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. $QDEDHQD VSKDHULFD Bornet et Flahault, $ SRUWRUHFHQVV N. L. Gardner, $ IHUWLOLVVLPD C. B. Rao, $ RUHQEXUJLL Dixit and $ DPELJXD 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.

=HQDE 6KDULDWPDGDUL <zeshariatmadari@yahoo.com> DQG +RVHQ5 LDKL FRUHVSRQGHQFH <h-riahi@cc.sbu.ac.ir>) DFXOW RI %LRVFLHQFHV 6KDKLG %HKHVKWL8 QLYHUVLW\ * & 7HKUDQ ,UDQ ± 6KDGHP DQ6KRNUDYL) DFXOW RI %DVF 6FLHQFH ,VODPLF $]DG8 QLYHUVLW\ * RUJDQ ,UDQ

. H\ZRUGV *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 نمونه های 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 مجمـوع ۳۳ نمونه متعلق به یازده گونه و یک واریته از جنس *Anabaena* شناسایی شد. در میان گونه‌های شناسای شده پنج گونه *زیر* برای نخستین بار از ایران گزارش می‌شود و کلید شناسایی، شرح و تصاویر گونه‌های شناسایی شده ارائه می‌گردد.

$QDEDHQD VSKDHULFD Bornet et Flahault, $ SRUWRUHFHQVV N. L. Gardner, A IHUWLOLVVLPD C. B. Rao, $ RUHQEXUJLL Dixit, $ DPELJXD 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). Nowruzi & 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.

RSULTS 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-quadrate. 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
$ YDULDELOLV var. HQORSKRUD F. E. Fritsch = 7UFKRUXV HQORSKRUXV (Fritsch) Komárek et Anagnostidis	+	+	-	-	+	+	-
$ YDJLQLFROD Fritsch et Rich = : RROHD YDJLQLFROD (Fritsch et Rich) R. N. Singh = $QDEDHQRVLV[YDJLQLFROD (Fritsch & Rich) Ghose	+	+	+	+	-	-	+
$QDEDHQD DPELJXD C.B.Rao = : RROHD DPELJXD (Rao) R.N.Singh	-	-	-	+	+	-	+
$ RU]DH Fritsch = $ JHDWLQRVD Fritsch ex De = 1 RVWRF RU]DH (F. E. Fritsch) J. Komárek et K. Anagnostidis	+	-	-	+	-	+	+
$ RVFLOODULRLGHV Bory ex Born. et Flah.	+	+	+	-	+	-	+
$ VSKDHULFD Bornet et Flahault	+	-	+	+	+	-	-
$ LHQJDUL Bharadwaja	+	-	+	-	+	-	-
$ SRURUHQLV N. L. Gardner	-	-	-	-	-	+	-
$ IHUWLOLVVLPD C. B. Rao = 7UFKRUXV IHUWLOLVVLPXV (C. B. Rao) Komárek et Anagnostidis	-	-	-	+	-	-	-
$ YLJXHUL Denis et Frémy = $QDEDHQD DIILQLV f. viguieri (Denis et Frémy) Komárek	-	-	-	-	+	-	-
$ RUHQWDOLV Dixit	-	-	-	-	-	+	-
Anabaena sp	+	-	-	-	-	-	-

1..Gilan province, 2. Mazandaran province, 3. Qazvin province, 4. Lorestan province, 5. Esfehan 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: : RROHD DPELJXD (Rao) Singh, R. N., Ann. Bot., Lond. n. s. 6: 606, 1942.

' HVFULSWLRQ 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 µ broad, 5-7 µ long, with pale blue-green, slightly granulated contents. Heterocysts spherical or sub-spherical, 9-10 µ broad. Akinetes ellipsoidal or widely oval, arise on both sides of heterocystes, usually with granular contents, 14-16 µ broad, 14-27 µ long.

$QDEDHQD DPELJXD was reported from the paddy fields and ponds of India, Pakistan and Cuba (Komárek 2005, Naz & al. 2004).

' LVWULEXWLRQ,Q,UDQ 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 7UFKRUXV IHUWLOLVVLPXV (C. B. Rao) Komárek & Anagnostidis

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

$QDEDHQD IHUWLOLVVLPD was recorded from ponds and rice fields of India and Pakistan (Desikachary 1959, Naz & al. 2004).

' LVWULEXWLRQ LQ ,UDQ Lorestan: Visan (33˚49´ N 48˚07´ E).

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

' HVFULSWLRQ 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 µ broad, 3-5 µ long; apical cells rounded or conical with rounded apex. Heterocysts spherical or elongated spherical, 6-6.5 µ broad, 6-7 µ long. Akinetes arise on both sides of heterocysts, single, ellipsoidal, 6-8.5 µ broad, 7-14 µ long.

$QDEDHQD LQHQJDUL 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).

' LVWULEXWLRQ LQ ,UDQ 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.: *$ JHDWLQRVD* Fritsch ex De 1939 *QRP HQ QXGXP non* Reinsch *non* Wood.

This name is currently regarded as a taxonomic synonym of *1 RVWRF RU]DH* (F. E. Fritsch) Komárek & Anagnostidis

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

$QDEDHQD RU]DH was reported from paddy fields of India, Pakistan and Iran (Desikachary 1959, Naz & al. 2004, Shariatmadari & Riahi 2010).

' LVWULEXWLRQ LQ ,UDQ 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. G¶KLVWQDW Fig. 3 A

' HVFULSWLRQ Thallus gelatinous, yellowish green. Trichome 4-5 µ broad. Cells barrel-shape, somewhat longer than broad, 4-5 µ broad, 8 µ long; apical cells rounded. Heterocysts oval or ellipsoidal with rounded ends, 5-6 µ broad, 8 µ 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 µ broad, 8-20 µ long; epispore smooth.

$QDEDHQD RVFLOODUURLGHV 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).

' LVWULEXWLRQ LQ ,UDQ 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

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

$QDEDHQD RUHQWDOLV was reported from aquatic ecosystems of India and rice fields of Pakistan (Desikachary 1959, Naz & al. 2004).

' LVWULEXWLRQ LQ ,UDQ 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

' HVFULSWLRQ Trichomes single, straight or bent, with rounded end cells. Cells barrel-shaped, 4-6 µ long, 4-5 µ broad, with pale blue-green contents, usually granulate. Heterocysts almost spherical or sub-spherical, 6-8 µ 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 µ broad, 9-10 µ long.

$QDEDHQD SRUWRULFHQVLV was originally described by Gardner (1927) from a ditch in Puetro Rico and also was reported from the Caribbean region and old paddy fields of Cuba (Komárek 2005).

' LVWULEXWLRQ LQ ,UDQ Khorasan Razavi: Kalat (36˚59´ N 59˚47´ E).

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

' HVFULSWLRQ Trichomes straight, single or several, arranged parallel, with an indistinct mucilaginous

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

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

' LVWULEXWLRQ IQ ,UDQ 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.: *$QDEDHQRWKUL[YDJLQLFROD* (Fritsch and Rich) Ghose and Randhawa in Randhawa, Proc. Indian Acad. Sci., B, 3: 407, 1936; *: RROHD YDJLQLFROD* (Fritsch et Rich) R. N. Singh., Ann. Bot., Lond., n.a. 6: 593-606, 1942.

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

$QDEDHQD YDJLQLFROD 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).

' LVWULEXWLRQ IQ ,UDQ 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 *7ULFKRUHXV HOOLSVRVSRUXV* (Fritsch) Komárek et Anagnostidis

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

$QDEDHQD YDULDELOLV var. *HOOLSVRVSRUD* was reported from paddy fields of India and Iran (Desikachary 1959, Shariatmadari & Riahi 2010).

' LVWULEXWLRQ IQ ,UDQ 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.: *$QDEDHQD DIILQLV* f. *YLJXLHUL* (Senis et Fremy) Komárek, Algolog. Studien, P. 124, 1958.

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

$QDEDHQD YLJXLHUL is common in the whole temporate 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 (Ramezanpoor 2004).

' LVWULEXWLRQ IQ ,UDQ 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 µ broad, 6 µ long; apical cells rounded. Heterocysts intercalary, oblong with rounded ends, 4 µ broad, 7 µ long. Akinetes cylindrical, single, in both sides of heterocyst, 4 µ broad, 13 µ long.

' LVWULEXWLRQ IQ ,UDQ Gilan: Rahimabad (36˚ 51´N 50˚ 13´E).

Before to this study *$ YDULDELOLV* Kützing ex Born et Flahult *$ WRUXORVD* (Carm.) Lagerh, *$ FILFLQDOLV* Rabenhorst ex Born. et Flah. and *$ VSLUROLGHV* Klebahn had been reported from paddy fields of Gilan and Golestan provinces (Abrkar & Riahi 1995, Nowruzi & Ahmadimoghadam 2006, Saadatnia & Riahi 2009), EXW ZH FDQ¶W WHVW WKHVH VSHFLHV DP RQ RXU 0D 2 I WKH recorded *Anabaena* species in this study, following species are new records to Iran. *$ VSKDHULFD* Bornet et Flahault, *$ SRUWRULFHQVLV* N. L. Gardner, *$ IHUWLOLVVLPD* C. B. Rao, *$ RULHQWDOLV* Dixit and *$ DPELJXD* C. B. Rao.

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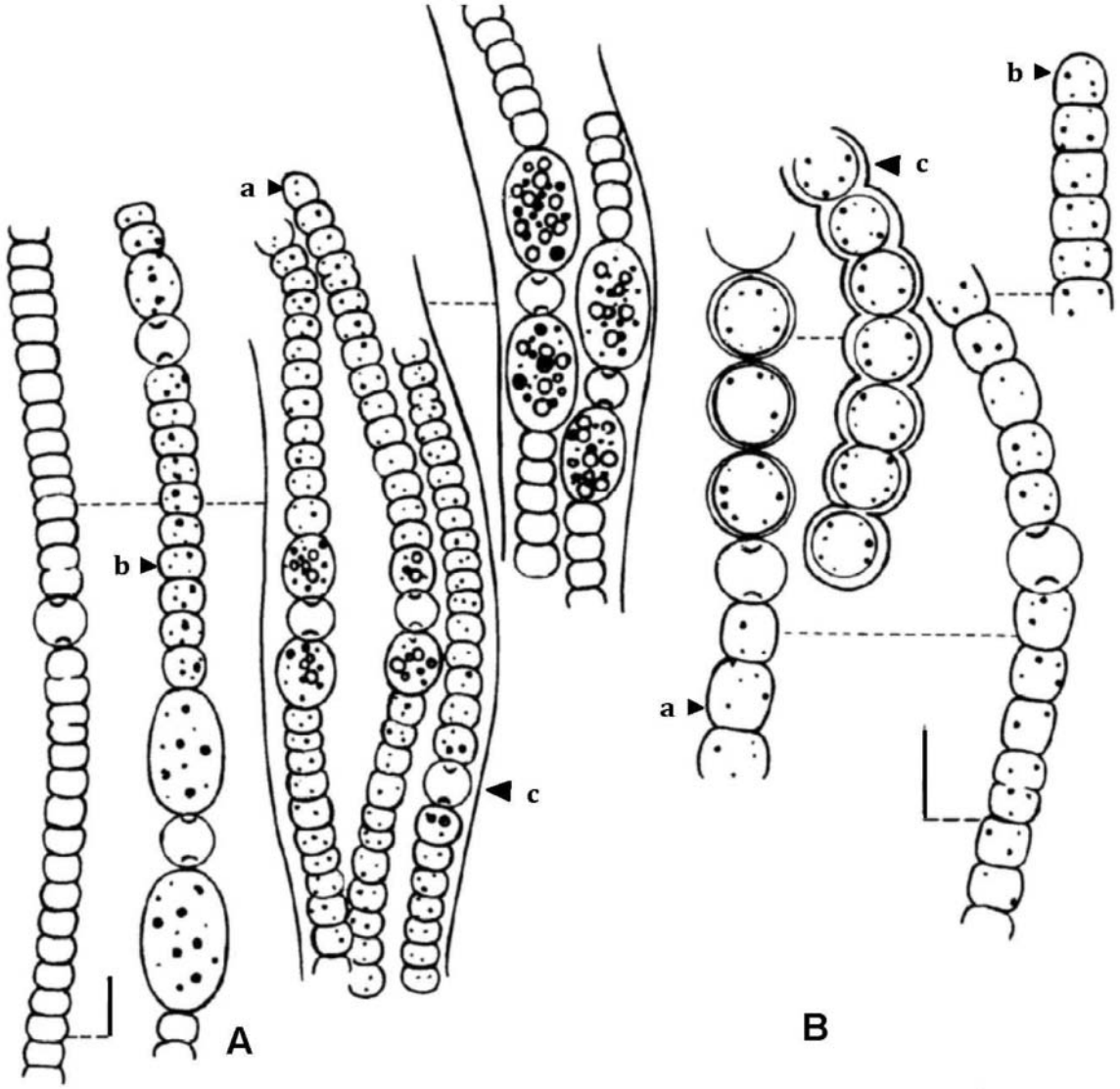

Fig. 1. A. *$QDEDHQD DPELJXD*. a- apical part of trichome, b- Part of trichomes with heterocysts and akinetes, c- mucilaginous envelop., B. *$QDEDHQD IHUWLOLVVLPD*. a- part of trichomes with heterocysts and akinetes, b- apical part of trichome, c- akinetes (Scale: 10 µm).

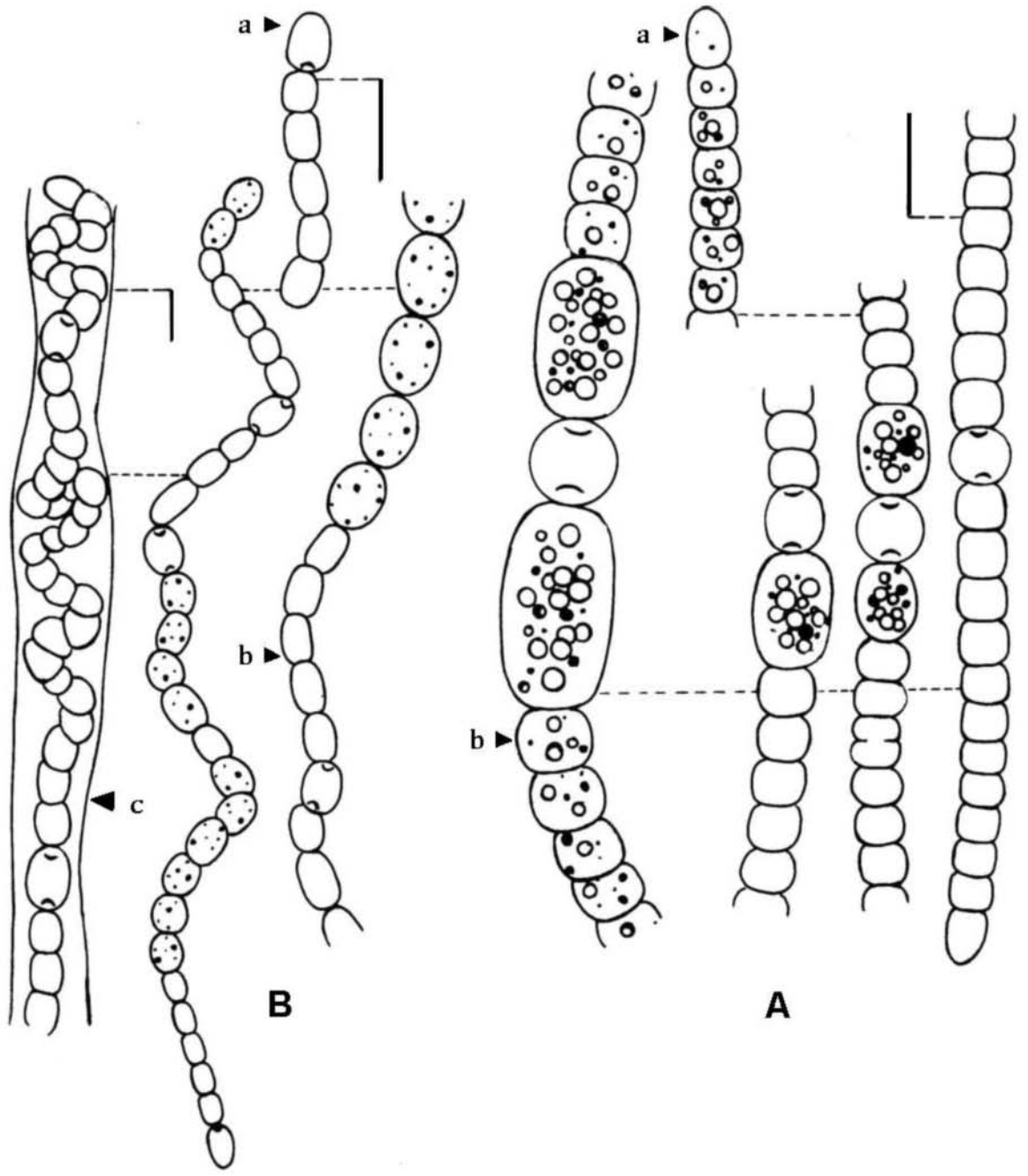

Fig. 2. A. *$QDEDHQD LHQIDUL*: a- apical part of trichome, b- part of trichomes with heterocysts and akinetes., B. *$QDEDHQD RU]DH* a- Terminal heterocyst, b- part of trichomes with heterocysts and akinetes., c- mucilaginous envelope (Scale: 10 µm).

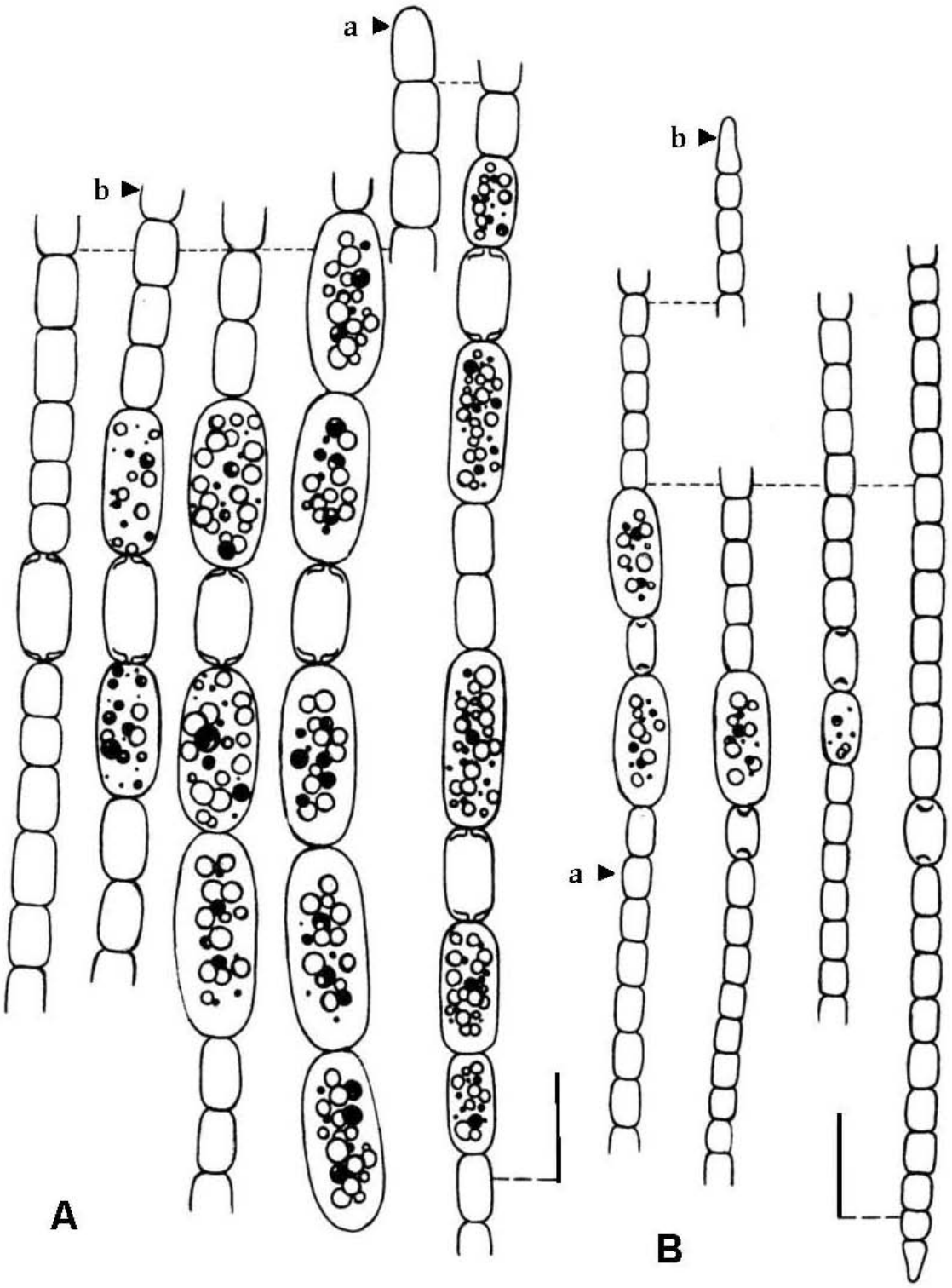

Fig. 3. A. *$QDEDHQD RVFLOODULRLGHV* a- apical part of trichome, b- part of trichomes with young akinetes., B. *$QDEDHQD RUHQWDOLV*. a- part of trichomes with heterocysts and akinetes., b- apical part of trichome (Scale: 10 µm).

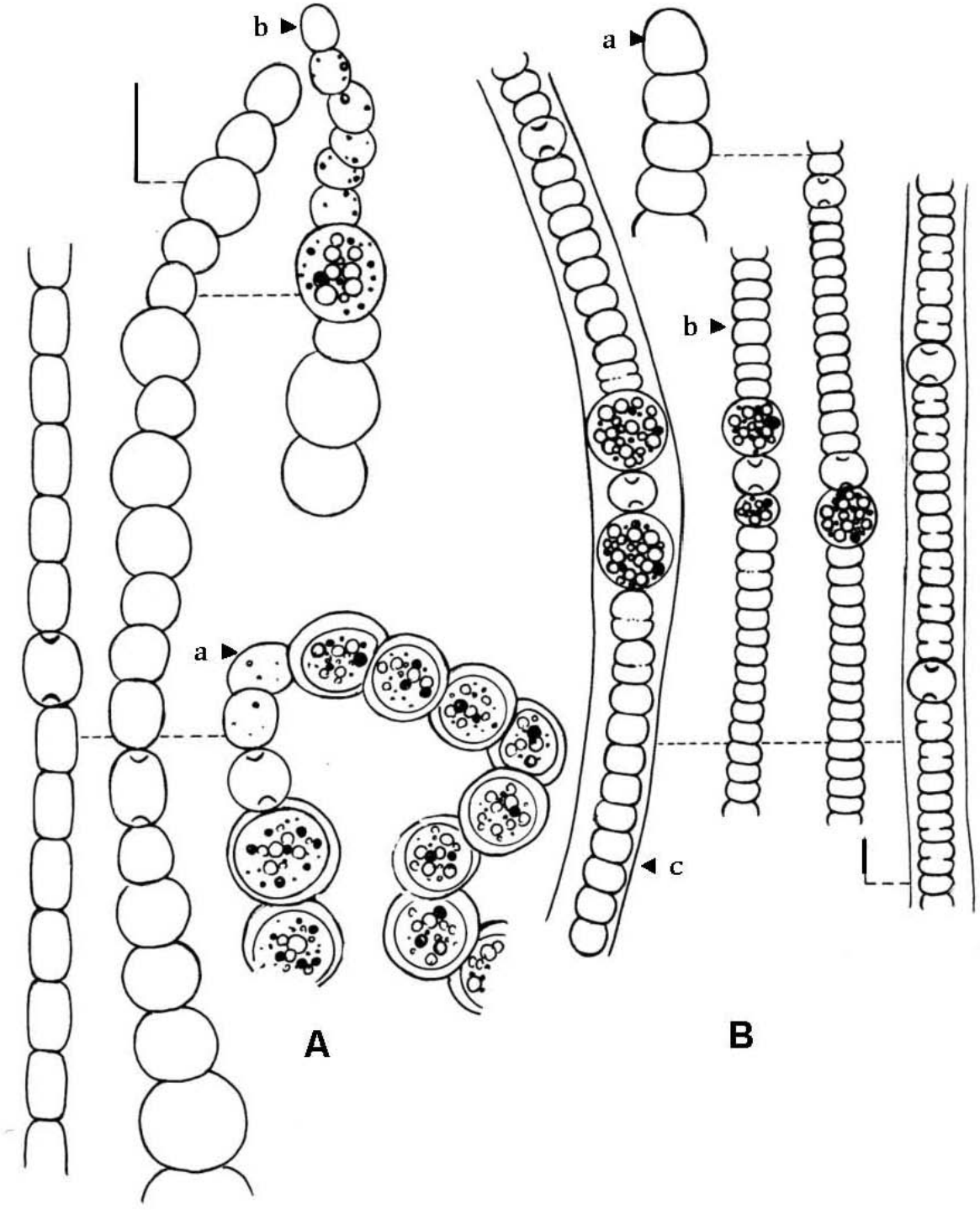

Fig. 4. A. *$QDEDHQD SRUWRUIHQVV* : a- part of trichomes with heterocysts and akinetes, b- apical part of trichome ., B. *$QDEDHQD VSKDHULFD* a- apical part of trichome, b - part of trichomes with young akinetes., c- mucilaginous envelope (Scale: 10 µm).

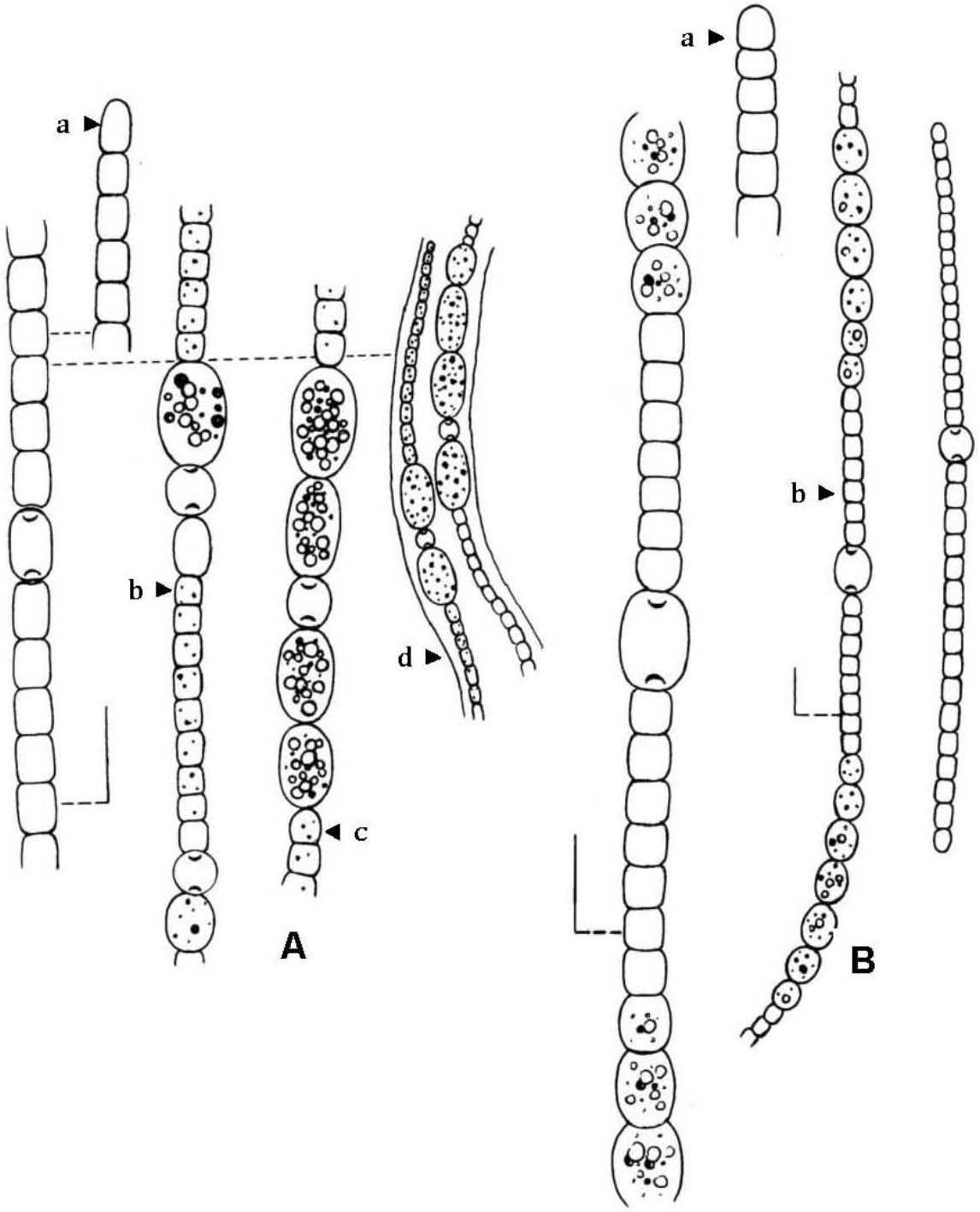

Fig. 5. A. *$QDEDHQD YDJLQLFROD* a- apical part of trichome, b- part of trichomes with young akinetes., c- part of trichomes with heterocysts and akinet, d- mucilaginous envelope., B. *$QDEDHQD YDULDELOLV* var. *HQOLVRVSRUD*. a- apical part of trichome, b-part of trichomes and akinetes (Scale: 10 µm).

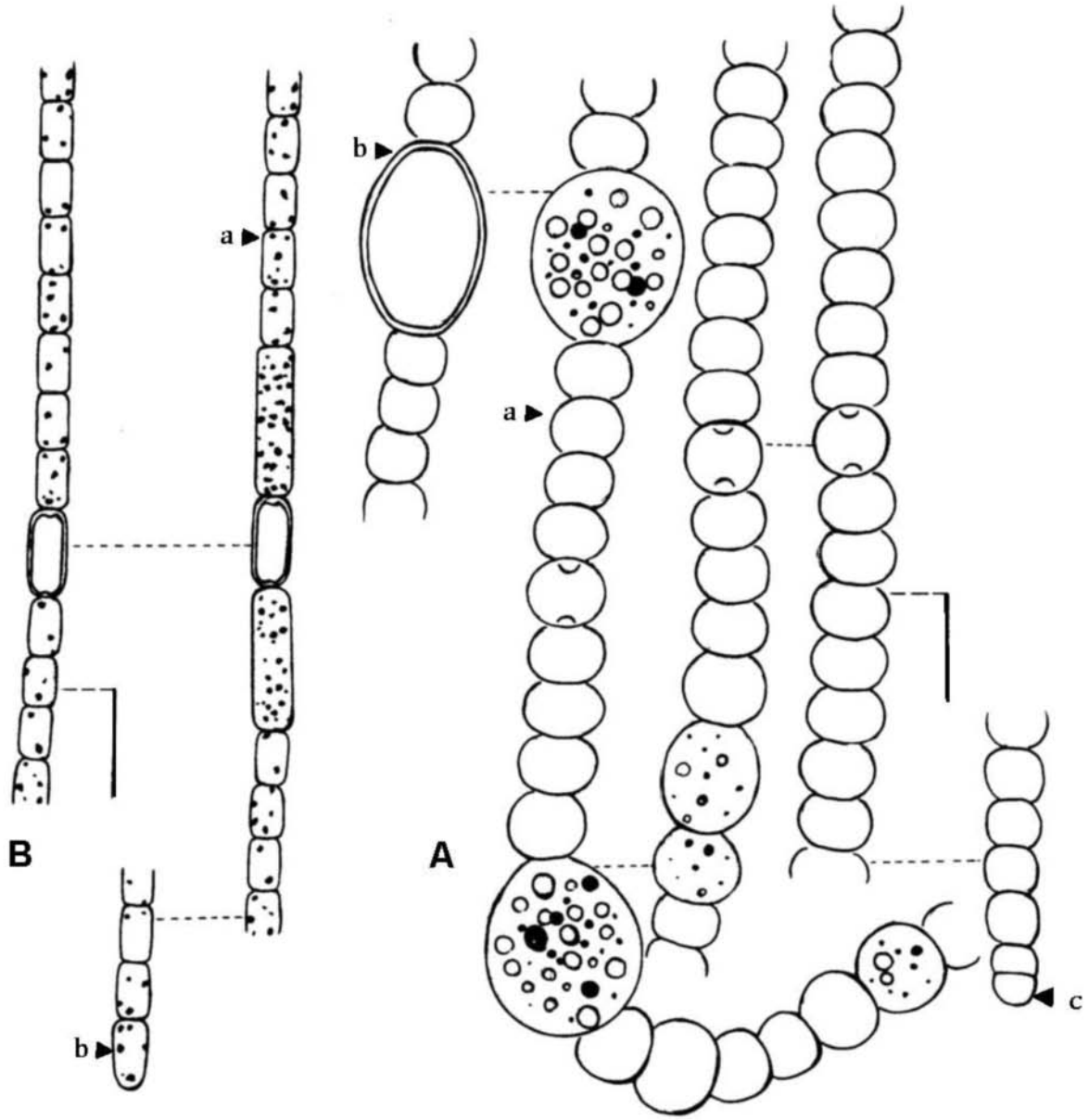

Fig. 6. A. *$QDEDHQD YLJXIHL*: a- part of trichomes with heterocysts and akinetes, b- akinetes, .c- apical part of trichome., B. *Anabaena* sp. : a- part of trichomes with heterocysts and akinetes., b- apical part of trichome (Scale: 10 µm).

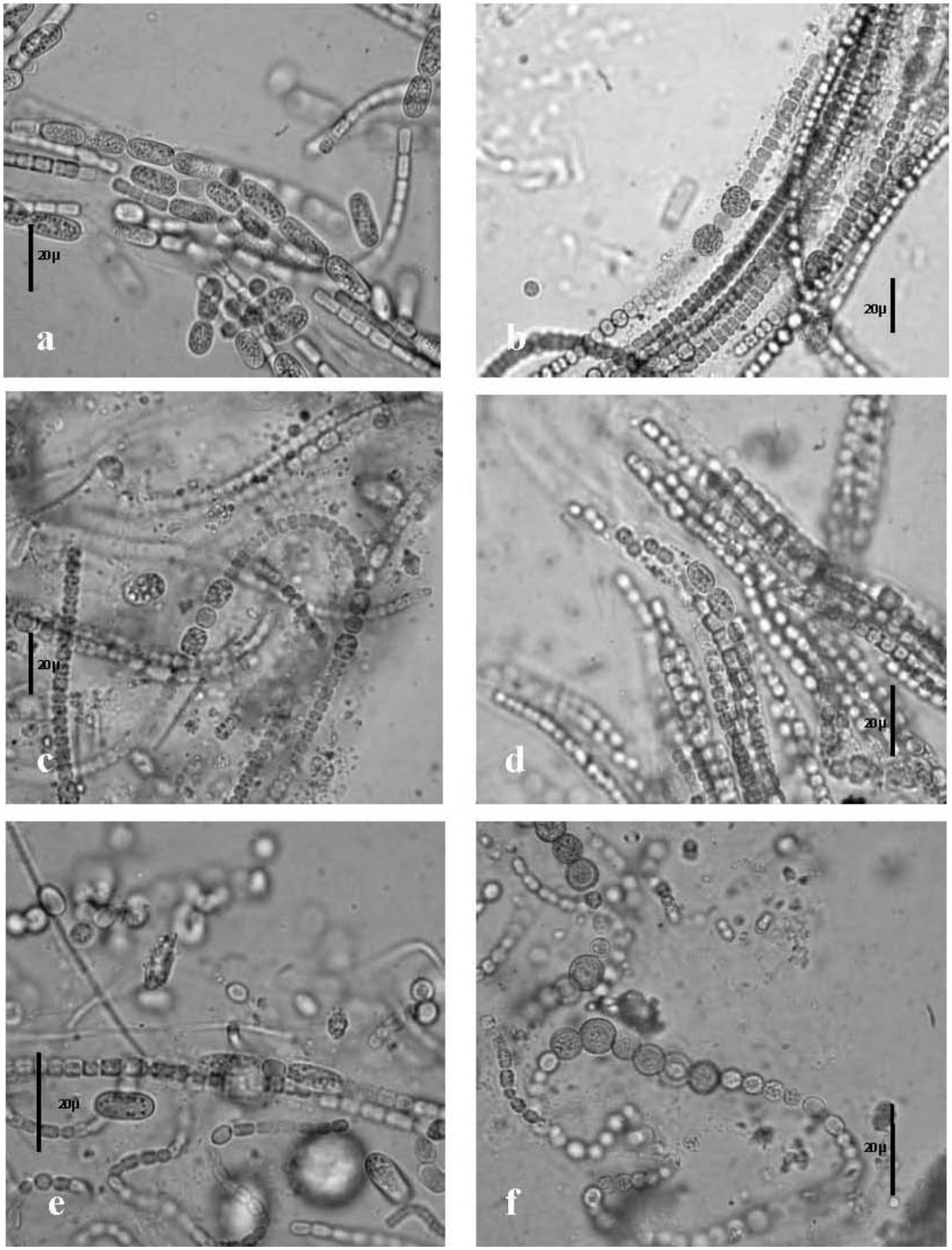

Fig. 7. a. *$QDEDHQD RVFLOODUURLGHV* b. *$ VSKDHULFD* c. *$ LQHQDUL* d. *$ YDULDELOLV* e. *$ RUHQEXUJL* f. *$ SRUWRUHFHQV*

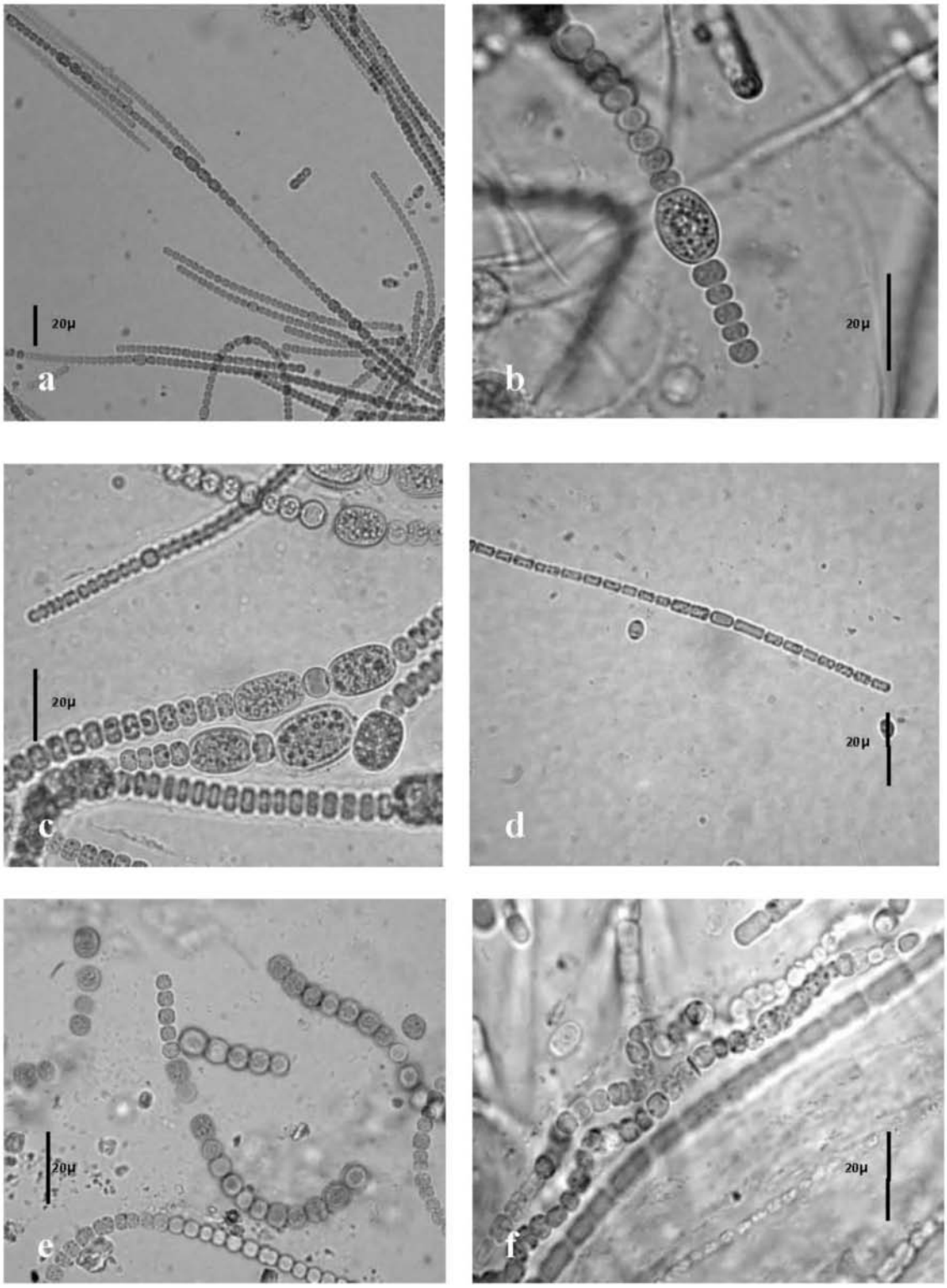

Fig. 8. a. *$QDEDHQD YDULDELOLV* var. *HQOLVRVSRUD*, b. *$ YLJXIHL* c. *$ DPELJXD* d. *$* sp., e. *$ IHUWLOLVVLPD* f. *$ RU]DH*

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