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TAXONOMIC STUDIES ON THE GENUS *ANABAENOPSIS*

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ABSTRACT : Based on the original diagnoses, species of *Anabaenopsis* with constricted and spirally coiled trichomes were analysed comparatively. Three species from the plankton collections from Hungary and Peru were similarly analysed. In this study, shape (length-breadth ratio) and breadth of vegetative cells and breadth of heterocysts and spores formed important criteria for the separation of taxa. The analyses led to the following taxonomic conclusions : *Anabaenopsis arnoldii* v. *indica* is synonymous with *A. magna* Evans, *A. teodorescui*, *A. venkataramanii*, *A. milleri* and *Anabaena knipowitschii* are synonymous with *Anabaenopsis arnoldii* Aptekarj. *A. intermedia*, *A. peruviana* and *A. nadsonii* are synonymous with *A. elenkinii* Miller and *A. kelifii*, *A. hungarica* and *A. circularis* v. *indica* are reduced to forms of *A. elenkinii*.

INTRODUCTION

THE genus *Anabaenopsis* was first described by Miller (1923) with *A. elenkinii* Miller as the type species. According to him the genus is characterized by "short, spirally coiled trichomes similar to *Anabaena*, with terminal heterocysts, young heterocysts always arising in pairs by unequal division of the two contiguous cells and the trichomes breaking between them into two almost equal parts, spores spherical or ellipsoidal and remote from the heterocysts". He also transferred *Anabaena tanganyikae* and *A. flosaquae* (Lyng.) Breb. var. *circularis* of G.S. West (1907) to his genus raising the latter to the specific rank. He does not, however, mention Woloszynska (1912) who had already treated these taxa of G.S. West under a separate section of *Anabaena* which was named by her "Anabaenopsis" giving the var. *circularis* a specific status (see also comments, Elenkin, 1923). Woloszynska (1912) also described a new species, *Anabaena* (Anabaenopsis) *raciborskii* Wolosz. and a new variety, *Anabeana* (Anabaenopsis *circularis* var. *javanica* Wolosz. Taylor (1932) made a comprehensive treatment of the genus *Anabaenopsis* and and transferred the var. *javanica* of Woloszynska to *Anabaenopsis arnoldii* Aptekarj. He does not, however, consider *A. nadsonii* and *A. milleri* of Woronichin (1929) both of which are listed in the monograph of Geitler (1932). Later Ramanathan (1938) described a new variety of A. arnoldii namely, v. indica from Madras and discussed the taxonomic problems involved at the generic and subgeneric levels. The revision of the genus by Komàrek (1958) deals with 15 species of which he recognises only 6 as good species. The following taxa have since been described having spirally coiled, constricted trichomes : A. peruviana Tutin (1940), A. woltereckii Behre (1956), A. teodorescui Moruzi (1960), A. magna Evans (1962) and A. circularis v. indica Nair (1967). Recently Seenayya and Subba-Raju (1972) made a critical reevaluation of the genus Anabaenopsis and transferred A. raciborskii to a new genus, Cylindrospermopsis. The latest revision of the genus by Jeeji Bai et al. (1977) lists all the known taxa of Anabaenopsis. However, it does not include the taxa described by Gonzalez-Guerrero (1928), Fukushima (1954) and Chandhyok (1966)*. Another new species A. indica described from Varanasi (Chintamani, 1979) agrees well in its diagnostic features with A. gangetica Nair (1967) which in turn, has already been treated as a synonym of A. tanganyikae G.S. West (Jeeji Bai et al., 1977). The problems involved in the generic distinction among Anabaena, Anabaenopsis Aphanizomenon, Cylindrospermum and Cylindrospermopsis have been discussed by Horecka and Komarek (1979).

All the taxa described so far, form part of the phytoplankton of water bodies of the tropical and sub-tropical regions. Rarely, members of this genus have also been reported from temperate zones (Mangelsdorf 1971; Scholz, 1960; Komàrek, 1958). Most species have been known from lakes and ponds with a high concentration of salts and from estuarine regions. Many also form water blooms.

During an investigation on the plankton composition of certain lakes and fish ponds from Hungary (Hegewald et al.,1975) we came across two species of Anabaenopsis which presented difficulties in their exact placement. This led to a comparative analysis of all the existing taxa which came into question (taxa having constricted, spirally-coiled trichomes). One of our species, which showed variability in morphology and dimensions covering several species known taxa was similarly analysed and compared. Two more species from plankton collections from lake Velencei, Hungary (kindly sent by Hajdu, Budapest) and from lake El Gato, Peru (courtesy Aldave, Trujillo) were also included in the comparative study.

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METHODS OF STUDY

The places and mode of collection of samples and description of the lakes and ponds (except lake Velencei, Hungary and lake El Gato, Peru) have already been described elsewhere (Hegewald et al, 1975). The study was based on preserved material. In all cases 50 measurements were taken for vegetative cells and the length/breadth ratio was calculated for the cells individually. For heterocysts and spores a minimum of 20 measurements were taken. The statistical average and the standard deviation was calculated and incorporated (Text-Figs. 2,4). For those type descriptions where available data are insufficient, they were supplemented from measurements taken from type figures (length/breadth ratio for vegetative cells) and standard deviation was likewise calculated before incorporation.

Comparative analysis of taxa having constricted, spirally coiled trichomes

The following species, varieties and forms of *Anabaenopsis* have been considered in the present study :

A. elenkini Miller (1923) (a)*
A. nadsonii Woronichin (1929)=*A. kulundinensis* Woronichin in Elenkin (1938) (b)
A. hungarica Halász (1939) (c)
A. woltereckii Behre (1956) (d)
A. intermedia Kogan (1967) (e)
A. kelifii Kogan (1962) (f)
A. milleri Woronichin (1929) (g)
A. arnoldii Aptekarj (1926) = *A. arnoldii* f. *rossica* Aptekarj in Elenkin (1938) (h)
A. arnoldii v. *natrophila* Kol (1929) (i)
A. arnoldii v. *indica* Ramanathan (1938) (j)
A. arnoldii v. *javanica* (Wolosz.) Taylor (1932) (k)
A. arnoldii f. *africana* Taylor in Elenkin (1938) (l)
A. arnoldii f. *philippinensis* Taylor in Elenkin (1938) (m)
A. arnoldii f. *kisseleviana* Elenkin (1938) (n)
A. circularis (G.S. West) Miller sensu Taylor (1932) (o)
A. circularis var. *indica* Nair (1967) (p)
A. luzonensis Taylor (1932) (q)
A. magna Evans (1962) (r)
A. teodorescui Moruzi (1960) (s)
A. peruviana Tutin (1940) (t)
A. venkataramanii Chandhyok (1966) (u)
Anabaena knipowitschii Usachev (1927) (v)
Anabaenopsis elenkinii f. *curta* Dedusenko (Dedusenko-Shegoleva, 1959)
A. elenkinii f. *ovalispora* Dedusenko (Dedusenko-Shegoleva,1959)
A. circularis f. *recta* Fukushima (1954, Sc. resear. Ozegahara Moor. p. 622-624)

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* These alphabets correspond to taxa in Text-Figs.1-4.

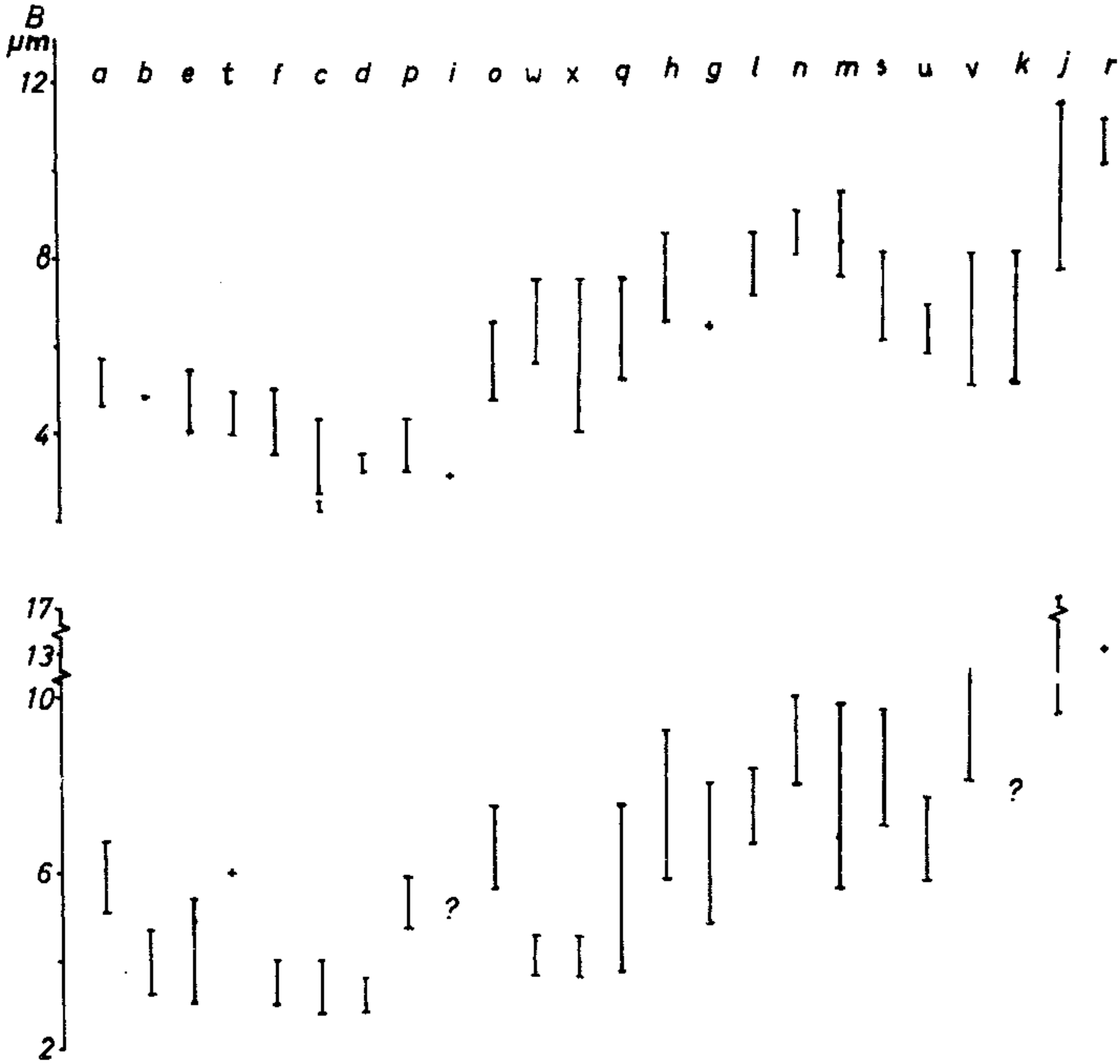
A. arnoldii v. recta Roll(1928)
A. hispanica Gonzalez-Guerrero (1928)
A. hispanica v. luteola Gonzalez-Guerrero (1928)
A. cuatrecasasii Gonzalez-Guerrero (1928)
A. issatchenkoi Woronichin (1934; after Elenkin 1938)
A. sturmiae Woronichin (1934; after Elenkin 1938)

Features of diagnostic value and measurements of the different cell types for the above taxa as provided in the original description have been summarised in Table 1. It is obvious that in many cases the taxa are based on very incomplete descritpions. Although in some cases this is due to the fact that one or the other feature (spores) was absent (A. circularis, A. woltereckii, A. arnoldii var. natrophila, f. kisseleviana and f. africana), in others important data have simply been omitted. Such being the case, a comparison becomes most difficult. Again, the taxa are hadly separable on the basis of trichome and heterocyst diameter (Text-Fig.1) only. If on the other hand, the ratio of length to breadth is used as an additional criterion (Text.Fig.2) some taxa become more distinct (for example, A. arnoldii var. natrophila vs. A. hungarica; A. circularis vs. A. arnoldii var. javanica). Therefore, cell shape becomes one of theimportant criteria for separation. In order to represent this feature, the length/breadth ratio was plotted against breadth (Text-Fig.2) so that, provided a range of measurements is available each taxon is represented by a rectangle. It deserves mention here that the measurements are based exclusively on type descriptions and figures.

As is evident from Text-Fig.2, while most of the taxa overlap to a smaller or larger extent, A. arnoldii var. natrophila seems quite distinct and might, thus, represent a good species, A. magna and A. arnoldii var. indica are also separable as one group in view of their rather short cells. A. luzonensis, A. circularis, A.elelnkinii, A. nadsonii, A. kelifii, A. hungarica A. circularis var. indica, A. peruviana, A. woltereckii would comprise the second group. A. intermedia also belongs here with major overlapping with the this group rather than with A. arnoldii var. javanica. The third groups would comprise A. arnoldii, A. arnoldii fa. africana, A. arnoldii f. philippinensis and f. kisseleviana and A. teodorescui. Again, in view of the generally shorter cells A. arnoldii v. javanica, A. milleri, A. venkataramanii and Anabaena knipowitschii could be included here, although they are characterized by somewhat narrower trichomes.

Morphological variation of Anabaenopsis in collection from Hungary and Peru

Our observations on plankton samples from Hungary and Peru demonstrate that at least 3 species exist. In one of our collections from Lake Kakasszeg from Hungary we could recognise two distinct species of Anabaenopsis which showed large differences in trichome width and cell length (Text-Fig.4, shaded squares). The smaller species (sp.1) occurred in other samples from Hungary also. The chemical composition of the lakes and ponds where it



Text-Fig.1 : Comparison of breadths of vegetative cells (top) and heterocysts (bottom) as provided in the original diagnosis. a-v : as given on page 117

occurred has been summarised in Table 2. In almost all cases the monovalent cations predominate. In Lake Belso the divalent cations predominate whereas in lake Valencei they are more or less equally distributed. The variation in dimensions of vegetative cells, heterocysts and spores of sp.1 has been given in Table 3 and Text-Fig.4. The alga from Valencei lake has been included here because it comes closest to sp.1. The morphology of the alga in all these lakes and ponds has been shown in Text-Figs.5,6,7,8 and 9.

As is evident in Text-Fig.4, the size ranges, though based on averages with standard deviation show considerable overlapping. However in samples A, C, D and H the measurements agree well with one another and this unit could be assigned to A. elenkinii The measurements in samples E and F also show good agreement, with each other and together may be assigned to A. kelifii Kogan (1962). These two entities are interconnected by the measurements in sample B which, in turn corresponds to A. intermedia Kogan (1967). But samples A-E are derived from ponds which are partially interconnected and receive water from one common source. Besides, their cationic composition (Table 2) is more or less identical. Therefore, we believe that we are dealing with only one species (Text-Figs.5,8) although the appearance (Text-Fig.6) of the alga in sample E poses a problem. In sample G and lake Valencei the trichomes are narrower with more elongate cells (Text-Figs.4,7 and 9). As such they correspond well with A. hungarica Halasz (1939) (Text-Fig.15). It may be mentioned here that the latter was described from lake Velencei.

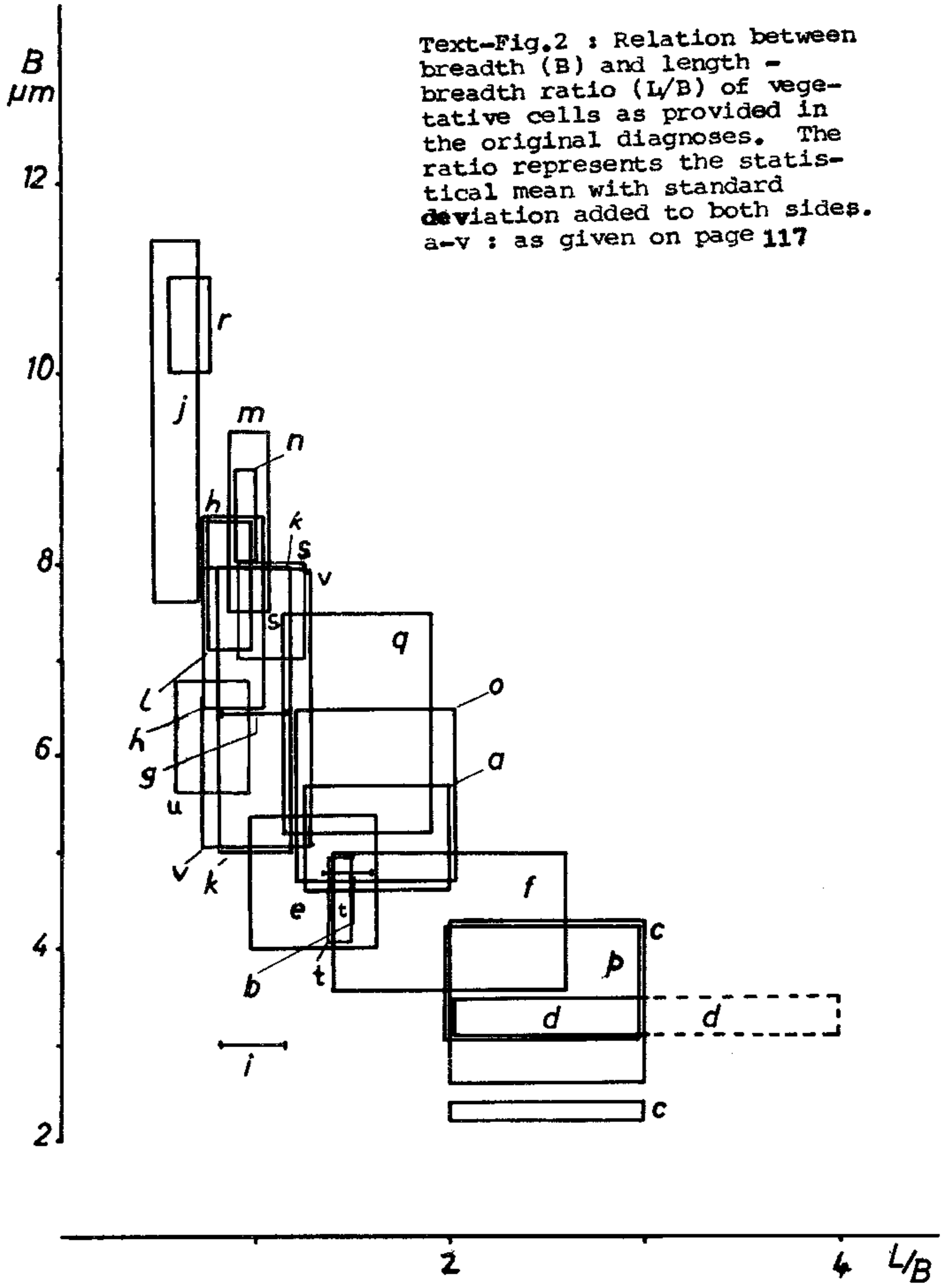
Following the general practice, if the extreme variation in each sample were considered, the above-mentioned groups become indistinguishable. Hence, it is concluded that a single species is involved which due to reasons of priority, is called A. elenkinii Miller. However, the groups which are recognisable are believed to represent forms.

The second species (sp.2) observed in lake Kakasszeg (Text-Fig. 10) is broader and cells are usually shorter than broad (Text-Fig.4 shaded; Table 2) and corresponds well with A. arnoldii (Text-Fig.17). Although, a certain amount of overlapping with sp.1 could be observed, they are distinct in sample F where they occur together (Text-Fig.4 shaded squares). Besides, in sp.2 the heterocysts are often ovoid and larger than the vegetative cells (Text-Fig.10).

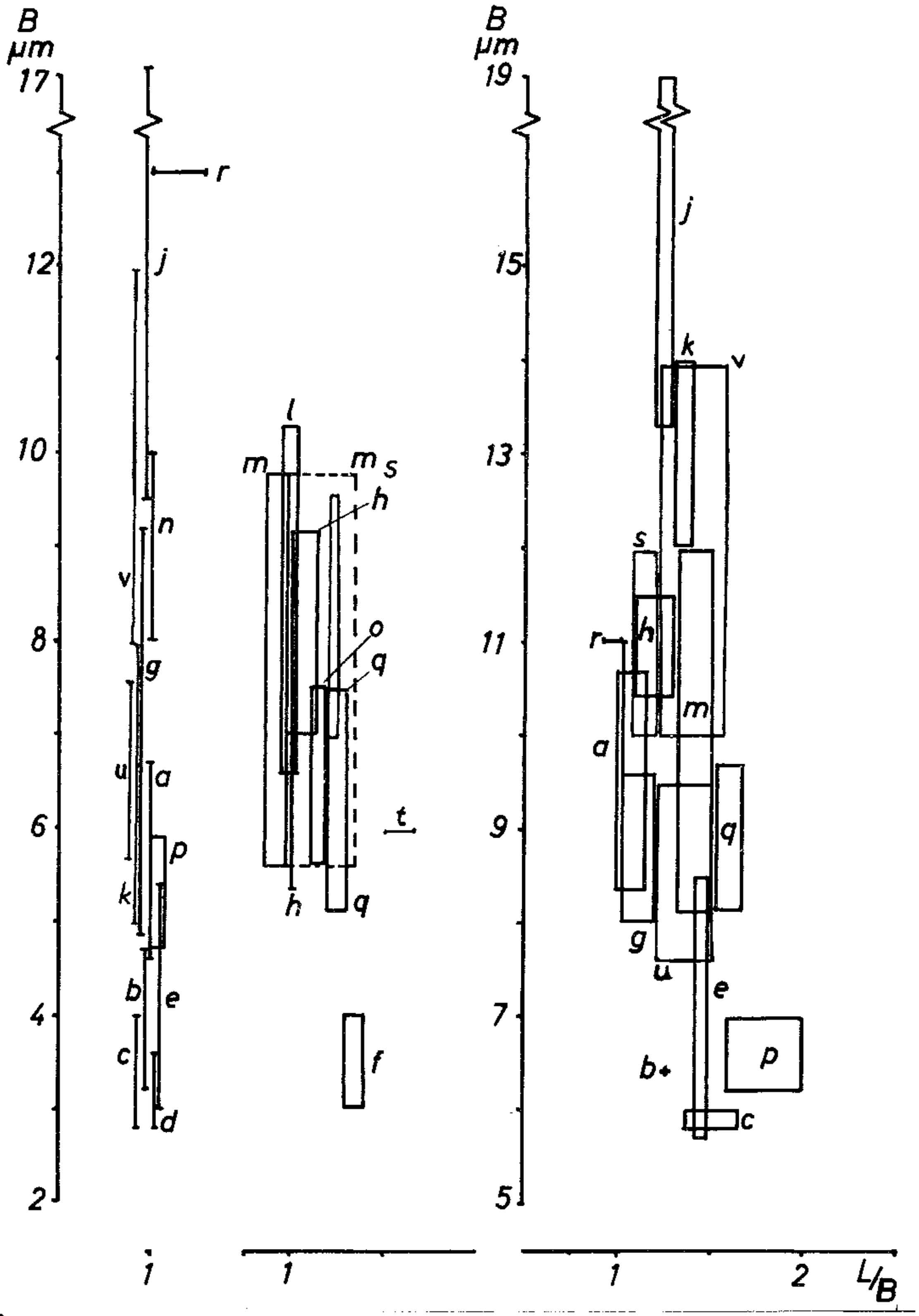
The Anabaenopsis from Peru (sp.3) is a considerably larger species (Text-Fig.4) with very short cells (Text-Fig.11). It agrees in both cell breadth and length/breadth ratio very well with A. arnoldii v. indica Ramanathan (1938), which in turn, includes A. magna Evans (1962) in its range of dimensions (Text-Fig.2).

Taxonomic conclusions

According to the original description, A. magna is quite distinct from A. arnoldii but still it is most related to it (Text-Figs.2,19). However A. arnoldii v. indica Ramanathan (Text-Fig.18) with its larger range of dimensions, connects the two species, although the overlapping with A. arnoldii is insignificant (Text-Fig.2). Therefore, as already pointed out, A. arnoldii v. indica is identical with A. magna which is agood species. However the latter needs to be amended bacause the breadth of spores according to the original diagnosis corresponds to the maximum value given for the breadth of vegetative cells (Text-Fig.3) and as such, cannot represent fully developed spores (Text-Fig.19c). They are most probably developing



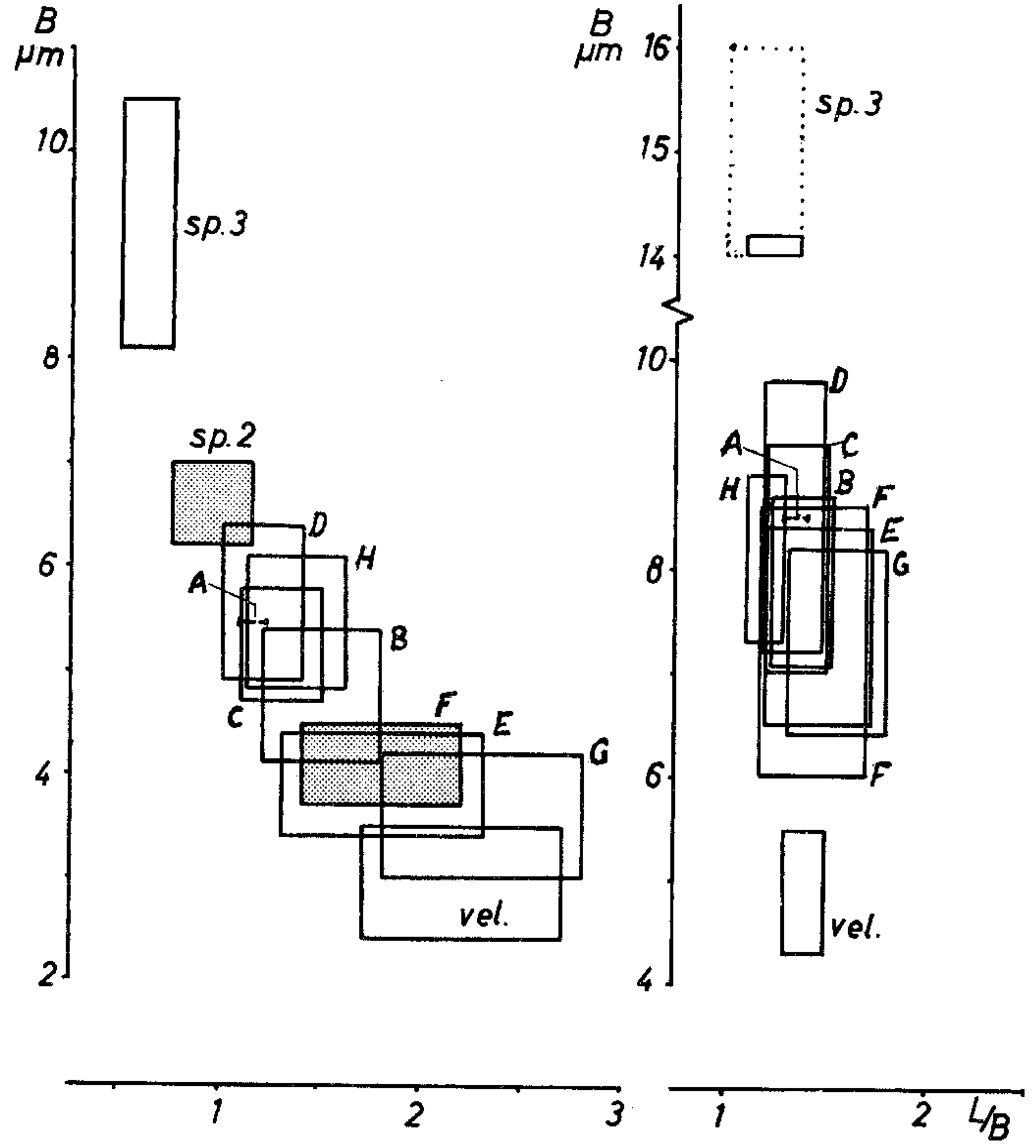
Text-Fig.2 : Relation between breadth (B) and length - breadth ratio (L/B) of vegetative cells as provided in the original diagnoses. The ratio represents the statistical mean with standard deviation added to both sides. a-v : as given on page 117



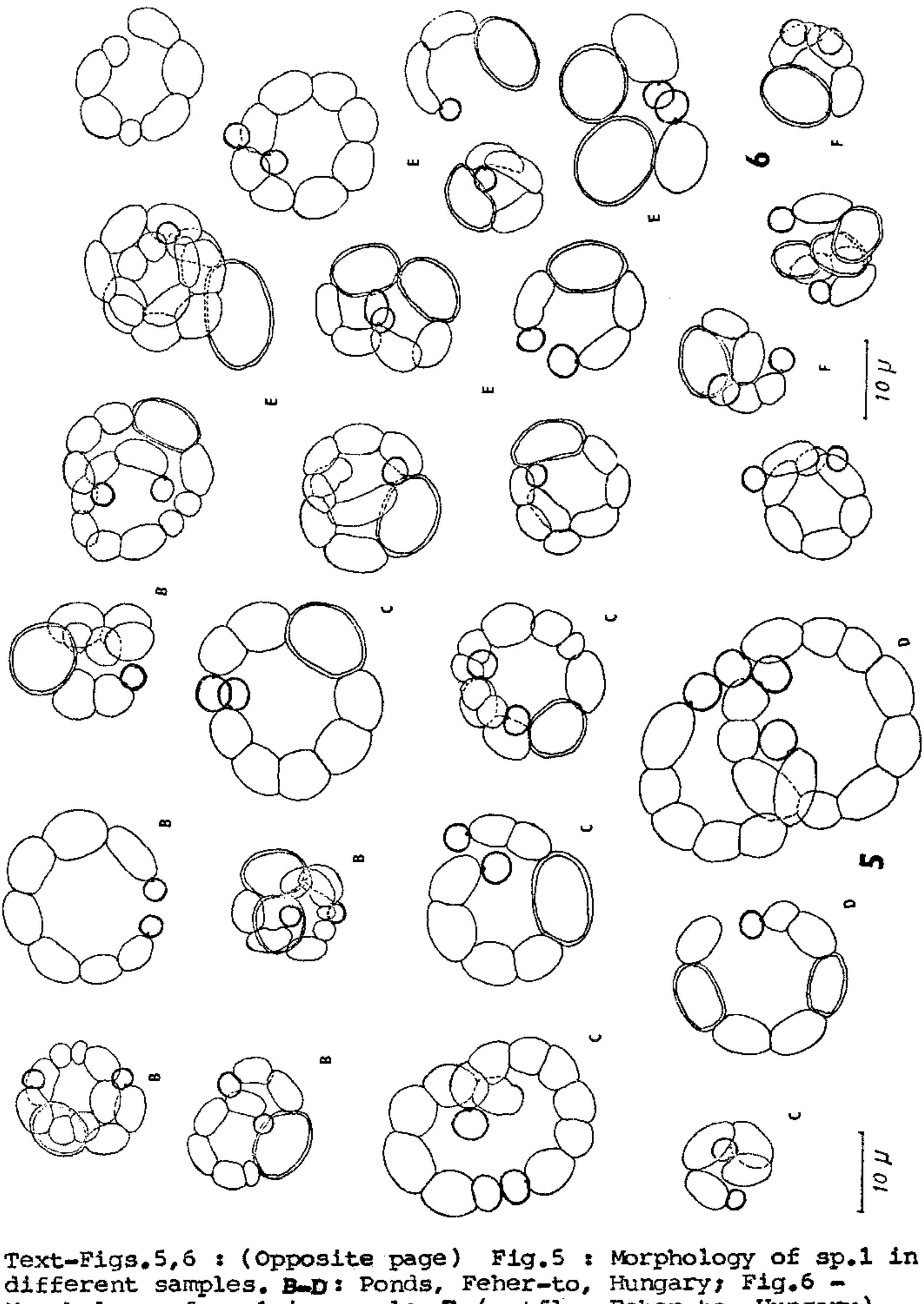
Text-Fig.3 : Relation between breadth (B) and length/breadth ratio (L/B) of heterocysts (left) and spores (right) as provided in the original diagnoses. The ratio represents the statistical mean with standard deviation added to both sides. a-v : as given on page 117 heterocysts. The breadth of spores as provided in the original diagnosis for A. arnoldii v. indica (Table 1) corresponds well to both taxa and can be considered to represent the spores of A. magna also. This is also supported by our measurements for the Peruvian alga for both vegetative cells as well as spores (Text-Figs. 2,3 and 4). A.magna has so far been reported from Kenya (Evans, 1962), India (Ramanathan, 1938) and Peru (Text-Fig.11).

The second good species is A. arnoldii (Text-Fig.17). Although the two forms of this species, namely f. philippinensis and f. kisseleviana are characterized by broader trichomes (Text-Fig.2), they cannot be separated from the species and f. africana fits well within the range of the species. A. teodorescui with somewhat longer vegetative cells and A. milleri with slightly narrower trichomes and longer cells, (Text-Figs. 2,20 and 21) provide no strong basis for separation from A. arnoldii and are hence included in it. Species 2 of our samples likewise belongs here (Text-Figs.4,10). A. milleri is therefore, not related to A. elenkinii as suggested earlier by Geitler (1932) and Komarek (1958). A. arnoldii v. javanica A. venkataramanii and Anabaena knipowitschii agree with Anabaenopsis arnoldii in general appearance (Text-Figs.22,23 and 24) except that their average breadth of trichomes is somewhat lower just as in A. milleri (Text-Fig.2). Hence, these three taxa are also included in A. arnoldii. However, the first two are characterized by heterocysts which are smaller than vegetative cells (Table 1) and the javanese alga has besides much larger spores (Text-Fig.3) and it has therefore, been maintained as a separate form. A. arnoldii v. natrophila Kol may be good species pending confirmation (Jeeji Bai et al., 1977). A. arnoldii v. recta Roll has already been treated as a synonym of A. arnoldii by Elenkin (1938) and Kondrateva (1968).

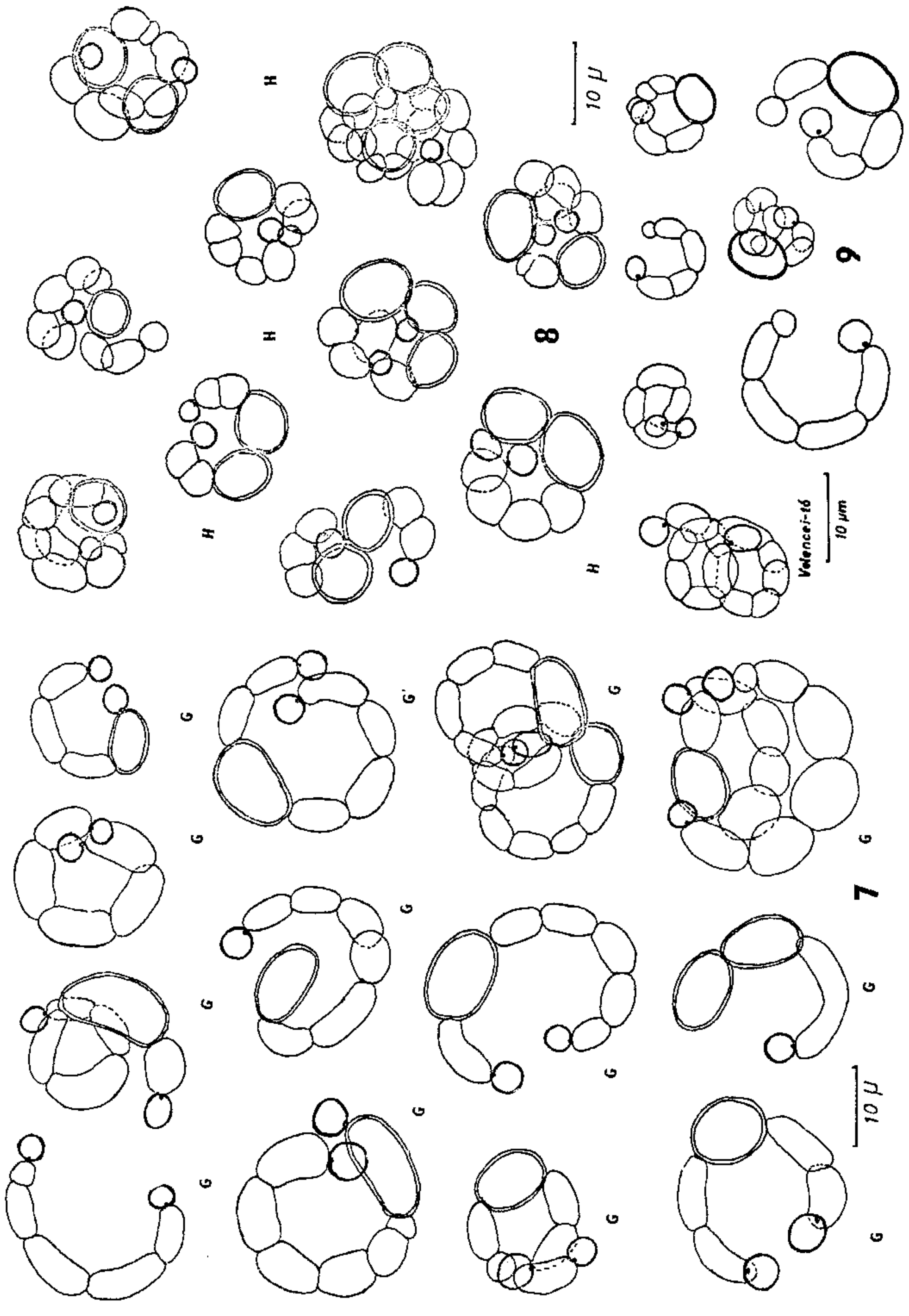
The third good species is a A. elenkinii (Text-Fig.16) which is the type. Based on the present study of variability in



Text-Fig. 4 : Relation between breadth (B) and length-breadth ratio (L/B) of vegetative cells (left) and spores (right) of species of Anabaenopsis from samples from Hungary and Peru. The ratio represents the statistical mean with standard deviation added to both sides. Letters and abbreviations as given in Table 3.



Text-Figs.5,6 : (Opposite page) Fig.5 : Morphology of sp.1 in different samples. B–D: Ponds, Feher-to, Hungary; Fig.6 – Morphology of sp.1 in sample E (outflow Feher-to, Hungary) and sample F (Kakasszeg-to, Hungary). ⟶



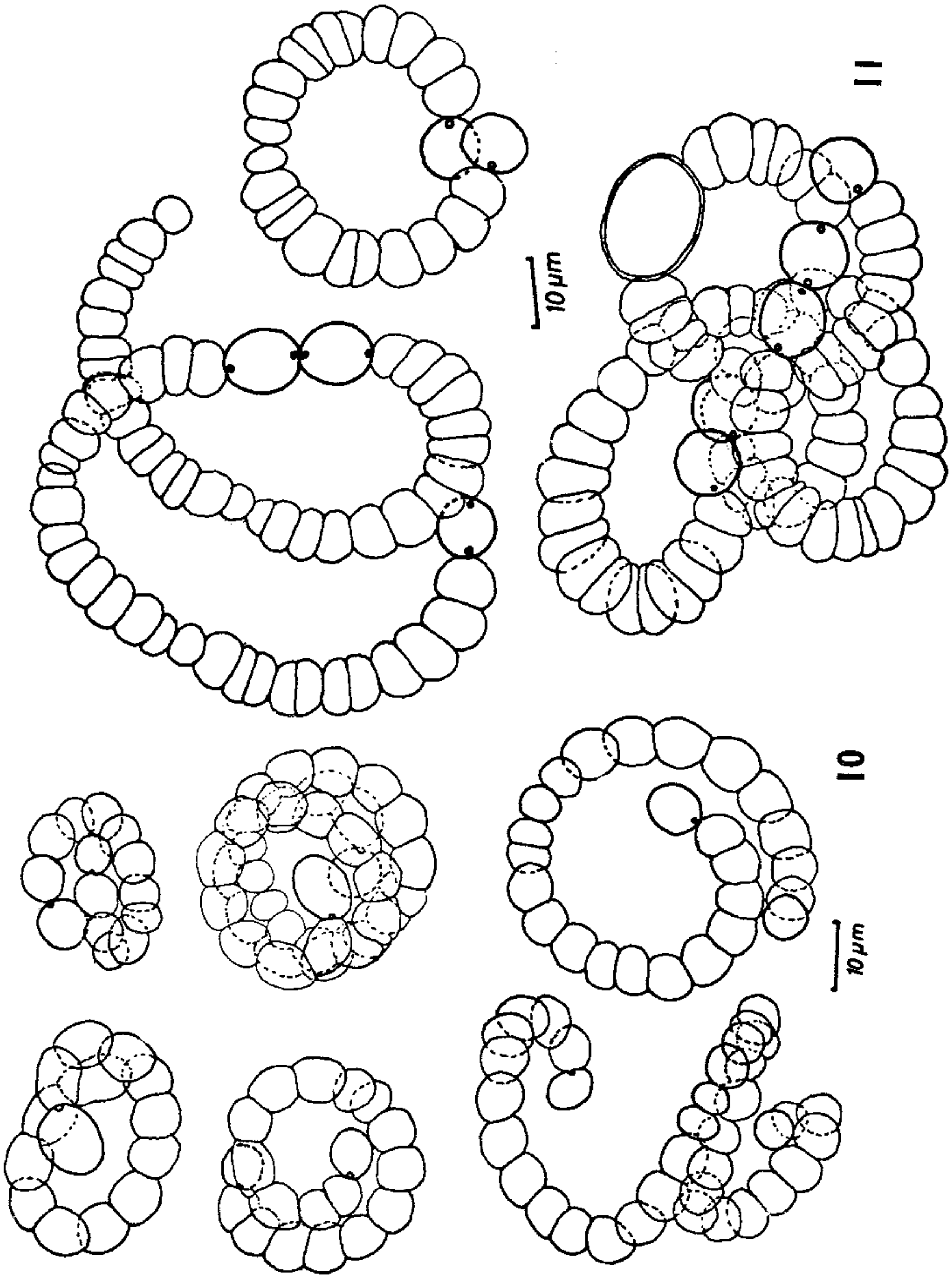
Text-Figs. 7-9 : Fig.7 - Morphology of sp.1 in sample G (Kunfeher-to, Hungary); Fig.8- Morphology of sp.1 in sample H (Belso-to, Hungary); Fig.9 - Morphology of sp.1 in Valencei-to, Hungary.

cellular dimensions (Table 3, Text-Fig. 4) this would include: A. nadsonii (Text-Fig.14), A. intermedia (Text-Fig.12), A. kelifii (Text-Fig.13), A. peruviana, A. circularis v. indica A. hungarica (Text-Fig.15) and A. woltereckii. As already mentioned (p.120) three forms can be recognized.

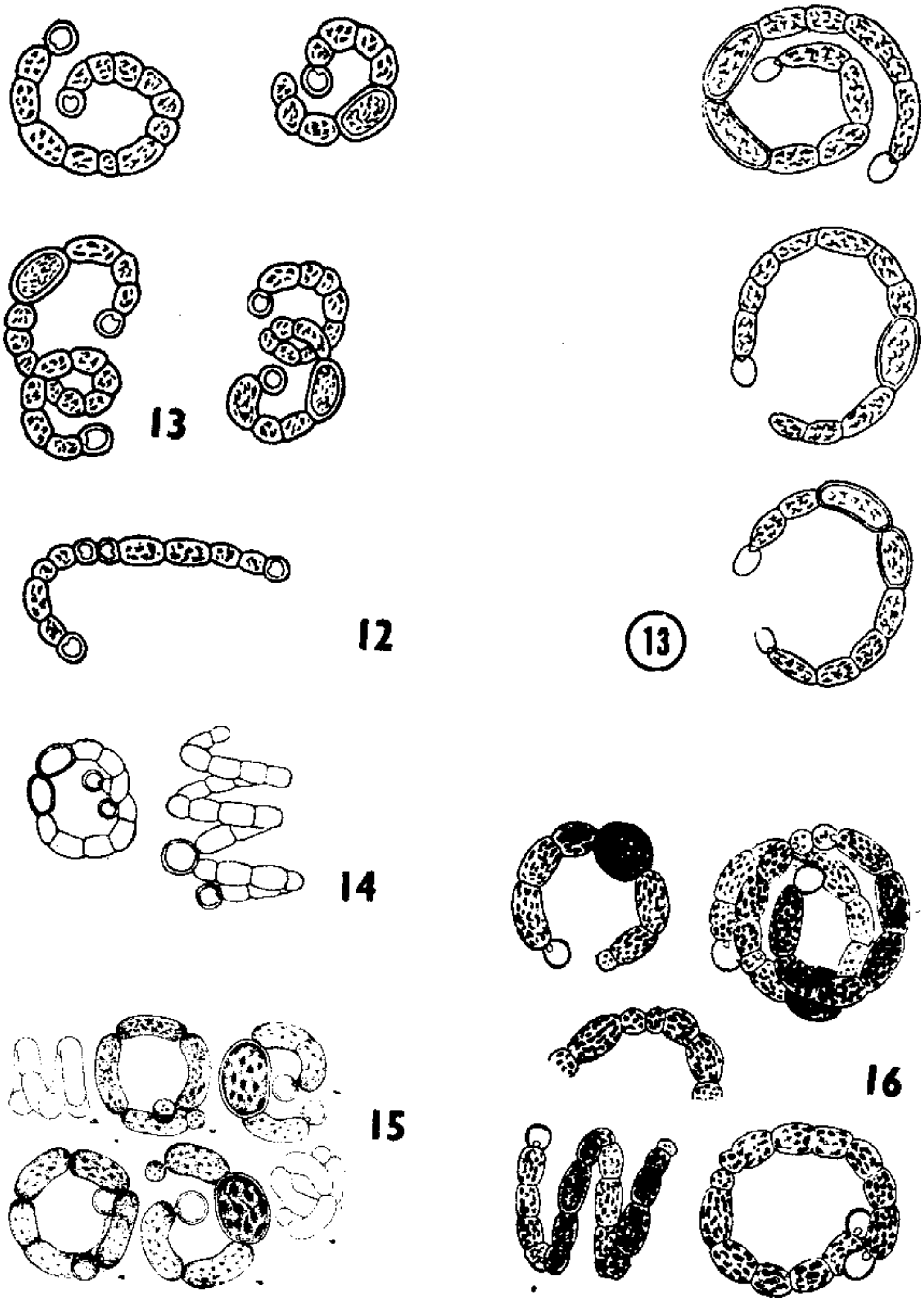
1. A. elenkinii f. elenkinii characterized by trichomes of average width between 4.5–6.0 µm and cells of average L/B ratio around 1.5.

2. A. elenkinii f. kelifii characterized by trichomes of average width between 3.5–5.0 µm and cells of average L/B ratio around 2.

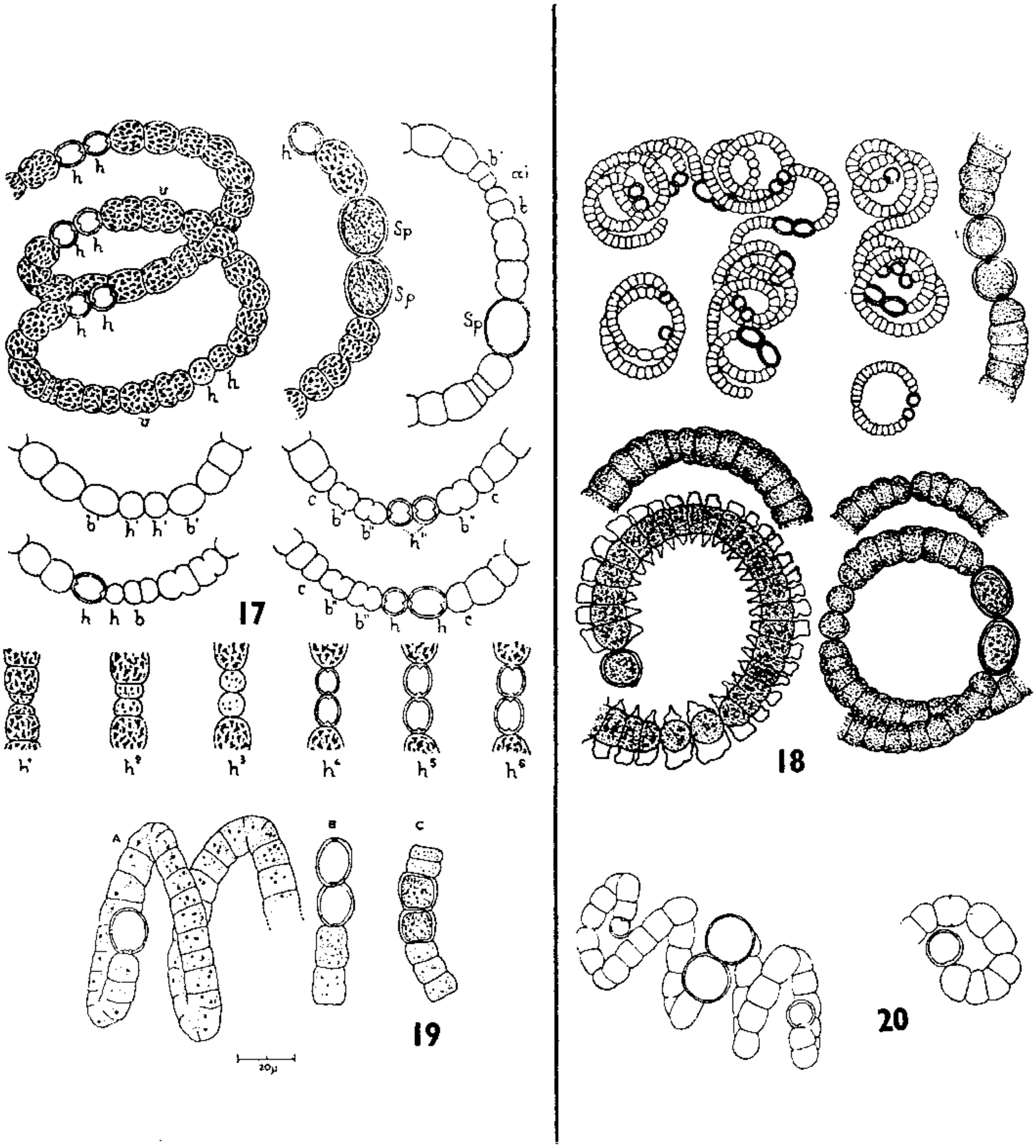
3. A. elenkinii f. hungarica characterized by trichomes of average width between 2.5–4.0 um and cells of average L/B ratio around 2.5. A. elenkinii f. indica (=A. circularis v. indica Nair) is also considered as distinct (Jeeji Bai et al., 1977) although it is similar to A. elenkinii f. hungarica, because of the larger, elongate heterocysts (Table 1). The two forms of A. elenkinii namely, f. ovalispora Dedus. and f. curta Dedus (Kondrateva. 1968, pl. 156, figs.4,5 and 6,7 respectively) cannot be related to the formae proposed above since their trichomes are much broader (Table 1). A. circularis (G.S.West) Miller sensu Taylor and A. luzonensis Taylor have already been treated as separate forms of A. elenkinii and the taxonomic status of A. sturmiae Woronichin and A. issatchenkoi Woronichin has also been discussed earlier (Jeeji Bai et al., 1977) . A. circularis f. recta Fukushima is probably a stright form as the name implies and may be identical with A. cunningtonii to be confirmed after seeing original diagnosis. The taxa of Gonzalez-Guerrero, A. hispanica, A. hispanica v. luteola and A. cuatrecasasii are characterized according to original diagnoses (in J. De Toni, 1939–46) by straight or curved trichomes having only terminal cylindrical to ellipsoid and often pointed heterocysts and subterminal spores with warted and smooth, often golden-brown epispores. They occur in the form of mucilaginous formations in stagnant pools or swamps. These features indicate that they most probably belong to Cylindrospermum as already suggested by Taylor (1932).



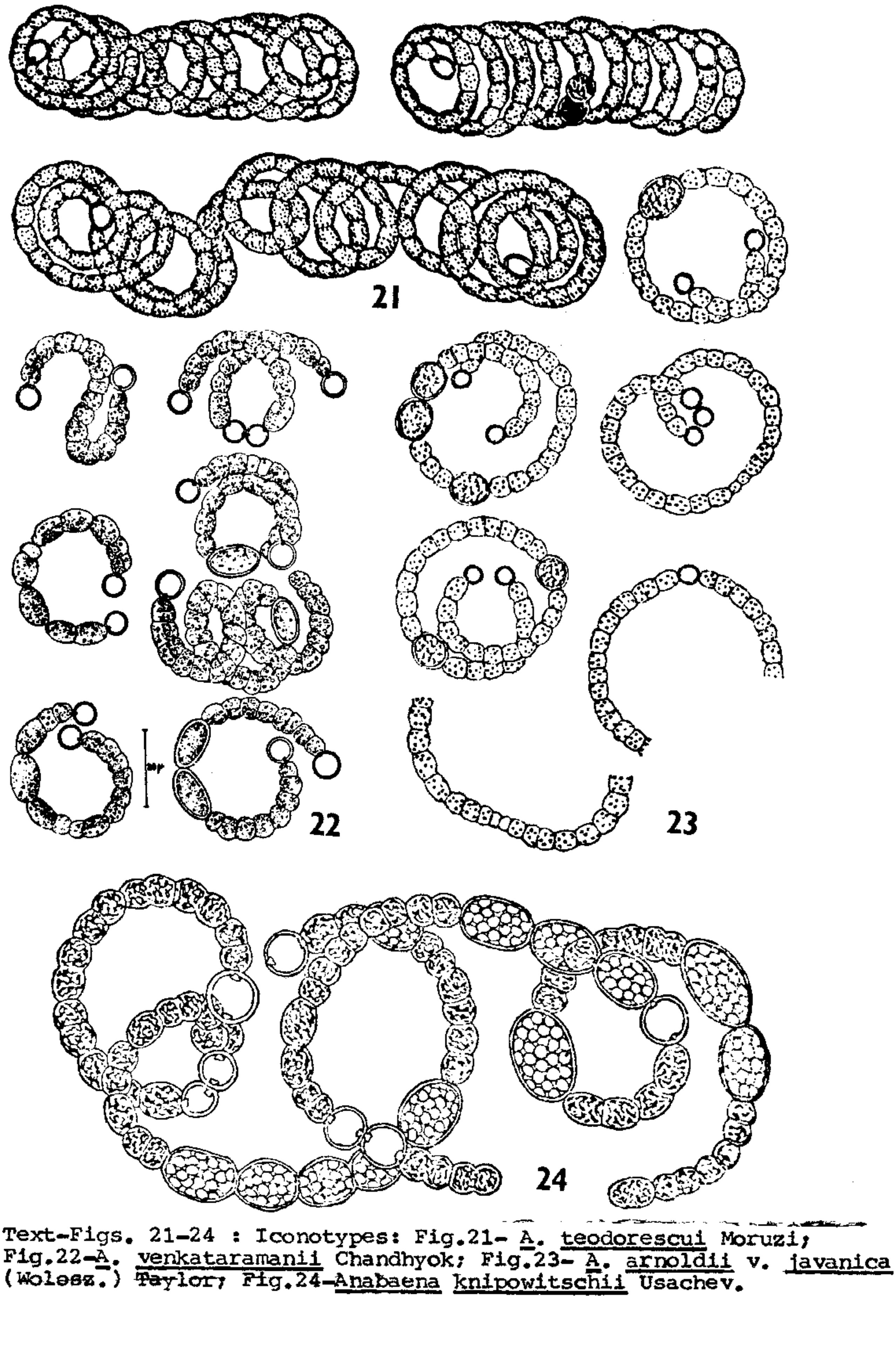
Text-Figs. 10,11 : Fig.10 - Morphology of sp.2 in sample F (Kakasszeg-to, Hungary); Fig.11 - Morphology of sp.3 in lake El Gato (Peru).



Text-Figs.12-16 : Iconotypes : Fig.12 - *A. intermedia* Kogan; Fig.13 - *A. kelifii* Kogan; Fig.14 - *A. nadsonii* Woronichin; Fig.15 - *A. hungarica* Halasz; Fig.16 - *A. elenkinii* Miller.



Text-Figs. 17-20 : Iconotypes. Fig.17-*A.arnoldii* Aptekarj; Fig.18 - *A. arnoldii* var. *indica* Ramanathan; Fig.19 - *A. magna* Evans; Fig.20 - *A. milleri* Woronichin.



Text-Figs. 21-24 : Iconotypes: Fig.21- *A. teodorescui* Moruzi; Fig.22-*A. venkataramanii* Chandhyok; Fig.23- *A. arnoldii* v. *javanica* (Wolosz.) Taylor; Fig.24-*Anabaena knipowitschii* Usachev.

Based on available data from literature and from our own observations on the genus *Anabaenopsis*, it has been made possible to recognize a few well-defined species. It has been shown that either breadth or length of cells alone is insufficient for a good separation and that the ratio of length to breadth gives a better idea of the shape of cells, which formed the basis for many new taxa. If, the mean value and the standard deviation are calculated from a possibly large number of measurements, thereby excluding the extreme values, and then analysed, the species which would otherwise overlap considerably, become separable (*A. arnoldii* and *A. arnoldii*, *V. indica*; *A. milleri* and *A. elenkinii*; *A. hungarica* and *A. arnoldii*, *V. natrophila*). If the average width of trichomes with standard deviation were also available for all the taxa based on a number of measurements, a further separation of the taxa in the *A. arnoldii* group may be possible. Thus for example it can be determined if the group of taxa represented by *A. milleri*, *A. arnoldii* v. *javanica*, *A. venkataramanii* and *Anabaena knipowitschii* could be separated from the rest of the group. Similarly it could be decided whether *A. circularis* and *A. luzonensis* with broader trichomes are separable from *A. elenkinii* as also the taxa having somewhat narrower trichomes.

Since the taxonomy of blue greens at the specific level is possible only on the basis of dimensions it would be desirable to provide, for all the newly described taxa mean values of demensions with standard deviation for all the cell types based on as many measurements as possible together with the extreme values. Besides it is also necessary to study the algae under defined conditions of culture in the laboratory. Thus for instance to what extent the size of heterocysts and spores in relation to that of vegetative cells is a consistent feature in a given species, is a question which can be answered only by studies with cultures. Otherwise, every attempt at a revision is bound to remain tentative.

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TABLE 1 : Comparative analysis of original diagnoses of taxa of *Anabaenopsis* considered in the present study. Averages (in the centre) and extreme values (at the ends) are given in parenthesis.

	A. elenkinii	*A. elenkinii* f. *curta*	*A. elenkinii* f. *ovalispora*	*A. milleri*	*A. luzonensis*
I. **Cell**					
1. Shape	ellipsoid	-	-	cylindrical	barrel shaped
2. Length µm	-	-	6.2-11.2	8,0	5,6 - 10,5
3. Length/ Breadth	1,25- 2	-	-	-	-
4. Breadth µm	4,6-5,7	5.6-7.5	4.0-7.5	6,4	5,2-(6,4)-7,5
II. **Heterocyst**					
5. Shape	spherical	spherical	spherical	spherical ellipsoid	oval
6. Length µm	-	-	-	8,0	(4,5)-6.0-(8.3)-9,6
7. Breadth µm	4,6-6,7	3,6-4.5	3.6-4.5	7,0 4,8-8,0	(3,7)5,1-(6,1)-7,5
III. **Spores**					
8. Shape	spherical ellipsoid	spherical	oval	spherical elongate	ovoid
9. Length µm	9,3-12,0	-	14.2-16.8	9,6-10,0	12,2-16,2
10. Breadth µm	8,3-10,5 8,3-10,7	8.4 - 14.8	9.0-13.7	8,6-9,6 (11)	8,1-9,7
IV. **Spiral**					
11. Number	3/4 -2½	-	-	2½ -6(7)	1-2
12. Diameter µm	-	-	-	24-27	28-45
13. Distance between µm	-	-	-	3,2-4,8	-

TABLE 1 : Contd ...

	A. magna	*A. teodorescui*	*A. venkataramanii*	*Anabaena knipowitschii*	*A. circularis*	*A. circularis* var. *indica*
I.						
1.	cylindrical	cylindrical	barrel-shaped	compressed barrel-shaped	cylindrical barrel-shaped	cylindrical barrel-shaped
2.	8,0 - 12,0	(7.0-)9.8-10.0	5.7-9.6	4.0-9.0	5,6-10,5	6,2-10,2
3.	-	-	-	-	1.4	2 - 3
4.	10,0-11,0	(6.0)-7.0-8.0	5.7-6.8	5.0-8.0	4,7-(5.3)-6,5	3,1 - 4,3
II.						
5.	spherical ellipsoid	oval/spherical	spherical	spherical/ compressed	elongate	spherical oval
6.	16,0	8.4 - 12.0	-	-	6,5-(7,1)-8,4	4,7 - 6,3
7.	13,0	7.0-9.6	5.7-7.6	8.0-12.0	5,6-(6.5)-7,5	4,7 - 5,9
III.						
8.	inflated cylindrical	oval/spherical	ellipsoidal	wide ellipsoid/ short cylindrical	-	ellipsoid oblong
9.	10,0-11,0	12.0-13.0	9.5-11.4	12.0-20.0(22.0)	-	10,1-14,1
10.	11,0	10.0-12.0	7.6-9.5	10.0-14.0	-	6,2-7,0
IV.						
11.	1-8	3-10	1-2½	-	1-1¹/3(3)	½-1½
12.	-	36-40	12.8-28.8	-	40-50	-
13.	-	-	-	-	-	-

TABLE 1 : Contd ...

	A. *nadsonii*	*A.* *intermedia*	*A.* *peruviana*	*A.* *kelifii*	*A.* *hungarica*	*A.* *woltereckii*
I.						
1.	cylindrical barrel shaped	cylindrical barrel shaped	cylindrical	cylindrical	long cylindrical	cylindrical
2.	4,8-6,4	4-8(12)	6.0-7.0	5-14	5,5-9,2	7-10.5(14)
3.	-	-	-	-	2-3	2-3(-4)
4.	4,8	4,0-5,4	4.0-5.0	3,5-5,0	2,6-4,3 2,2-2,4	3,1-3,5
II.						
5.	spherical	spherical	ellipsoid	ellipsoid	spherical	spherical
6.	-	-	9.0-10.0	4,0-5,5	-	-
7.	3,2-4,7	3,0-5,4	6.0	3,0-4,0	2,8-4,0	2,8-3,2 (-3,6)
III.						
8.	spherical ellipsoid	ellipsoid	-	elliptic elongate	ellipsoid	-
9.	8,0	8,1-12,6	-	9,0-15,0	8,0-10.0	-
10.	6,4	5,7-8,5	-	6,0-8,0	5,8-6,0	-
IV.						
11.	1½ -4	0-2	2	-	1-2 (3)	3/4
12.	16-19	18 - 27	-	30-39	13 - 17	-
13.	3.2 - 4.8	-	-	-	2,6-4,3	-

TABLE 1 : Contd ...

	A. arnoldii	*A. arnoldii* f. *africana*	*A. arnoldii* f. *kisselviana*	*A. arnoldii* f. *philippinensis*	*A. arnoldi* v. *javanica*	*A. arnoldii* v. *indica*	*A. arnoldii* v. *natrophila*
I.							
1.	compressed spherical	compressed spherical	-	truncate/ spherical/ ovoid	spherical elongate	short barrel shaped	?
2.	7,0-9,0	8,3	7,0-8,0	-	-	5,7-(7,6)-9,5	-
3.	-	-	-	-	-	-	-
4.	6,5-8,5	7,1-(7,7)-8,5	8,0-9,0	7,5-(8,7)-9,4	5,0-8,0	7,6-(9,5)-11,4	3,0
II.							
5.	spherical ellipsoid	subspherical	-	truncate spherical/oval	spherical	spherical	?
6.	8,0-10,5	8,5-(9,4)-10,3	-	7,5-(7,9)-9,4	-	-	-
7.	7,0-9,2 5,8-7,0	6,6-(9,8)-10,3	8,0-10,0	5,6-(7,9)-9.8	5,0-8,0	9,5-(13.3)-17,1	-
III.							
8.	ellipsoid	-	-	spherical-oval	ellipsoid	ellipsoid	-
9.	11,5-14,5	-	-	12,0-16,0	16,0-18,0	17,1-(19,0)-22,8	-
10.	10,4-11,5	-	-	8,1-12,0	12,0-14,0	13,3-(15,2)-19,0	-
IV.							
11.	½-9	$1-1^{1}/3(3)$	-	1-2	1-3	½-16	-
12.	25 - 58	50 -65	-	30 - 65	40-(55)-60	30-80	25-30
13.	7 -32	-	-	-	-	-	-

TABLE 2 : Cation composition (mg/1) and pH values of the lakes and ponds studied (after Hegewald et al., 1975). The values for Velencei-to' lake are after Woynarovich (1941).

	Sample	pH	K	Na	Mg	Ca	Fe
Feher-to pond	A	9,8	7,7	352,0	42,0	14,3	0,2
Feher-to pond	B	9,3	14,5	364,0	65,0	17,6	0,2
Feher-to pond	C	8,4	17,1	384,0	86,0	26,0	0,2
Feher-to pond	D	8,4	17,7	380,0	85,5	28,0	0,2
Feher-to Outflow	E	8,8	17,1	483,0	67,0	18,8	0,2
Kakasszeg-to	F 1)	9,2	38,4	1312,0	22,2	12,2	1,4
	2)	9,4	31,0	1210,0	14,8	13,7	0,8
Kunfeher-to	G	9,2	166,0	800,0	121,0	5,6	0,2
Belso-to	H	9,0	40,6	74,4	159,0	18,3	0,2
Velencei-to	1)	-	1,47	5007	46,31	1,17	0,97
	2)	-	3,31	44,64	47,60	4,10	-

TABLE 3 : Summarisation of the morphological variation of the species of Anabaeopsis from Hungary and Peru. Samples A-H and Velencei-to are derived from Hungary. Numbers in parenthesis denote averages. Where the specimens were rare (sample A, spores for sp.3) averages are not given.

	Sp.1 Feher-to(A)	Sp.1 Feher-to(B)	Sp.1 Feher-to(C)	Sp.1 Feher-to(D)	Sp.1 Feher-to(E)	Sp.1 Feher-to(F)
Cell						
1. Shape	ellipsoid	ellipsoid	ellipsoid	spherical to ellipsoid	ellipsoid to long cylin-drical	ellipsoid to long cylin-drical
2. Length µm	5.4-7.5	4.8-(7.1)-9.9	5.4-(7.4)-11.6	4.0-(6.8)-9.6	5.7-(7.3)-9.2	4.2-(7.2)-10.8
3. Length/ breadth	1.1-1.3	1.0-(1.5)-2.0	0.8-(1.4)-2.3	0.8-(1.2)-1.6	1.0-(1.9)-2.7	1.0-(1.8)-2.9
4. Breadth µm	4.8-6.1	3.2-(4.7)-6.5	3.9-(5.4)-7.2	4.2-(5.6)-7.2	3.2-(3.9)-6.0	3.2-(4.1)-5.1
Heterocyst						
5. Shape	spherical	spherical	spherical	spherical	spherical	spherical to somewhat elongate
6. Length µm	-	-	-	-	-	-
7. Length/ Breadth	1.0	1.0	1.0	1.0	1.0-1.3	1.0-1.2
8. Breadth µm	4.5-5.6	3.0-(3.8)-4.8	3.5-(4.3)-6.6	3.6-(5.2)-6.1	2.4-(3.7)-4.6	3.0-(3.8)-5.0
Spores						
9. Number	single	single	1-3 in chain	single double	1-3 in chain	1-3 in chain
10. Shape	ellipsoid	ellipsoid	ellipsoid	ellipsoid	ellipsoid	ellipsoid
11. Length µm	10.8-14.4	8.5-(10.5)-12.7	8.4-(10.9)-13.5	9.0-(11.7)-15.3	9.2-(11.2)-13.8	7.8-(10.9)-12.0
12. Breadth µm	7.8-10.2	5.8-(7.8)-9.6	6.0-(8.4)-9.6	6.0-(8.5)-10.5	6.0-(7.6)-9.2	5.0-(7.7)-9.9
Spirals						
13. Number	1/2-3/4	1/2-2 1/2	3/4-3	3/4-2	1/2-2	1/2 -1½
14. Diameter µm	18-25	12-21	9-28	12-27	9-18	9-18
15. Distance between µm	-	4.0-12.0	6.0-12.0	9.0-12.0	4.8-12.0	6.0-9.0

TABLE 3 - Contd...

	Sp.1 Kunfeher-to(G)	Sp.1 Belso-to(H)	Sp.1 Velencei-to	Sp.2 Kakasszeg-to(F)	Sp.3 El Gato,Peru
Cell					
1. Shape	long cylindrical	spherical to ellipsoid	long cylindrical	short barred shaped	short barred shaped
2. Length µm	6.0-(8.1)-10.8	4.7-(6.8)-9.4	3.3-(6.2)-9.3	4.3-(5.9)-7.5	3.6-(5.6)-7.2
3. Length/Breadth	1.4-(2.3)-3.6	0.9-(1.3)-1.9	1.2-(2.2)-3.2	0.6-(0.9)-1.6	0.4-(0.6)-0.9
4. Breadth µm	2.8-(3.6)-(4.9)	3.8-(5.3)-6.4	1.8-(2.9)-4.2	6.0-(6.6)-7.4	7.2-(9.3)-11.1
Heterocyst					
5. Shape	spherical to somewhat elongate	spherical to compressed	spherical to somewhat elongate	ovoid	spherical
6. Length µm	-	-	-	7.8-(10.0)-13.3	6.6-(9.1)-11.4
7. Length/Breadth	1.0-1.4	0.9-1.0	1.0-1.2	1.0-(1.3)-1.7	0.9-(10)-1.1
8. Breadth µm	2.7-(3.1)-5.0	3.1-(3.7)-4.0	1.5-(2.8)-3.6	5.8-(7.6)-9.4	6.6-(9.0)-13.2
Spores					
9. Number	1-3 in chain	1-4 in chain	single	-	single,double
10. Shape	ellipsoid	ellipsoid	ellipsoid	-	ellipsoid
11. Length µm	7.0-(11.0)-16.0	8.0-(9.8)-12.7	5.3-(6.8)-8.1	-	16.2-19.0
12. Breadth µm	4.7-(7.3)-9.6	6.1-(8.0)-9.4	3.5-(4.7)-6.0	-	10.8-14.4
Spirals					
13. Number	½ - 4	½ - 2	½ - 4	½ - 5	½ - 5
14. Diameter µm	6-30	9 -18	7 -15	21-42	28-67
15. Distance between µm	9-11	-	-	6-10	-