

**PHENOTYPIC PLASTICITY OF MORPHO-ANATOMICAL  
CHARACTERS OF SELECTED PLANT SPECIES IN  
ADAPTATION TO RIPARIAN AND UPLAND ECOSYSTEMS.**

**BY**

**OLADIPO EBENEZER ADELEYE**

**B.Sc. (Ife)**

**A THESIS SUBMITTED TO THE DEPARTMENT OF BOTANY,  
FACULTY OF SCIENCE, OBAFEMI AWOLOWO UNIVERSITY,**

**ILE-IFE**

**IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE  
AWARD OF THE MASTER OF SCIENCE DEGREE (M.Sc.), BOTANY.**

**2015**

## CERTIFICATION

This is to certify that the research study was carried out by OLADIPO EBENEZER ADELEYE, SCP12/13/H/0509, as part of the requirement for the award of Master of Science degree in Botany of the Obafemi Awolowo University, Ile-Ife.

**DR. SAHEED S. ADEKILEKUN**  
**Name of Supervisor**

\_\_\_\_\_  
**Signature**

\_\_\_\_\_  
**Date**

**DR. E.A. FOLORUNSO**  
**Name Head of Department**

\_\_\_\_\_  
**Signature**

\_\_\_\_\_  
**Date**

**DEDICATION**

To JEHOVAH, the GOD ALMIGHTY, my wonderful parent and siblings.

OBAFEMI AWOLOWO UNIVERSITY

## ACKNOWLEDGEMENTS

I am forever indebted to my parents, Mr. and Mrs. Kayode Adeleye for their moral, financial and spiritual support over my life in making sure that I am refined and being the best among equals. I am confident to say, you are the best parent I can ever wish for. You are gods among men. Thank you for bringing me to the right path. I will never cease to appreciate you.

To the best supervisor, Dr. Sefiu Adekilekun Saheed, the man who saw gold in me when I was mere mud. Sir, I am sincerely grateful for the moral support, your words of encouragement, your constructive criticism and your corrections have all been pivotal in making the success I am today. To my beloved Pastor, Dr. Adewole Adedeji, thank you for the seasoned words of God, fatherly advice, spiritual and moral advice when I needed them most. I pray that the Lord God will continue to bless and enrich you and your ministry. Amen.

I am grateful to the following academic staff of the Department of Botany: Professors A. O. Isichei, J.I. Muoghalu, J.O. Faluyi, A.A. Adelusi, S.O. Oke, O. Adedeji, Drs. A.E. Folorunso, A.M. Makinde, A.I. Odiwe, O.T. Oladipo, F.A. Oloyede, A.M.A. Sakpere, M. Oziegbe, Messers B.E. Ayisire, A.Z. Ogbimi, D.S Akinyemi, Mrs. O.O. Arogundade, Mrs. A.O. Bolaji, Mrs. E.R. Ogbimi and Mrs. S.O. Azeez, God bless you all. I must not forget to appreciate the effort of the former curator, Mr. Ighanesebhor, who helped in the identification of most of the plant species and Mr. Bernard Omomoh who also took me to various locations for identification and collection of plant specimens. I appreciate the technical assistance rendered to me during the anatomical and photomicrography procedures by Mr. A.J. Akinloye, and the access granted me to use his personal office, may the Lord continue to support you. The effort of Mrs. Ighonor, Mrs. Ayeloja, Mrs. Shittu, Mr. Oladepo, Mr.

Ademoriyo, Mr. A. Omole and other administrative and technical staff of Department of Botany is highly appreciated.

I must not forget to appreciate the love shown by my colleagues in Botany Department with whom I crossed most of the academic hurdles. They are Mr. Idowu Johnson, Mr. Borisade Tolulope, Mr. Akinsulire Opeyemi, Mrs. Ajala Titilayo and Miss. Ogundare Folasade a.k.a. Afolly poyoyo and also to my friends who are too numerous to mention.

OBAFEMI AWOLOWO UNIVERSITY

## TABLE OF CONTENTS

	PAGES
Title Page	i
Certification	ii
Dedication	iii
Acknowledgements	iv
Table of Contents	vi
List of Plates	ix
List of Figures	x
List of Appendices	xii
List of Abbreviations	xiii
Abstract	ix
<b>CHAPTER ONE: INTRODUCTION</b>	<b>1</b>
1.1 Ecosystem	1
1.1.1 Riparian Ecosystem	1
1.1.2 Upland Ecosystem	2
1.2 Plasticity of Forms and Organs	3
1.3 Justification of The Study	4
1.4 Specific Objectives of The Study	4
1.5 Expected Contribution to Knowledge	4
<b>CHAPTER TWO: LITERATURE REVIEW</b>	<b>5</b>
2.1 History of The Ecozones	5
2.2 Vegetation of The Ecozones	5
2.3 Structural Adaptation of Plants to The Ecozones	7
<b>CHAPTER THREE: MATERIALS AND METHODS</b>	<b>10</b>

3.1	<b>Study Sites and Plant Collection</b>	10
3.2	<b>Plant Materials</b>	12
3.2.1	Morphological Studies	24
3.2.2	Anatomical Studies	24
3.2.2.1	Leaf Epidermal Studies	24
3.2.2.2	Transverse Section of the Leaf	25
3.2.2.3	Transverse Section of the Petiole	25
3.3	<b>Data Analysis</b>	25
<b>CHAPTER FOUR: RESULTS</b>		26
4.1	<b>Leaf Morphology</b>	26
4.1.1	Leaf Area	26
4.1.2	Petiole Length	28
4.2	<b>Leaf Anatomy</b>	30
4.2.1	Upper Cuticle	30
4.2.2	Upper Epidermis	33
4.2.3	Palisade Mesophyll	35
4.2.4	Spongy Mesophyll	37
4.2.5	Lower Epidermis	39
4.2.6	Lower Cuticle	41
4.3	<b>Petiole Anatomy</b>	43
4.3.1	Petiole Epidermis	43
4.3.2	Collenchyma	46
4.3.3	Parenchyma	48
4.3.4	Phloem	50
4.3.5	Xylem	52

4.3.6	Pith	54
4.3.7	Trichome	56
4.4	<b>Important Adaxial and Abaxial Epidermal Features</b>	58
4.4.1	Number of Stomata on Adaxial surface	59
4.4.2	Number of Stomata on Abaxial surface	61
4.4.3	Stomata Size on Adaxial surface	63
4.4.4	Stomata Size on Abaxial surface	65
4.4.5	Number of Epidermal cell on the Adaxial surface	67
4.4.6	Number of Epidermal Cell on the Abaxial surface	69
4.4.7	Epidermal Cell Length on Adaxial surface	71
4.4.8	Epidermal Cell Length on Abaxial surface	73
4.4.9	Epidermal Cell Width on Adaxial surface	75
4.4.10	Epidermal Cell Width on Abaxial surface	77
4.4.11	Number of Trichomes on the Adaxial epidermis	79
4.4.12	Number of Trichomes on the Abaxial epidermis	81
4.4.13	Trichome Length on Adaxial epidermis	83
4.4.14	Trichome Length on Abaxial epidermis	85
4.4.15	Trichome Width on Adaxial epidermis	87
4.4.16	Trichom Width on Abaxial epidermis	89
<b>CHAPTER FIVE:</b>	<b>DISCUSSION</b>	91
<b>REFERENCES</b>		100



LIST OF PLATES

PLATES	Pages
1 (A); Habit of <i>Celtis zenkeri</i>	13
(B); Habit of <i>Funtumia elastica</i>	13
2 (A); Habit of <i>Holarrhena floribunda</i>	15
(B); Habit of <i>Rauvolfia vomitoria</i>	15
3 (A); Habit of <i>Alchorne acordifolia</i>	17
(B); Habit of <i>Chromolaena odorata</i>	17
4 (A); Habit of <i>Cnestis ferruginea</i>	18
(B); Habit of <i>Hedranthera barteri</i>	18
5 (A); Habit of <i>Icacina trichantha</i>	20
(B); Habit of <i>Rothmannia longiflora</i>	20
(C); Habit of <i>Sphenocentrum jollyanum</i>	20
6 (A); Habit of <i>Asystasia gangetica</i>	22
(B); Habit of <i>Emilia coccinea</i>	22
7 (A); Habit of <i>Guyonia ciliata</i>	23
(B); Habit of <i>Synedrella nodiflora</i>	23
8 Transverse section of <i>Sphenocentrum jollyanum</i> leaf showing the area measured	31
9 Transverse section of <i>Alchornea cordifolia</i> petiole showing the area measured	44
10 (A); Epidermal peel of <i>Holarrhena floribunda</i> showing epidermal cell length and epidermal cell width	59
(B); Epidermal peel of <i>Funtumia elastica</i> showing stomata size	59
(C); Epidermal peel of <i>Celtis zenkeri</i> showing trichome	59

LIST OF FIGURES

Figures	Pages
1 Map of Obafemi Awolowo University Senior Staff Quarters showing the sampling locations	11
2 Mean leaf area of the species studied	27
3 Mean petiole length of the species studied	29
4 Mean upper cuticle thickness of the species studied	32
5 Mean upper epidermal thickness of the species studied	34
6 Mean palisade parenchyma thickness of the species studied	36
7 Mean spongy parenchyma thickness of the species studied	38
8 Mean lower epidermal thickness of the species studied	40
9 Mean lower cuticle thickness of the species studied	42
10 Mean petiole epidermal thickness of the species studied	45
11 Mean collenchyma thickness of the petiole of the species studied	47
12 Mean parenchyma thickness of the petiole of the species studied	49
13 Mean phloem thickness of the petiole of the species studied	51
14 Mean xylem thickness of the petiole of the species studied	53
15 Mean petiole pith diameter of the species studied	55
16 Mean petiole trichome length of the species studied	57
17 Mean stomata number on the adaxial surface of the species studied	60
18 Mean stomata number on the abaxial surface of the species studied	62
19 Mean stomata size on the adaxial surface of the species studied	64
20 Mean stomata size on the abaxial surface of the species studied	66
21 Mean epidermal cell number on the adaxial surface of the species studied	68
22 Mean epidermal cell number on the abaxial surface of the species studied	70

23	Mean epidermal cell length on the adaxial surface of the species studied	72
24	Mean epidermal cell length on the abaxial surface of the species studied	74
25	Mean epidermal cell width on the adaxial surface of the species studied	76
26	Mean epidermal cell width on the abaxial surface of the species studied	78
27	Mean trichome number on the adaxial surface of the species studied	80
28	Mean trichome number on the abaxial surface of the species studied	82
29	Mean trichome length on the adaxial surface of the species studied	84
30	Mean trichome length on the abaxial surface of the species studied	86
31	Mean trichome width on the adaxial surface of the species studied	88
32	Mean trichome width on the abaxial surface of the species studied	90

**LIST OF APPENDICES**

Appendix		Pages
I	Summary of important leaf morphological features studied	115
II	Summary of important anatomical features of the leaf studied	116
III	Summary of important anatomical features of the petiole studied	117
IV	Summary of important adaxial epidermal features in the leaves of plant species studied.	118
V	Summary of important abaxial epidermal features in the leaves of plant species studied.	119

**LIST OF ABBREVIATIONS**

Abbreviation	Meaning
cm	Centimetre
cm <sup>2</sup>	Squared centimetre
µm	Micrometre
µm <sup>2</sup>	Square micrometre
g	Gram
ECL	Epidermal cell length
ECW	Epidermal cell width
SS	Stomata size
UEP	Upper epidermis
PP	Palisade parenchyma
SP	Spongy parenchyma
LEP	Lower epidermis
C	Collenchyma thickness
E	Epidermal thickness
P	Parenchyma thickness
PH	Phloem thickness
XY	Xylem thickness
PT	Pith diameter
S.E	Standard error
TR	Trichome

## ABSTRACT

The study evaluated the foliar morphological and anatomical responses of fifteen plant species (four trees, seven shrubs and four herbs) having three different habits to two different ecosystems within Obafemi Awolowo University, Ile-Ife. The tree species studied were: *Celtis zenkeri* Engl.; *Funtumia elastica* (Preuss) Stapf.; *Holarrhena floribunda* (G. Don) T. Durand. and Schinz.; *Rauvolfia vomitoria* Afzel. The shrub species were: *Alchornea cordifolia* Mull. Arg.; *Chromolaena odorata* (L.) King and H.E. Robbins.; *Cnestis ferruginea* Vahl ex DC.; *Hedranthera barteri* (Hook. F.) Pichon.; *Icacina trichantha* Oliv.; *Rothmannia longiflora* Salisb.; *Sphenocentrum jollyanum* Pierre. The herbs were: *Asystasia gangetica* (L.) T. Anderson.; *Emilia coccinea* (Sims.) G. Don.; *Guyonia ciliata* Hook F. and *Synedrella nodiflora* (L.) J. Gaertner. This was with a view to providing explanation for the underlining mechanism behind these responses.

Exomorphological assessment was carried out on petiole length and leaf area using visual assessments. Anatomical evaluation was conducted on the leaf, petiole and epidermis following standard established protocols and using light microscopy. The epidermal features focused on stomata frequency and size, epidermal cell number, length and width, trichome frequency as well as their length and width. Other characters of leaf tissues investigated include; thickness of the cuticle, epidermis, spongy and palisade mesophyll, while petiole anatomical characters considered were thickness of the epidermis, collenchyma, parenchyma, phloem, and xylem cells along with pith diameter and trichome length.

The result revealed that most plant species showed significant ( $p < 0.05$ ) reduction in leaf area and petiole length from riparian to upland ecosystem. However, *Rauvolfia vomitoria*,

*Chromolaena odorata*, *Rothmannia longiflora*, *Guyonia ciliata* and *Synedrella nodiflora* showed some level of numerical decrease in petiole length but not significantly different ( $p < 0.05$ ) from riparian to upland ecozones. Foliar anatomical data revealed that stomata and trichome frequency, epidermal cell size significantly increased ( $p < 0.05$ ) from riparian to upland ecosystem for most of the species while number of epidermal cell, trichome and stomata size reduced significantly ( $p < 0.05$ ). In addition, significant increase ( $p < 0.05$ ) from the riparian to upland ecosystems occurs in cuticle thickness, epidermal cell, palisade and spongy mesophyll cells except for the lower cuticle. However, tissues of the petiole reduced significantly ( $p < 0.05$ ) from riparian to upland ecosystem except parenchyma cells.

The study concluded that *Funtumia elastica*, *Cnestis ferruginea* and *Synedrella nodiflora* were the most adapted to the two ecozones among all the species studied in trees, shrubs and herbs respectively. This study further established the usefulness of anatomical studies in explaining the mechanism underlining the observed morphological responses of plants to varying ecosystems specifically in riparian and upland ecosystems.

## CHAPTER ONE

### INTRODUCTION

#### 1.1 Background to the Study

##### Ecosystem

Ecosystem consists of all plants, animals and microorganisms (biotic factors) in an area functioning together with all the non-living physical (abiotic) factors of the environment (Christopherson, 1997). It is the entire assemblage of organisms living together in a certain space with their environment, this include an ecosystem called “riparian”. The term riparian is derived from the Latin word “*riparius*” which means stream bank. It was initially used in the United States in the early 1800’s as a legal term (Klett, 2002). Riparian ecosystem is one of the biosphere’s most complex ecological systems but also one of the most important for maintaining the vitality of landscape and its rivers (Naiman and DeCamps, 1997). Riparian sites are systems with a high water table because of proximity to an aquatic site or subsurface water and have distinct vegetation and soil characteristics (Poff *et al.*, 2011). These sites are not only unique because they have high species diversity and densities as well as high productivity. They also allow for continuous interactions to occur between riparian, aquatic, and upland terrestrial sites through exchanges of energy, nutrients, and species (Johnson and McCormick, 1978). Riparian systems can also be defined as the interface between aquatic and terrestrial sites that occur along rivers and creeks (Johansen and Phinn, 2006). Riparian zones can extend to the limit of river margin when flooded, and its vegetation plays an important role in the ecological balance of river sites (Muller, 1997).

##### 1.1.1 Riparian Ecosystem



Riparian forests are among the most biologically diverse portions of the terrestrial landscape and they provide numerous benefits to stream and terrestrial habitat (Salo and Cundy, 1987; Naiman *et al.*, 1993; Nilsson *et al.*, 1994; Pollock *et al.*, 1998). Among these important benefits are regulation of input within the stream network of large wood, fine organic material, nutrients, sediment, water and thermal energy (Chan *et al.*, 2004). Riparian communities typically consist of one or more deciduous tree species with an assorted understorey of shrubs and herbs (Holland and Keil, 1995). The transition between riparian habitats and adjacent non-riparian habitats often is abrupt, especially in montane areas where the topography is steep (Grenfell, 1988). Riparian communities are most often recognized as ribbons of green vegetation along a permanent supply of water or a stream as it flows through agricultural fields and down through ravines and valleys to eventually join a major river system (Naiman *et al.*, 1993). Riparian forest sites occupy a transition zone which is distinguished from the upland areas by a difference in topography, soils and hydrologic regime. This zone stretches from the waters' edge up through the adjoining floodplain (Smith and Hellmund, 1993).

### 1.1.2 Upland Ecosystem

Upland forests consist of vegetation types commonly thought of as prototypical forests, which excludes wetland forests types such as swamps (NRI, 2007). Uplands often comprise more than 99% of the watershed's area, with the floodplain and stream channel making up the rest (BCMF, 2002). Uplands are associated with lowlands through the flow of water, either overland or through the soil. Vegetation slows the flow of water in the uplands so that it infiltrates the soil. Upland forest also contains a diverse assemblage composed of various subgroups based on height and strata (BCMF, 2002). Riparian and adjacent upland sites often contrast conspicuously in physical condition, disturbance regime and vegetation pattern (Brinson, 1990; Naiman *et al.*,

1993, Wajirou *et al.*, 2002). In riparian forests, the soil is usually mesic or wet, and a fluvial floodplain is formed by debris of coarse textures with or without organic soil, while the upland has deep organic soil which is slightly dry or moderately moist (Wajirou *et al.*, 2002). The natural disturbance regimes in both sites are also different; multiple natural disturbance regimes, such as flooding, debris torrents, channel migration and landslides as well as tree-falls occur in riparian areas, while only tree-falls take place in uplands (Gregory *et al.*, 1991; Naiman *et al.*, 1993, Wajirou *et al.*, 2002) and as a result, plants in these sites adapt to these varying natural disturbance regimes.

## 1.2 Plasticity of Forms and Organs

Plasticity of forms and organs is one of the ways by which plants show adaptation to heterogeneous or changes in environments. Plant morphological plasticity therefore enables a plant to change its growth pattern as it encounters different stresses (Guo *et al.*, 2007). It has been noted over the years that anatomical and morphological characters may serve as reliable indicators in the study and understanding genetic relationships, physiological processes and ecological adaptations of living organisms (Fahn, 1964; Hlwatika and Bhat, 2002). Individual plants can respond to the environment in two ways: in the short-term they can respond via morphological, physiological and biochemical changes (Bradshaw, 1965), while in the long-term, plant populations respond by changing their genetic composition (Hlwatika and Bhat, 2002). Phenotypic plasticity is defined as the ability of an organism to express different phenotypes with respect to different environments (Agrawal, 2001; Garland and Kelly, 2006). It may take the form of a flexible behaviour that changes over a few seconds or a developmental switch that permanently affects the adult form.

It is important to note that among the organs of the plant that shows a high level of plasticity of forms and structures is the leaf. This is because the leaf structural features which determined the plasticity of forms are associated with the amount of sunlight exposure (Abrams and Kubiske, 1990), or the water available in the habitat (Fahn and Cutler, 1992). According to Passioura (1976), the control of leaf area and morphology is the most powerful means by which a mesophytic plant can influence its fate when subjected to long-term water stress in the field.

OBAFEMI AWOLowo UNIVERSITY

OBAFEMI AWOLowo UNIVERSITY