

A New and Three Rare Species of Planktonic *Anabaena* (Nostocales, Cyanophyta/Cyanobacteria) from Japan

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Abstract A new species of planktonic *Anabaena*, *A. tsugaruensis*, is described from Lake Higurashi-no-ike of the Tsugaru-Juniko lakes in Aomori Prefecture, northern Japan. Further, three rare species of planktonic *Anabaena*, *A. cf. heterospora* Nyg., *A. levanderi* Lemm., and *A. cf. solitaria* Kleb., are added to the Japanese cyanophyte flora with taxonomic notes.

Key words: new species, new records, *Anabaena*, plankton, Cyanophyta, Japan.

Since Professor Okamura recorded planktonic *Anabaena*, *A. flos-aquae* and *A. spiroides* var. *crassa* from Japanese waters for the first time (Okamura 1916), 25 planktonic species of the genus *Anabaena* have been recorded up to now. The present author has recorded 20 planktonic species of *Anabaena* including five new species (*A. akankoensis*, *A. citrispora*, *A. minispora*, *A. oumiana*, and *A. pseudocompacta*) from Japan and proposed two new combinations (*A. smithii* and *A. ucrainica*) for the Japanese populations (Watanabe 1985, 1992, 1996, 1996a, 1998, 2003, and Watanabe et al. 2004). Further, the author adds a new and three rare planktonic species of *Anabaena* to the Japanese cyanophyte flora in this paper.

Materials and Methods

The sources of the materials used in this study are shown in Table 1. One specimen collected from a shallow pool along the Shirarutoro River in the Kushiro marsh land in July, 1967 has been lost and only data with measurements and drawings remain now. The other specimens were deposited in the herbarium of the Department of Botany, National Science Museum in Tokyo (TNS).

Results and Discussions

Anabaena cf. heterospora Nygaard, 1949

(Figs. 1–5)

Trichomes free-floating, straight, constricted at the cross walls, delicately attenuated at the apices. Cells barrel-shaped or shortly cylindrical, 3.2–3.8 μm wide, 2–6 μm long. Heterocytes spherical or cylindrical, 4.5–5 μm wide, 5–7 μm long. Akinetes cylindrical, with rounded ends, 5–6 μm wide, 10–23 μm long, usually near the both side of the heterocytes.

The author collected this alga at Lake Shupun-to (Oonuma), Wakkanai, Hokkaido in July, 1970 for the first time. In a specimen he could merely observe immature akinetes, and then identification was impossible (Fig. 5). In July 1991 Mr. Yutaka Iikura of the Tokyo Metropolitan Waterworks Bureau brought an *Anabaena* culture isolated from the waters of Watarase flood control zone in Tochigi Prefecture to the present author for identification. The *Anabaena* culture produces enough akinetes to identify and it is found to most closely resemble *Anabaena heterospora* Nyg. (Figs. 1–4). But it differs in discontinuously smaller dimensions in all of vegetative cells, heterocytes and akinetes respectively (Table 2). *Anabaena heterospora* Nyg. was characterized originally as producing spores of a double origin.

Table 1. Specimens used in this study.

Species	Specimen no.	Locality	Date of collection	Collector
<i>Anabaena</i> cf. <i>heterospora</i>	AL-50735	Lake Shupunto, Wakkanai, Hokkaido	July, 1971	M. Watanabe
<i>Anabaena levanderi</i>	AL-52806	Lake Suigetsu-ko, Mikatacho, Fukui Pref.	Sept., 1984	M. Watanabe
<i>Anabaena tsugaruensis</i>	AL-55688	Lake Higurashi-no-ike, Tsugaru-juniko lakes, Aomori Pref.	May, 2000	S. Tateishi
<i>Anabaena</i> cf. <i>heterospora</i>	AL-55700	a pond in Watarase flood controlling zone, Tochigi Pref.	July, 1991	Y. Iikura

Namely the species produces two different types of akinetes in maturity. One is cylindrical with rounded ends and the other one is long ellipsoidal. The present alga produces cylindrical akinetes only, the same as the alga recorded from Finland (Komárková-Legnerová and Eloranta 1992). As mentioned above the alga deviates in some morphological characteristics from *A. heterospora* sensu auct. but seems most similar to this species among the known relatives.

Specimen examined: AL-55700. Locality: Lake Shupunto, Hokkaido; Watarase flood control area, Tochigi Pref.

Anabaena levanderi Lemmermann, 1906

(Figs. 6–7)

Trichomes free-floating, straight, slightly constricted at the cross walls. Cells cylindrical, 3.5–4 μm wide, 5.5–15 μm long, with gas vesicles. Heterocytes spherical, about 5 μm wide. Akinetes ellipsoidal, 10.5–11 μm wide, 11–15 μm long, solitary or sometimes in pairs.

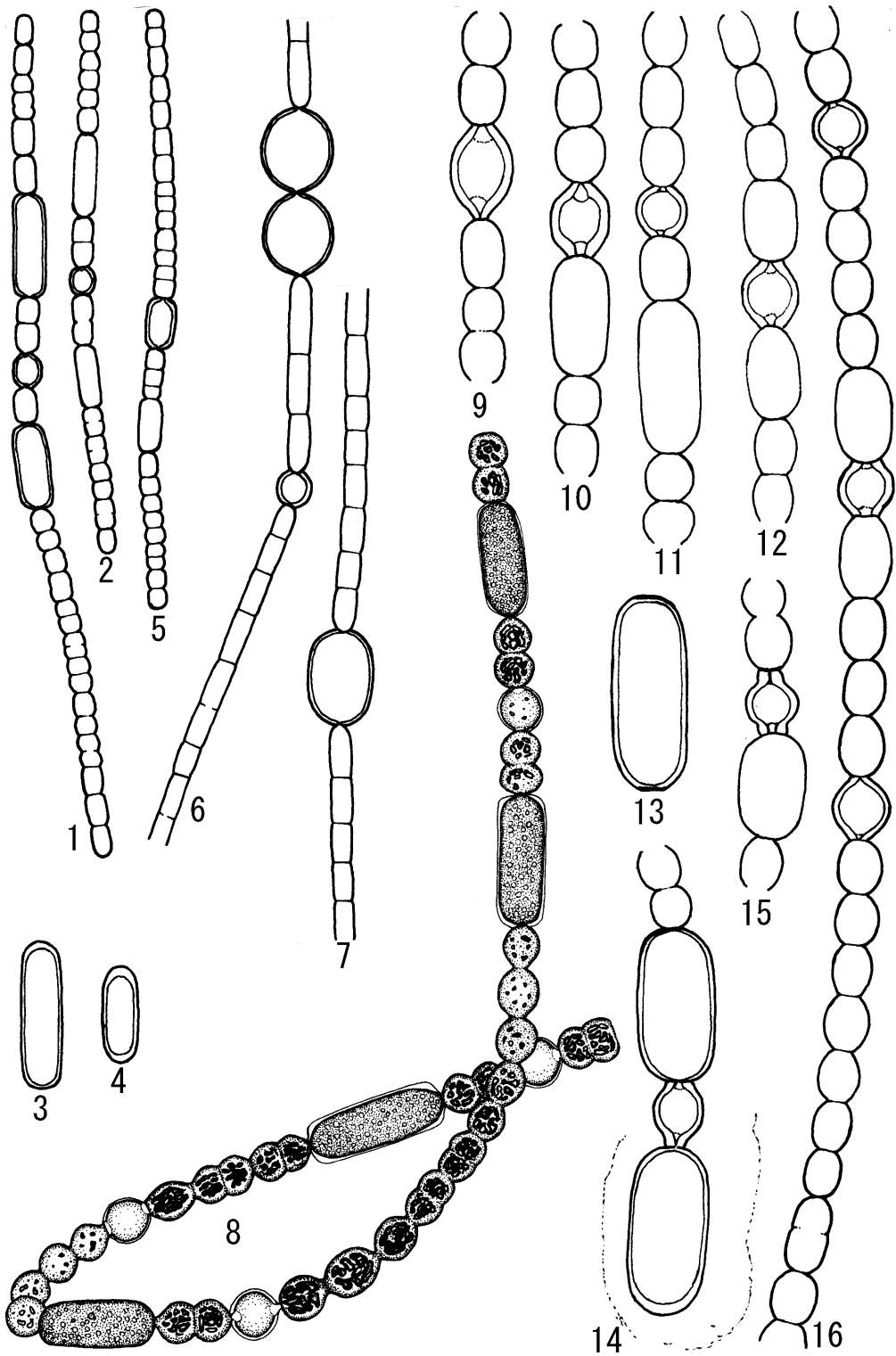
Anabaena levanderi Lemm. was characterized by its long cylindrical cells. The dimensions of the vegetative cells and the akinetes of the present alga correspond to the minimum dimensions shown in the original description of the species. After Lemmermann (1906) described this species Smith (1920) recorded the species in Chain lake, Wisconsin, Frémy (1930) from Equatorial Africa, and Geitler (1932) from Europe, however they cited intact the original measurements.

Specimen examined: AL-52806. Locality: Lake Suigetsu-ko, Fukui Pref.

Anabaena cf. *solitaria* Klebahn, 1895 (Fig. 8)

Trichomes straight or irregularly bent in rare cases. Cells spherical or lemon-shaped, about 5.2 μm wide, slightly longer or shorter than wide, with gas vesicles. Heterocytes almost spherical, 6.5–7 μm wide. Akinetes usually at one or both sides of heterocytes, usually including two cells between akinete and heterocyte, cylindrical, abruptly rounded ends, 5.8–6.6 μm wide, 15.5–20 μm long.

The present author recorded this alga in 1971



Figs. 1-16. 1-5: *Anabaena cf. heterospora* Nyg., 6, 7: *Anabaena levanderi* Lemm., 8: *Anabaena cf. solitaria* Kleb. (after Watanabe 1971), 9-16: *Anabaena tsugaruensis* sp. nov. ($\times 1000$)

Table 2. Differences in dimensions (μm) of vegetative cells, heterocytes, akinetes among populations from Japan, Denmark (type loc.) and Finland.

Species	Vegetative cells						Heterocytes						Akinetes			Sources	
	width		length		width		length		width		length		width		length		
	min	max	min	max	min	max	min	max	min	max	min	max	min	max	min		max
<i>A. cf. heterospora</i>	3.2	3.8	2.0	6.0	4.5	5.0	5.0	7.0	5.0	5.0	5.0	7.0	5.0	6.0	10.0	23.0	"present study, Japan" "Nygaard 1949 orig. publ., Denmark" "Komarkova-L. & Elor. 1992, Finland"
<i>A. heterospora</i>	5.0	6.0	4.0	6.5	6.0	7.0	5.5	8.0	8.0	9.0	8.0	9.0	8.0	9.0	26.0	33.0	
<i>A. heterospora</i>	4.5	5.7	4.5	7.0	5.5	6.5	slightly longer	longer	5.6	10.0	5.6	10.0	25.0	36.0	unripe		

(Watanabe 1971) from shallow water along the Shirarutoro river flowing through the Kushiro marsh land for the first time as *Anabaena* sp. (? *A. solitaria*). After this publication, written in Japanese, no corresponding alga has been found, so the author has tried to record again the existence of this alga with additional taxonomic notes. The alga is discontinuously smaller in dimensions than the known *Anabaena solitaria* reported in Europe (Klebahn 1895, Skuja 1956, and Komárková-Legnerová and Eloranta 1992), nevertheless it is the nearest to *A. solitaria* systematically because of its appearance in trichomes, and especially in the arrangement among cells, heterocytes and akinetes.

The specimen of the alga has been lost, but an original line drawing and measurements are available.

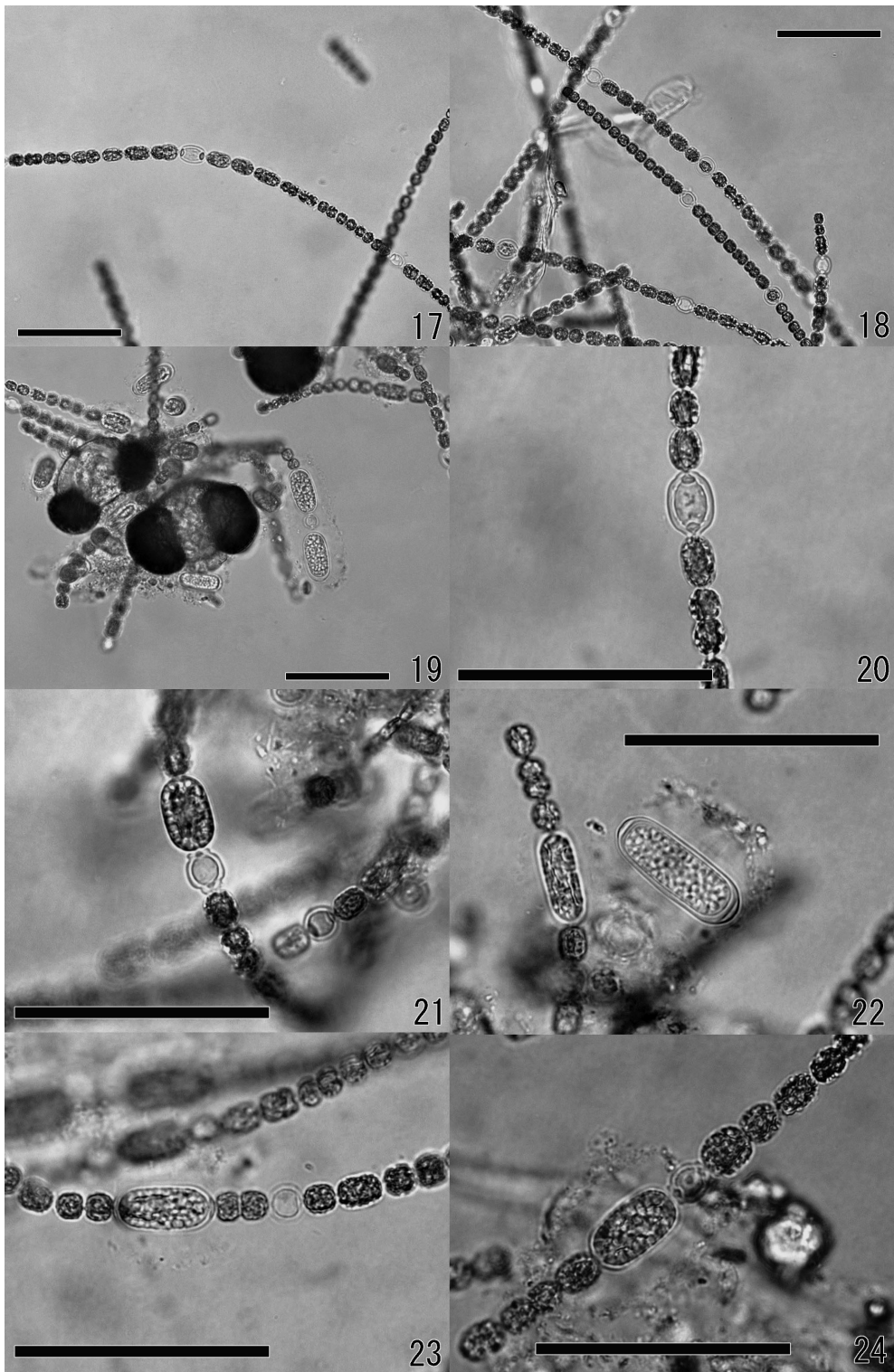
Anabaena tsugaruensis sp. nov. (Figs. 9–24)

Trichomata stricta, cum vagina mucosa densa circumdantia. Cellulae sphaericae, leviter elongata vel cupiformes, 5.1–7.0 μm latae, 3.8–10.1 μm longae. Heterocytes sphaericae, leviter elongatae vel interdum breviter cylindricae, 6.4–8.6 μm latae, 6.5–11.7 μm longae. Akineta cylindrica, apice rotundata, vulgo ad latera utriusque vel raro ad unilaterus heterocytis affixa, plerumque e heterocytis in uni- vel bi-cellulis distantia efferentia, 8.1–11.6 μm lata, 15.1–28.1 μm longa, 1.6–2.6-pro longiora quam latiora.

Iconotypus: Figurae 9–16.

Locus typicus: in lac Higurashi-no-ike, Aomori, Japoniae.

Trichomes straight, with thick mucilaginous sheath. Cells spherical to slightly elongated or barrel-shaped, 5.1–7.0 μm wide, 3.8–10.1 μm long, with gas vesicles. Heterocytes spherical to slightly elongated or sometimes short-cylindrical, 6.4–8.6 μm wide, 6.5–11.7 μm long. Akinetes cylindrical, with rounded ends, attached at one or both sides of the heterocyte, or one to two cells distant from the heterocyte, 8.1–11.6 μm wide, 15.1–28.1 μm long, 1.6–2.6 times longer than wide.



Figs. 17–24. *Anabaena tsugaruensis* sp. nov.
Scale bar=50 μ m

Table 3. Differences in dimensions (μm) of vegetative cells, heterocytes, akinetes among *Anabaena tsugaruensis* sp. nov. and related taxa.

Species	Vegetative cells						Heterocytes											
	width			length			width			length								
	min	max	sd	min	max	sd	n=	min	max	sd	min	max	sd	n=				
<i>A. tsugaruensis</i> sp. nov.	5.1	7.0	6.0	0.4	3.8	10.1	6.9	1.1	50	6.4	8.6	7.6	0.5	6.5	11.7	7.9	1.2	20
<i>A. akankoensis</i> M. Watan.	7.4	10.5	9.0	1.1	6.5	11.3	9.2	1.2	50	9.7	11.4	10.7	0.5	9.5	12.3	10.8	0.9	12
<i>A. fusca</i> Hill	5.5	6.5			6.0	10.0				6.0	8.5			6.5	9.0			
<i>A. solitaria</i> Klebahn	8				ca. 8					8	9			9	10			
<i>A. solitaria</i> Klebahn	8.5	10			8	11				bis 10.5 μ ,	von	ähnlichem	Aussehen	wie	die	vegetativen	Zellen	
<i>A. cf. solitaria</i> Klebahn	ca 5.2									6.5	7							

Table 3. (continued)

Species	Akinetes						Sources			
	width			length						
	min	max	sd	min	max	sd		n=		
<i>A. tsugaruensis</i> sp. nov.	8.1	11.6	9.7	0.9	15.1	28.1	22.5	3.0	20	present study, Tsugaru-jumiko lakes, Japan
<i>A. akankoensis</i> M. Watan.	10.8	13.0	12.0	0.7	23.3	42.3	28.1	5.5	29	Watanabe 2003, Lake Akan, Japan
<i>A. fusca</i> Hill	7.5	12.0			16.0	52.0				Hill 1976, Minessota lake, USA
<i>A. solitaria</i> Klebahn	9	10			28	35				Klebahn 1895, Uklei See, Germany
<i>A. solitaria</i> Klebahn	10	13.5			(25-35-40-60					Skuja 1956, Hallaren, Sweden
<i>A. cf. solitaria</i> Klebahn	5.8	6.6			15.5	20				Watanabe 1971, Kushiro marsh-land, Japan

- Watanabe, M. 1992. Studies on Planktonic Blue-green Algae 4. Some *Anabaena* species with straight trichomes in Japan. Bull. Natn. Sci. Mus., Tokyo, Ser. B, 18: 123–137.
- Watanabe, M. 1996. Studies on Planktonic Blue-green Algae 6. Bloom-forming species in Lake Biwa (Japan) in the Summer of 1994. Bull. Natn. Sci. Mus., Tokyo, Ser. B, 22: 1–10.
- Watanabe, M. 1996a. Studies on Planktonic Blue-green Algae 7. *Anabaena pseudocompacta* sp. nov. from eutrophic lakes in central Japan. Bull. Natn. Sci. Mus., Tokyo, Ser. B, 22: 93–97.
- Watanabe, M. 1998. Studies on Planktonic Blue-green Algae 8. *Anabaena* species with twisted trichomes in Japan. Bull. Natn. Sci. Mus., Tokyo, Ser. B, 24: 1–13.
- Watanabe, M. 2003. Studies on Planktonic Blue-green Algae 9. *Anabaena akankoensis* sp. nov. from Lake Akan, Hokkaido. Bull. Natn. Sci. Mus., Tokyo, Ser. B, 29: 9–13.
- Watanabe, M., Y. Niiyama and A. Tuji. 2004. Studies on Planktonic Blue-green Algae 10. Classification of Planktonic *Anabaena* with Coiled Trichomes Maintained in the National Science Museum, Tokyo Bull. Natn. Sci. Mus., Tokyo, B, 30: 135–149.