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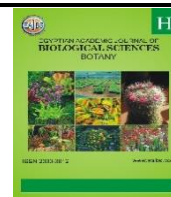
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The Bryoflora of Kafr El-Sheikh Governorate, Nile Delta, Egypt, With Special Reference to *Physcomitrium niloticum* (Delile) Müll. Hal.

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ABSTRACT

Eighteen moss taxa were recorded from Kafr El-Sheikh governorate, Nile Delta. *Brachytheciastrum velutinum* (Hedw.) Ignatov & Huttunen was a new record to the Nile Delta and 9 taxa were new to Kafr El-Sheikh governorate. This raised the number of identified moss taxa recorded from the Nile Delta to 53 taxa. Notes on the morphological differences between old and newly collected specimens of *Physcomitrium niloticum* (Delile) Müll. Hal. were given with illustrations.

INTRODUCTION

Up till now, the bryoflora of Egypt has reached 193 moss taxa, belonging to 60 genera, 17 families, and 10 orders (Taha, 2020; Abou-Salama *et al.*, 2021; Lashin *et al.*, 2022). These mosses are distributed along 11 different phytogeographic territories of Egypt. Nile Delta (ND) is the fifth richest one after Southern Sinai, Mediterranean coastal land, Cairo, and Isthmic Desert in terms of recorded mosses, with 52 taxa (El-Saadawi *et al.*, 2015; Abou-Salama *et al.*, 2021; Lashin *et al.*, 2022).

The last study on Kafr El-Sheikh governorate bryoflora, as a part of the ND territory, was performed more than four decades ago (El-Saadawi *et al.*, 1986). This last study identified preciously 9 moss taxa, namely: *Barbula bolleana* (Müll. Hal.) Broth, *B. indica* (Hook.) Spreng., *B. unguiculata* Hedw., *Didymodon tophaceus* (Brid.) Lisa, *Bryum radiculosum* Brid., *Philonotis hastata* (Duby) Wijk & Margad., *Funaria hygrometrica* Hedw., *Physcomitrium niloticum* (Delile) Müll. Hal. and *Fissidens viridulus* (Sw. ex anon.) Wahlenb. var. *viridulus*, as well as two taxa with doubtful identifications namely, *Gymnostomum* cf. *calcareum* Nees & Hornsch. and *Bryum* cf. *apiculatum* Schwägr.

The present paper aims to update, revise, and increase our knowledge about the Bryoflora of Kafr El-Sheikh governorate.

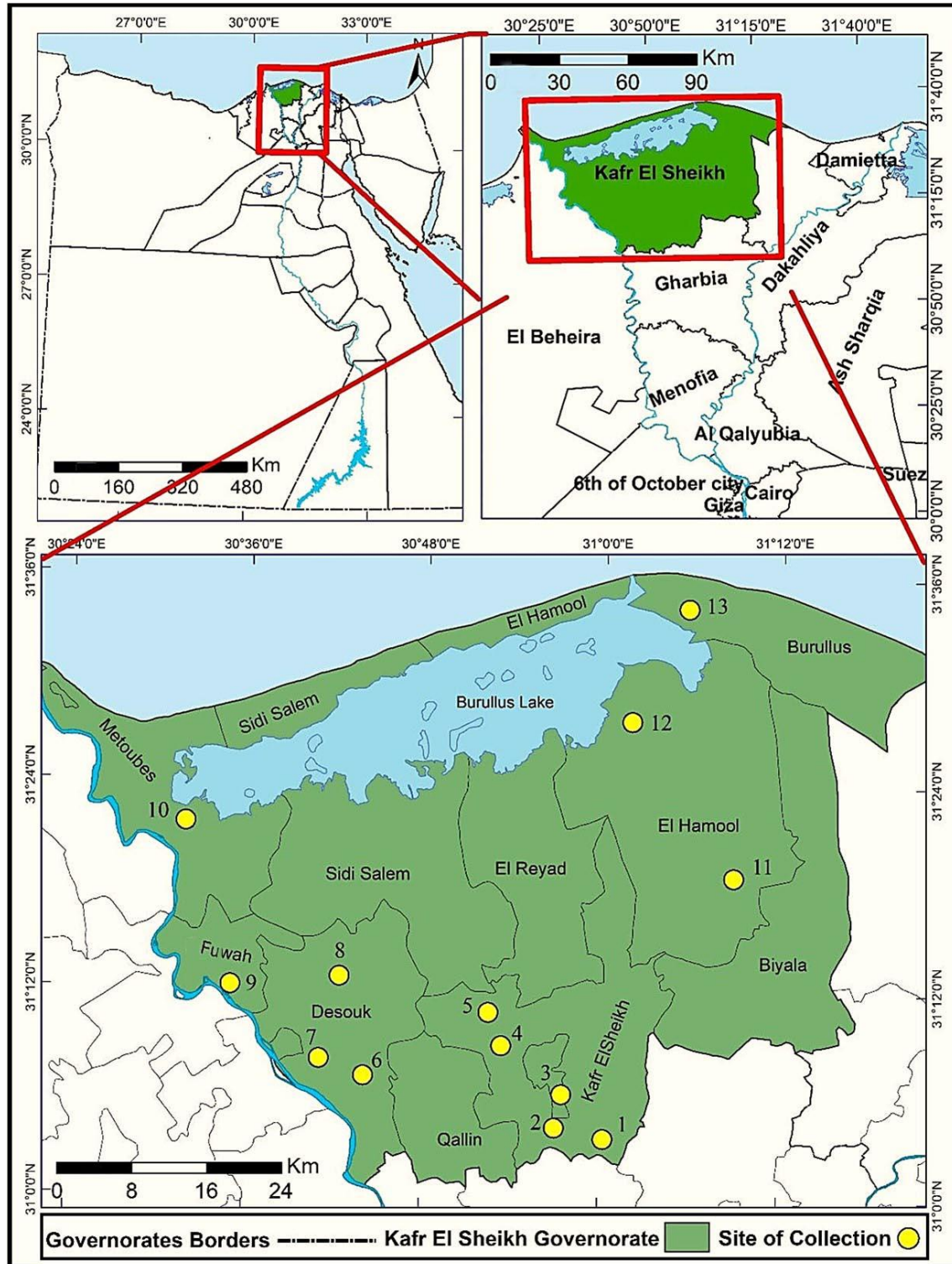
MATERIALS AND METHODS

Study Area:

Kafr El-Sheikh governorate is one of the Nile Delta governorates. It was located in the northern part of Egypt along the Nile Delta coast, between longitudes 30° 21' 53" E and

Mai A. Taha* and Manal I. Khalil

31° 20' 43" E and latitudes 30° 59' 38" N and 31° 36' 7" N (Map) at an elevation of 9.14 meters a. s. l., and its area ca. 3734.74 km² (Alkhawaga *et al.*, 2022). It is bounded by the Mediterranean Sea in the north, Gharbia governorate in the south, El Beheira governorate, and Rosetta Nile Branch in the west, and Dakahliya governorate in the east (El-Ramady *et al.*, 2019).



Map: The location of Kafr El-Sheikh governorate in Egypt and Nile Delta territory, with collection site numbers (After ESRI., 2019).

The Bryoflora of Kafr El-Sheikh Governorate, Nile Delta, Egypt.

The governorate is divided administratively into ten districts namely, El Hamool, Baltim, Biyala, Desouk, Fuwah, Kafr El Sheikh, Metoubes, Qallin, El Reyad, and Sidi Salem (El-Ramady *et al.*, 2019).

The habitats of studied samples were usually shaded places, on red brick walls or limestone walls of water basins, irrigation canals, water wheels, or water reservoirs, and walls covered by a thin layer of mud. According to El-Ramady *et al.* (2019), the soil in Kafr El-Sheikh governorate is mainly composed of fertile alluvial soil, which is deposited by the Nile River. This soil is ideal for agriculture, as it is rich in nutrients and moisture. The Nile River serves as the main supply of fresh water for the governorate's activities, represented by the Rosetta branch and main canals (Alkhwaga *et al.*, 2022).

According to ESRI. (2019), in 1979 and 1980 the monthly mean daily maximum air temperature of the governorate in summer ranged from 21-32 °C, while in winter it ranged from 10-20°C. The annual rainfall in the Kafr El-Sheikh governorate was 42-59 mm.

Data of climate from 1991-2021, according to <https://en.climate-data.org/> the monthly mean of daily maximum air temperature of the governorate in summer ranged from 27-40 °C while in winter it ranged from 14-25°C. The annual rainfall in the governorate was 20-25 mm. In general, temperature increased by 7°C in the summer and by around 4°C in the winter, while rainfall dropped by 28 mm in the last four decades. Therefore, the climate of the governorate has changed obviously in the past 45 years.

Materials:

Forty-six moss samples have been studied. Twenty-nine out of them were collected through 5 excursions by Dr. Refai M. S. from 10 sites (11 localities) in 1979 and 1980, in addition, 17 new samples were collected through an excursion by the authors from three sites (5 localities) in November 2021. All samples were numbered and kept at CAIA (Table 1 and the Map).

Some samples were mixed, while others were pure. Mixed ones were separated before investigation which brought the 46 samples to 71 specimens (Table 2).

All data regarding old and new collected samples were represented in Table 1, and the Map.

Table 1: Data of the new and old studied herbarium samples from Kafr El-Sheikh governorate.

District	Site number as in the Map	Date of collection	Locality of collection	Habitat	Herbarium number at CAIA
Kafr El-Sheikh	1	09-08-79	Misir	on a thin layer of mud on the wall of an irrigation canal	R1006 a, b, c
	2	18-04-80	El-Qarada	on a red brick wall of a water wheel	R1149 a, b
				on a red brick wall of a water wheel	R1150
				on a red brick wall of a water wheel	R1151a, b
			El-Mofty village	on a limestone wall of a water reservoir	R1152a, b
	on a thin layer of mud on a lime-stone wall of an irrigation canal	R1153a, b			
	3	19-11-21	Salah Abu Said area	on red brick exposed mixed with filaments of alga	M.T. 1-5
				on the wall of a water basin	M.T.6
			land of the El-Sabeen beside Mit Yazid canal	grow on the inside wall of the water basin shade	M.T. 7-8
				grow on tree trunks, exposed	M.I. 9-10
				grow on a red brick cover with a cement layer, exposed, on agricultural land	M.I. 11-12
				grow on clay of a water canal, shade	M.I. 13
	4		El-Hamraa Sallam	grow on a wall of water basin, shade	M.I.14
grow on the red brick of a house shade, the border area in front of the western canal				M.I.15-16	
5		El-Hedoud	grow on a red brick wall of water basin with a water pump, shade	M.I.17	
Desouk	6	09-03-80	Sanhour	on a red brick wall of a bridge	R1064 b
	7	26-03-80	Desouk	on a thin layer of mud on a red brick wall of an irrigation canal	R1079, R1080 a, b
	8	18-04-80	Abo Mandor village (Ezbet Hamad)	on a red brick wall of a water wheel	R1154 a, b
Fuwwah	9	18-04-80	Fuwah village	on a red brick wall of a bridge	R1155
		26-03-80		on a narrow irrigation canal between grass on mud	R1083
Metoubes	10	26-03-80	Berenbal	on a thin layer of mud on the wall of a narrow irrigation canal	R1081
				on a limestone wall of a water wheel	R1082
Hamool	11	09-03-80	El-Hamool	on a red brick wall of a water wheel	R1065 a, b
	12	28-09-79	Zain village, (Ezbet Zaidan)	on a red brick wall of a bridge	R1020
Baltim	13	28-09-79	Baltim	on a red brick wall of a water wheel	R1021 a, b, R1022 a, b

RESULTS

The investigation of 71 specimens showed that Kafr El-Sheikh governorate bryoflora include 18 moss taxa representing seven families namely: Bartramiaceae, Brachytheciaceae, Bryaceae, Fissidentaceae, Funariaceae, Messiaceae, and Pottiaceae. The

The Bryoflora of Kafr El-Sheikh Governorate, Nile Delta, Egypt.

last family is the largest one represented by 8 taxa followed by Bryaceae represented by 4 taxa, then Funariaceae represented by 2 taxa, and the rest families were represented by one taxon each (Table 2).

Table 2: Showing names of the 18 moss taxa recorded in Kafr El-Sheikh governorate, their families and herbarium numbers were giving. (⊠) new record to the Nile delta and (*) new records to the governorate, (▲) Taxa recorded in the old and new collections, (⊖) taxa recorded only in old collections.

Orders and families	Identification according to the present study	Herbarium number at CAIA	Total
Pottiales	▲ <i>Barbula bolleana</i> (Müll. Hal.) Broth.	M.T.1a, M.T.3c, M.I.14a, R1006b	4
Family: Pottiaceae	▲ <i>B. indica</i> (Hook.) Spreng.	R1022bC, R1079c, R1152a, M.T.4a	4
	▲ <i>B. unguiculata</i> Hedw.	R1021bB, R1006aA, R1064b, R1065a, b, R1079a, R1080a, R1081, R1149a, R1150, R1151a, b, R1153, R1154aA, R1154b, R1155, M.T.4b, M.I.11a, M.I.12a	19
	⊖ <i>Didymodon tophaceus</i> (Brid.) Lisa	R1022aA, R1022bA, R1006aB, R1006c	4
	* <i>D. vinealis</i> (Brid.) R.H.Zander	R1006aC	1
	* <i>Splachnobryum obtusum</i> (Brid.) Müll. Hal.	M.T.1a, M.T.2, M.T.3b, M.T.5b, M.I.15, M.I.16	6
	* <i>Tortula muralis</i> Hedw.	M.I.17a	1
	* <i>Trichostomum brachydontium</i> Bruch	R1079d, R1154aB, M.T.5c	3
Bryales	* <i>Bryum dichotomum</i> Hedw.	M.T.6b	1
Family 1: Bryaceae	▲ <i>B. radiculosum</i> Brid.	R1006aD, M.I.12b	2
	* <i>B. subapiculatum</i> Hampe	M.T. 6a, M.I.14b	2
	* <i>Ptychostomum imbricatulum</i> (Müll. Hal.) D. T. Holyoak & N. Pedersen	M.T.3a, 5a, 7, 8, M.I.11b, M.I.14c, M.I.17c, R1022aB, R1022bB	9
Family 2: Bartramiaceae	⊖ <i>Philonotis hastata</i> (Duby) Wijk & Margad.	R1021bA, R1083	2
Family 3: Messiaceae	* <i>Leptobryum pyriforme</i> (Hedw.) Wilson	M.I.10	1
Funariales	▲ <i>Funaria hygrometrica</i> Hedw	R1079b, R1149b, R1020, M.I.9a, M.I.13, M.I.17b	6
Family: Funariaceae	▲ <i>Physcomitrium niloticum</i> (Delile) Müll. Hal.	R1082, R1080b, M.I.9b	3
Fissidentales	⊖ <i>Fissidens viridulus</i> (Sw. ex anon.)	R1021a, R1153b	2
Family: Fissidentaceae	⊠ <i>Brachytheciastrum velutinum</i> (Hedw.) Ignatov & Huttunen	R1152b	1
Family: Brachytheciaceae			
Total number of Specimens			71

Mai A. Taha* and Manal I. Khalil

The most dominant taxon was *Barbula unguiculata* which was represented by 19 specimens (Table 2). Nine out of 18 moss taxa were new records to the governorate, and one of them namely, *Brachytheciastrum velutinum* was a new record to ND. This raises the total number of known moss taxa of the Kafr El-Sheikh governorate to 18 and of ND to 53.

The revision of the doubtful sample of *Gymnostomum* cf. *calcareum* Nees & Hornsch. revealed that it was a mixed sample containing both *Didymodon tophaceus* (Brid.) Lisa and *Ptychostomum imbricatulum* (Müll. Hal.) D. T. Holyoak & N. Pedersen. doubtful sample(s) of *Bryum* cf. *apiculatum* Schwägr. was unavailable. The combination of its unavailability as a herbarium sample and doubts about its definition brought the tendency to delete it from the bryoflora of the governorate forward.

Many locations in districts Desouk and Kafr El-Sheikh, which previously flourished to some extent by mosses, became now free from them. Also, the occurrence and distribution of some mosses namely, *Didymodon tophaceus*, *D. vinealis*, *Philonotis hastata*, *Fissidens viridulus*, and *Brachytheciastrum velutinum* were decreased so they were not recorded in the new collection. On the contrary, some moss taxa namely, *Bryum dichotomum*, *B. subapiculatum*, *Leptobryum pyriforme*, *Splachnobryum obtusum*, and *Tortula muralis* appeared in only a new collection (Table 2).

All recorded taxa from Kafr El-Sheikh governorate were fruitless, except *Tortula muralis*, *Funaria hygrometrica* and *Physcomitrium niloticum* (Table 3). Archegonia were recorded in eight taxa namely, *Barbula bolleana*, *B. unguiculata*, *Didymodon tophaceus*, *Trichostomum brachydontium*, *Bryum radiculosum*, *B. subapiculatum*, *Ptychostomum imbricatulum*, and *Physcomitrium niloticum*; in comparison, antheridia were found only one time at the newly collected sample of *Physcomitrium niloticum* (Table 3).

Also, it is obvious from Table (3) that vegetative propagules (rhizoidal gemmae, axillary gemmae and bulbils) were recorded in nine taxa. It is worth mentioning, that there were four moss taxa without any reproductive organs (Table 3).

Table 3: Existence of sexual and vegetative reproductive organs in moss taxa of Kafr El-Sheikh governorate. Spo: Sporophyte; Arc: Archegonia; Anth: Antheridia; RG: Rhizoidal Gemmae; AG: Axillary Gemmae; Bul: Bulbils

Taxa	Spo	Arc	Anth	RG	AG	Bul
<i>Barbula bolleana</i> (Müll. Hal.) Broth		+				
<i>B. indica</i> (Hook.) Spreng.					+	
<i>B. unguiculata</i> Hedw.		+			+	
<i>Didymodon tophaceus</i> (Brid.) Lisa		+				
<i>D. vinealis</i> (Brid.) R. H. Zander				+		
<i>Splachnobryum obtusum</i> (Brid.) Müll. Hal.						
<i>Tortula muralis</i> Hedw.	+					
<i>Trichostomum brachydontium</i> Bruch		+			+	
<i>Bryum dichotomum</i> Hedw.				+		+
<i>B. radiculosum</i> Brid.		+		+		
<i>B. subapiculatum</i> Hampe		+		+		
<i>Ptychostomum imbricatulum</i> (Müll.Hal.) D. T. Holyoak & N. Pedersen		+		+		
<i>Philonotis hastata</i> (Duby) Wijk & Margad.						
<i>Leptobryum pyriforme</i> (Hedw.) Wilson				+		
<i>Funaria hygrometrica</i> Hedw.	+					
<i>Physcomitrium niloticum</i> (Delile) Müll. Hal.	+	+	+			
<i>Fissidens viridulus</i> (Sw. ex anon.)						
<i>Brachytheciastrum velutinum</i> (Hedw.) Ignatov & Huttunen						

FLORISTIC REMARKS

Some traits in *Physcomitrium niloticum* (Delile) Müll. Hal., such as acute apex, costa ending below apex, non-lax upper laminal cells, and spinose spores, have been observed in recently collected samples (Plate). These traits were different from what was previously known about this plant in ND and in other phytogeographical territories of Egypt (El-Saadawi, 1972). *Physcomitrium niloticum* has a broad spectrum of morphological characters which was mentioned and illustrated by Magill (1981), Kürschner (2000), and Kürschner and Frey (2011). According to Schlichting and Pigliucci (1998), the availability of water and nutrients around mosses plays a tangible role in changing their mega- and micro-morphological characteristics as in leaf morphology. Also, Proctor (1979, 1984) mentioned that the moss under drought conditions may tend to form small and thick wall lamina cells as a drought-resistance mechanism. Therefore, the morphological changes that appeared in the newly collected *Physcomitrium niloticum* are consistent with our results and related to the climatic changes in the Kafr El-Sheikh governorate.

According to (Jägerbrand, 2006; Pantović *et al.*, 2023), the numerous climatic changes (e.g. rising temperatures and lowering perceptions), and human interventions (e.g. upper Nile projects, conversion of farmland to buildings, canal linings, etc.) had an obvious influence on reducing opportunities for moss growth.

Dennis (2001) showed that the increase in the temperature reduced the occurrence of some taxa, as well as helped in increasing the occurrence of others. He also stated that some moss taxa have a relatively wide tolerance range to temperature and this tolerance is largely due to their water relations, since they can withstand, to a certain extent, temperature extremes when dry than when wet.

The presence of sporophytes, archegonia, and vegetative propagules are usually considered indications of the taxon establishment in an area (During, 1979; Wafiq, 2005). Shabbara (1990) mentioned that the high temperature and desiccation conditions commonly encourage vegetative propagules production, which were found in nine moss taxa out of 18 taxa.

Gametangia is not recorded in some taxa that formed sporophytes, this may be attributed to the dehiscence of the sexual oranges after fertilization, or as a result of long-timed preservation.

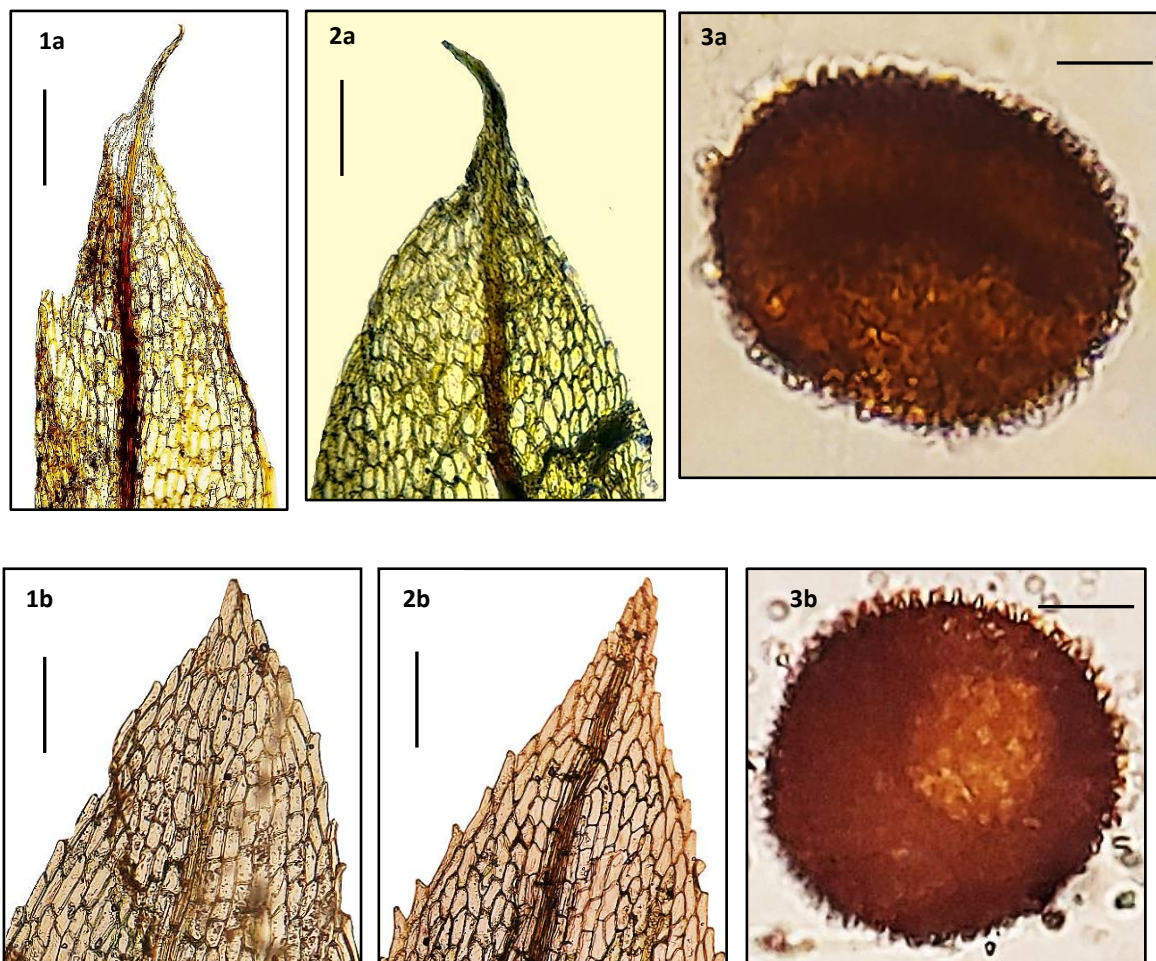


Plate: *Physcomitrium niloticum* (Delile) Müll. Hal.; Figs. 1a-3a: Old record; 1a, 2a. The upper part of the leaf, 3a. Spore, Figs. 1b-3b: Recent record; 1b, 2b. The upper part of the leaf, 3b. Spore.

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ARABIC SUMMARY

Physcomitrium niloticum الفلوره الحزازية بمحافظة كفر الشيخ، دلتا النيل، مصر، مع إشارة خاصة للحزاز (Delile) Müll. Hal.

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تم تسجّل 18 حزازاً من محافظة كفر الشيخ بدلتا النيل، منها *Brachytheciastrum velutinum* (Hedw.) Ignatov & Huttunen الذي يعتبر تسجيلاً جديداً لدلتا النيل، وتسعة أنواع جديدة على الفلوره الحزازيه لمحافظة كفر الشيخ، فأرتفع عدد الحزازيات المسجلة في دلتا النيل الى 53 وحده تصنيفيه، ومن محافظة كفر الشيخ الى 18 وحده تصنيفيه. كما تناولت الدراسة تسجيل بعض الأختلافات في الشكل الظاهري بين العينات المجمعة سابقاً وحديثاً للحزاز *Physcomitrium niloticum* (Delile) Müll. Hal. مع تقديم صور ضوئيه لهذه الأختلافات.