

# A TAXONOMIC STUDY ON SOIL TAXA OF ANABAENA BORY EX BORNET ET FLAHAULT (NOSTOCACEAE) IN IRAN

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In a revision of the genus *Anabaena* Bory ex Bornet et Flahault (*Nostocaceae*) in terrestrial habitats, 33 specimens belonging to eleven species and one variety were identified. Specimens were collected from 18 paddy field soils located in seven provinces of Iran. *Anabaena sphaerica* Bornet et Flahault, *A. portoricensis* N. L. Gardner, *A. fertilissima* C. B. Rao, *A. orientalis* Dixit and *A. ambigua* C. B. Rao are reported as five new records from Iran. An identification key, description and pictures of these species are presented in this study.

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**Key words.** *Anabaena*, *Nostocaceae*, morphospecies, new record, paddy field, Iran.

## مطالعه نمونه‌های خاکزی جنس *Anabaena* Bory ex Bornet et Flahault از تیره *Nostocaceae* در ایران

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جهت بررسی نمونه‌های خاکزی جنس *Anabaena* Bory ex Bornet et Flahault از تیره *Nostocaceae* تاکسونهای موجود در خاک ۱۸ ایستگاه از ۷ استان دارای قابلیت کشت برنج کشور مورد مطالعه قرار گرفت. طی این تحقیق در مجموع ۳۳ نمونه متعلق به یازده گونه و یک واریته از جنس *Anabaena* شناسایی شد. در میان گونه‌های شناسایی شده پنج گونه زیر برای نخستین بار از ایران گزارش می‌شود و کلید شناسایی، شرح و تصاویر گونه‌های شناسایی شده ارائه می‌گردد.

*Anabaena sphaerica* Bornet et Flahault, *A. portoricensis* N. L. Gardner, *A. fertilissima* C. B. Rao, *A. orientalis* Dixit, *A. ambigua* C.B.Rao

## INTRODUCTION

The genus *Anabaena* Bory ex Bornet et Flahault, is one of the nostocacean cyanobacteria. Nostocacean cyanobacteria are filamentous, heterocystous, not branched and not polarized morphotypes, classified traditionally in *Nostocaceae* family (Komárek 2010). These are cosmopolitan microorganisms, which play significant roles in diverse ecosystems such as paddy fields. The paddy field ecosystem represents a favorable environment for the growth of cyanobacteria fulfilling the requirements of light, water, temperature, humidity and nutrient availability in an optimal manner (Prasanna & Nayak 2007). Up to now, several species from different genera of *Nostocaceae* were reported from paddy fields of Iran but most of records related to

northern provinces of Iran. Report of two species of *Anabaena* from paddy fields of Gilan province in 1995 was the first record of this genus from paddy soils of Iran (Abrkar & Riahi 1995). Nowruzzi & Ahmadimoghadam (2006) reported four species of *Anabaena* from paddy fields of Golestan province and also Saadatnia & Riahi (2009) reported four species and Shariatmadari & Riahi (2010) reported 4 species and one variety of this genus from Gilan province. This study is focused on seven main rice cultivation provinces situated in north, centre, south, west and east of Iran. In present study, an attempt is made to contribute a new knowledge about *Anabaena* species and their distribution in the terrestrial ecosystems.

Table 1. Geographical details of the sampling locations.

Location	Geographic location	Province
Rostamabad	36°53' N 49°20' E	Gilan
Omsheh	37°16' N 49°35' E	-
Saravan	37°05' N 49°24' E	-
Rahimabad	36°51' N 50°13' E	-
Tonkabon	36°48' N 50°52' E	Mazandaran
Tazehabad	36°39' N 51°25' E	-
Alamut	36°23' N 50°33' E	Qazvin
Visan	33°49' N 48°07' E	Lorestan
Ebrahimabad	29°00' N 52°56' E	Fars
Easmaeelabad	28°85' N 53°83' E	-
Fathabad	29°19' N 52°37' E	-
Kamfiroz	30°15' N 52°17' E	-
Ghahdarijan	32°30' N 51°30' E	Esfahan
Falavarjan	32°32' N 51°30' E	-
Jujil	32°34' N 51°28' E	-
Zarrinshahr	32°22' N 51°22' E	-
Varnamkhast	32°21' N 51°22' E	-
Kalat	36°59' N 59°47' E	Khorasan Razavi

**MATERIALS AND METHODS**

Soil samples were collected from 18 paddy fields from April 2008 to May 2010 (Table 1) according to Rangaswamy method (1996). The collected soil samples were transferred to sterile petri dishes and sterilized nitrate free BG-11 medium (Stanier & al. 1971) was added and the pH adjusted in 7.1 after sterilization. The petri dishes were placed in a culture chamber at 25±5°C and a 12/12h light-dark cycle at artificial illumination (2000-2500 Lux) for two weeks. After colonization, cyanobacteria were transferred to the agar plates for purification. Taxonomic determination was carried out by light microscopy and based on Desikachary (1959), Prescott (1970), Wehr & al. (2002), Whitford & Schumacher (1973), Komárek (2005) and Komárek & Zapomělová (2008) by prepared semipermanent slides. The vegetative and reproductive characters used in the taxonomic determination were: Shape, color and size of the thallus; wide and length of trichomes; shape, size and color of vegetative cells, heterocysts and akinetes; as well as texture, color and ornamentation of cell walls of the akinetes and heterocyst.

**RESULTS AND DISCUSSION**

In this study, 33 specimens belonging to eleven *Anabaena* morphospecies and one variety were identified (Figs. 7, 8). All species and their distribution are listed in Table 2.

**A key to *Anabaena* species distributed in paddy fields soil of Iran**

1. Trichomes with terminal heterocyst *A. oryzae* (4)

- Trichomes often without terminal heterocyst 2
- 2. Akinetes spherical or sub-spherical 3
- Akinetes not spherical 5
- 3. Akinetes one to few together. Cells discoid *A. sphaerica* (8)
- Akinetes several in long chains. Cells barrel shape 4
- 4. Akinetes ripen irregularly in uneven size *A. portoricensis* (7)
- Akinetes regularly in even size *A. fertilissima* (2)
- 5. Akinetes not contiguous to the heterocysts 6
- Akinetes usually contiguous to the heterocysts 7
- 6. Akinetes in long series *A. variabilis* var. *ellipsospora* (10)
- Akinetes solitary or in pairs *A. viguieri* (11)
- 7. Heterocysts spherical or sub-spherical 8
- Heterocysts otherwise 10
- 8. Cells discoid. Akinetes 15-27 µ length. Heterocysts length higher than 9 µ *A. ambigua* (1)
- Cells short barrel-shape or sub-quadrangle. Akinetes 7-14 µ length. Heterocyst length lower than 9 µ 9
- 9. Trichomes single, without mucilaginous sheath. Akinetes single or two on both sides of the heterocyst *A. iyengarii* (3)
- Trichomes several, rarely single, with a common mucilaginous sheath. Akinetes several in both sides of heterocyst *A. vaginicola* (9)
- 10. Akinetes ellipsoidal or oblong 11
- Akinetes cylindrical *A. sp.* (12)
- 11. Apical cells rounded. Akinetes oblong, several in both sides of heterocyst *A. oscillarioides* (5)
- Apical cells conical. Akinetes ellipsoidal, one in both sides of heterocyst *A. orientalis* (6)

Table 2. List of soil *Anabaena* species recorded from Iran and their distributions.

Species	1	2	3	4	5	6	7
<i>A. variabilis</i> var. <i>ellipsospora</i> F. E. Fritsch = <i>Trichormus ellipsosporus</i> (Fritsch) Komárek et Anagnostidis	+	+	-	-	+	+	-
<i>A. vaginicola</i> Fritsch et Rich = <i>Wollea vaginicola</i> (Fritsch et Rich) R. N. Singh = <i>Anabaenothrix vaginicola</i> (Fritsch & Rich) Ghose	+	+	+	+	-	-	+
<i>Anabaena ambigua</i> C.B.Rao = <i>Wollea ambigua</i> (Rao) R.N.Singh	-	-	-	+	+	-	+
<i>A. oryzae</i> Fritsch = <i>A. gelatinosa</i> Fritsch ex De = <i>Nostoc oryzae</i> (F. E. Fritsch) J. Komárek et K. Anagnostidis	+	-	-	+	-	+	+
<i>A. oscillarioides</i> Bory ex Born. et Flah.	+	+	+	-	+	-	+
<i>A. sphaerica</i> Bornet et Flahault	+	-	+	+	+	-	-
<i>A. iyengari</i> Bharadwaja	+	-	+	-	+	-	-
<i>A. portoricensis</i> N. L. Gardner	-	-	-	-	-	+	-
<i>A. fertilissima</i> C. B. Rao = <i>Trichormus fertilissimus</i> (C. B. Rao) Komárek et Anagnostidis	-	-	-	+	-	-	-
<i>A. viguieri</i> Denis et Frémy = <i>Anabaena affinis</i> f. <i>viguieri</i> (Denis et Frémy) Komárek	-	-	-	-	+	-	-
<i>A. orientalis</i> Dixit	-	-	-	-	-	+	-
<i>Anabaena</i> sp.	+	-	-	-	-	-	-

1. Gilan province, 2. Mazandaran province, 3. Qazvin province, 4. Lorestan province, 5. Esfahan province, 6. Khorasan province, 7. Fars province.

1. *A. ambigua* C. B. Rao, Proc. Indian Acad. Sci., B, 5:101, 1937. Fig. 1 A

Syn: *Wollea ambigua* (Rao) Singh, R. N., Ann. Bot., Lond. n. s. 6: 606, 1942.

*Description.* Trichome free or enclosed in a mucilaginous envelope, straight, shortly narrowed at the ends, clearly constricted at cross walls, with terminal cells widely rounded. Cells shorter than wide, discoid, 9  $\mu$  broad, 5-7  $\mu$  long, with pale blue-green, slightly granulated contents. Heterocysts spherical or sub-spherical, 9-10  $\mu$  broad. Akinetes ellipsoidal or widely oval, arise on both sides of heterocysts, usually with granular contents, 14-16  $\mu$  broad, 14-27  $\mu$  long.

*Anabaena ambigua* was reported from the paddy fields and ponds of India, Pakistan and Cuba (Komárek 2005, Naz & al. 2004).

*Distribution in Iran.* Lorestan: Visan (33° 49' N 48° 07' E). -Esfahan: Falavarjan (32° 32' N 51° 30' E). -Fars: Ebrahimabad (29° 00' N 52° 56' E).

2. *A. fertilissima* C. B. Rao, Proc. Indian Acad. Sci., B, 6: 363, 1937. Fig. 1 B

This name is currently regarded as a taxonomic synonym of *Trichormus fertilissimus* (C. B. Rao) Komárek & Anagnostidis

*Description.* Trichome single, straight or bent. Cells barrel-shaped, 6  $\mu$  broad, 5  $\mu$  long, with rounded apical cells. Heterocysts sub spherical, 5-7  $\mu$  broad. Akinetes in long chains, often making the whole trichome spongenous, adjoining the heterocysts, almost spherical, with a smooth hyaline outer wall, 8  $\mu$  broad, 9  $\mu$  long.

*Anabaena fertilissima* was recorded from ponds and rice fields of India and Pakistan (Desikachary 1959, Naz & al. 2004).

*Distribution in Iran.* Lorestan: Visan (33° 49' N 48° 07' E).

3. *A. iyengarii* Bharadwaja, Proc. Indian Acad. Sci., B, 2:105, 1935. Fig. 2 A

*Description.* Trichome single, straight or irregularly curved, not attenuated towards ends, distinctly constricted at cross walls. Cells barrel shaped, with blue-green content, 3-4.5  $\mu$  broad, 3-5  $\mu$  long; apical cells rounded or conical with rounded apex. Heterocysts spherical or elongated spherical, 6-6.5  $\mu$  broad, 6-7  $\mu$  long. Akinetes arise on both sides of heterocysts, single, ellipsoidal, 6-8.5  $\mu$  broad, 7-14  $\mu$  long.

*Anabaena iyengarii* was recorded from pools and puddles, rice fields, swamps and littoral zones of ponds and lakes of India, Pakistan, Cuba and Iran (Desikachary 1959, Naz & al. 2004, Komárek 2005, Shariatmadari & Riahi 2010).

*Distribution in Iran.* Gilan: Omsheh (37° 16' N 49° 35' E). -Qazvin: Alamut (36° 23' N 50° 33' E). -Esfahan: Falavarjan (32° 32' N 51° 30' E).

4. *A. oryzae* Fritsch, J. Indian Bot. Soc., 28: 135, 1949. Fig. 2 B

Syn.: *A. gelatinosa* Fritsch ex De 1939 (*nomen nudum*) non Reinsch non Wood.

This name is currently regarded as a taxonomic synonym of *Nostoc oryzae* (F. E. Fritsch) Komárek & Anagnostidis

*Description.* Thallus green, gelatinous, memberanous. Trichomes short, straight. Cells barrel-shaped, 1  $\frac{1}{2}$  times as long as broad, 4  $\mu$  broad, 5  $\mu$  long. Heterocysts terminal and intercalary; intercalary heterocysts sub-spherical, 4-5  $\mu$  broad, 4-5  $\mu$  long; terminal heterocysts conical and longer than broad, 3-3.5  $\mu$  broad, 4-4.5  $\mu$  long. Akinetes 3-6 in series, sub-spherical, 5-6  $\mu$  broad, 6-7  $\mu$  long.

*Anabaena oryzae* was reported from paddy fields of India, Pakistan and Iran (Desikachary 1959, Naz & al. 2004, Shariatmadari & Riahi 2010).

*Distribution in Iran.* Gilan: Omsheh (37° 16' N 49° 35' E). -Lorestan: Visan (33° 49' N 48° 07' E). -Khorasan Razavi: Kalat (36° 59' N 59° 47' E). -Fars: Esmaeelabad (28° 85' N 53° 83' E).

5. *A. oscillarioides* Bory ex Born. et Flah., Dict., class. d'hist, nat., 1:308, 1822. Fig. 3 A

*Description.* Thallus gelatinous, yellowish green. Trichome 4-5  $\mu$  broad. Cells barrel-shape, somewhat

longer than broad, 4-5  $\mu$  broad, 8  $\mu$  long; apical cells rounded. Heterocysts oval or ellipsoidal with rounded ends, 5-6  $\mu$  broad, 8  $\mu$  long. Akinetes oblong or cylindrical with rounded ends, contiguous with the heterocysts, one or 2-3 in both sides of heterocyst, rarely up to 4 in chain, 5-7  $\mu$  broad, 8-20  $\mu$  long; epispore smooth.

*Anabaena oscillarioides* is common in several regions of the world. From Asia, this species was reported from Myanmar (Skuja 1949), India (Carter 1926, Gonzalves & Joshi 1946), Pakistan (Naz & al. 2004) and also from paddy fields of Iran (Nowruzi & Ahmadimoghadam 2006, Saadatnia & Riahi 2009).

*Distribution in Iran.* Gilan: Saravan (37° 5' N 49° 24' E). -Mazandaran: Tazehabad (36° 39' N 51° 25' E). -Qazvin: Alamut (36° 23' N 50° 33' E). -Esfahan: Jojil (32° 34' N 51° 28' E). -Fars: Ebrahimabad (29° 00' N 52° 56' E).

6. *A. orientalis* Dixit, Proc. Indian Acad. Sci., B, 3: 101, 1936. Fig. 3 B

*Description.* Trichome single, straight. Cells sub-quadrate, 2-3  $\mu$  long, 2.5-3  $\mu$  broad; end cell conical with rounded apex. Heterocysts single, intercalary, cylindrical with rounded apex, 5-7  $\mu$  long, 3-4  $\mu$  broad. Akinetes one on each side of a heterocysts, ellipsoidal, 7-15  $\mu$  long, 5-6  $\mu$  broad.

*Anabaena orientalis* was reported from aquatic ecosystems of India and rice fields of Pakistan (Desikachary 1959, Naz & al. 2004).

*Distribution in Iran.* Khorasan Razavi: Kalat (36° 59' N 59° 47' E).

7. *A. portoricensis* N. L. Gardner, Mem. New York Bot. Garden 7: 62, 1927. Fig. 4 A

*Description.* Trichomes single, straight or bent, with rounded end cells. Cells barrel-shaped, 4-6  $\mu$  long, 4-5  $\mu$  broad, with pale blue-green contents, usually granulate. Heterocysts almost spherical or sub-spherical, 6-8  $\mu$  broad, with homogeneous, yellow-green contents. Akinetes ripen very irregularly and within rows occur in uneven size, spherical, with blue-green, granular contents, slightly brownish endospore and colourless exospores, 8-9  $\mu$  broad, 9-10  $\mu$  long.

*Anabaena portoricensis* was originally described by Gardner (1927) from a ditch in Puerto Rico and also was reported from the Caribbean region and old paddy fields of Cuba (Komárek 2005).

*Distribution in Iran.* Khorasan Razavi: Kalat (36° 59' N 59° 47' E).

8. *A. sphaerica* Bornet et Flahault, Revision des Nostocacées heterocystées, 228, 1888. Fig. 4 B

*Description.* Trichomes straight, single or several, arranged parallel, with an indistinct mucilaginous

sheath. Cells discoid, 8-9  $\mu$  broad, 5-7  $\mu$  long, apical cells rounded. Heterocysts spherical or sub-spherical, 8-11  $\mu$  broad. Akinetes one or two on one or two sides of the heterocysts, sub-spherical, 11-16  $\mu$  broad, 12-16  $\mu$  long; epispore smooth, yellowish brown.

*Anabaena sphaerica* was reported from several regions such as Europe, Australia, New Zealand and also from lakes and rivers of India and Pakistan (Naz & al. 2004).

*Distribution in Iran.* Gilan: Omsheh (37° 16' N 49° 35' E). -Qazvin: Alamut (36° 23' N 50° 33' E). -Lorestan: Visan (33° 49' N 48° 07' E). -Esfahan: Jujil (32° 34' N 51° 28' E).

9. *A. vaginicola* Fritsch et Rich., Trans. Roy. Soc. S. Afr., 18 (1): 87, 1929. Fig. 5 A

Syn.: *Anabaenothrix vaginicola* (Fritsch and Rich) Ghose and Randhawa in Randhawa, Proc. Indian Acad. Sci., B, 3: 407, 1936; *Wollea vaginicola* (Fritsch et Rich) R. N. Singh., Ann. Bot., Lond., n.a. 6: 593-606, 1942.

*Description.* Trichomes many and parallel in a common mucilaginous sheath, single in initial stage; single trichome with sheath 10-12  $\mu$  broad. Cells sub-quadrate, 4-5  $\mu$  broad, 5  $\mu$  long; apical cell conical with rounded apex or rarely rounded. Heterocysts cylindrical or elongated spherical or spherical, 5-6  $\mu$  broad, 5.5-7  $\mu$  long. Akinetes oblong, contiguous with the heterocysts, often 2-4 in series, 6-8  $\mu$  broad, 8-11  $\mu$  long.

*Anabaena vaginicola* were reported from India, Pakistan and Africa often from aquatic ecosystems (Desikachary 1959, Naz & al. 2004). Also this species reported from paddy fields of Iran (Shariatmadari & Riahi 2010).

*Distribution in Iran.* Gilan: Omsheh (37° 16' N 49° 35' E). -Mazandaran:Tazehabad (36° 39' N 51° 25' E). -Qazvin: Alamut (36° 23' N 50° 33' E). -Lorestan: Visan (33° 49' N 48° 07' E). -Fars: Kamfiroz (30° 15' N 52° 17' E).

10. *A. variabilis* var. *ellipsospora* Fritsch, J. Indian Bot. Soc., 28: 142, 1949. Fig. 5 B

This name is currently regarded as a taxonomic synonymy of *Trichormus ellipsosporus* (Fritsch) Komárek et Agnastididis

*Description.* Trichome without any sheath, constricted at the cross-walls. Cells barrel-shaped or sub-quadrate, 3-4  $\mu$  broad, 4.5-5  $\mu$  long; apical end cells rounded. Heterocysts intercalary, barrel-shaped, 4-6  $\mu$  broad, 4-8  $\mu$  long. Akinetes away from heterocysts, in long series, ellipsoidal with rounded ends, 4-6  $\mu$  broad, 5-8  $\mu$  long.

*Anabaena variabilis* var. *ellipsospora* was reported from paddy fields of India and Iran (Desikachary 1959, Shariatmadari & Riahi 2010).

*Distribution in Iran.* Gilan: Rahimabad (36° 51' N 50° 13' E). -Mazandaran:Tazehabad (36° 39' N 51° 25' E). -Esfahan: Falavarjan (32° 32' N 51° 30' E). -Khorasan Razavi: Kalat (36° 59' N 59° 47' E).

11. *A. viguieri* Denis et Fremy, Bull. Soc. Linn. Normandie, Ser. 7, 6: 122, 1924. Fig. 6 A

Syn.: *Anabaena affinis* f. *viguieri* (Senis et Fremy) Komárek, Algolog. Studien, P. 124, 1958.

Trichomes straight or curved, without mucilaginous sheath. Cells discoid or short barrel-shaped, 4  $\mu$  long, 6  $\mu$  broad, apical cells rounded. Heterocysts intercalary, spherical, 6  $\mu$  broad. Akinetes ellipsoidal, oval or sub-spherical, distant from the heterocysts, single or in pairs, 7-9  $\mu$  broad, 6-15  $\mu$  long.

*Anabaena viguieri* is common in the whole temperate zones, Europe to Central Asia and also reported from North America often in planktonic form (Komárek & Zapomělová 2008). Planktic form of this species also reported from aquatic ecosystems of Iran (Ramezani 2004).

*Distribution in Iran.* Esfahan: Falavarjan (32° 32' N 51° 30' E).

12. *Anabaena* sp. Fig. 6 B

Trichomes short, straight, single, dark blue-green; gelatinous sheath not present. Cells cylindrical, 3  $\mu$  broad, 6  $\mu$  long; apical cells rounded. Heterocysts intercalary, oblong with rounded ends, 4  $\mu$  broad, 7  $\mu$  long. Akinetes cylindrical, single, in both sides of heterocyst, 4  $\mu$  broad, 13  $\mu$  long.

*Distribution in Iran.* Gilan: Rahimabad (36° 51' N 50° 13' E).

Before to this study *A. variabilis* Kützting ex Born et Flahult, *A. torulosa* (Carm.) Lagerh, *A. circinalis* Rabenhorst ex Born. et Flah. and *A. spiroides* Klebahn had been reported from paddy fields of Gilan and Golestan provinces (Abrkar & Riahi 1995, Nowruzzi & Ahmadimoghdam 2006, Saadatnia & Riahi 2009), but we can't see these species among our taxa. Of the recorded *Anabaena* species in this study, following species are new records to Iran. *A. sphaerica* Bornet et Flahault, *A. portoricensis* N. L. Gardner, *A. fertilissima* C. B. Rao, *A. orientalis* Dixit and *A. ambigua* C. B. Rao.

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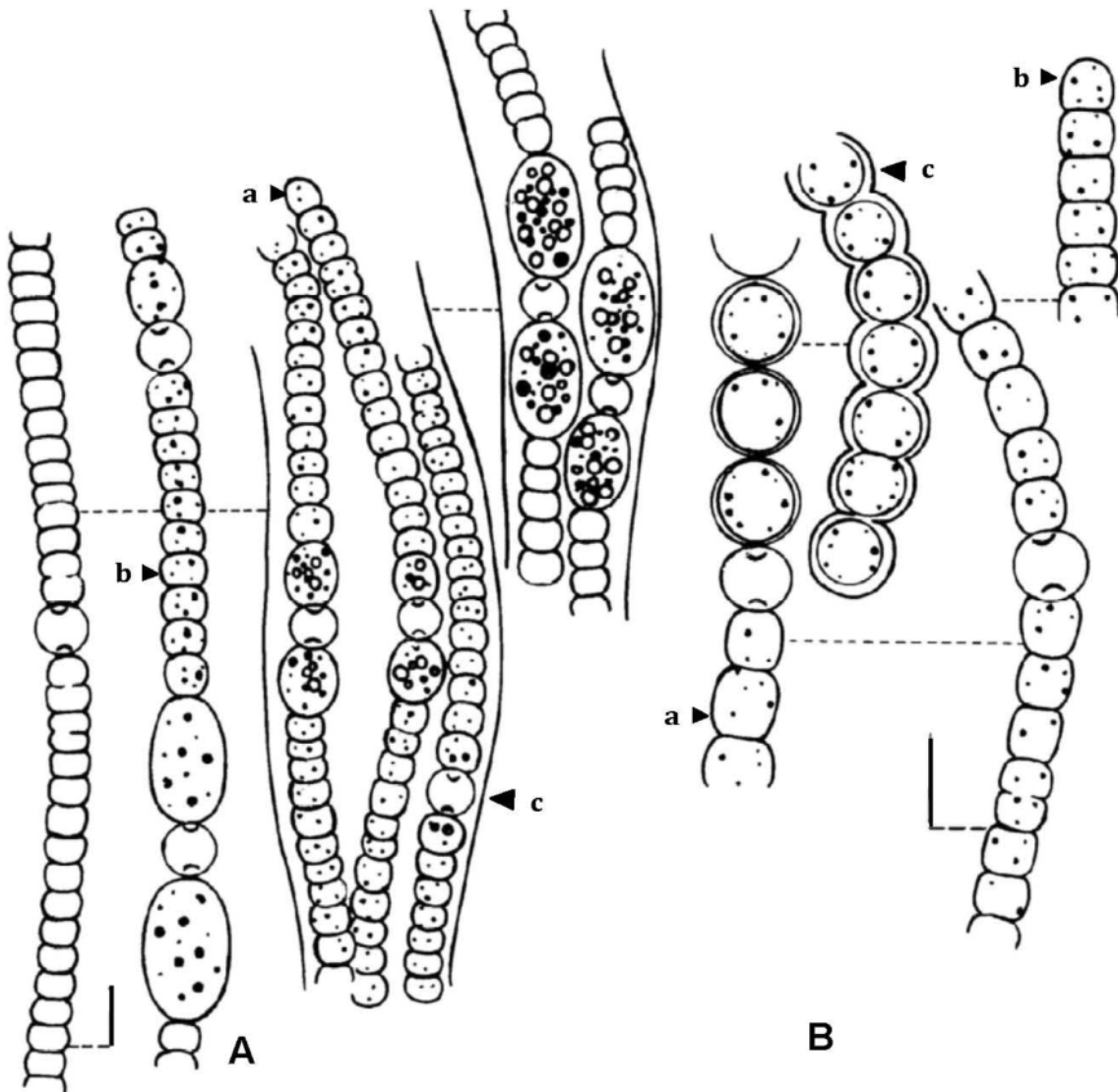


Fig. 1. A. *Anabaena ambigua*: a- apical part of trichome, b- Part of trichomes with heterocysts and akinetes, c- mucilaginous envelop., B. *Anabaena fertilissima*: a- part of trichomes with heterocysts and akinetes, b- apical part of trichome, c- akinetes (Scale: 10  $\mu$ m).

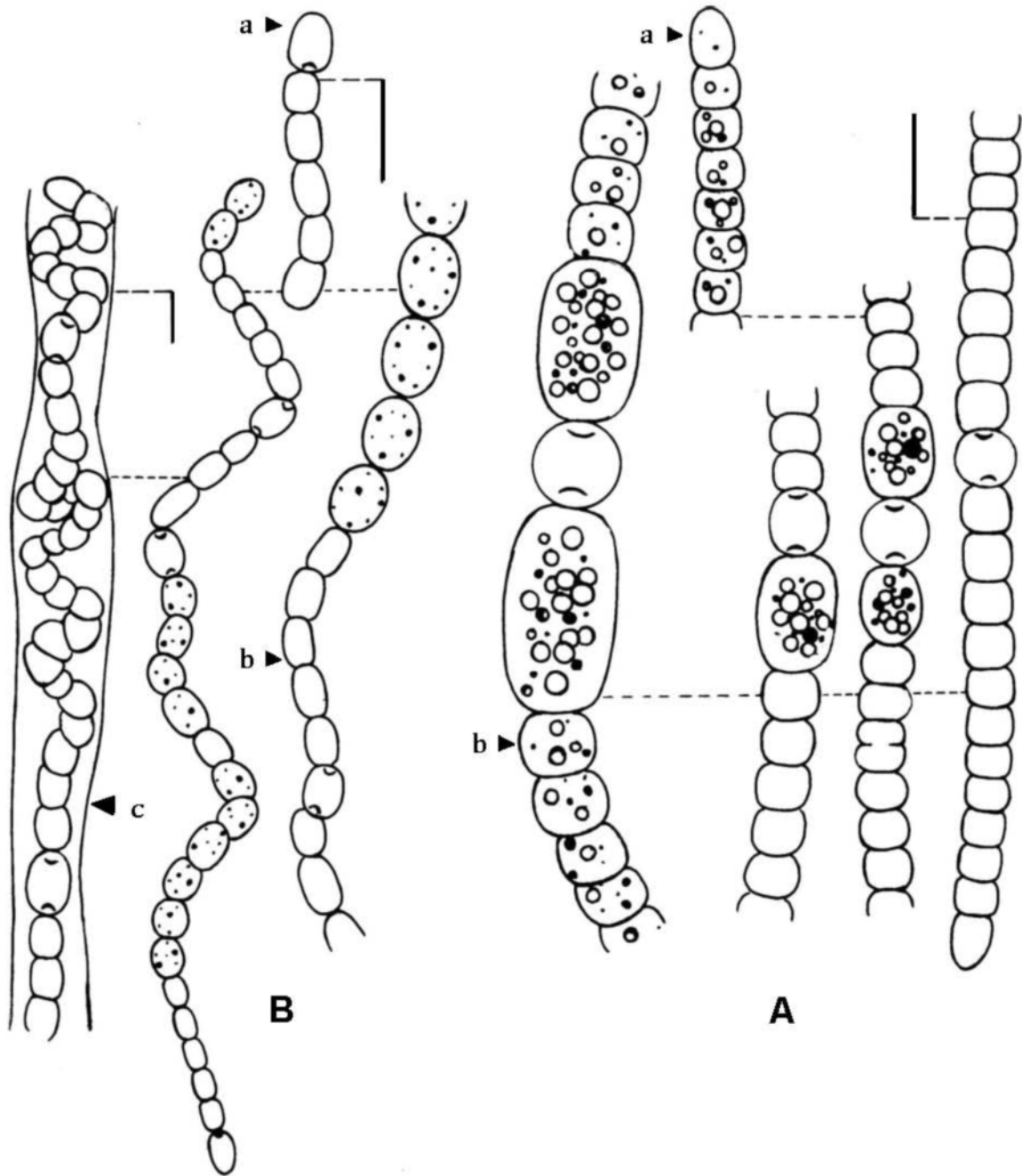


Fig. 2. A. *Anabaena iyengarii*: a- apical part of trichome, b- part of trichomes with heterocysts and akinetes., B. *Anabaena oryzae*: a- Terminal heterocyst, b- part of trichomes with heterocysts and akinetes., c- mucilaginous envelope (Scale: 10  $\mu$ m).

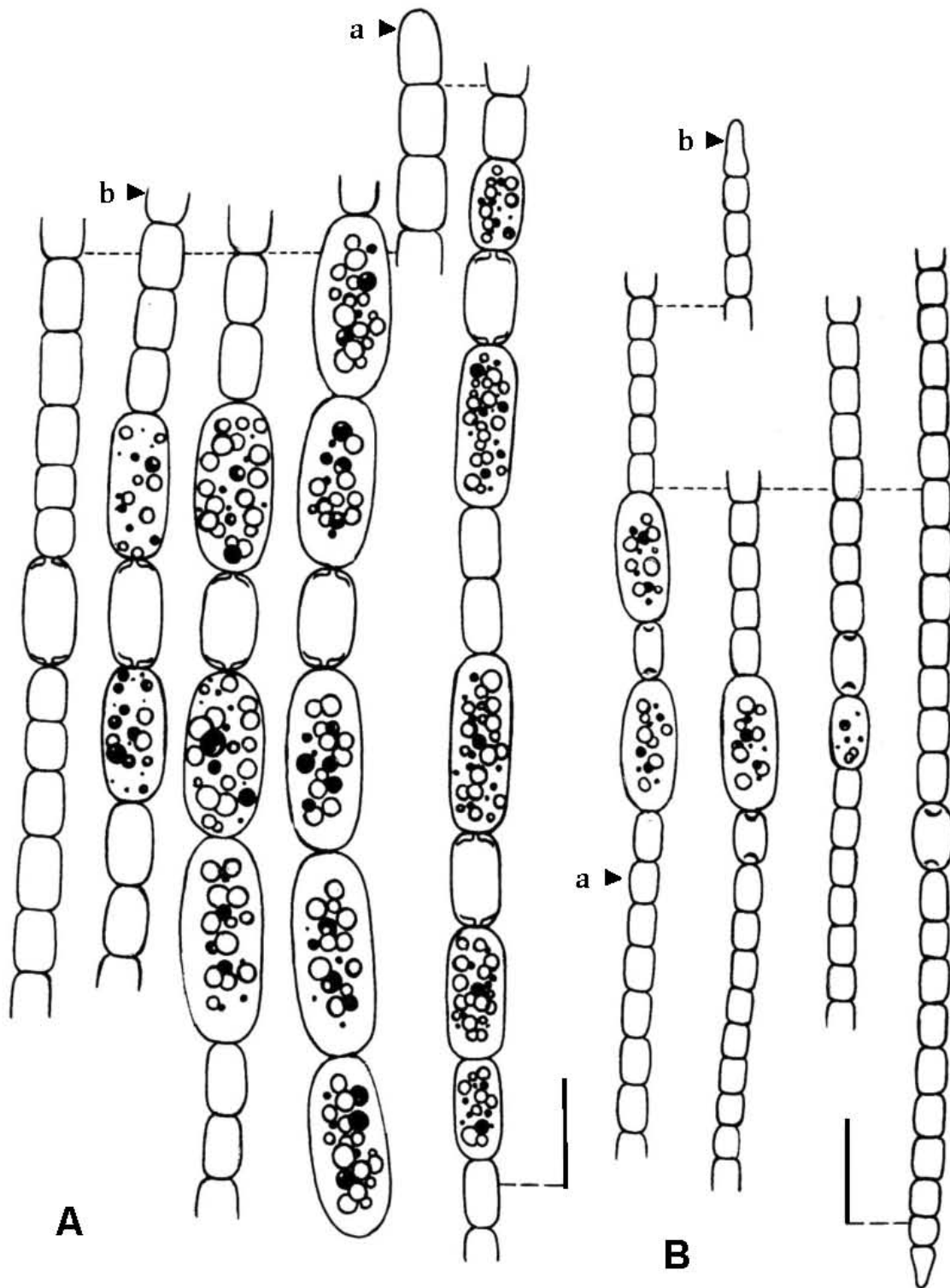


Fig. 3. A. *Anabaena oscillarioides*: a- apical part of trichome, b- part of trichomes with young akinetes., B. *Anabaena orientalis*: a- part of trichomes with heterocysts and akinetes., b- apical part of trichome (Scale: 10  $\mu$ m).



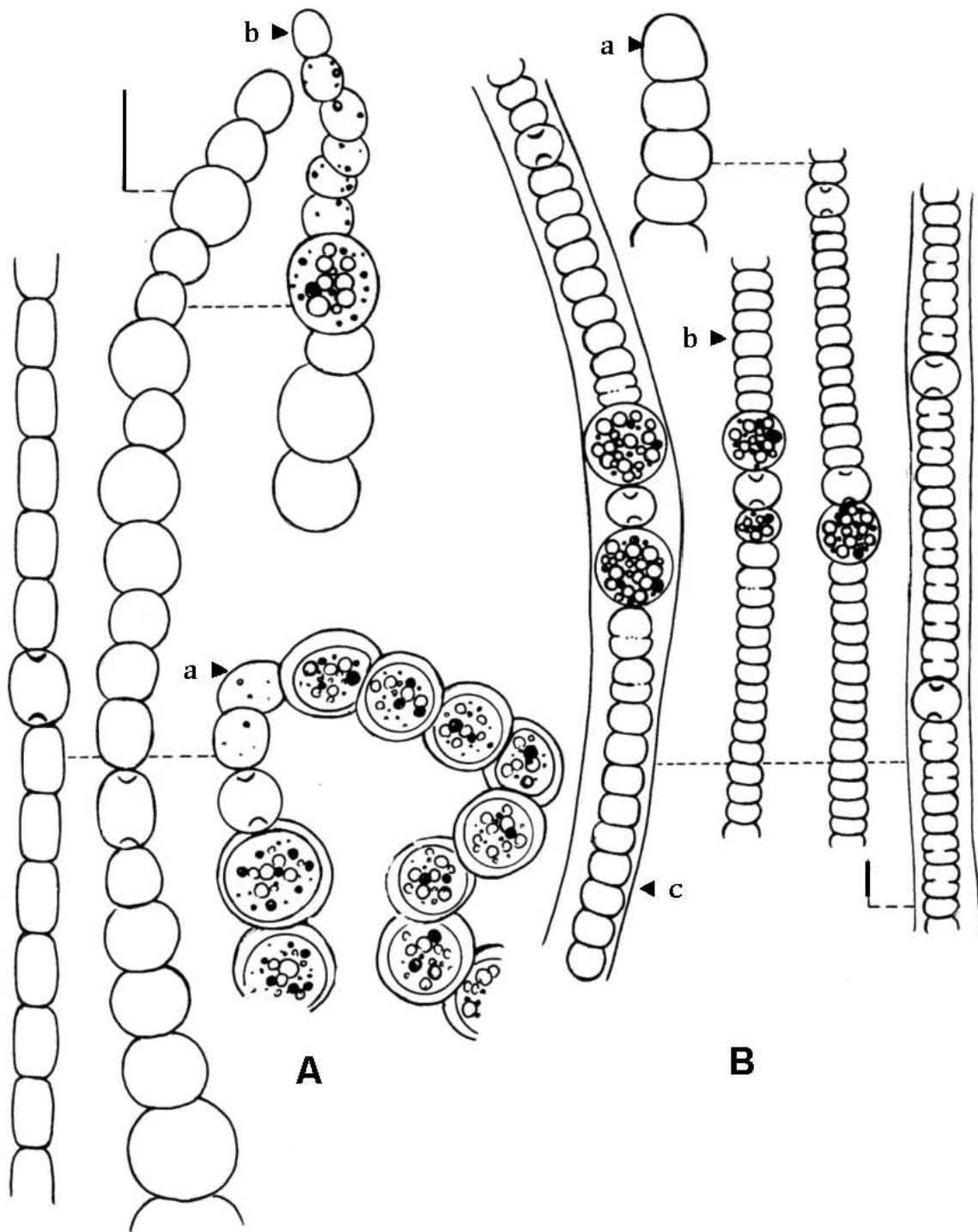


Fig. 4. A. *Anabaena portoricensis* : a- part of trichomes with heterocysts and akinetes, b- apical part of trichome ., B. *Anabaena sphaerica*: a- apical part of trichome, b - part of trichomes with young akinetes., c- mucilaginous envelope (Scale: 10  $\mu$ m).

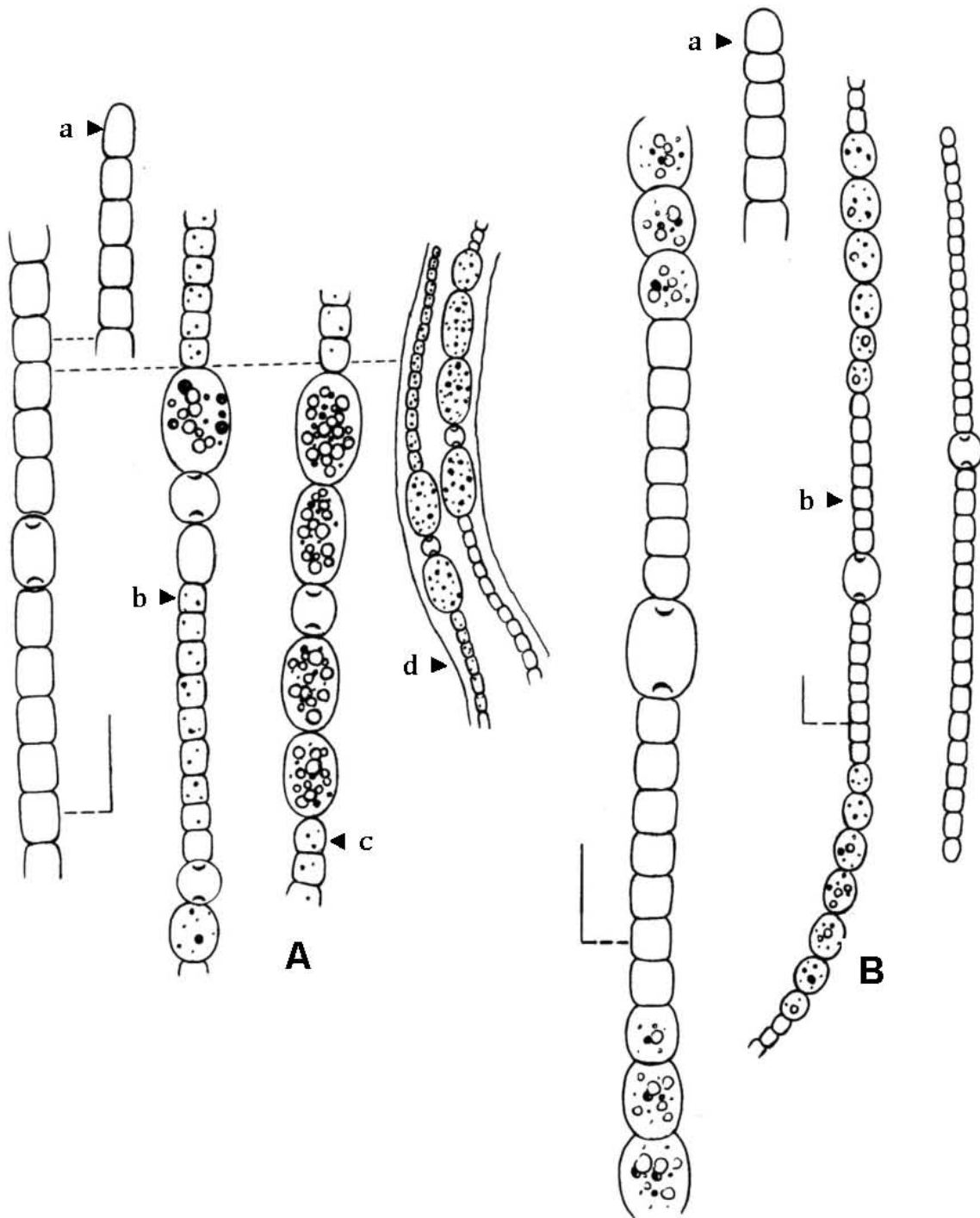


Fig. 5. A. *Anabaena vaginicola*: a- apical part of trichome, b- part of trichomes with young akinetes., c- part of trichomes with heterocysts and akinete, d- mucilaginous envelope., B. *Anabaena variabilis* var. *ellipsozona*: a- apical part of trichome, b- part of trichomes with heterocysts and akinetes (Scale: 10 μm).

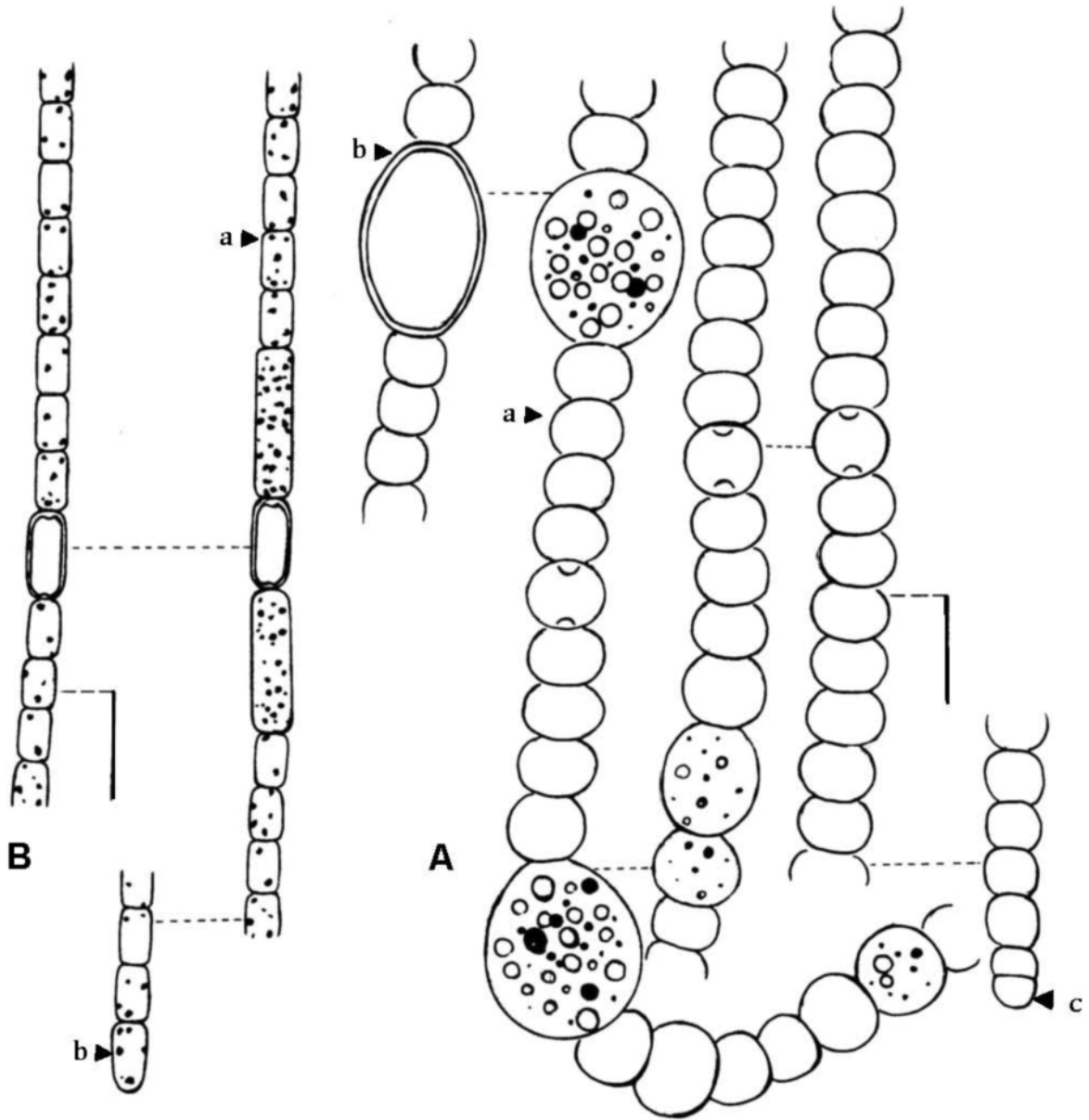


Fig. 6. A. *Anabaena viguieri*: a- part of trichomes with heterocysts and akinetes, b- akinetes, c- apical part of trichome., B. *Anabaena* sp. : a- part of trichomes with heterocysts and akinetes., b- apical part of trichome (Scale: 10  $\mu$ m).

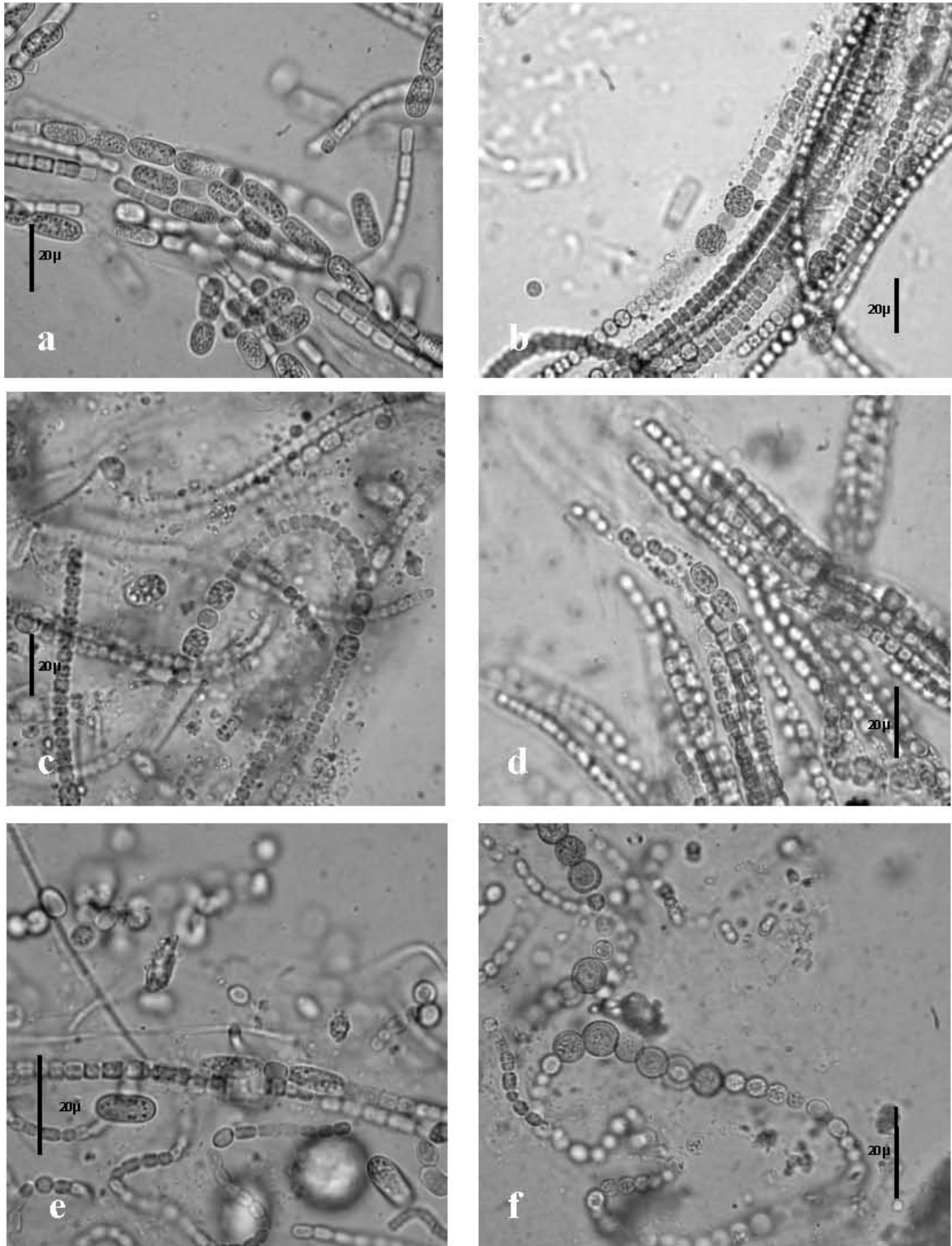


Fig. 7. a. *Anabaena oscillarioides*, b. *A. sphaerica*, c. *A. iyengarii*, d. *A. vaginicola*, e. *A. orientalis*, f. *A. portoricensis*.

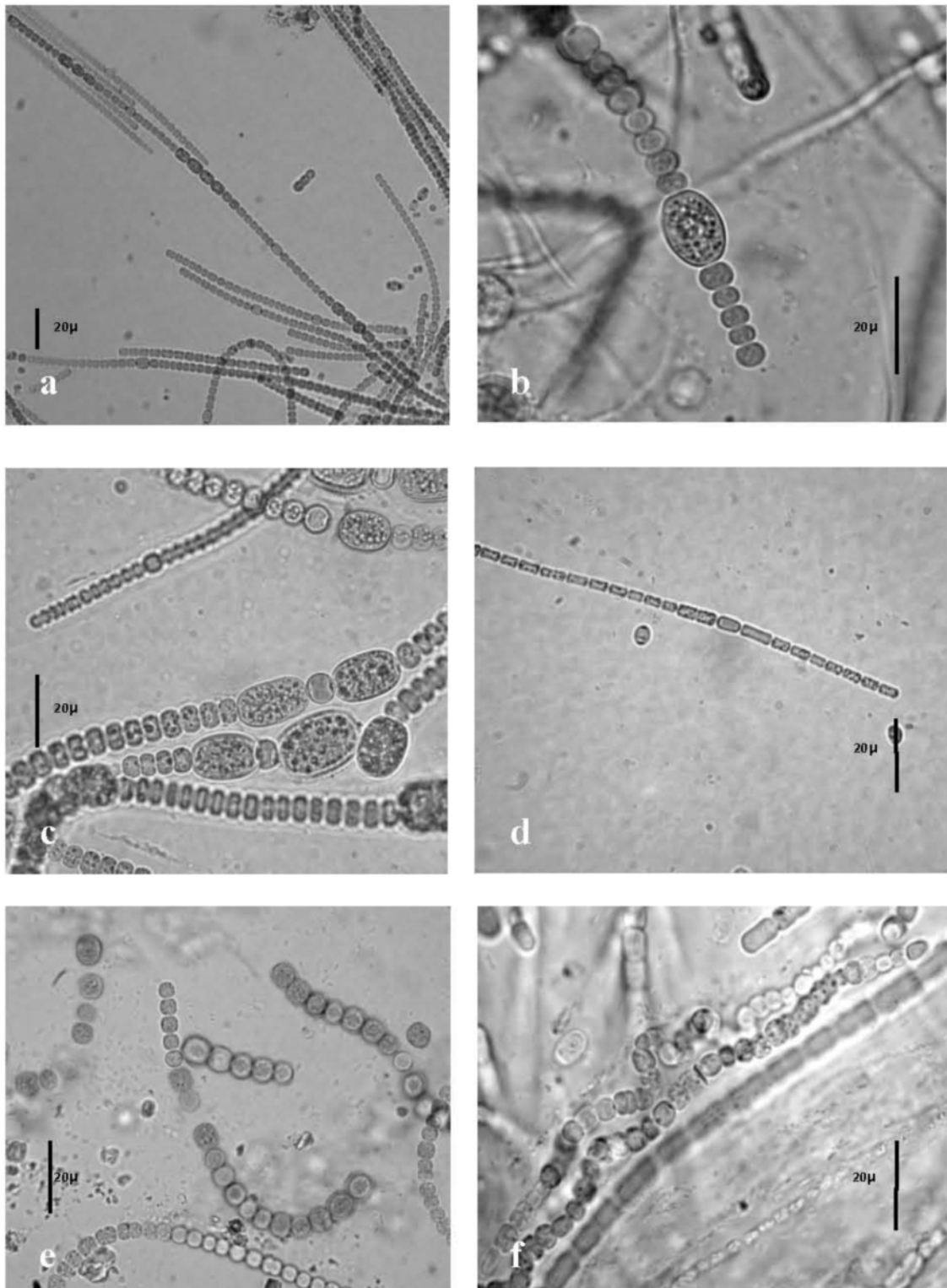


Fig. 8. a. *Anabaena variabilis* var. *ellipsospora*, b. *A. viguieri*, c. *A. ambigua*, d. *A. sp.*, e. *A. fertilissima*, f. *A. oryzae*.

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