 11. Shizunai R.; 12. Saru R.; 13. Mukawa R.; 14. Atsuma R.; 15. Abira R.; 16. Shiraoi R.; 17. Monbetsu R.; 18. Rukotsu R.; 19. Ohnuma Lake; 20. Ohno R.; 21. Hekiriji R.; 22. Ryukei R.; 23. Toubetsu R.; 24. Kamekawa R.; 25. Kikonai R.; 26. Shiriuchi R.; 27. Assabu R.; 28. Futoro R.; Chitose tributary, Ishikari drainage, (29-31), 29. Ashiribetsu R.; 30. Chitose R.; 31. Osatsu R.; Sorachi tributary, Ishikari drainage, (32), 32. Ruuomansorappchi R.; Uryu tributary, Ishikari drainage, (33), 33. Butokamabetsu R.; 34. Shokanbetsu R.; 35. Kotodo R.; 36. Moshosanbetsu R.; 37. Yuuchi R.

Remarks

Berg (1931, 1948-1949), Sato (1951), and Miyadi et al. (1976) recognized the Siberian lamprey as a subspecies of the Arctic lamprey *L. japonicum*, but Matsubara (1955), Nakamura (1963), and the Ichthyological Society of Japan (1981) used *kessleri* as a species name. Since our study showed that the Siberian lamprey is different from the Arctic lamprey in morphological and ecological features, we recognize the Siberian lamprey as a different species from the Arctic lamprey.

Vladykov and Kott (1978) described *L. matsubarai* from the Shokotsu River in

Hokkaido (Fig. 2). The characters of *L. matsubarai* were not different from those of *L. kessleri* (Tables 4, 5, 6). *L. matsubarai* should be synonymized with *L. kessleri*.

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References

Berg, L.S. (1931). A review of the lampreys of the Northern Hemisphere. *Ann. Mus. Zool. Acad. Sci. USSR*, **31**: 87-116.

Berg, L.S. (1948-1949). *Freshwater fishes of the U.S.R. and adjacent countries: Guide to the fauna of the U.S.S.R., Academy of Sciences of the U.S.S.R.* Zoological Institute Nos. 27-30. 4th ed. Israel Program. Sci. Transl. Ltd., Jerusalem. Vol. 1 (1962), vi+504 p.

Hieda, K. (1984). *Freshwater fishes of Hokkaido.* Supervised by T. Kubo. Hokkaido Shinbunsha, Sapporo, 254 p. (In Japanese).

Ichthyological Society of Japan. (1981). *Dictionary of Japanese fish names and their foreign equivalents.* Sanseido, Tokyo, vii+834 p. (In Japanese).

Matsubara, K. (1955). *Fish morphology and hierachy I-III.* Ishizaki Shoten, Tokyo, xi+1605 p., 135 pls. (In Japanese).

Miyadi, D., H. Kawanabe and N. Mizuno. (1976). *Colored illustrations of the freshwater fishes of Japan.* Hoikusha, Osaka, 462 p. (In Japanese).

Nakamura, M. (1963). *Keys to the freshwater fishes of Japan fully illustrated in colors.* Hokuryukan, Tokyo, 260 p. (In japanese).

Sato, S. (1951). Studies on the lampreys of Hokkaido. *Bull. Fac. Fish. Hokkaido Univ.*, **1**: 54-62. (In Japanese with English summary).

Vladykov, V.D., and W.I. Follett. (1965). *Lampetra richardsoni*, a new nonparasitic species of lamprey (Petromyzonidae) from western North America. *J. Fish. Res. Bd. Can.*, **22**: 139-158.

Vladykov, V.D., and W.I. Follett. (1967). The teeth of lampreys (Petromyzonidae): their terminology and use in a key to the Holarctic genera. *J. Fish. Res. Bd. Can.*, **24** : 1067-1075.

Vladykov, V.D., and E. Kott. (1978). A new nonparasitic species of *Lethenteron* Creaser and Hubbs 1922 (Petromyzonidae) from Hokkaido, Japan. *Can. J. Zool.*, **56** : 1792-1800.

Vladykov, V.D., and E. Kott. (1979). Satellite species among the holarctic lampreys. *Can. J. Zool.*, **57**: 860-867.

Vladykov, V.D., and E. Kott. (1982). List of Northern Hemisphere Lampreys (Petromyzonidae) and Their Distribution. *Fish. Mar. Serv. Misc. Sper. Publ.* **42**: iv+30 p.

Youson, J.H. and I.C. Potter. (1979). A discription of the stages in the metamorphosis of the anadromous sea lamprey, *Petromyzon marinus* L. *Can. J. Zool.*, **57**: 1808-1817.