Faculty of Science
Botany Department

Taxonomic study on Plantaginaceae Juss. and some related taxa

A Thesis Submitted for the Degree of Master of Science
in Botany (Taxonomy of Flowering Plants)

By

Nareman Kamal Hosney

B.Sc. (2009)

Supervisors

Prof. Dr. Karima Abd-Elkhelk Hamed
(Professor of Plant Taxonomy)
Botany Department, Faculty of Science, Ain Shams University

Dr. Soad Abd-Allah Hassan
(Assistant Professor of Plant Taxonomy)
Botany Department, Faculty of Science, Ain Shams University

Dr. Alsafa Hassan Mohamed Hussein
(Lecturer of Plant Taxonomy)
Botany Department, Faculty of Science, Ain Shams University

(2014)

Declaration

This thesis has not been submitted for a degree of this or any other University.

Nareman Kamal Hosney

Dedication

I dedicate this work to

My parents

My lovely sister

For their supporting and encouraging during all my life, thanks for being here for me.

Nareman Kamal

Acknowledgements

First of all, I am grateful to **Allah**, the most beneficent and most merciful. I would like to express my sincere gratitude to **Prof. Karima Abd-ElKhelk Hamed** Professor of Plant Taxonomy, Botany Department, Faculty of Science, Ain Shams University for her kind supervision, advice and sincere efforts throughout this work.

I am indebted to **Dr. Soad Abdallah Hassan** Assistant professor of Plant Taxonomy, Botany Department, Faculty of Science, Ain Shams University for her help, valuable guidance and assistance towards the completion of this work.

I acknowledge with all the thanks **Dr. Alsafa Hassan Mohamed Hussein** Lecturer of Plant Taxonomy, Botany Department, Faculty of Science, Ain Shams University for her encouragement and support on the academic and personal level.

Many thanks to **Prof. Mohamed El-Sayed Tantawy**, Head of Botany Department for offering his generous support.

Many thanks to the Regional Centre of Mycology and Biotechnology, El-Azhar University, Cairo.

Special thanks to the staff members and colleagues of the Botany Department, Faculty of Science, Ain Shams University.

I am heartily thankful to all the staff members in the Taxonomy Unit, Botany Department, Faculty of Science, Ain Shams University.

Finally, I place on record my gratefulness to my colleagues **Mariam Ibrahim**, **Salma Said** and **Mohamed Abd El-Fatah** because they were there for me by all means. They gave me advice whenever required and were constantly there for help.

Abstract

The traditional Plantaginaceae *s.s.* includes three genera (*Plantago* L., *Littorella* L., *Bougueria* L.) or sometimes accepted as a monogeneric family with only *Plantago*. Recently, Plantaginaceae *s.l.* has received some Scrophulariaceous genera.

This study on six *Plantago* species as representatives of Plantaginaceae as well as 12 taxa representatives to Scrophulariaceae was carried out to accept or refuse the transferring of the latter genera. The criteria for this purpose are taken from studying their macro-, micromorphological characters as well as the palynological characters using both light and scanning electron microscope.

The resulted data were analyzed numerically by NTSYS-pc program package using the UPGMA clustering method to indicate the relationships among the studied taxa. Three dendrograms were obtained based on macro-, micromorphological and palynological characters, and a fourth one represents a combination of the criteria obtained from the previous characters.

The most obvious finding from the results of the three dendrograms; based on macromorphological, palynological and the fourth one (combined) revealed the isolation of the six studied *Plantago* species in a separate monogeneric family (Plantaginaceae *s.s.*) away from the other remaining 12 taxa. This finding was congruent with earlier taxonomic view. On the other hand, only the micromorphological based dendrogram supports the transfer of the eight Scrophulariaceous taxa to the Plantaginaceae *s.l.* with the studied six *Plantago* species as recently assigned by **APG III (2009)**.

Keywords: Plantaginaceae, Scrophulariaceae, pollen grain sculpture.

Contents

Contents		Page
Scope of Thesis		1
Preface		3
Part 1: Introduction		
Section A: Historical Introduction		
I- Systematy		
a. Taxonomic history of Plantaginaceae		6
b. Taxonomic Position of Plantaginaceae and its related family Scrophulariaceae		8
c. Taxonomic position of studied genera according to different systems		16
II-Macromorphological characters		19
III-Micromorphological characters		22
IV-Palynological characters		23
Section B: Materials and Methods		
I. Materials		26
II. Methods		29
Part 2: Observations		
Section A: Macromorphological & Micromorphological characters		
Genus 1: *Anarrhinum*		
1	*A. pubescens*	36
Genus 2: *Antirrhinum*		
2	*Antirrhinum majus*	41
Genus 3: *Digitalis*		
3	*D. purpurea*	44

Genus 4: *Kickxia*		
4	*K. acerbiana*	48
5	*K. aegyptiaca*	51
Genus 5: *Linaria*		
6	*L. maroccana*	54
Genus 6: *Nemesia*		
7	*N. strumosa*	57
Genus 7: *Plantago*		
8	*P. albicans*	60
9	*P. crypsoides*	63
10	*P. lagopus*	66
11	*P. lanceolata*	70
12	*P. major*	74
13	*P. ovata*	78
Genus 8: *Russelia*		
14	*R. equisetiformis*	81
Genus 9: *Scrophularia*		
15	*S. deserti*	84
Genus 10: *Verbascum*		
16	*V. sinaiticum*	87
17	*V. sinuatum*	91
Genus 11:*Veronica*		
18	*V. anagallis–aquatica*	95
Section B: Palynological characters		98
Part 3: Results & Discussion		
I. Macromorphological characters and its numerical analysis		134
II. Micromorphological characters and its numerical analysis		156

III. Palynological characters and its numerical analysis	188
IV. Numerical analysis of combined data	206
Summery	210
References	214
Arabic summary	

List of Plates

Number	Title	Page
I	Macro- and Micromorphology of *Anarrhinum pubescens*	40
II	Macro- and Micromorphology of *Antirrhinum majus*	43
III	Macro- and Micromorphology of *Digitalis purpurea*	47
IV	Macro- and Micromorphology of *Kickxia acerbiana*	50
V	Macro- and Micromorphology of *K. aegyptiaca*	53
VI	Macro- and Micromorphology of *Linaria maroccana*	56
VII	Macro- and Micromorphology of *Nemesia strumosa*	59
VIII	Macro- and Micromorphology of *Plantago albicans*	62
IX	Macro- and Micromorphology of *P. crypsoides*	65
X	Macro- and Micromorphology of *P. lagopus*	69
XI	Macro- and Micromorphology of *P. lanceolata*	73
XII	Macro- and Micromorphology of *P. major*	77
XIII	Macro- and Micromorphology of *P. ovata*	80
XIV	Macro- and Micromorphology of *Russelia equesitifolia*.	83
XV	Macro- and Micromorphology of *Scrophularia deserti*	86
XVI	Macro- and Micromorphology of *Verbascum sinaiticum*	90
XVII	Macro- and Micromorphology of *V. sinuatum*	94
XVIII	Macro- and Micromorphology of *Veronica anagallis-aquatica*	97
XIX	Pollen morphology of *Anarrhinum pubescens*	99
XX	Pollen morphology of *Antirrhinum majus*	101
XXI	Pollen morphology of *Digitalis purpurea*	103
XXII	Pollen morphology of *Kickxia acerbiana*	105
XXIII	Pollen morphology of *K. aegyptiaca*	107

XXIV	Pollen morphology of *Linaria maroccana*	109
XXV	Pollen morphology of *Nemesia strumosa*	111
XXVI	Pollen morphology of *Plantago albicans*	113
XXVII	Pollen morphology of *P. crypsoides*	115
XXVIII	Pollen morphology of *P. lagopus*	117
XXIX	Pollen morphology of *P. lanceolata*	119
XXX	Pollen morphology of *P. major*	121
XXXI	Pollen morphology of *P. ovata*	123
XXXII	Pollen morphology of *Russelia equisetiformis*	125
XXXIII	Pollen morphology of *Scrophularia deserti*	127
XXXIV	Pollen morphology of *Verbascum sinaiticum*	129
XXXV	Pollen morphology of *V. sinuatum*	131
XXXVI	pollen morphology of *Veronica anagallis-aquatica*	133
XXXVII	Stem micrographs showing three outline aspects of stem	167
XXXVIII	Petiole micrographs showing three outline aspects of stem	168
XXXIX	Lamina micrographs showing five outline aspects of midrib	169
XXXX	Different types of trichomes	170
XXXXI	Different types of pollen classes	194
XXXXII	Different types of sculpturing	195

List of Tables

Number	Title	Page
1	List of the studied taxa and their localities	27
2	Types of shape classes of pollen grains	31
3	Data matrix of macromorphological characters for studied taxa	143
4	The relationships among the studied taxa based on numerical analysis of macromorphological characters	152
5	Data matrix of stem anatomical characters for studied taxa	172
6	Data matrix of petiole anatomical characters for studied taxa	176
7	Data matrix of lamina anatomical characters for studied taxa	178
8	The relationships among the studied taxa based on numerical analysis of micromorphological characters	184
9	Data matrix of palynological characters for studied taxa	197
10	The relationships among the studied taxa based on numerical analysis of palynological characters	202
11	The relationships among the studied taxa based on numerical analysis of combined data	208

List of Figures

Number	Title	Page
1	Dendrogram indicating the relationships among the studied taxa based on macromorphological characters analysis	151
2	Dendrogram indicating the relationships among the studied taxa based on micromorphological characters analysis	183
3	Dendrogram indicating the relationships among the studied taxa based on palynological characters analysis	201
4	Dendrogram indicating the relationships among the studied taxa based on combined data analysis	207

Scope of the thesis

Plantaginaceae is a cosmopolitan family distributed in temperate and tropical regions. The traditional Plantaginaceae *s.s.* includes three genera (*Plantago* L, *Littorella* L, *Bougueria* L) or sometimes accepted as a monogeneric family with only *Plantago.*

Recently, taxonomists have suggested different classifications to this family. Plantaginaceae *s.l.* has received a considerable attention as regards its position among the allied families particularly the Scrophulariaceae. Many genera that were formerly assigned to the Scrophulariaceae (*Antirrhinum, Digitalis, Linaria, Kickxia, Bacopa, Veronica*) are recently transferred to the Plantaginaceae.

Several studies have dealt with the Plantaginaceae *s.s.* while little ones performed on Plantaginaceae *s.l.* Thus, the subsequent objectives aimed to:

1. Investigation of the micro and macromorphological characters of the vegetative and reproductive parts of the studied taxa by using both light and scanning electron microscope (LM, SEM respectively).

2. Studying the palynological characters using LM and SEM to get the fine details.

3. Design cumulative tables, plates and figures to show the similarities and dissimilarities between the studied taxa.

4. Searching for the contribution of the macro-, micromorphological and palynological characters of the studied taxa in the process of taxa delimitation.

5. Determination of the degree of the affinity and interrelationships between the studied taxa through the application of a numerical analysis by applying various mathematical algorithms to numerically coded data for the different taxa to obtain a dendrogram, which would describe the taxonomic distance more efficiently.

6. Making of a comparative study of the proposed taxonomic treatment in this work versus different classification systems of Plantaginaceae.

Preface

Plantaginaceae is a cosmopolitan family represented by three genera *Plantago* L., *Littorella* L., *Bougueria* L. and about 275 species distributed in diverse habitats throughout the world (**Bentham 1846, 1876; Wettstein 1891; Bellini 1907; Dahlgren 1975; Cronquist 1981; Heywood 1993; Takhtajan 1997).** However, **Rahn (1996)** considered it as a monogeneric family with only *Plantago*.

Several authors stressed on the close relationship between Plantaginaceae and Scrophulariaceae **(Hallier 1912; Warming 1913; Wettstein 1935; Takhtajan 1980; Heywood 1993; Mabberley 1997).** Moreover in a classification presented by **APG III (2009)** the concept of Plantaginaceae was broadened to include many genera that were formerly assigned to Scrophulariaceae (e.g. *Anarrhinum, Antirrhinum, Digitalis, Kickxia, Linaria* and *Veronica*) based on molecular criteria **(Olmstead *et al.*, 1992a, 1992b, 1993; Olmstead & Reeves 1995; Wagstaff & Olmstead 1996).**

Reveal *et al.* (1999) made a proposal to name the expanded Plantaginaceae which includes Scrophulariaceae genera Antirrhinaceae or Veronicaceae to prevent confusion with the traditional Plantaginaceae, but Plantaginaceae the oldest conserved name had the priority according to International Code of Botanical Nomenclature (ICBN). Plantaginaceae *s.s.*is used to refer to the traditional family and Plantaginaceae *s.l.* refers to the family with the added genera from Scrophulariaceae.