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Research Article

On the Taxonomy of *Plantaginaceae* Juss. *Sensu Lato:* evidence from SEM of the Seed Coat

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Abstract: SEM of the seed coat was studied in 41 taxa of the *Plantaginaceae* sensu lato. The study included 31 taxa of *Plantago* L. and 10 taxa that were formerly assigned to the *Scrophulariaceae*, representing the genera *Antirrhinum* L., *Digitalis* L., *Linaria* Mill. and *Veronica* L. The obtained data were analysed by the NT sys-PC program package using the UPGMA clustering method. The study showed that *Veronica* possessed certain affinities to *Plantago* species, thus giving extra support to earlier views that *Plantaginaceae* sensu stricto and *Scrophulariaceae* sensu lato are allied through *Veronica*. The study also favoured the paraphyly of *Plantago* subgenus *Albicans sensu* Rahn (1996) and the retention of *P. camtschatica* Link. subgenus *Plantago* L. and *P. alpina* L. , *P. crassifolia* Forssk. and *P. salsa* Pall. subgenus *Coronopus* (Lam. & DC.) Rahn as distinct taxa. The monophyly of *Plantaginaceae sensu lato* was reassessed to a certain extent.

Key Words: *Plantaginaceae, Plantago, Scrophulariaceae*, SEM, Seed coat, Taxonomy

Introduction

Plantaginaceae, as generally circumscribed, is a cosmopolitan family of 3 related genera, i.e. *Bougueria* Decne., *Littorella* P. Bergius and *Plantago* L. and about 275 species are distributed in diverse habitats throughout the world (Cronquist, 1981; Heywood, 1993; Mabberley, 1997) or it is considered a monogeneric family with only *Plantago* as recognised by Rahn (1996). However, the relationships of the family, either with other families or between its genera, are still unclear and need to be clarified (Heywood, 1993; Albach et al., 2004). Regarding the relations between its genera, *Bougueria* and *Littorella* were included in *Plantago* by Rahn (1996). Bentham & Hooker (1876) considered the family as representing an anomalous group. Sachs (1882) and Gaebel (1933) placed the family near *Verbenaceae*. Several authors stressed a close relationship between the *Plantaginaceae* with *Scrophulariaceae* (Hallier, 1912; Warming, 1913; Wettstein, 1935; Corner, 1976; Takhtajan, 1980; Heywood, 1993; Mabberley, 1997). Moreover, in a classification presented by Judd et al. (1999) and APG (2003), the concept of the *Plantaginaceae* was broadened to include many genera that were formerly assigned to the *Scrophulariceae*: *Antirrhinum* L., *Calceolaria* L., *Digitalis* L., *Gratiola* L., *Limnophila* R.Br., *Linaria* Mill., *Lindernia* All., *Nemesia* Vent., *Penstemon* Schmid., *Scoparia* L., and *Veronica* L. Their view was based mainly on studies based on molecular criteria (Olmstead et al., 1992a, 1992b, 1993; Olmstead & Reeves, 1995; Wagstaff & Olmstead, 1996). These studies showed that cpDNA characters supported the monophyly of the *Plantaginaceae sensu lato* (including the added genera of the *Scrophulariaceae*). Moreover, Albach et al. (2004) added more genera from the *Scrophulariaceae* to the tribe *Veroniceae* nested within the expanded *Plantaginaceae*. Although few studies have been carried out on *Plantaginaceae sensu lato*, numerous studies have been performed on *Plantaginaceae sensu stricto* to deduce the phylogenetic relationships among its taxa, yet the majority of studies concentrated on *Plantago* and utilised different criteria, such as molecular systematics

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(Ronsted et al., 2002), chromosome numbers and karyology (Matsu & Noguchi, 1989; Hamoud et al., 1993; Pramanik and Sen-Raychoudhuri, 1997; Badr, 1999; and several others), anatomy and morphology (Andrzejeuska Golec, 1992a, 1992b; Park & Kim, 1998; Hosny & Waly, 2001; and several others) and palynology (Saad, 1986). However, the results of these studies were very different, mainly because the taxa included in a certain study were not the same as those presented in another and they utilised different criteria, and thus could not be compared objectively as Heywood (2001) pointed out in a review article about the future of studies related to floristics and monography.

As far as the infrageneric classification of *Plantago* is concerned, Pilger (1937) subdivided the genus into 2 subgenera, *Plantago* and *Psyllium* L. Rahn (1978) published a revision of the genus in which he divided it into 3 subgenera, i.e. *Plantago*, *Cornopus* and *Psyllium* (Juss.) Harms & Reiche. Rahn (1996) proposed a new infrageneric classification of *Plantago*. In this classification, the genus includes 6 subgenera: *Plantago, Cornopus, Albicans*, *Psyllium*, *Littorella* and the subgenus *Bougueria*. Concerning *Plantaginaceae sensu stricto*, several studies have shown that seed micromorphology can be a valuable tool in addressing the phylogeny and the relationships in the family (Misra 1964a, 1964b, Corner, 1976; Rezk, 1980, 1987; Kamel, 2003; and several others). Barthlott (1981) stated that SEM of the seed coat can be a good taxonomic and phylogenetic marker at the subgeneric to subfamilial level.

The aim of this study was to test the relationships among *Plantago* species as well as between certain taxa of *Plantaginaceae sensu lato* (as presented in the classification system of Judd et al. (1999) that were formerly assigned to the *Srophulariaceae*, utilising data sets from SEM of the seed coat. The results are discussed in the light of the current system of classification of *Plantaginaceae* (*sensu* Judd et al. 1999) and the infrageneric classifications of the genus *Plantago* (Pilger, 1937; Rahn, 1978, 1996).

Materials and Methods

The investigated taxa included 31 species of *Plantago* representing the subgenera *Albicans, Coronopus, Plantago* and *Psyllium* (*sensu* Rahn 1996) and 10 taxa belonging to 4 genera that were formerly assigned to the *Scrophulariaceae*: *Antirrhinum*, *Digitalis*, *Linaria* and *Veronica* (Appendix).

Some of these taxa were collected from several localities in Egypt, while the rest were obtained from various botanic gardens in Germany, France, Italy, Spain and Portugal.

The external macromorphological aspects of the seeds of the studied taxa were investigated with the aid of a stereomicroscope. For SEM observations, dried mature seeds were mounted on brass stubs and coated with a thin layer of gold using JEOL-JFCL 1100E ion sputtering. Coated seeds were examined and photographed on a JEOL-JSM5300 SEM with an accelerating voltage of 15 kV at the Electron Microscopic Unit, Faculty of Science, Alexandria University.

The terminology of Stearn (1966) and Barthlott (1981) was adopted to describe the SEM aspects of the seed coat.

For creating a data matrix for numerical analysis of the results, the recorded characters were analysed by the NT sys-PC program package, using UPGMA clustering (Rohlf, 1989). The relationships between the studied taxa, expressed by average taxonomic distance (dissimilarity), were demonstrated in a phenogram.

Results and Discussion

The macromorphological aspects of the studied taxa showed that the seed shape is variable (oblong, cymbiform, ovate, fusiform, lenticular, rounded, angular, ellipsoid and reniform). Size ranged from relatively large seeds (more than 5 mm long) in *Plantago amplexicaulis* Cav. and *P. tenuiflora* Waldst. & Kit. to medium sized seeds (more than 3 mm long) in *P. afra* L., *P. albicans* L., *P. arabica* Boiss., *P. arborescens* Poir., *P. saxatilis* M. and *P. sempervirens* Crantz. The rest of the studied taxa possessed seeds less than 3 mm long.

The SEM of the seed coat's micromorphological aspects is presented in (Table 1 & Figure A [1-41]). The constructed phenogram (Figure B), based on the coding of 41 applicable character states belonging to 8 characters from the SEM of the seed coat, shows the following:

i) Most of the investigated taxa that were formerly assigned to the *Scrophulariaceae* (1, 2, 3, 4, 5, 6, 38, 39, 40, 41) were scattered across the constructed phenogram along with the *Plantago* taxa (Figure B).

Table 1. Seed coat's micromorphological aspects.

	Character / Taxa	Overall seed coat pattern	Cell shape	Anticlinal walls				Periclinal walls	
				Shape	Thickness degree	Pattern of thickening	Level	Level	Texture
1	*Antirrhinum majus*	Reticulate	Angular	Slightly undulate	Thick	Buttressed to beaded	Highly raised	± flat	Granulate
2	*Digitalis lanata*	Reticulate	Angular	Straight	Slightly thick	Smooth	Highly raised	± flat	Ribbed
3	*Digitalis lutea*	Reticulate	Angular	Straight	Thick	Slightly beaded to smooth	Highly raised	Concave	Ribbed
4	*Digitalis parviflora*	Reticulate	Angular	Straight	Thick	Slightly beaded to smooth	Highly raised	Concave	Ribbed
5	*Linaria purpurea*	Verrucate	Variable	Straight	Slightly thick	Slightly beaded to smooth	Channeled	Convex	Granulate
6	*Linaria tenuis*	Colliculate	Variable	Straight	Slightly thick	Slightly beaded to smooth	Channeled	Convex	Granulate
7	*Plantago afra*	Scalariform to reticulate	Angular	Straight	Thin	Irregular	Channeled	± flat	Microreticulate
8	*Plantago albicans*	Reticulate	Angular to rounded	Slightly undulate	Slightly thick	Buttressed to beaded	Raised	± flat	Ruminate
9	*Plantago alpina*	Reticulate	Angular	Slightly undulate	Slightly thick	Irregular	Raised	± flat	Ruminate
10	*Plantago altissima*	Scalariform to reticulate	Angular	Slightly undulate	Slightly thick	Buttressed to beaded	Channeled	± flat	Rugose
11	*Plantago amplexicaulis*	Scalariform to reticulate	Angular	Straight	Slightly thick	Irregular	Raised	± flat	Rugose
12	*Plantago arborescens*	Scalariform	Angular	Straight	Thin	Buttressed to beaded	Channeled	Convex	Ruminate
13	*Plantago arenaria*	Scalariform	Angular	Straight	Thin	Buttressed to beaded	Raised	± flat	Scalariform
14	*Plantago aschersonii*	Reticulate	Angular	Undulate	Slightly thick	Irregular	Raised	± flat	Ruminate
15	*Plantago australis*	Reticulate	Angular	Straight	Slightly thick	Buttressed to beaded	Raised	Convex	Striated
16	*Plantago bellardii.*	Reticulate	Rounded	Slightly undulate	Slightly thick	Irregular	Raised	± flat	Reticulate
17	*Plantago camtschatica*	Scalariform	Angular	Straight	Thin	Irregular	Channelled	Concave	Ribbed
18	*Plantago ciliata*	Scalariform to reticulate	Angular	Straight	Thin	Irregular	Channelled	± flat	Reticulate
19	*Plantago coronopus*	Reticulate	Undulate	Undulate	Slightly thick	Irregular	Raised	± flat	Ruminate
20	*Plantago crassifolia*	Reticulate	Undulate	Undulate	Irregular	Thick	Raised	± flat	Ruminate

Table 1. (Contunued).

	Character / Taxa	Overall seed coat pattern	Cell shape	Anticlinal walls				Periclinal walls	
				Shape	Thickness degree	Pattern of thickening	Level	Level	Texture
21	*Plantago cylindrica*	Scalariform to reticulate	Angular	Straight	Irregular	Thin	Raised	± flat	Reticulate
22	*Plantago holosteum*	Reticulate	Undulate	Undulate	Thick	Irregular	Raised	Concave	Ruminate
23	*Plantago lagopus*	Reticulate	Undulate	Slightly undulate	Slightly thick	Irregular	Raised	Concave	Ribbed to striate
24	*Plantago lanceolata*	Scalariform to reticulate	Angular	Straight	Slightly thick	Irregular	Raised	± flat	Ruminate
25	*Plantago major*	Reticulate	Angular	Straight	Thin	Irregular	Channelled	± flat	Striate
26	*Plantago maritima*	Reticulate	Rounded	Undulate	Slightly thick	Irregular	Channelled	Concave	Striate to ruminate
27	*Plantago maxima*	Scalariform	Angular	Straight	Slightly thick	Irregular	Channelled	± flat	Striate
28	*Plantago ovata*	Scalariform	Angular	Straight	Slightly thick	Irregular	Raised	± flat	Scalariform
29	*Plantago patagonica*	Scalariform	Angular	Straight	Slightly thick	Buttressed to beaded	Raised	± flat	Scalariform
30	*Plantago salsa*	Reticulate	Angular to round	Slightly undulate	Thick	Irregular	Raised	Concave	Favoulariate
31	*Plantago saxatilis*	Scalariform	Angular	Straight	Slightly thick to beaded	Buttressed	Raised	± flat	Favoulariate
32	*Plantago sempervirens*	Reticulate	Undulate	Undulate	Slightly thick	Irregular	Raised	Concave	Striate to ruminate
33	*Plantago sinaica*	Reticulate	Angular	Straight	Thin	Slightly beaded to smooth	Channelled	± flat	Granulate
34	*Plantago squarrosa*	Scalariform	Angular	Straight	Thin	Irregular	Channelled	Convex	Ruminate
35	*Plantago stepposa*	Reticulate	Angular to round	Straight	Slightly thick	Irregular	Channelled	± flat	Striate
36	*Plantago tenuiflora*	Reticulate	Angular to round	Slightly undulate	Slightly thick	Irregular	Raised	± flat	Favoulariate
37	*Plantago triandra*	Reticulate	Angular	Slightly undulate	Thin	Irregular	Channelled	± flat	Favoulariate
38	*Veronica anagallis*	Reticulate	Angular to rounded	Slightly undulate	Thick	Slightly beaded to smooth	Raised	Convex	Tuberculate
39	*Veronica officinalis*	Reticulate to colliculate	Angular to rounded	Slightly undulate	Slightly thick	Slightly beaded to smooth	Raised	Concave	Slightly ribbed
40	*Veronica scutellata*	Reticulate to colliculate	Angular to rounded	Slightly undulate	Slightly thick	Smooth	Raised	Concave	Slightly ribbed
41	*Veronica virginica*	Reticulate	Angular to rounded		Slightly undulate	Slightly thick	Irregular	Raised	± flat Striate

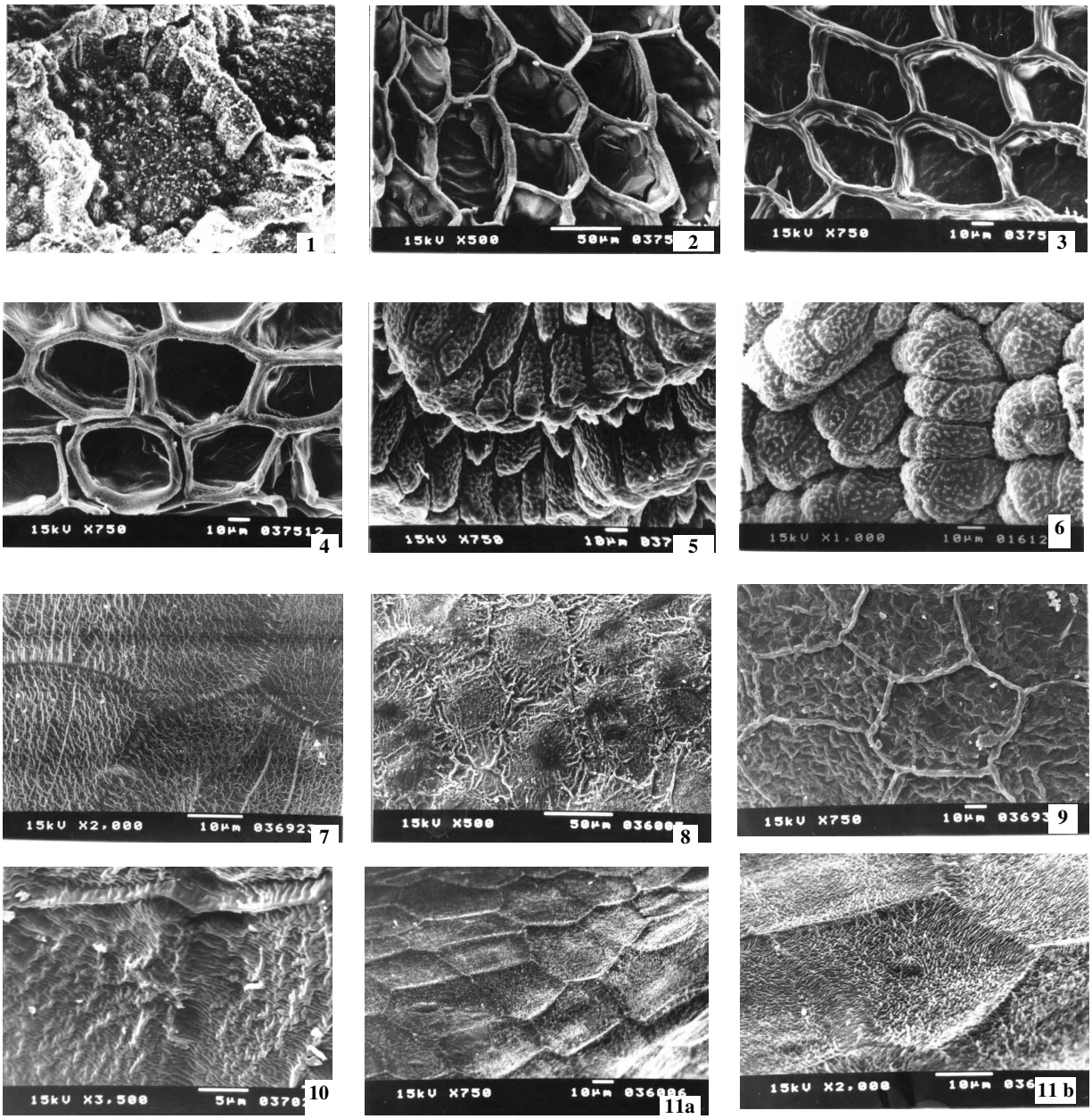

Figure A (1-11). Scanning electron micrographs of the seed surface of the studied taxa.

1: Antirrhinum majus L. (x350).

2: Digitalis lanata (x 500).

3: Digitalis lutea (x750).

4: Digitalis parviflora (x750).

5: Linaria purpurea (x750).

6: Linaria tenuis (x1000).

7: Plantago afra (x2000).

8: Plantago albicans (x500).

9: Plantago alpina (x750).

10: Plantago altissima (x3500).

11: (a & b) Plantago amplexicaulis (x750 & x2000).

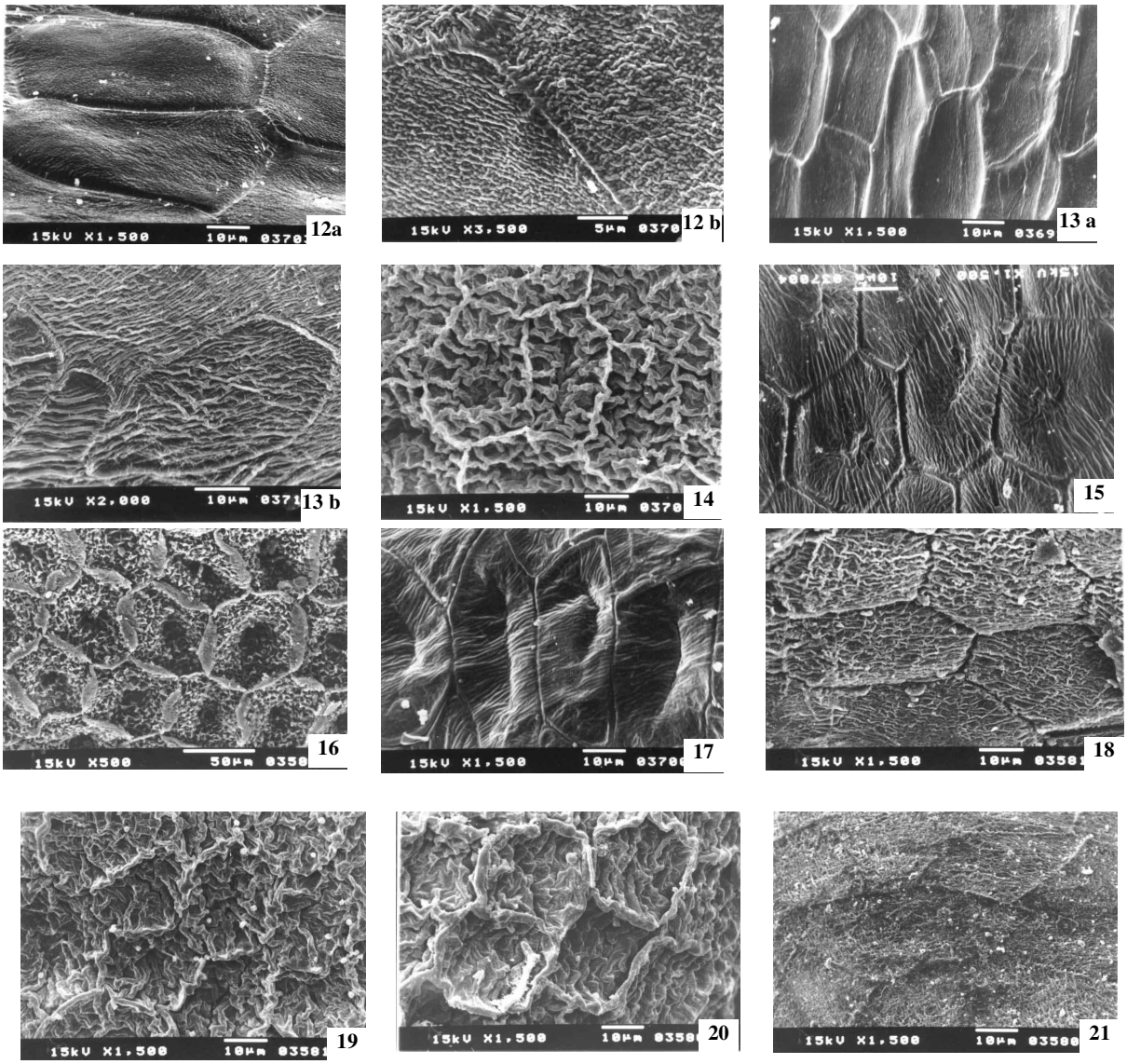

Figure A (12-21). Scanning electron micrographs of the seed surface of the studied Taxa.

12: (a&b) Plantago arborescens (x1500 & x3500).

13: (a & b) Plantago arenaria (x1500 & x2000).

14: Plantago aschersonii (x1500).

15: Plantago australis (x1500).

16: Plantago bellardi (x1500).

17: Plantago camtschatica (x1500).

18: Plantago ciliata (x1500).

19: Plantago coronopus (x1500).

20: Plantago crassifolia (x1500).

21: Plantago cylindrica (x1500).

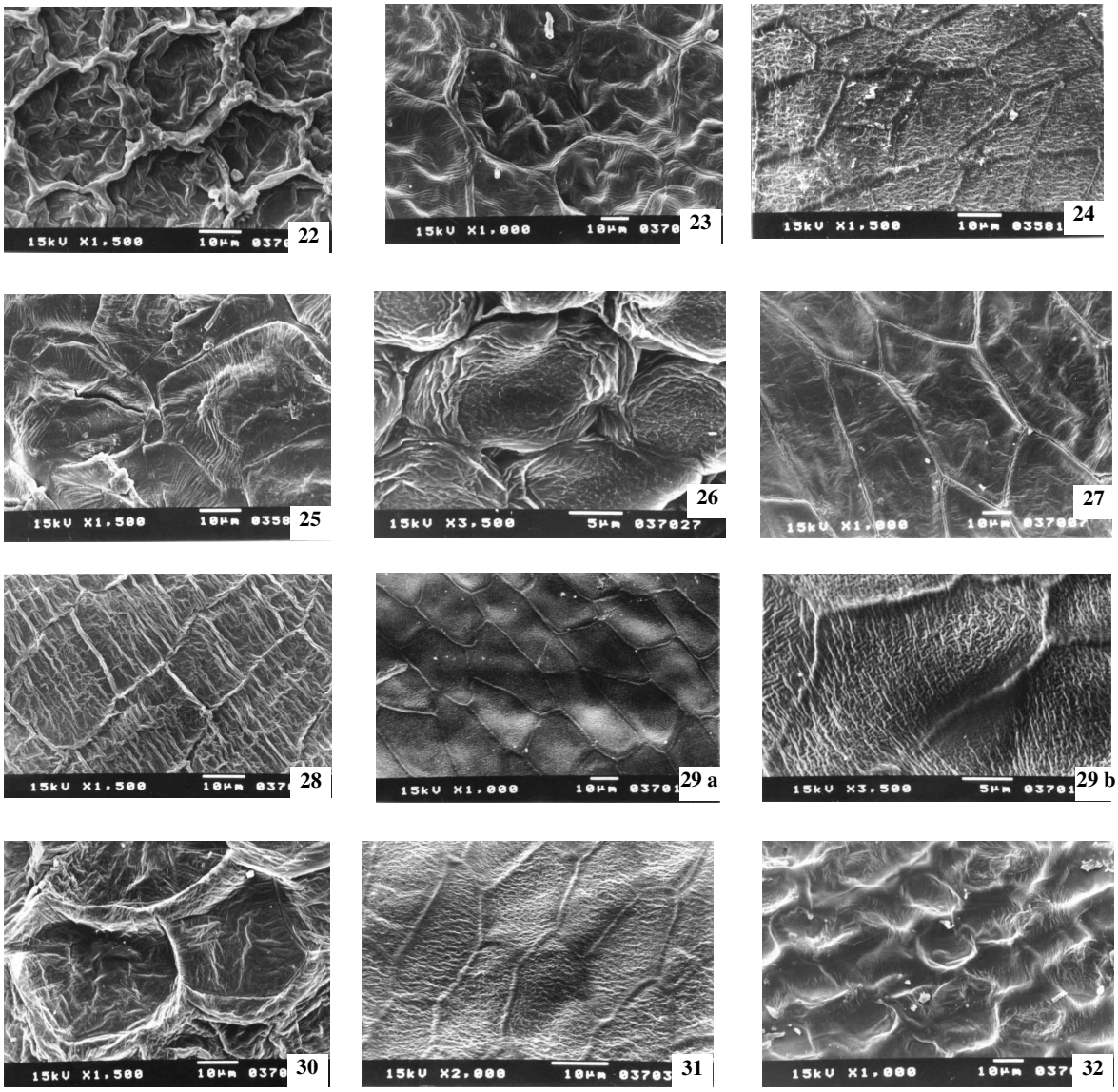

Figure A (22-32). Scanning electron micrographs of the seed surface of the studied Taxa.

22: Plantago holosteum (x1500). 23: Plantago lagopus (x1000).

24: Plantago lanceolata (x1500). 25:Plantago major (x1500).

26: Plantago maritima (x3500). 27:Plantago maxima (x1000).

28: Plantago ovata (x1500). 29: (a&b)Plantago patagonica (x1000&x3500).

30: Plantago salsa (x1500). 31: Plantago saxatilis (x2000).

32: Plantago sempervirens (x1000).

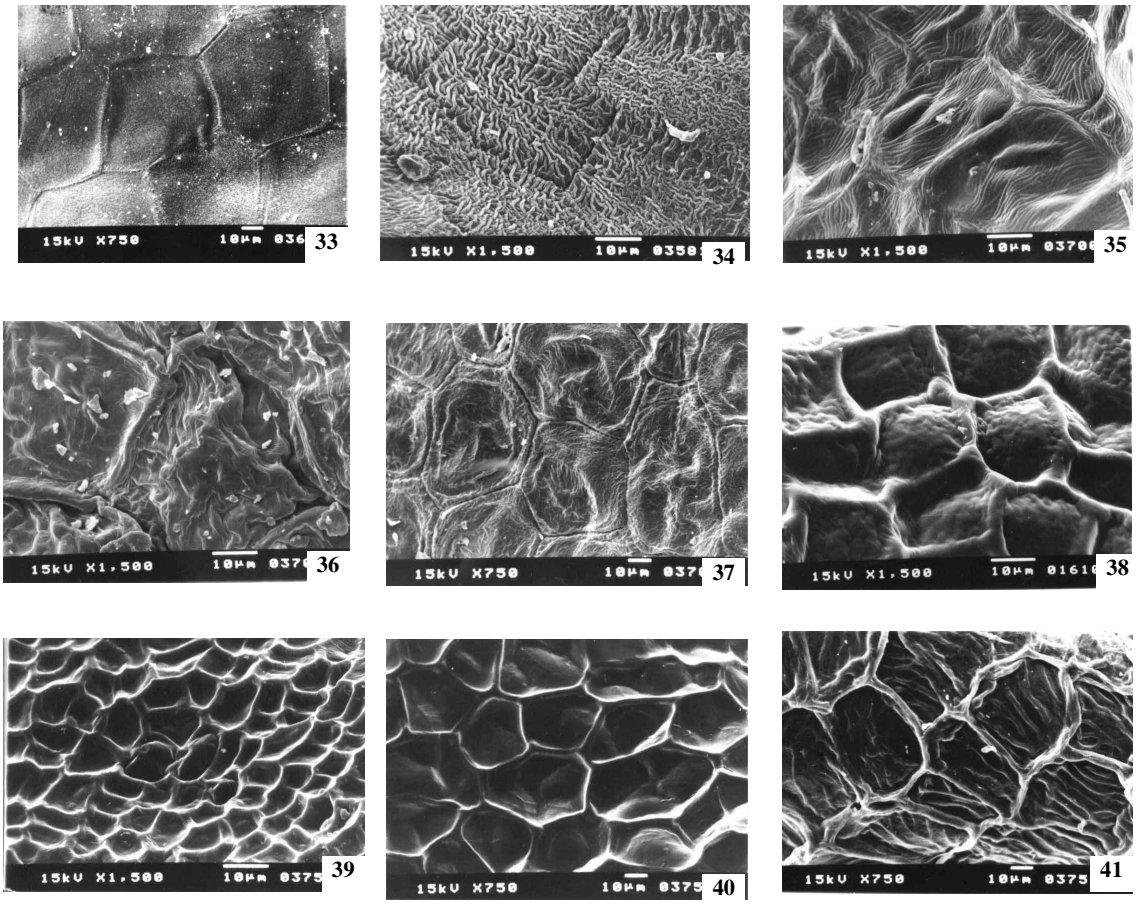

Figure A (33-41). Scanning electron micrographs of the seed surface of the studied Taxa.

33: Plantago sinaica (x750).

34: Plantago squarrosa (x1500).

35: Plantago stepposa (x1500).

36: Plantago tenuiflora (x1500).

37: Plantago triandra (x750).

38: Veronica anagallis aquatica (x1500).

39: Veronica officinalis (x1500).

40: Veronica scutellata (x750).

41: Veronica virginica (x750).

The previous aspects may thus favour the views held earlier by Hallier (1912) and Takhtajan (1980), who stated that the *Plantaginaceae* is very near to and perhaps derived from the *Scrophulariaceae*. Furthermore, this can give extra support to the recent views held by Olmstead et al. (1992a, 1992b, 1993), Olmstead & Reeves (1995), Judd et al. (1999) and APG (2003), who stressed the monophyly of *Plantaginaceae sensu lato* (including the added genera of the *Scrophulariaceae*).

The most remarkable finding was the clustering of *Veronica virginica* L. (41) with *Plantago albicans* (8) and *P. alpina* (9) at the dissimilarity level of 0.68, due to their sharing the following attributes: reticulate overall seed coat pattern with angular to rounded cell walls, slightly undulate and raised anticlinal cell walls and more or less flat periclinal walls (Figure A-8,9). This relationship, although relatively weak, may support the earlier views of Warming (1913), and Wettstein (1935) who thought that the *Plantaginaceae* is allied to *Scrophulariaceae* through *Veronica,* which shows a typical tetramerous condition that arises by the suppression of the posterior sepal and by union of 2 posterior petals.

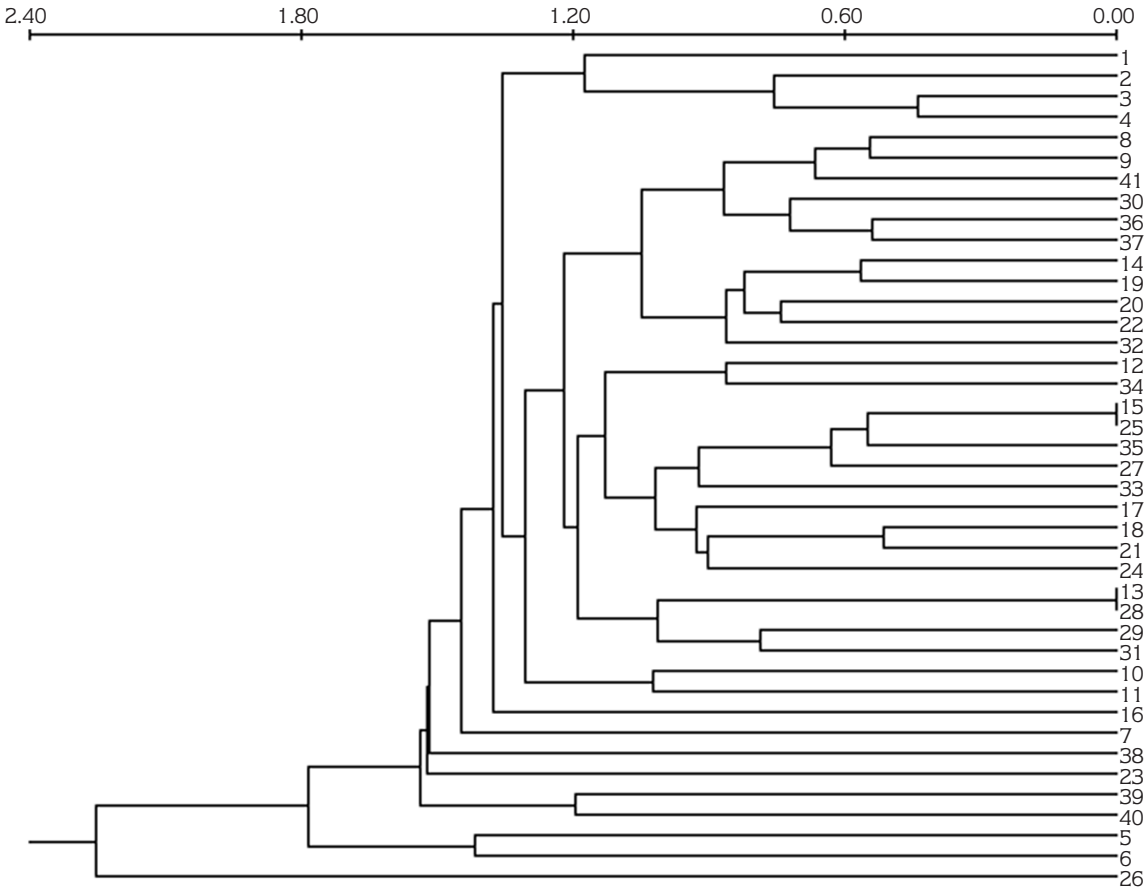

Figure B. UPGMA- Phenogram illustrating the similarities between the studied taxa based on the coding of 41 character states belonging to 8 characters from the SEM of the seed coat.

ii) Concerning the studied taxa of *Plantago* (Table 2), a remarkable finding was the splitting of *P. maritima* L. (26) subgenus *Coronopus* from the rest of the studied taxa at the dissimilarity level of 2.34. This was due to its possessing a reticulate faveolate overall seed coat pattern with rounded cells and variable shaped channelled anticlinal walls and striate to ruminate periclinal walls. *Plantago alpina* (9), *P. crassifolia* (20) and *P. salsa* (30) were often considered either synonyms or subspecies of *P. maritima* L. In the present study *P. alpina* was clustered with *P. albicans* (8) subgenus *Albicans* at 0.57, *P. crassifolia* clustered with *P. holosteum* Scop. (22) subgenus *Coronopus* at the dissimilarity level of 0.7 and *P. salsa* clustered with *P. tenuifolia* (36) and *P. triandra* Berggr. (37) subgenus *Plantago* at the dissimilarity level of 0.73. *P. crassifolia* (20) differed from *P. maritima* (26) in its possessing a reticulate overall seed coat pattern with undulate cell shape, raised anticlinal walls and more or less flat ruminate periclinal walls, (Figure A 20, 26).

P. salsa (30) differed from *P. maritima* mainly by its possessing angular to rounded cells, with foveolariate periclinal walls (Figure A 30, 26).

Chater & Cartier (1976) stated that *P. maritima* is a highly variable taxon and that attempts to subdivide it have proved very difficult morphologically.

Thus, from the present study, we suggest the retention of *P. alpina, P. crassifolia* and *P. salsa* as distinct taxa. The same view can be suggested in the case of *P. camtschatica* (17). This taxon was considered a synonym of *P. major* (25). However, the former taxon was clustered with 3 taxa of the subgenus *Albicans,* i.e. *P. ciliata* Desf. (18), *P. cylindrical* Forssk. (21) and *P. lanceolata* L. (24), at the dissimilarity level of 0.98, while

Table 2. the infrageneric classification of the studied taxa of *Plantago*.

Taxa	Subgenera and sections (Pilger, 1937)	Subgenera and sections (Rahn, 1978)	Subgenera (Rahn, 1996)
Plantago afra	Psyllium sect. Psyllium	Psyllium sect. Lanceifolia	Albicans
Plantago albicans	Plantago sect. Leucopsyllium	Psyllium sect. Albicans	Albicans
Plantago alpina	Plantago sect. Coronopus	Coronopus sect. Coronopus	Coronopus
Plantago altissima	Plantago sect. Arnoglossum	Psyllium sect. Lanceifolia	Albicans
Plantago amplexicaulis	Plantago sect. Bauphula	Psyllium sect. Bauphula	Albicans
Plantago arborescens	Psyllium sect. Psyllium	Psyllium sect. Psyllium	Psyllium
Plantago arenaria	Psyllium sect. Psyllium	Psyllium sect. Psyllium	Psyllium
Plantago aschersonii	Plantago sect. Coronopus	Coronopus sect. Coronopus	Coronopus
Plantago australis	Plantago sect. Novorbis	Plantago sect. Novorbis	Plantago
Plantago bellardii	Plantago sect. Hymenopsyllium	Psyllium sect. Hymenopsyllium	Albicans
Plantago camtschatica = P. major	Plantago sect. Mesembrynia	Plantago sect. Mesembrynia	Plantago
Plantago ciliata	Plantago sect. Leucopsyllium	Psyllium sect. Albicans	Albicans
Plantago coronopus	Plantago sect. Coronopus	Coronopus sect. Coronopus	Coronopus
Plantago crassifolia	Plantago sect. Coronopus	Coronopus sect. Coronopus	Coronopus
Plantago cylindrica	Plantago sect. Leucopsyllium	Psyllium sect. Albicans	Albicans
Plantago holosteum	Plantago sect. Coronopus	Coronopus sect. Coronopus	Coronopus
Plantago lagopus	Plantago sect. Arnoglossum	Psyllium sect. Lanceifolia	Albicans
Plantago lanceolata	Plantago sect. Arnoglossum	Psyllium sect. Lanceifolia	Albicans
Plantago major	Plantago sect. Plantago	Plantago sect. Plantago	Plantago
Plantago maritima	Plantago sect. Coronopus	Coronopus sect. Maritima	Coronopus
Plantago maxima	Plantago sect. Lamprosantha	Plantago sect. Lamprosantha	Plantago
Plantago ovata	Plantago sect. Novorbis	Plantago sect. Novorbis	Plantago
Plantago patagonica	Plantago sect. Leucopsyllium	Plantago sect. Leucopsyllium	Albicans
Plantago salsa = P. maritima	Plantago sect. Coronopus	Coronopus sect. Maritima	Coronopus
Plantago saxatilis = P. atrata	Plantago sect. Oreades	Psyllium sect. Montana	Albicans
Plantago sempervirens	Psyllium sect. Psyllium	Plantago sect. Oliganthos	Plantago
Plantago sinaica	Psyllium sect. Psyllium	Psyllium sect. Psyllium	Psyllium
Plantago squarrosa	Psyllium sect. Psyllium	Psyllium sect. Psyllium	Psyllium
Plantago stepposa	Plantago	*	*
Plantago tenuiflora	Plantago sect. Micropsyllium	Plantago sect. Micropsyllium	Plantago
Plantago triandra	Plantago sect. Microcalyx	Plantago sect. Microcalyx	Plantago

* Data on this taxon could not be traced in the presented classificatory systems.

P. major (25) showed a marked similarity to *P. australis* Lam. (15). Both taxa were clustered at the dissimilarity level of only 0.01.

Concerning the subgenus *Psyllium*, another marked similarity was observed between *P. arenaria* Waldst. and *P. ovata* Forssk. (28) subgenus *Plantago*. Both taxa were clustered at the dissimilarity level of only 0.01. However, the scattering of taxa belonging to the subgenus *Albicans* (8, 18, 21, 29, 31, 10, 11, 16, 7) across the phenogram and their similarities to other subgenera of *Plantago* can give extra evidence to Ronsted et al. (2002), who stated that the results of chemical and molecular studies have

shown that the subgenus *Albicans* (*sensu* Rahn, 1996) may be paraphyletic.

Finally, this investigation is preliminary and more material and additional criteria need to be investigated in order to achieve more concrete results about the reliability of transferring certain genera of *Scrophulariaceae* to *Plantaginaceae* or to throw more light on the infrageneric classification of *Plantago.*

Acknowledgements

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Appendix List of the investigated taxa and their sources.

	Taxa	Source
1-	*Antirrhinum majus* L.	Horticultural species, Botanic Garden, Faculty of Science, Alexandria University.
2-	*Digitalis lanata* Ehrh.	Gene bank der Bundesanstalt für Zuchtungsforschung an kulturpflanzen sammlung Pflanzengenetischer Ressourcen, Braunschewing , Germany.
3-	*Digitalis lutea* L.	Gene bank der Bundesanstalt für Zuchtungsforschung an kulturpflanzen sammlung Pflanzengenetischer Ressourcen, Braunschewing , Germany.
4-	*Digitalis parviflora* Jacq.	Gene bank der Bundesanstalt für Zuchtungsforschung an kulturpflanzen sammlung Pflanzengenetischer Ressourcen, Braunschewing , Germany.
5-	*Linaria purpurea* (L.) Mill.	Botanischer Garten der Universität Bonn, Germany.
6-	*Linaria tenuis* (Viv.) Spreng.	Desert Research, Center, Cairo, Egypt.
7-	*Plantago afra* L., = *P. psyllium* L.	Gebel Elba, Eastern desert Egypt.
8-	*Plantago albicans* L.	Eastern Mediterranean Coastal Region, Egypt.
9-	*Plantago alpina* L. = *P. maritima* subsp. *alpina* (L.)	Göttingen University, Germany.
10-	*Plantago altissima* L. = *P. lanceolata* L.	Institut Fur Botanik Botanischer Garten der Universität Innsbruck, Austria.
11-	*Plantago amplexicaulis* Cav. (= *P. bauphula* Edgew. Hook.)	Gatard Jean luc les Ouzinieres, Reamur, France.
12-	*Plantago arborescens* Poir	Hortus Botanicus, Coimbra-Portugal.
13-	*Plantago arenaria* Waldst. = *P. indica* L. = *P. psyllium* L.	Botanischer Garten der Universität Strabe, Germany.
14-	*Plantago aschersonii* Bolle	Jardin de Aclimatacion, Puerto De La Cruz – Tenerife – Spain.
15-	*Plantago australis* Lam.	Orto Botanico Dell'universita Di Padova – Italy.
16-	*Plantago bellardii* L.	Hortus Botanicus, Coimbra-Portugal.
17-	*Plantago camtschatica* Link.= *P. major* L.	Tsukuba Medicinal Plant Research Station National Institute of Hygienic Sciences, Tsukuba, Japan.

Appendix (Contunued).

	Taxa	Source
18-	*Plantago ciliata* Desf.,	El Arish, Sinai, Egypt.
19-	*Plantago coronopus* L.	Botanischer Garten der Universität Oldenburg, Germany.
20-	*Plantago crassifolia* Forssk .= *P. maritima* L. subsp. *crassifolia* (Forssk.) Holmboe.	Orto Botanico Dell'universita Di Padova – Italy.
21-	*Plantago cylindrica* Forssk.	El Omayed region (80 k. west of Alexandria), Egypt.
22-	*Plantago holosteum* Scop. = *P. subulata* subsp. *holosteum* (Scop.) O. de Bolos & J.Vigo.	Botanischer Garten der Universität Doberaner Strabe, Germany.
23-	*Plantago lagopus* L. = *P. lusitanica* L.	Burg El Arab region, Alexandria, Egypt.
24-	*Plantago lanceolata* L.	Institute für Botanik, Botanischer Garten der Universität Innsbruck, Austria.
25-	*Plantago major* L. = *P. intermedia* Gilib. = *P. major* L.subsp. *Intermedia* (Gilib.) Lange	Western Mediterranean Coastal Region, Egypt.
26-	*Plantago maritima* L. = *P. dentata* Roth.	Orto Botanico Dell'universita Di Padova – Italy.
27-	*Plantago maxima* Juss.	Hortus Botanicus, Coimbra-Portugal.
28-	*Plantago ovata* Forssk.= *P. decumbens* Forssk.	Nile Delta, Egypt.
29-	*Plantago patagonica* Jacq.	Gatard Jean luc les Ouzinieres, Reamur France.
30-	*Plantago salsa* Pall. = *P. maritima* L.	Orto Botanico Dell'universita Di Padova – Italy.
31-	*Plantago saxatilis* M. = *P. atrata* Hoppe	Gatard Jean luc les Ouzinieres, Reamur, France.
32-	*Plantago sempervirens* Crantz = *P. cynops* L.	Botanischer Garten der Universität Bonn, Germany.
33-	*Plantago sinaica* [Barn] Decne = *P. arabica* Boiss. = *P. psyllium* L. var. *sinaica* Barn. = *Psyllium sinaicum* (Barn.) Holub.	Sinai proper., Egypt.
34-	*Plantago squarrosa* Murray. = *P. aegyptiaca* Jacq.	Nile Delta region, Egypt.
35-	*Plantago stepposa* Kuprian	Gatard Jean luc les Ouzinieres, Reamur, France.
36-	*Plantago tenuiflora* Waldst. & Kit.	Gatard Jean luc les Ouzinieres, Reamur, France.
37-	*Plantago triandra* Berggr.	Gatard Jean luc les Ouzinieres, Reamur, France.
38-	*Veronica anagallis* aquatica L.	Desert Research, Center, Cairo, Egypt.
39-	*Veronica officinalis* L.	Botanischer Garten der Universität Bonn, Germany.
40-	*Veronica scutellata* L.	Botanischer Garten der Universität Bonn, Germany.
41-	*Veronica virginica* L.	Botanischer Garten der Universität Bonn, Germany.

Voucher specimens are kept at the Botany Department, Faculty of Science, Alexandria University.

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