بسم الله الرحمن الرحيم

∞∞∞

تم رفع هذه الرسالة بواسطة / مني مغربي أحمد

بقسم التوثيق الإلكتروني بمركز الشبكات وتكنولوجيا المعلومات دون أدنى مسئولية عن محتوى هذه الرسالة.

ملاحظات: لا يوجد

Botany Department

Mosses as Bioindicators of Spatial and Temporal Environmental Variations

A Thesis submitted for the degree of Doctor of Philosophy in Science in Botany

By

Mohamed Farag Abu Elhamd Ali

To
Department: Botany
Faculty of Science -Ain Shams University

Supervised by

Dr. Wagieh El-Sayed El-Saadawi

Emeritus Professor of Botany
Faculty of Science
Ain Shams University

Dr. Hanaa Mostafa Shabbara

Emeritus Professor of Bryology
Faculty of Science
Ain Shams University

Dr. Mahmoud Magdy Abdallah

Associate Professor of Genetics
Faculty of Agriculture
Ain Shams University

Dr. Olaf Franziskus Werner

Researcher of Molecular Systematics
Faculty of Biology
Murcia University-Spain

(2022)

Ph.D. Degree Supervisor's Signatures

Mosses as Bioindicators of Spatial and Temporal Environmental Variations

A Thesis submitted for the degree of Doctor of Philosophy in Science in Botany

By

Mohamed Farag Abu Elhamd Ali

To
Department: Botany
Faculty of Science -Ain Shams University

Supervised by

Dr. Wagieh El-Sayed El-Saadawi

Emeritus Professor of Botany
Faculty of Science
Ain Shams University

Dr. Hanaa Mostafa Shabbara

Emeritus Professor of Bryology
Faculty of Science
Ain Shams University

Dr. Mahmoud Magdy Abdallah

Associate Professor of Genetics
Faculty of Agriculture
Ain Shams University

Dr. Olaf Franziskus Werner

Researcher of Molecular Systematics
Faculty of Biology
Murcia University-Spain

(2022)

Ain Shams University

Validity of Ph.D. of Science Thesis in Botany

- **Student Name:** Mohamed Farag Abu Elhamd Ali
- **Title of Thesis:** Mosses as Bioindicators of Spatial and Temporal Environmental Variations
- **Degree:** Ph.D. of Science (Botany)
- **Supervisory Authority**

1. Prof. Dr. Wagieh El-Sayed El-Saadawi
2. Prof. Dr. Hanaa Mostafa Shabbara
3. Dr. Mahmoud Magdy Abdallah
4. Dr. Olaf Franziskus Werner

- **Members of the Judging Committee**

1.
2.
3.
4.

Data for the administration of postgraduate studies

- **Date of defense of the thesis: / /**
- **Department Council approval date: / /**
- **Date of approval of the Faculty Board: / /**
- **Date of approval of the University Council: / /**

Employee Signature **Director of Studies**
Department Signature

Faculty Secretary

كلية العلوم – ١١٥٦٦ شارع الخليفة المأمون – العباسية - القاهرة – جمهورية مصر العربية
Faculty of Science –University of Ain Shams- 11566 Abbassia – Cairo - Egypt

Declaration

This thesis has not been previously submitted for any degree at this or any other university. The references in the text will show specifically the extent to which I have availed myself of the work of other authors.

This work was a result of co-operation between three laboratories:

A. Archegoniatae Lab- Botany Department- Faculty of Science- Ain Shams University-Egypt.
B. Molecular Genetics Lab- Genetics Department- Faculty of Agriculture- Ain Shams University-Egypt.
C. Bryoflora, Biogeographic and Molecular Systematics Lab- Botany Department-Faculty of Biology- Murcia University-Spain.

This work was funded by culture affairs and scholar sector- High Education and Scientific Research Ministry as joint-supervision scholarship (2018-2020) between Ain Shams University and Murcia University.

Mohamed Farag

كلية العلوم – ١١٥٦٦ شارع الخليفة المأمون – العباسية - القاهرة – جمهورية مصر العربية
Faculty of Science –University of Ain Shams- 11566 Abbassia – Cairo - Egypt

Acknowledgements

First of all, the ultimate praise gratitude and thanks be to Allah for granting me the ability to accomplish this work.

I would like to express my deep thanks and gratitude to

Prof.Dr. Wagieh El-Saadawi for supervising this work, effort to facilitate its production and critical revision of the manuscript.

I am deeply grateful to Prof.Dr. Hanaa Shabbara, for supervising this work, valuable suggestions, encouragement during this work, her kind help and patience.

All the words of thanks to Dr. Mahmoud Magdy. He is an advisor, supervisor, friend, and brother. All credit goes to him to put my foot on this track of molecular analysis, and he has taught me all that I have now.

My appreciation and thanks are to Dr. Olaf Werner, for his guidance and supervision of the practical work in his laboratory for two years. His advice was amazingly effective in solving technical problems during the analysis of data

It was an honour for me to deal with Prof. Dr. Rosa Maria Ros, who is considered for me as the fifth supervisor on this thesis. I have learnt a lot from her experience. I am very appreciative of her huge effort with me in all paper works when I was under her supervision in Spain.

"I will always be in debt for their great help and support"

Thanks, and gratitude are to ex-Heads of Botany Department, Faculty of Science, Ain Shams University and Prof. Dr. Amal Ahmed Morsi - Head of Botany Department- for their support and continuous help during the period of my Ph.D.

كلية العلوم – ١١٥٦٦ شارع الخليفة المأمون – العباسية - القاهرة – جمهورية مصر العربية
Faculty of Science –University of Ain Shams- 11566 Abbassia – Cairo - Egypt

Special thanks are offered to my colleagues Dr. Manal Ibrahim, Dr. Sahar Ibrahim and Dr. Mai Taha, Mr. Ahmed Sherif in the faculty of Science, Ms. Hageer Hafny and Mr. Mostafa Nafe3 in the lab of genetics and Dr. Elena de la Cruz-Martínez in the lab at Murcia University. They shared with me the stages of this work, and always provided me with their useful assistance and continuous guidance throughout this work.

I wish to express my gratitude to the following people who generously contributed relevant literature and for their open discussions and help in this work: Dr. Abdulla Samy and Miss. Aliaa Mohamed (Faculty of Science, Ain Shams University) for their help in the revising of the part of species distribution modelling. I am very grateful to Dr. Yasmin Ibrahim (Lecturer-Faculty of Science- Suez Canal University) and Ms. Haidy Issac (Teaching assistant- Faculty of Education- Ain Shams University) for providing me with samples of Funaria hygrometrica from Ismailia and Beny Suef, respectively. Thanks continued to Eng. Ahmed Khalid (GIS solving problem engineer-ESRI) for teaching me the basics of GIS and maps editing. Thanks to all members of the Botany Department for their support, help and encouragement.

All my respectful gratitude is to my big family; my mother, father, brother, and sisters for their support through my life steps.

There are no words to express my thanks for my small family my lovely wife Randa and my daughters Habiba and Hanin and I apologize for leaving them two years during my scholarship.

Mohamed Farag

كلية العلوم – ١١٥٦٦ شارع الخليفة المأمون – العباسية - القاهرة – جمهورية مصر العربية
Faculty of Science –University of Ain Shams- 11566 Abbassia – Cairo - Egypt

List of Contents

List of Tables

List of Figures