DOCTOR OF PHILOSOPHY

Medicinal plant resources with special reference to Pterocarpus Tinctorius and Strychnos Spinosa at Urumwa, Tabora region, Tanzania

Augustino, Suzana

Award date:
2006

Awarding institution:
University of Wales, Bangor

MEDICINAL PLANT RESOURCES WITH SPECIAL REFERENCE TO *PTEROCARPUS TINCTORIUS* AND *STRYCHNOS SPINOSA* AT URUMWA, TABORA REGION, TANZANIA

SUZANA AUGUSTINO

B.Sc. & M.Sc. (FOR.),

(SOKOINE UNIVERSITY OF AGRICULTURE, TANZANIA)

A THESIS SUBMITTED IN FULFILLMENT FOR THE PHILOSOPHIAE DOCTORAL DEGREE AT THE UNIVERSITY OF WALES, BANGOR

SCHOOL OF ENVIRONMENT AND NATURAL RESOURCES, UNIVERSITY OF WALES, BANGOR, UNITED KINGDOM

NOVEMBER 2006

DEDICATION

This thesis is dedicated to:

- ❖ My beloved parents whose contribution towards my success is invaluable. Dad Augustine, God bless you and,
- ❖ The memories of my mum Angelina, who passed away amid of my academic struggles in Bangor, UK. We miss you so much and pray that, your soul rest peacefully forever, in a specially prepared place. Amen!
- ❖ My husband Revo, whose encouragement, understanding, patience, moral support and willingness to share all the difficulties for the entire period of my study outside Tanzania will never be forgotten. Thank you very much and God bless us!
- ❖ Almighty God for keeping me alive, providing all the blessings, strength and guidance to accomplish my dream.

TABLE OF CONTENTS

DECLARATION i

DEDICATION ii

TABLE OF CONTENTS iii

LIST OF TABLES ix

LIST OF FIGURES xiii

LIST OF APPENDICES xvi

ABBREVIATIONS AND ACRONYMS xviii

GLOSSARY OF TERMS xxi

ABSTRACT xxiv

ACKNOWLEDGEMENTS xxv

CHAPTER I: GENERAL INTRODUCTION 1

1.1 Background 1

1.1.1 Tanzania forest resources and its significance 1

1.1.2 This study 6

1.1.2.1 Overall objectives 6

1.1.2.2 Specific objectives 7

1.1.3 Thesis organization 7

CHAPTER II: LITERATURE REVIEW AND STUDY AREA 8

2.1 Medicinal plants context 8

2.1.1 The use and importance 8

2.1.2 Medicinal plants and gender roles 10

2.1.3 Challenges and future prospects 11

2.2 Taxonomic and phytochemical review of the 'case study' species 13

2.2.1 *Pterocarpus tinctorius* Welw. 13

2.2.1.1 Taxonomic context 15

2.2.1.2 Phytochemical context 18

2.2.2 *Strychnos spinosa* Lam... 19

2.2.2.1 Taxonomic context 20

2.2.2.2 Phytochemical context 22

2.3 Study area description 23

2.3.1 Location... 23

2.3.2 Climate 25

2.3.3 Topography and drainage 26

2.3.4 Soil and vegetation 29

2.3.5 Socio-economic activities 29

CHAPTER III: MEDICINAL PLANT ETHNOBOTANY AND GENDER AT URUMWA 31

3.1 Background 31

3.1.1 Ethnobotany, gender and traditional medicine.................................. 31

3.1.2 Statement of purpose 33

3.2 Methods 33

3.2.1 Socio-economic, ethnobotanical and conservation awareness data 34

3.2.1.1 Survey rationale and framework 34

3.2.1.2 Data acquisition.. 35

Questionnaire survey 38

Participatory rural appraisal 39

3.2.1.3 Data processing and analysis 40

3.3 Results 41

3.3.1 Respondents' profile 41

3.3.2 Ethnobotanical knowledge 43

3.3.2.1 The ethnobotanical data set 43

3.3.2.2 Species reported to be used 43

3.3.2.3 Reported usage...44

3.3.2.4 Villages, respondent gender and plant uses 46

3.3.2.5 Most-reported species 48

Species x village 48

Species x respondent gender 49

Species x use sub-categories 54

Species x use categories 54

3.3.2.6 Similarity assessments based on reported species...................... 56

Village similarity 56

Gender similarity 56

Use category similarity 57

3.3.2.7 Application of practices 57

3.3.3 Community perceptions of responsibility 60

3.3.3.1 Perceptions in utilization 60

3.3.3.2 Perceptions in conservation 60

3.3.4 Conservation awareness and measures 63

3.3.4.1 Medicinal plants harvesting methods 63

3.3.4.2 Status of medicinal plants 64

3.3.4.3 Potential medicinal species 64

3.3.4.4 Threats to medicinal plants 65

3.3.4.5 Measures to conserve medicinal plants 67

3.3.4.6 Community views on conservation 67

3.4 Discussion 68

3.4.1 Medicinal plants ethnobotany and practices 68

3.4.2. Gender role perceptions in utilization ... 69

3.4.3 Gender role perceptions in conservation ... 70

3.4.4 Conservation awareness and views at Urumwa ... 72

CHAPTER IV: POPULATIONS STATUS OF THE 'CASE STUDY' SPECIES: *PTEROCARPUS TINCTORIUS* AND *STRYCHNOS SPINOSA* AT URUMWA 76

4.1 Background ... 76

4.1.1 Medicinal plants as wild resources ... 76

4.1.2 Tree population dynamics ... 77

4.1.3 The choice of target species ... 78

4.1.4 Statement of purpose ... 80

4.2 Data collection methods ... 80

4.2.1 Strategic approach ... 80

4.2.2 Sampling and recording ... 81

4.2.3 Data processing and analysis ... 82

4.3 Results ... 83

4.3.1 Population structure by diameters size-class ... 83

4.3.2 Nearest neighbour distances ... 84

4.3.3 Population density by size class ... 88

4.4 Discussion ... 90

CHAPTER V: BIOACTIVE COMPOUNDS IN *PTEROCARPUS TINCTORIUS* WITH SPECIAL REFERENCE TO ISOFLAVONOIDS ... 93

5.1 Background ... 93

5.2 Materials and methods ... 97

5.2.1 Sampling strategy ... 97

5.2.1.1 Plant selection and identification ... 97

5.2.1.2 Plant materials collection ... 97

5.2.1.3 Sample field treatment and processing ... 98

5.2.2 Laboratory procedures and data analysis 99
5.2.2.1 Chemicals and standards preparation 99
5.2.2.2 Plant materials preparations and extractions 99
5.2.2.3 Analytical procedures 100
HPLC/UV-VIS 100
HPLC-MS 101
5.2.2.4 Data generation 102
5.3 Results 103
5.3.1 Isoflavonoids in crude extracts 103
5.3.2 Isoflavonoids concentrations 110
5.3.3 Other compounds isolated from parts of *P. tinctorius* 111
5.4 Discussion 112
CHAPTER VI: BIOACTIVE COMPOUNDS IN *STRYCHNOS SPINOSA* WITH SPECIAL REFERENCE TO INDOLE ALKALOIDS 114
6.1 Background 114
6.2 Materials and methods 119
6.2.1 Sampling strategy 119
6.2.1.1 Plant selection and identification 119
6.2.1.2 Plant material collection 120
6.2.1.3 Sample field treatment and processing 120
6.2.2 Laboratory procedures and data analysis 121
6.2.1.1 Chemicals and standards preparations 121
6.2.2.2 Plant materials preparations and extractions 121
6.2.2.3 Analytical procedures 122
HPLC/UV-VIS 122
HPLC-MS 122

6.2.2.4 Data generation ... 123

6.3 Results ... 124

6.3.1 Strychnine and brucine in crude extracts ... 124

6.3.2 Indole alkaloids concentrations ... 128

6.3.3. Other compounds isolated from *S. spinosa* ... 128

6.4 Discussion ... 129

CHAPTER VII: GENERAL DISCUSSION ... 132

7.1 Ethnobotany and gender roles ... 132

7.2 Medicinal plant status in relation to utilization ... 133

7.3 Phytochemical potential of medicinal plants ... 135

CHAPTER VIII: CONCLUSIONS AND FUTURE DIRECTIONS ... 137

8.1 Conclusions ... 137

8.1.1 Medicinal plants knowledge ... 137

8.1.2 Gender roles in use and conservation of medicinal plants ... 137

8.1.3 Population status of 'case study' species ... 138

8.1.4 Phytochemical status of 'case study' species ... 139

8.2 Future directions ... 139

REFERENCES ... 141

REFERENCES TO APPENDIX VIa ... 174

REFERENCES TO APPENDIX VIb ... 180

REFERENCES TO APPENDIX VIIb ... 182

APPENDICES ... 194

LIST OF TABLES

Table		Page
1.1	Some medicinal plants pharmacologically screened by Institute of Traditional Medicine, Dar es salaam, Tanzania.	5
1.2	Other phytochemically screened plants with proved bioactivity in Tanzania.	6
2.1	Summary of infraspecific variation of *Pterocarpus tinctorius* in its ecological range.	12
2.2	Uses of *Pterocarpus tinctorius.*	12
3.1	Sampling scale used during ethnobotanical survey in villages around Urumwa Forest Reserve, Tabora Region, Tanzania.	37
3.2	Matrix of potential medicinal plant species at Urumwa Forest Reserve, Tabora Region, Tanzania.	40
3.3a	Frequency distribution of age and occupation of respondents at Urumwa, Tabora Region, Tanzania.	42
3.3b	Respondents education profiles around Urumwa Forest Reserve, Tabora Region, Tanzania.	43
3.4	Variation in numbers of records among medicinal plant use categories reported by 115 respondents at Urumwa Forest Reserve, Tabora Region, Tanzania.	45
3.5	Breakdown of ethnobotanical records from six villages around Urumwa Forest Reserve, Tanzania, by medicinal category, village and gender of respondent.	47
3.6	Top-ranked species for six villages – based on combined records per species across categories of use and gender at Urumwa Forest	50

Reserve, Tabora Region, Tanzania.

3.7 Key medicinal plants, use categories and sub-categories with records (combined for six villages) by gender for Urumwa Forest Reserve, Tabora Region, Tanzania. 51

3.8 Numbers of reports for most frequently reported species, by gender (villages and use categories combined), at Urumwa Forest Reserve, Tabora Region, Tanzania 53

3.9 Numbers of medicinal plants mentioned by men and women at Urumwa Forest Reserve, Tabora Region, Tanzania. 53

3.10 Numbers of reports for most frequently reported species, by medicinal plant use category (genders and villages combined), at Urumwa Forest Reserve, Tabora Region, Tanzania. 55

3.11 Sørensen indices of similarity for all pairs of villages (reported medicinal plant species represented only by single records excluded) at Urumwa Forest Reserve, Tabora Region, Tanzania. 56

3.12 Sørensen indices of similarity for all pairs of use categories (reported medicinal plant species represented only by single records excluded) at Urumwa Forest Reserve, Tabora Region, Tanzania. 57

3.13 Medicinal plant parts used for medicine by communities at Urumwa Forest Reserve, Tabora Region, Tanzania. 58

3.14 Plant remedies preparation methods in communities at Urumwa Forest Reserve, Tabora Region, Tanzania. 58

3.15 Forms of remedies used by communities around Urumwa Forest Reserve, Tabora Region, Tanzania. 59

3.16 Modes of administering remedies used by communities around Urumwa Forest Reserve, Tabora Region, Tanzania. 59

3.17 Dosage knowledge around Urumwa communities, Tabora Region, 60

Tanzania.

3.18 Community perceptions of gender roles in the utilization of medicinal plants at Urumwa Forest Reserve, Tabora Region, Tanzania. 61

3.19a Community perceptions of gender roles in conservation of medicinal plants at Urumwa Forest Reserve, Tabora Region, Tanzania. 62

3.19b Gendered respondent perceptions on adherence to JFM rules for accessing Urumwa Forest Reserve, Tabora Region, Tanzania. 63

3.20 Medicinal plants harvesting methods used in communities around Urumwa Forest Reserve, Tabora Region, Tanzania. 63

3.21 Potential ("priority") medicinal plants of Urumwa Forest Reserve, Tabora Region, Tanzania arranged according to their importance to the local communities. 66

3.22 Community views to promote conservation of medicinal plants at Urumwa Forest Reserve, Tabora Region, Tanzania. 68

3.23 Traditional medicine use, phytochemical and pharmacological evidences relevant to the identified priority medicinal species at Urumwa Forest Reserve, Tabora Region, Tanzania. 74

4.1 List of potentially targeted medicinal plants for study from Urumwa Forest Reserve, Tabora Region, Tanzania. 79

4.2 Diameter frequency of *Pterocarpus* tree by size class in sampled populations at Urumwa Forest Reserve, Tabora Region, Tanzania. 83

4.3 Diameter frequency of *Strychnos* tree by size class in sampled populations at Urumwa Forest Reserve, Tabora Region, Tanzania. 84

4.4 Proximity (m) of nearest conspecific neighbour for target species at Urumwa Forest Reserve, Tabora Region, Tanzania. 85

4.5	Per hectare *Pterocarpus* tree density by size class in sampled populations at Urumwa Forest Reserve, Tabora Region, Tanzania.	88
4.6	Per hectare *Strychnos* tree density by size class in sampled populations at Urumwa Forest Reserve, Tabora Region, Tanzania.	89
5.1	List of flavonoids and other compounds reported to occur in the genus *Pterocarpus.*	94
5.2	List of initially targeted compounds of interest for *Pterocarpus tinctorius* analysis.	96
5.3	Mean retention times of standard references versus plant extracts of *Pterocarpus tinctorius* from Urumwa Forest Reserve, Tanzania.	104
5.4	Other compounds isolated from leaves, stem bark and root bark of *Pterocarpus tinctorius* from Urumwa Forest Reserve, Tabora Region, Tanzania.	111
6.1	Indole alkaloids reported to occur in African members of section Spinosae and related sections of the genus *Strychnos.*	115
6.2	List of initially targeted compounds of interest for *Strychnos spinosa* analysis.	118
6.3	Mean retention times of standard reference compounds versus plant extracts of *Strychnos spinosa* from Urumwa Forest Reserve, Tabora Region, Tanzania.	125
6.4	Other compounds identified in stem bark and root bark extracts of *Strychnos spinosa* from Urumwa Forest Reserve, Tabora region, Tanzania.	129

LIST OF FIGURES

Figure		Page
1.1	The distribution of miombo woodlands in Tanzania (shaded area).	2
2.1	Map showing distribution of *Pterocarpus* species in the three geographical regions of the world.	17
2.2	Phylogenetic tree of the '*Pterocarpus* clade.'	18
2.3	Phylogenetic tree of the 'Loganiaceae clade.'	21
2.4	Structures of Strychnos alkaloid skeletons.	23
2.5a	Location of the study area in Tanzania.	24
2.5b	Map showing the surveyed and other villages bordering Urumwa Forest Reserve, Tabora Region, Tanzania.	25
2.6a	Climatic diagrams of three stations bordering Urumwa Forest Reserve, Tabora Region, Tanzania.	27
2.6b	Rainfall distributions of nine stations near Urumwa Forest Reserve, Tabora Region, Tanzania.	28
3.1	Diagrammatic summary of sampling strategy used for ethnobotanical survey in villages around Urumwa Forest Reserve, Tabora Region, Tanzania.	36
3.2	Distribution of records against species listed from communities around Urumwa Forest Reserve, Tanzania.	44
3.3	Distribution of sub-categories level against use sub-categories of plants from communities around Urumwa Forest Reserve, Tabora Region, Tanzania.	45
3.4	Community responses on the status of medicinal plants at Urumwa	64

Forest Reserve, Tabora Region, Tanzania.

3.5 Views on threats posed to medicinal plants at Urumwa Forest Reserve, Tabora Region, Tanzania. 65

3.6 Medicinal plants conservation measures in communities around Urumwa Forest Reserve, Tabora Region, Tanzania. 67

4.1a Distribution of *Pterocarpus tinctorius* in sampled area of North Walla I at Urumwa Forest Reserve, Tabora Region, Tanzania. 86

4.1b Distribution of *Pterocarpus tinctorius* in sampled area of North Walla II (a) and South Walla I (b) at Urumwa Forest Reserve, Tabora Region, Tanzania. 86

4.1c Distribution of *Pterocarpus tinctorius* in sampled area of south Walla II at Urumwa Forest Reserve, Tabora Region, Tanzania. 87

4.2a Distribution of *Strychnos spinosa* in sampled area of north Walla I at Urumwa Forest Reserve, Tabora Region, Tanzania. 87

4.2b Distribution of *Strychnos spinosa* in sampled area of North Walla II (a)- and South Walla I (b) at Urumwa Forest Reserve, Tabora Region, Tanzania. 87

4.3a Individual per hactare, by size class, all samples combined for *Pterocarpus tinctorius* at Urumwa Forest Reserve, Tabora Region, Tanzania. 89

4.3b Individual per hectare, by size class, all samples combined for *Strychnos spinosa* at Urumwa Forest Reserve, Tabora Region, Tanzania. 90

4.4 Some of the disturbances encountered inside Urumwa Forest Reserve, Tabora Region, Tanzania. 91

5.1 Structures of isoflavonoids analysed in parts of *Pterocarpus tinctorius*. 103

5.2a HPLC-UV/VIS chromatograms of standard formononetin versus methanolic plant extracts of *Pterocarpus tinctorius* from Urumwa Forest Reserve, Tanzania. 105

5.2b HPLC-UV/VIS chromatograms of standard genistein versus methanolic plant extracts of *Pterocarpus tinctorius* from Urumwa Forest Reserve, Tanzania. 106

5.2c HPLC-UV/VIS chromatograms of standard homopterocarpin versus methanolic plant extracts of *Pterocarpus tinctorius* from Urumwa Forest Reserve, Tanzania. 107

5.2d HPLC-UV/VIS chromatograms of standard prunetin versus methanolic plant extracts of *Pterocarpus tinctorius* from Urumwa Forest Reserve, Tanzania. 108

5.2e HPLC-UV/VIS chromatograms of standard vestitol versus methanolic plant extracts of *Pterocarpus tinctorius* from Urumwa Forest Reserve, Tanzania. 109

5.3 Mean isoflavonoid concentration in parts of *Pterocarpus tinctorius* from Urumwa Forest Reserve, Tabora Region, Tanzania. 110

6.1 Structures of indole alkaloids analysed in parts of *Strychnos spinosa*. 124

6.2a HPLC-UV/VIS chromatograms of strychnine and methanolic extracts of roots and barks of *Strychnos spinosa* from Urumwa forest reserve, Tabora region, Tanzania. 126

6.2b HPLC-UV/VIS chromatograms of brucine and methanolic extracts of roots and barks of *Strychnos spinosa* from Urumwa Forest Reserve, Tabora Region, Tanzania. 127

6.3 Mean concentrations of strychnine and brucine in *Strychnos spinosa* from Urumwa Forest Reserve, Tanzania. 128

LIST OF APPENDICES

Appendix		Page
Ia	PRA checklist used for survey of utilized medicinal plants from Urumwa Forest Reserve, Tabora Region, Tanzania.	195
Ib	Questionnaire survey on gender roles in utilization and conservation of medicinal plants from Urumwa Forest Reserve, Tabora Region, Tanzania.	196
Ic	Variables definition and coding applied to questions administered to communities around Urumwa Forest Reserve, Tabora Region, Tanzania.	207
IIa	List by frequency of reports, of medicinal plants species considered abundant at Urumwa Forest Reserve, Tabora Region, Tanzania.	209
IIb	List by frequency of reports, of medicinal plants considered scarce at Urumwa Forest Reserve, Tabora Region, Tanzania.	211
IIIa	Combined alphabetical list of medicinal plants with their vernacular names, family, part(s) used, habit, diseases/complications cured and application methods recorded from Urumwa Forest Reserve, Tabora Region, Tanzania.	212
IIIb	Alphabetical list of other utilized medicinal plants with their vernacular names, family, part(s) used, habit, diseases/complications cured and application methods recorded from outside* Urumwa Forest Reserve, Tabora Region, Tanzania.	220
IV	Alphabetical list of diseases and their respective medicinal plants as identified by male and female respondents in communities around Urumwa Forest Reserve, Tabora Region, Tanzania.	221

V	Inventory form used during medicinal plants species survey at Urumwa Forest Reserve, Tabora Region, Tanzania.	227
VIa	The flavonoids and alkaloids reported from *Pterocarpus* species and other members of the '*Pterocarpus* clade' with their medicinal application arranged according to their degree of closeness to *Pterocarpus tinctorius*.	228
VIb	Bioactivity of flavonoids and alkaloids reported from genus *Pterocarpus* Jacq. and other related genera of the '*Pterocarpus* clade.'	233
VIIa	Indole alkaloids reported to occur in African members of section Spinosae and related sections of genus *Strychnos*.	237
VIIb	The indole alkaloids and medicinal application reported from African *Strychnos* species and other members of 'Loganiaceae clade' grouped according to their degree of closeness to *Strychnos spinosa*.	239
VIIc	Bioactivity of indole alkaloids reported from genus *Strychnos* and other related genera of the 'Loganiaceae clade.'	258
VIIIa	Other bioactive compounds isolated from the leaves of *Pterocarpus tinctorius* and their spectra characteristics.	261
VIIIb	Other bioactive compounds isolated from the stem bark of *Pterocarpus tinctorius* and their spectra characteristics.	263
VIIIc	Other bioactive compounds isolated from the root bark of *Pterocarpus tinctorius* and their spectra characteristics.	265
IXa	Other bioactive compounds isolated and identified from the stem bark of *Strychnos spinosa* and their spectra characteristics.	269
IXb	Other bioactive componds isolated and identified from the root bark of *Stychnos spinosa* and their spectra characteristics.	271

ABBREVIATIONS AND ACRONYMS

ANOVA	Analysis of Variance
AFORNET	African Forest Research Network
CIFOR	Centre for Forestry Research
CITES	Convention on International Trade in Endangered Species of Wild Flora and Fauna
COSTECH	Commission for Science and Technology
DANIDA	Danish International Development Agency
DFO	District Forest Officer
DNA	Deoxyribonucleic Acid
ETFRN	European Tropical Forest Research Network
FAO	Food and Agricultural Organization
FRMP	Forest Research Management Project
GEF	Global Environmental Facility
GPS	Global Positioning System
HIV/AIDS	Human Immuno Virus/Acquired Immuno Deficiency Syndrome
HPLC	High Performance Liquid Chromatography
ICRAF	International Centre for Research in Agroforestry
IDRC	International Development Research Centre
IK	Indigenous Knowledge
ITM	Institute of Traditional Medicine
IPGRI	International Plant Genetic Resources Institute
IPR	Intellectual Property Rights
IUCN	International Union for Conservation of Nature and Natural Resources
ITTO	International Tropical Timber Organization

FFI	Fauna and Flora International
JFM	Joint Forest Management
LC-MS	Liquid Chromatography-Mass Spectrometry
LSD	Least Significant Differences
MNRSA	Management of Natural Resources and Sustainable Agriculture
MNRT	Ministry of Natural Resources and Tourism
MWRC	Miombo Woodland Research Centre
MRLP	Minimum Required Performance Limit
NGOs	Non-Governmental Organizations
NIMR	National Institute for Medical Research
NTFPs	Non Timber Forest Products
NWFPs	Non Wood Forest Products
PRA	Participatory Rural Appraisal
ppm	Parts per million
PROTA	Plant Resources of Tropical Africa
RNA	Ribonucleic Acid
RFO	Regional Forest Officer
RELMA	Regional Land Management
RSCU	Regional Soil Conservation Unit
SAREC	Swedish Agency for Research Cooperation
SD	Standard Deviation
SERN	School of Environment and Natural Resources
SIDA	Swedesh International Development Cooperation Agency
STDs	Sexual Transmitted Diseases
SPSS	Statistical Packages for Social Sciences
SUA	Sokoine University of Agriculture

TAFORI	Tanzania Forestry Research Institute
TK	Traditional Knowledge
TTSA	Tanzania Tree Seed Authority
UFR	Urumwa Forest Reserve
UK	United Kingdom
UNCTAD	United Nations Conference on Trade and Development.
UNDP	United Nations Development Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNEP	United Nations Environmental Programme
UNSO	United Nations Sudano-Sahelian Office
URT	United Republic of Tanzania
USAID	United States Agency for International Development
UV/VIS	Ultra Violet Visible Spectrum
UWB	University of Wales, Bangor
WADA	World-Anti Doping Agency
WCMC	World Conservation Monitoring Centre
WHO	World Health Organization
WWF	World Wide Funds for Nature

GLOSSARY OF TERMS

Abortion	induced expulsion of or spontaneous expulsion of a human foetus during the first 12 weeks of gestation.
Anaemia	a condition in which the blood is deficient in red blood cells, in haemoglobin, or in total volume.
Antianaphylactic	a substance that inhibits or prevents occurrence of serious allergic reaction that affects a number of different areas of the body at one time.
Anthelmintic	a substance that kills or expels intestinal worms.
Antiabortion	a substance that inhibits or prevents abortion.
Antiatherogenic	a substance that inhibits or prevents formation of atheromas, plaques in the inner lining of arteries.
Antibacterial	a substance that kills or inhibits growth of bacteria.
Anticancer	a substance that prevents or alleviates cancer.
Anticarcinogenic	a substance that tends to inhibit or prevents the activity of a carcinogen or the development of carcinoma (*i.e.* a malignant tumour of epithelial origin).
Antifungal	a substance that kills or inhibits growth of fungi.
Antihepatitis	a substance that inhibits or prevents inflammation of the liver from one of the hepatitis viruses or another virus, cytomegalovirus disease or yellow fever.
Antihepatotoxic	a substance that inhibits or prevents toxicity or injury to the liver.
Antihyperglycaemic	a substance that helps to lower excess sugar in the blood.
Antihypolipidaemic	a substance that lowers or decreases the level of lipids in the blood.
Anti-inflammatory	a substance that causes symptomatic relief of inflammation (*i.e.* localized swelling, redness and pain as a result of an infection or injury).
Antimicrobial	a substance that kills or inhibits the growth of micro-organisms.
Antimutagenic	a substance that prevents permanent change or structural alteration in the DNA or RNA.
Antiosteoporotic	a substance that inhibits or prevents loss of the normal density of bone and fragile bone decreasing the risk of breaking bones.
Antioxidant	a substance that is able to protect cells or counteract the damage caused by oxidation and oxygen free radicals. Also known as radical scavengers.
Antispasmodic	a substance that reduces muscular spasms and tension.

Antitumour a substance that counteracts tumour formation or growth (*i.e.* abnormal growth tissue).

Antiulcers a substance that prevents or inhibits ulcers.

Aphrodisiac a substance that increases sexual desire.

Bilious disordered liver function resulting from excessive secretion of bile in the body.

Boil a localized swelling and inflammation of the skin resulting from usually bacterial infection.

Concentrate form of remedy similar to infusion where chopped barks, leaves, seeds, fruits, stems or roots are stepped in water and drunk as an emetic or an enema.

Decoction form of medicinal plant remedy prepared by combining parts of water with plant parts/herbs, boiled slowly till boiling point is reached, cooled until warm and strained ready for use.

Diabetes mellitus abnormally high blood sugar level caused by lack of insulin.

Diarrhoea abnormally infrequent discharge of watery stool more than three times per day.

Dysentery inflammation of the colon; often caused by bacteria (Shigellosis) or viruses, accompanied by pain and severe diarrhoea.

Fever an abnormal bodily state characterized by increased production of heat, accelerated heart action and pulse, and systemic debility with weakness, loss of appetite, and thirst.

Infusion form of remedy prepared by adding a quantity of fresh grounded or dried plant parts/herbs to a cup of boiled water, then the mixture is infused for few minutes, strained and used.

Leucorrhoea a white, yellowish or greenish white viscid discharge from the vagina resulting from inflammation or congestion of the uterine or vaginal mucous membrane.

Malaria an acute or chronic disease caused by the presence of protozoan parasites of the genus *Plasmodium* in the red blood cells, transmitted from an infected to an uninfected individual by the bite of Anopheline mosquitoes, and characterized by periodic attacks of chills and fever that coincide with mass destruction of blood cells and the release of toxic substances by the parasite at the end of each reproductive cycle.

Mouth thrush infection of the mouth caused by the Candida fungus, also known as yeast.

Nephritis an acute or chronic inflammation of the kidney affecting the structure.

Oestrogenic a substance that induces production of oestrogen hormone in the body.

Poultices form of remedy where fresh leaves of fleshly plants are applied to wounds, sores and other skin ailments.

Protective charms form of remedy made from live or dried plants for protection purposes. It can be worn on body, planted or scattered around homesteads.

Prickly heat non-contiguous cutaneous eruption of red pimples with intense itching and tingling caused by inflammation around the sweat ducts - called also heat rash.

Rheumatism any of various conditions characterized by inflammation or pain in muscles, joints or fibrous tissue.

Ringworm any of several contagious diseases of the skin, hair or nails of humans caused by fungi and characterized by ring-shaped discoloured patches on the skin that are covered with vesicles and scales.

Schistosomiasis infestation with or disease caused by schistosomes caused by any of three trematode worms of the genus *Schistosoma* (*S. haematobium, S. mansoni,* and *S. japonicum*), called also Bilharzias, Bilharziasis or snail fever.

Sores vesicular lesions that typically occurs in or around the body, that initially causes pain, burning, or itching before bursting and crusting over.

Sore throat painful throat due to inflammation of the fauces and pharynx.

Sprains the condition resulting from a sprain (*i.e.* a sudden or violent twist or wrench of a joint causing the stretching or tearing of ligaments) that is usually marked by swelling, inflammation, haemorrhage and discoloration.

Stomatitis a progressive painful infection with ulceration, swelling and sloughing off of dead tissue from the mouth and throat due to the spread of infection from the gums.

Tumour an abnormal benign or malignant new growth of tissue that possesses no physiological function and arises from uncontrolled usually rapid cellular proliferation *e.g.* cancer.

Ulcers a lesion on the skin or on a mucous membrane.

Urinal antiseptic a substance that prevents or arrests the growth of micro organisms in urine.

Urethritis inflammation of urethra (*i.e.* the canal that in most mammals carries off the urine from the bladder and in the male serves also as a passageway for semen).

Wound a physical injury to the body consisting of a laceration or breaking of the skin or mucous membrane.

ABSTRACT

A study of medicinal plant ethnobotany, utilization and conservation within a gender context has been carried out. Fieldwork (an ethnobotanical survey and a tree population survey) was undertaken in the Urumwa Forest Reserve, Tabora Region, western Tanzania, and in local communities around the reserve. Plant material from two important medicinal tree species was collected from Urumwa and investigated in Bangor, UK, for phytochemical content.

The ethnobotanical survey involved 62 male and 53 female respondents who completed questionnaires and a complementary PRA exercise (36 key informants). Communities around Urumwa are indicated to be highly knowledgeable about medicinal plants including general awareness by both genders of plants useful medicinally for gastro-intestinal and urino-genital disorders. Men and women around Urumwa, nevertheless, utilize and conserve medicinal plant resources differently. In utilization; men are active traditional practitioners, traders and are specialized in treating a variety of diseases and conditions. In conservation, women are the active domesticators of plants around homesteads compared with men who are harvesters, and decision-makers in aspects regarding protection of the reserve and its resources. Traditional cultures and socio-economic aspects (*e.g.* taboos and income generation) seem to influence the observed gender role differences at Urumwa. For the majority of medicinal plant users however, there is lack of standardized dosages. In general, the medicinal plant resources of the miombo of Urumwa are sparsely distributed.

The tree population survey involved two species (*Pterocarpus tinctorius* and *Strychnos spinosa*) indicated as priority species by the ethnobotanical work, belonging to genera known as sources of bioactive phytochemicals. The status of each was assessed in the field and showed that *Pterocarpus tinctorius* has many large individual trees (>25 cm dbh) but few small ones, while *Strychnos spinosa* is well stocked in terms of small individuals (<10 cm dbh). However, both adequately meet local stakeholder demand, although possible exploitation for more distant market calls for an effort to introduce active conservation, including domestication initiatives.

The laboratory work used high performance liquid chromatography techniques and confirmed the presence of five isoflavonoids (formononetin, genistein, homopterocarpin, prunetin and vestitol) in the leaves and stem bark and root bark of *Pterocarpus tinctorius*, and the presence of two monoterpenoid indole alkaloids (strychnine and brucine) in the stem bark and root bark of *Strychnos spinosa*. In both species the compounds are in low concentrations (< 50 ppm for isoflavonoids; < 1 ppm for indole alkaloids).

Because it combines ethnobotanic, conservation and phytochemical aspects, this study represents a new breadth of integration in the exploration of the role of medicinal plants in primary health care in an area of Tanzania. The advantages of the approach as a basis more enlightened future management and use of local medicinal plants are discussed.

ACKNOWLEDGEMENTS

My first very special thanks go to Dr. John B. Hall whose constant academic supervision and guidance providing critical comments, advice and encouragement throughout the entire period of my studies has been a great honour. My sincere thanks also go to Prof. Douglas L. Godbold for his advice during preparations of my laboratory work. His friendly behaviour and permit to use laboratory facilities to accomplish my work is highly appreciated.

I am indebted to Sokoine University of Agriculture for granting me the leave to study under Association of Commonwealth Universities sponsorship, without which I could never have accomplished doing this work at Bangor.

I would like to thank the following people who provided various information and assistance prior to and during the actual data collection period. Firstly, thanks to Mr. H. Liana (Tabora Natural Resource Officer), Mr. E. Kushoka (DFO - Tabora-Uyui District), and Tabora Municipal Council management for permission and introduction to the respective wards and village government officials as an entrance to conduct my research. The support and cooperation of TAFORI-MWRC and Regional Forest Office could not go without mention. Mr. H. Haule (former RFO, Tabora Region), the late Mr. R. Luhende (former Director –MRWC, may God rest your soul in peace. Amen) and all support staffs are sincerely thanked for hospitality and cooperation. Appreciations to all drivers without forgeting: E. Mwami, Isaack and Maalim Said, for being careful in driving the entire research team daily, around and within Urumwa Forest Reserve. Special thanks should also go to Mr. G. Mwiga for his tireless effort to prepare herbarium voucher specimen apart from being hand to hand during ethnobotanical survey.

Secondly, I am highly indebted to all herbalists, vendors, medicinal plants collectors and local communities around Urumwa, without which this study could have been incomplete. Your great hospitality, cooperation and respect to my research work for the whole time I spent with you will never be forgotten. My sincerely thanks also go to Mr. Mussa Kawili and Halfani Juma from Isukamahela and Masimba village respectively for assistance in local plant identification and tireless long walk inside Urumwa during preliminary and actual species inventory exercise.

Thirdly, from the Department of Forest Biology, Sokoine University of Agriculture, much thanks to the late Prof. V.R. Nsolomo (former Head of Department - may God rest your soul in peace. Amen) and the chief technician, Mr. S. Maseki for granting permission to use the grinder machine during processing of my plant materials. Mr. Kilonzo and all laboratory staffs - you also deserve many thanks for dedicating your time to share with me the inhalation of plant material dust during the grinding process.

Fourthly, from the Institute of Traditional Medicine, Muhimbili (ITM), I am grateful to Prof. R.L.A Mahunnah and Dr. Uiso, for advice and consultation you provided while proposing to start my research work at Urumwa, Tabora Region. Thanks to Mr. Lawrence Mbwambo of the Department of Forest Products Utilization - TAFORI, Morogoro, for providing preliminary information and literature about Urumwa. Mr. C.K. Ruffo of Tanzania Tree Seed Authority (TSSA), I thank you very much for devoting your time to assist in plant identification including providing valuable information about Urumwa and Tabora in general. Dr. Z. Mbwambo, you are highly acknowledged for accepting and assisting the deposit of plant voucher specimens at ITM herbarium, when I was constrained with time to return back to Bangor, UK after my fieldwork.

Once more, I should not forget to thank Mr. J. Evans – Chief Technician, School of Environment and Natural Resources (SERN), for being a great friend and close technical assistant during the entire laboratory work. Mr. D. William – Chief Technician Department of Chemistry, thank you too for assisting with analysis of plant extracts using mass spectrometer.

Last but not least, thanks to all my colleagues at Bangor who made my stay memorable. Dr. F.B.S. Makonda, wife Rozalia and daughter Shillya - your warmly welcome for the first time I arrived at Bangor healed my homesickness and brought my mind back to what I came for. I really thank you and appreciate your company. Dr. T. Easdale and wife Ferneranda, Mr. P. Swappnendu and family, Toshihide and Chikako - thank you all for your good company. I would not forget Dr. (Mrs) M. Morapeli-Mphale, for being a good sister and great friend of my family, sharing all academic and life difficulties while in Bangor. Since it is difficult to acknowledge all individuals who contributed in one way or another to the success of this work, I wish here therefore to give collective thanks and pray that, God bless you all in future.

General introduction

CHAPTER I

GENERAL INTRODUCTION

This chapter provides a brief general overview of the study on the medicinal plant resource base of the miombo woodland, with particular reference to two 'case study' species: *Pterocarpus tinctorius* and *Strychnos spinosa* at Urumwa Forest Reserve, Tabora Region, Tanzania. The chapter has three sections subdivided in subsections. There is a brief account of the state of forest resources and significance in Tanzania (1.1.1), followed by the present study (1.1.2) objectives, both overall (1.1.2.1) and specific (1.1.2.2). A brief summary describing the organization structure of this thesis is provided in Section 1.1.3.

1.1 Background

1.1.1 Tanzania forest resources and its significance

The forest resource in Tanzania, supporting national environmental and economic needs, is based on 44 million hectares of natural forests including forests and woodlands (including the miombo woodlands) (MNRT, 1998). This resource provides numerous wood and non-wood forest products (NWFPs), including medicinal plants for human needs (Gauslaa, 1988). A large proportion of Tanzanian's forest state over about half of the surface is miombo vegetation (Figure 1).

Miombo is an informal term used to describe the floristically rich and widespread indigenous woodlands of central, southern and eastern Africa, largely characterized by the closely related genera *Brachystegia, Julbernardia, Isoberlinia* (White, 1983). The miombo woodland ecoregion extends across the African sub-humid tropical zone from Tanzania and the Democratic Republic of Congo in the north, through Zambia, Malawi and eastern Angola, to Mozambique and Zimbabwe in the south. Over 75 million people are estimated to live within the ecoregion, its resources directly supporting their livelihoods. A further 15 million people who live in towns and cities through the ecoregion also depend on the woodlands for a variety of products (Bradley and McNamara 1993; Dewees, 1994).

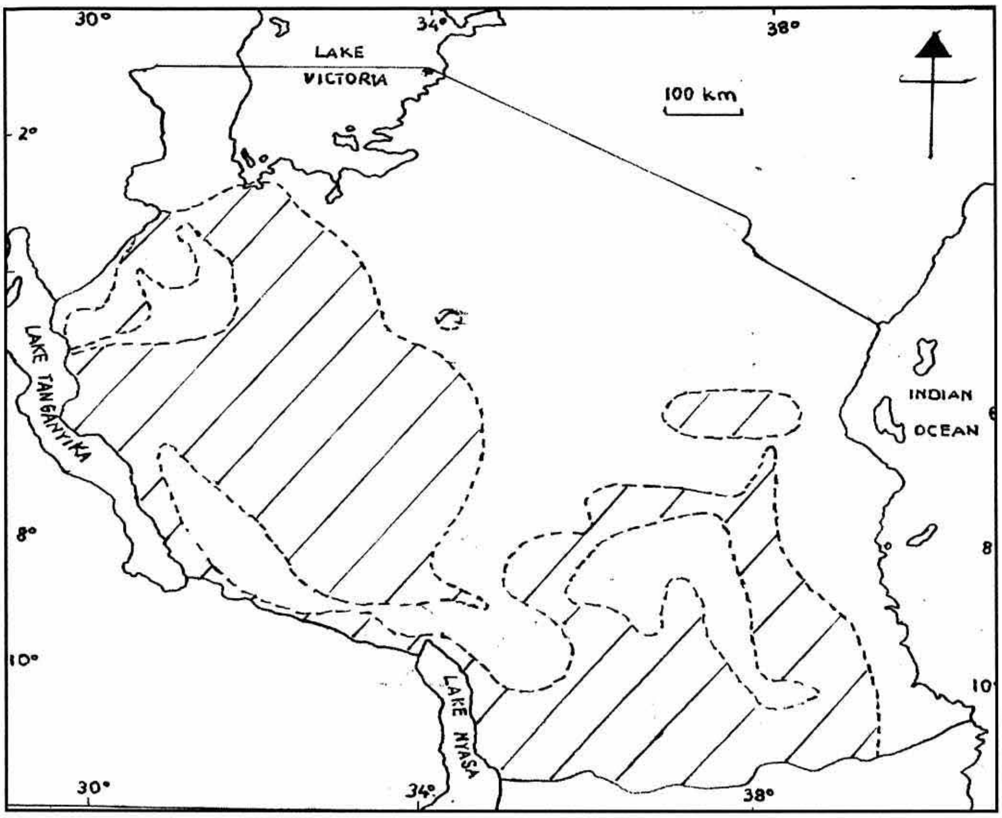


Figure 1.1 The distribution of miombo woodlands in Tanzania (shaded area)

Source (Mbwambo, 2000).

This study explores the medicinal relevance of locally collected plant material for the communities around Urumwa Forest Reserve, Uyui District (former Tabora Rural), in Tabora Region, Tanzania (Figure 6a,b). This is an area lying on the central plateau of Tanzania, in the northern part of Africa's vast (3,000,000 km^2) miombo region. In terms of the natural vegetation cover, the study area is ecologically representative of what White (1983) terms "Drier Zambezian miombo woodland".

Forests have long been regarded primarily as sources of timber, but now the value of non-wood forest products has become increasingly appreciated (Padua *et al.,* 1999-2003), with medicinal plants being considered important non-wood forest products for priority protection in forests. It is generally acknowledged (WHO, 2002) that locally gathered plant materials remain a significant, and for many the only, source of medicines in Sub-Saharan Africa, and that population growth has increased pressure on the wild plant resources involved. In Tanzania, for instance, despite their essential roles, the miombo woodlands currently face major risks of degradation due to the following reasons (Iddi, 2002; Dallu, 2003): uncontrolled commercial harvesting, population growth, shifting cultivation, overgrazing and wild fires. Equally, the influx of refugees from the neighbouring countries of Rwanda and Burundi has had devastating effects on miombo woodlands of western Tanzania. FAO (2001) estimated that Tanzania lost approximately 92,000 ha or 0.2% of its forest land in recent years, through deforestation resulting from encroachment and over utilization (Kiunsi, 1994), especially in forest reserves, due to unsustainable management by central and local governments.

In rural communities throughout Africa, medicinal plants constitute a fundamental component of traditional healthcare systems (Garí, 2002), which demonstrates their contribution to the reduction of excessive mortality and disability due to diseases such as HIV/AIDS, malaria, tuberculosis, sickle-cell anaemia, diabetes and mental disorders; and reduces poverty by increasing the economic well-being of communities (Elujoba *et al.*, 2005). HIV/AIDS has been reported to severely affect the countries making up the miombo ecoregion, including Tanzania where rural affected households appear to rely increasingly on miombo woodland resources due to limited access to pharmaceutical drugs (FAO, 2004) for treatment of opportunistic infections. This signifies the importance of woodlands as a safety net for HIV/AIDS-affected households.

Medicinal plants are a cross-cutting issue concerning several national policies, like forestry, land use and health in Tanzania. Their policy recognition arises from their importance in improving the primary health care in both rural and urban Tanzania and the forestry policy stresses gender equality participation in sustainable utilization of the resources for future generations and developments. The Health Policy - Act 23 of 2002 on traditional medicine, recognizes traditional healers and birth attendants and encourages the important of traditional medicine use and control. Land tenure is an important issue for the conservation of medicinal plants through cultivation; in Tanzania this is not problematic, however, since the 1999 Land and Village Acts provide for the use and occupation of land through the system of right of occupancy. Furthermore, the customary and statutory rights of occupancy are still recognized, where village governments are empowered to enact village bylaws to protect forests/woodlands using traditional rules.

Despite the significant role of medicinal plants in the primary health care system, the majority of medicinal plants in Tanzania have not been adequately studied as evidenced by paucity of information and the limited research carried out (Ishengoma and Gillah, 2002), notwithstanding the efforts of the Institute of Traditional Medicine (ITM). Considering the situation in the miombo woodlands, the majority of medicinal plants especially in the western part of Tanzania are not well studied or documented. There is a general lack of understanding of gender roles within traditional medicinal practice outside the dependent communities, and a need to gain this understanding for effective support through rural initiatives. Despite widespread use of medicinal plants in Tanzania, there is inadequate evidence to support their use in the traditional medicine system due to so few attempts to determine biologically active compounds (Ruffo *et al.*, 2002), responsible for the pharmacological activity and use efficacy.

The focus on the medicinal plant resource base at Urumwa is based on its potential to sustain the primary health care system of communities around, a system which is threatened by on-going anthropogenic activities. Locally gathered medicinal materials are an integral and essential support for a community of 22,500 population (187 households), and that a further estimated 80% of the population (151,046 people) within 16 km of Urumwa and beyond are in the same situation. On a still wider basis, Urumwa can be considered representative of Africa's drier miombo region generally and, in many respects, knowledge gathered, interpreted and applied to livelihood improvement is relevant to the whole miombo region.

Research on medicinal plants has been conducted in Tanzania for more than 30 years, after the establishment of the Institute of Traditional Medicine as a research unit, dealing with ethnobotany, anthropology, chemical and biological studies. About 1,000 plant species are used in traditional medicinal plant practice in Tanzania, representing 10% of the country's flora and some 80% of the species are used in drug prescriptions by some world pharmacopoeias. Furthermore, from research, 30 plant species have shown promising clinical effect in treating parasitic infectious (Urio *et al.*, 1996). At ITM there has been success in research work with confirmation of some tree species that have been pharmacologically screened (Table 1.1) to support their ethnomedical uses in treating and curing diseases including chronic ones like cancer and diabetes.

Table 1.1 Some medicinal plants pharmacologically screened by Institute of Traditional Medicine in Dar es salaam, Tanzania

Botanical name	Parts used	Diseases cured
Abrus precatorius	Leaves	Epilepsy[4]
Acacia xanthophloea	Roots	Cancer[1]
Albizia anthelmintica	Roots, bark	Round worms[1]
Centella asiatica	Whole plant	Diabetes[3]
Clausena anisata	Roots, Leaves	Epilepsy[4]
Dalbergia melanoxylon	Roots, bark	Diarrhoea[1]
Hoslundia opposita	Roots, barks	Epilepsy[4]
Kigelia africana	Stem, bark	Diabetes, female sterility[1]
Lannea stuhlmannii	Roots, bark	Cancer[1]
Pterocarpus angolensis	Stem bark	Menstrual disorders[1]
Synadenium glaucescens	Leaves	Asthma[1]
Terminalia sericea	Roots	Diarrhoea, Diabetes[2]
Zanthoxylum chalybeum	Roots, bark	Pneumonia , Cough[1]

[1]Ishengoma and Gillah (2002), [3]Mutayabarwa *et al.* (2003), [2]Moshi and Mbwambo (2005), [4]Moshi *et al.* (2005)

In the 20th century and as the 21st century starts, major medicinal research interest in Tanzania has been in the following study areas: evaluation of therapeutics used by traditional practitioners to treat HIV/AIDS (*e.g.* Runyoro *et al.*, 2006), discovery of antimalarial compounds from both marine invertebrates and terrestrial plants and searches for plant derived compounds for treatment of chronic diseases like Type II-diabetes and cancer (*e.g.* Kamuhabwa *et al.*, 2000; Moshi *et al.*, 2006) and formulation and standardization of herbal medicines. Nevertheless, ethnobotanical studies and ex-situ conservation of potential medicinal plants are part of on-going activities. All these activities at the institute have been conducted in collaboration with other partners inside and outside Africa with WHO, SIDA and IDRC being the driving forces. Other international agencies (including the World Bank, UNDP/GEF, IUCN, FAO, UNESCO, UNEP and DANIDA) have also been working with institutions and non-governmental organizations in Tanzania, targeting medicinal plants and the need for their conservation. The number of phytochemically screened species (Table 1.2) used in traditional medicine in Tanzania including some with proved bioactivity has been increasing.

Table 1.2 Other phytochemically screened plants with proved bioactivity in Tanzania

Botanical name	Parts	Compound(s)	Bioactivity
Boscia salicifolia	Leaves	Flavonoids	-
Cassia abbreviata	Leaves, roots, bark	Anthraquinones, triterpenoids[8]	-
Cassia petersiana	Leaves, roots	Flavonoids, sterols, anthraquinones, monoterpenoids, triterpenoids, aliphatic hydrocarbons[8]	-
Croton macrostachys	Roots	Diterpenoids[1]	-
Helichrysum fulgidum	Aerial parts	Essential oils[5]	Antimicrobial
Isolona cauliflora	Stem, roots	Prenyindoles[6]	Antifungal
Markhamia lutea	Roots	Phenylpropanoid glycosides[7]	Antiviral
Securidaca longepedunculata	Roots	Benzophenones[2]	Antibacterial
Uvaria scheffleri	Roots	Monoterpenoids[3]	Antimalarial
	Barks, Leaves	Steroids, Flavonoids[3]	antibacterial and antifungal
Uvaria leptocladon	Roots	Benzylated dihydrochalcones[3]	Antimicrobial
Vismia orientalis	Barks	Anthranoids compounds[4]	Antiprotozoal
Zanthoxylum chalybeum	Roots	Alkaloids[9]	Anti-inflammatory

Walter and Séquin (1990), [9]Müller-Jakic *et al.* (1993), [8]Mutasa and Khan (1993; 1995), [7]Kerman *et al.* (1998), [1]Kapingu *et al.* (2000), [6]Makaranga *et al.* (2003), [5]Boughatsos *et al.* (2004), [3]Moshi *et al.* (2004) and Nkunya *et al.* (1993; 2004), [4]Mbwambo *et al.* (2004), [2]Joseph *et al.* (2006).

1.1.2 This study

In this study, social science methods have been applied to understand the pattern of utilization and conservation of medicinal plants within a gender context. The findings represent a starting point for considering ways of conserving local medicinal plant knowledge which is in danger of disappearing. An ethnopharmacological approach has been used to document used medicinal plants and obtain a list of potential (priority) species for communities around Urumwa, species which need attention especially in terms of conservation and further pharmacological, toxicological and or clinical developments.

1.1.2.1 Overall objectives

The overall objectives of these studies in the miombo woodlands of Urumwa Forest Reserve, Tabora Region, Tanzania, were to characterize the ethnobotanical, utilization and conservation roles of men and women and conduct a case study of each of two important species, looking at the resource base and the resource quality.

1.1.2.2 Specific objectives

Specific objectives were:

i. to assess the community medicinal plants ethnobotanical knowledge, perceptions of responsibility within the gender context, and conservation awareness with respect to the miombo woodlands of the study area,

ii. to assess and characterise the population structures of selected 'case study' species (*Pterocarpus tinctorius* and *Strychnos spinosa*) in the miombo woodlands of the study area,

iii. To determine the presence and composition of isoflavonoids and monoterpenoid indole alkaloids in parts of the selected 'case study' species.

The study involved three key assumptions:

- there are significant differences in medicinal plants knowledge between men and women from communities around the miombo woodlands of Urumwa ,
- there are significant differences in community perceptions of gender responsibilities in utilization and conservation of medicinal plants around the miombo woodlands of Urumwa,
- the different plant parts of selected 'case study' species contain bioactive isoflavonoids and monoterpenoid indole alkaloids with pharmacological significance justifying their use in traditional medicine.

1.1.3 Thesis organization

This thesis is presented in eight chapters starting with a general introduction (Chapter I) followed by a literature review and a description of the study area (Chapter II). The main body of results, exploring ethnobotany and gender roles (Chapter III), 'case study' species population status (Chapter IV) and phytochemical aspects (Chapters V and VI) make-up the next four chapters. A general discussion (Chapter VII), and conclusions and recommendations from the study (Chapter VIII) conclude the thesis.

Literature Review & Study Area

CHAPTER II

LITERATURE REVIEW AND STUDY AREA

This chapter reviews the state-of-knowledge of the present study including a detailed description of the study area. In the preceding chapters, however, a brief state-of-knowledge will be noted on the start of every chapter as a supplement to what has been reviewed in this chapter. Section 2.1 discusses the context of medicinal plants in terms of use and importance (Section 2.1.1) followed by gender roles (Section 2.1.2) and the existing challenges and future prospects (Section 2.1.3). The taxonomic and phytochemical review of the 'case study' species: *Pterocarpus tinctorius* (2.2.1) and *Strychnos spinosa* (Section 2.2.2) is provided in Section 2.2. The description of the study area (Section 2.3) is finally presented including the location (Section 2.3.1), climate (Section 2.3.2), topography and drainage (Section 2.3.3), Soil and vegetation (2.3.4) and Section 2.3.5 is the socio-economic activities.

2.1 Medicinal plants context

2.1.1 The use and importance

Tanzania is among those tropical countries endowed with exceptional natural resources. The vascular fauna alone is of over 10,000 species, of which 1122 are endemic. The wealth of the traditional ethno-pharmacopoeia is indicated by the extensive use of medicinal plants in traditional healing systems (Mahunnah, 1992). An estimated 80% of Tanzania's 24 million people live in rural areas where forest resources are central for their livelihood (FAO, 1986; URT, 1991). It is questionable if this situation will change in near future and the use of medicinal plants is most likely to continue contributing to primary health care (Medius, 1998) as the human population grows.

A high proportion of the population of Tanzania lives in rural areas and more than half are women (Byers, 2001). The rural poor, particularly women and those in sectors of the community with limited alternative income generating opportunities are stakeholders in the medicinal plants trade (Cunningham, 1991; Mander, 1998). Commercialisation and trade in woodland and forest products is increasing in most parts of Africa as more people, particularly women, seek additional opportunities for cash income (Shackleton and Willis, 2000).

Limited involvement of women in the traditional medicine system has been reported in Tanzania (Urio *et al.*, 1996), but the new Tanzania Forest Act of 2002 encourages active participation of both men and women in the conservation and management of natural resources - including medicinal plants - for the benefit of present and future generations. Talhouk *et al.* (2001) observed that women's uses of forest resources differ from those of men and there is a tendency to overlook their contribution. The same authors regard lack of gender awareness often as a constraint to development and management strategies for forest ecosystems. If it was available to managers, knowledge and perceptions of resource users (both men and women) would provide valuable insight into the *in situ* conservation needs of wild populations of vulnerable resources like medicinal plant species.

Traditional treatments using medicinal plants enjoy considerable popularity and are practiced by numerous healers all over the Tanzania, despite western medicine being the mainstream of the health care system (Ruffo, 1990; Ishengoma and Gillah, 2002). In most African communities medicinal plants, as the most important components of the system, are sold in market places and or are prescribed by herbalists, taking advantage of the total biodiversity of plant species to cure various diseases (Gelfand *et al.*, 1985; Ndubani and Hojer, 1999). Indigenous knowledge about the uses of plants has been passed from generation to generation by oral tradition (Wyk *et al.*, 1997; Boer *et al.*, 2005) however; there is a danger of losing this knowledge because transmission between the older and younger generations is not always assured (Mahunnah, 1992; Anyinam, 1995).

By the late 1990's Tanzania had more than 30,000 traditional healers who mainly operated in rural communities, but with poor involvement of women (Urio *et al.*, 1996). Considering the population of Tanzania, Ishengoma and Gillah (2002) noted that at least one healer serves 750 people, whereas 50,000 people are served by one qualified medical doctor. The reported figures are higher than the 1:400 traditional healer: patients ratio reported by Cunningham in 1993, implying that demand for medicinal plants products and services has increased, while the practitioners' population remain constant. The reliance of most Tanzanian populations on traditional medicine could be a result of the policy of cost sharing in public medical services introduced in the early 1990's, where the majority could not afford to pay for the services (Urio *et al.*, 1996). Nonetheless, medicinal plants are currently gaining wider recognition and utilization both for primary health care and income generation due to tribal beliefs in the power of herbs or tree parts to bring fortunes or misfortunes, and good health. Inadequate modern medical facilities and the shortage of qualified personnel in hospitals and the well-publicized search for new phyto-pharmaceuticals for the prevention and cure of emerging new, and so far incurable, diseases such as cancer and HIV/AIDS, are other contributing matters (Chhabra *et al.*, 1984; Ruffo *et al.*, 1989; Hines and Eckman, 1993; Luoga *et al.*, 2000a; Hamilton, 2003).

A change in the use of medicinal plants through traditional medicine has been observed (Sofowora, 1993), from alternative medicine to use out of necessity. Previously, the plants were used in rural areas only, where modern health facilities were unavailable. There is general concern about negative side-effects from synthetic drugs and medicinal plant compounds are considered less dangerous and traditional medicines safe and acceptable on the basis of a long history of safe use (van Wyk and Wink, 2004).

2.1.2 Medicinal plants and gender roles

The term "Gender" does not refer to women alone, but to the socially constructed roles of, and relationships between, men and women in a society (Bunning and Hill, 1996). Gender roles refer both to 'who should do what' and 'who actually does what'. Gender roles are dynamic not static and their analysis may start by looking at the normative framework, that is, what activities (including decisions) are seen as culturally appropriate for women and men to undertake (Meadows and Sutherland, 2000). Generally, men and women are reported to have different knowledge of medicinal plants, and their knowledge is structured in a different way, which is related not only to the division of labour but also to social power (Howard, 2003b; Singhal, 2005).

Gender researchers have shown that the majority of plant species and varieties used for medicine are conserved and managed at household level by women (Balakrishnan, 2000, Howard, 2003a; Kothari 2003). Women, rather than men are the more active participants in non-wood forest products harvesting and in the gathering of specialized resources such as medicinal plants for the welfare of their families (Tatuariana and

Tauran, 1997). In developing countries, according to Srivastava *et al.* (1996), women play vital roles in the cultivation and collection of medicinal plants. Observations have also been made in part of Africa and Latin America that women constitute the majority of traditional healers, and are primary gatherers of medicinal plants for sale to generate income (Lambert *et al.*, 1997) to support the subsistence needs of their families.

2.1.3 Challenges and future prospects

There are still challenges to the promotion of medicinal plants in terms of justifying their safety and efficacy as to improvers of overall health in developing countries like Tanzania. More than 90% of the estimated flora in Tanzania theoretically has potential significance for drugs but has not been appreciated simply because chemical compositions have not been studied (Rulangaranga, 1991). It has, however, been urged that some African plants used specifically for the treatment of particular diseases (Kokwaro, 1993) merit further investigation of their chemical composition and their reaction on the diseases in question.

Worldwide, the search for biologically active extracts based on traditionally used plants (Tyler, 2000) is also still relevant due to the emergency of microbial resistance to many antibiotics and the occurrence of fatal opportunistic infections. The chemical analysis and biomedical potential of less than 1% of the earth's higher plants (Farnworth, 1988) have been determined, and un-investigated species in the remaining 99% are disappearing at an alarming rate (Sheldon *et al.*, 1997). Many wild populations of medicinal plants throughout the tropics and sub-tropics are under increasing pressure (Akerele *et al.*, 1991; Lange and Schippmann, 1997; Leanman *et al.*, 1999) due to local over-exploitation, rapidly growing international trade, habitat degradation and loss and erosion of traditional knowledge. These threats are creating an urgent need for improved use of vital plant resources through conservation.

One existing legal tool which has been suggested as a means of protecting ethnobotanical knowledge in future (Nabhan *et al.*, 1996) is the intellectual property right (IPR) which involves ethically proper use of patents, copyrights, trade marks and trade secrets. Tanzania is among the developing countries applying an IPR policy especially in relation to realistic returns to local communities, institutions and organizations involved in plant genetic resources studies (Mahunnah and Mshigeni, 1996). The need to protect intellectual property rights according to Lambert *et al.* (1997) is an essential need - both for developing countries whose genetic resources are being exploited, and for developed countries whose patent law cannot always be enforced in developing countries. However, a recent report by WHO (2002) indicates that intellectual property issues are not yet resolved, causing access problems for the traditional medicine system. Increasingly, it appears that knowledge of traditional medicine is being appropriated, adapted and patented by scientists and industry, with little or no compensation to the original custodians, and without their informed consent (Brush, 1996; UNCTAD, 2000).

The traditional medicine system is not well formalized in Tanzania, in contrast with the formal health sector; although the two systems share the common goal of improving the quality of health services for the Tanzanian population in line with the goal of the national health policy. According to Mhame (2000) and WHO (2005), herbal medicines are currently not regulated in Tanzania, and are chiefly used for self-medication purposes. No claims can be made about herbal medicines in law due to existence of neither national pharmacopoeia nor national monograph, and manufacturing and safety assessment requirements are limited to traditional use without demonstrated harmful effects. No registration system exists for herbal medicines, nor are they included on the essential drug list.

Generally, the most important medicinal plants used in traditional medicine in Tanzania are found in local and national markets. International trade in medicinal plant material is limited to selected species such as *Cinchona* spp, *Prunus africana* (Hook. f.) Kalkm. and *Warburgia salutaris* (Bertol. f.) Chiov. (FAO, 2001). These limitations underline the challenges which need urgent attention, if the traditional medicine system is to improve and operate hand in hand with the modern health care system while allowing all medicinal plants stakeholders to realize proper benefits.

2.2 Taxonomic and phytochemical review of the 'case study' species

2.2.1 *Pterocarpus tinctorius* Welw.

Pterocarpus tinctorius is an evergreen tropical deciduous tree up to 30 m tall, with a flattish crown and spreading branches. The bark is grey or brownish in colour, and whitish when slashed, producing blood-red resinous exudates (Polhill, 1971, Rojo, 1972). The tree is found in *Brachystegia* woodland, moister wooded savanna areas, dry evergreen and riverine forests, and on rocky hills, on plateau or stony soils at altitudes from 50 m to 1360 m. There is limited information on the phenology of the tree species, but in Southern Africa most of *Pterocarpus* species (Palgrave, 1988) are reported to flower in the period from August to December and fruit in the period from January to May. The situation could apply to *P. tinctorius* though detailed phenological studies are required in future. In East Africa, *P. tinctorius* is a variable species and Polhill (1971) took account of this variation by distinguishing three "races": *megalocarpus, stolzii* and *tinctorius*, which can be differentiated morphologically, geographically and ecologically (Table 2.1).

P. tinctorius utility varies from food, timber, building poles and shade to traditional medicine (Table 2.2). The timber from this species is not so popular in Tanzania and thus less utilized. A study by Ishengoma *et al.* (1997) however, noted that the properties of "*P. stolzii*", a race of *P. tinctorius*, were comparable with those of *Pterocarpus angolensis*. Lower utilization as durable timber is reported in Tanzania due to the species being poorly known. Currently there is no published information existing on the use of the species in traditional medicine, although the species is among the 'potential' medicinal plant species selected by local communities around Urumwa Forest Reserve in Tabora region, western Tanzania to cure various ailments (*Pers. obs.* 2004).

Table 2.1 Summary of infraspecific variation of *Pterocarpus tinctorius* in its ecological range

Races and variants/ Floristic references	**Category 1**	**Category 2**	**Category 3**	**Category 4**
Hauman (1954) account for Burundi, Democratic Republic of Congo and Rwanda	This race does not extend to Congo according to Polhill (1971)	This race does not extend to Congo according to Polhill (1971)	As *P. tinctorius* var. *chrysothrix* (Synonyms: *P. cabrae, P. chrysothrix, P. delevoyi*)	As *P. tinctorius* var. *odoratus* (Synonyms: *P. kaessneri, P. odoratus*)
Polhill (1971) account for Tanzania, Kenya and Uganda	Synonyms: *P. megalocarpus, P. holtzii*	Synonyms: *P. stolzii, P. zimmermannii*	Synonyms: *P. chrysothrix, P. tinctorius* var. *chrysothrix*	Synonyms: *P. odoratus, P. kaessneri, P. tinctorius* var. *odoratus*
Rojo (1972) global treatment	*P. megalocarpus* (Synonyms: *P. holtzii, P. albopubescens, P. velutinus*)	*P. tinctorius* (typical) (Synonym: *P. tinctorius* var. *macrophyllus, P. stolzii*)	*P. chrysothrix* (Synonyms: *P. cabrae, P. tinctorius* var. *chrysothrix*)	*P. odoratus* (Synonyms: *P. tinctorius* var. *odoratus*)
Ecology of species (Polhill, 1971)	Occurs in riverine forest and moister areas in wooded grassland and evergreen thicket at an altitude ranged from ± 300 – 600 m.	Occurs in rain forest, dry evergreen and riverine forest at an altitude ranged from 280 – 1500 m.	*Brachystegia* woodland, wooded savanna and moister areas, often on rocky hills, scarps or stony soils as well as dry evergreen thicket and riverine forests, at an altitude ranging from 750 – 1520 m.	Occurs in *Brachystegia* woodland, often on rocky hills, also in *Acacia* woodland fringing Lake Victoria
Geographical distribution (Polhill, 1971)	Can be found in Tanzania (Morogoro, Lindi and Masasi districts), Northern Mozambique	Can be found in Tanzania (East Usambara Mountains, Tanga, Mbozi and Songea districts).	Can be found in Tanzania (Tabora, Mpanda and Mbeya districts), Congo, Zambia, Malawi, Mozambique and Angola.	Can be found in Tanzania (Biharamulo, Kahama and Tabora districts), Northern Zambia
UNEP-WCMC (2005)		Malawi	Burundi	

Note: Category 1 = race "*megalocarpus*", Category 2 = race "*stolzii*", Category 3 = variant "*tinctorius*", Category 4 = variant "*odoratus*"

Table 2.2 Uses of *Pterocarpus tinctorius*

Use category	Remarks and references
Food and dye	The fruits, leaf/shoots and flowers of *P. tinctorius* are reported to be eaten by Chimpanzees (Suzuki, 1969; Kano, 1972; Wrangham, 1977; Nishida and Uehara, 1983). The tree secretes red resin which can be used as dye (Delevoy, 1929).
Timber and shade	The tree species produces red, hard and medium-heavy wood, thus used for timber (Delevoy, 1929, Ishengoma *et al.*, 1997), building poles, tool handles and carvings as well as shade (Mbwambo, 2000).
Medicine	Decoctions from the roots and stem barks are drunk to cure diarrhoea, stomach ache, anaemia and prevent early abortion in pregnant women. Stem bark infusion is bathed through eyes to treat trachoma and other eyes related problems. Roots and stem barks are ground into powder and massaged to treating wounds and snakebites (*Pers. obs.* 2004).

2.2.1.1 Taxonomic context

Pterocarpus is a pantropical genus of woody plants with more than 20 species recognized (Rojo, 1972, 1977): Indo-Malesia/Pacific region, five species; tropical America, six species; tropical Africa, eleven species (Figure 2.1). The older taxonomy of *Pterocarpus* has been challenged in the past three decades (*e.g.* Rojo, 1977 for Indo-Malesia/Pacific; Lewis, 1987 for tropical America) and sometimes modified to reflect the different views of scientists describing the species only in their own geographical areas. For the entire range Rojo (1972) reduced the number of species from 70 to 20 with only two represented in more than one region. For the purpose of this study, Rojo's views on species circumscriptions are followed since for Africa they have not proved controversial.

Rojo (1972) describes the genus as homogeneous and dismissed the sectional and sub sectional sub-divisions of earlier workers, though without any detailed evaluation of their merits and demerits, and presents information on them in alphabetical sequence. In the absence of a clear alternative, and while new phylogenetic classifications based on genetics are awaited, the broad relationships originating with Harms (1915) and adopted by Baker (1929) and Chalk *et al.* (1932) are used as a guide to close and more distant relationships for the African species. It should be noted that Harms' framework underlay that for the Flore du Congo Belge et du Ruanda-Urundi (Hauman, 1954) and that of Polhill (1971), who was in contact with Rojo when preparing his treatment for the Flora of Tropical East Africa. In summary, the closest relatives of *P. tinctorius* are taken as species in Harms' section Leiodiscus Group Orbiculares (*mildbraedii, officinalis, soyauxii, tessmanii*). The next most closely related are species of Section Leiodiscus Group Lucentes (*brenanii, rotundifolius*). Species of Sections Acanthodiscus (*osun*) and Echinodiscus (*angolensis, erinaceus*) and Thelodiscus (*santalinoides*) are considered more distantly related.

As the closest relatives at generic level, the South American *Tipuana* and *Fissicalyx* are suggested by Rojo and Alonzo (1993). More recently, however, phylogenetic contexts by Lavin *et al.* (2001) have been provided for *Pterocarpus*, challenging many of the earlier ideas. The genus is one of 21 genera in a monophyletic grouping of dalbergioid legumes named the "*Pterocarpus* clade" (Figure 2.2), a well-defined unit in the more general phylogeny of the papilionoid legumes which all share a distinctive base chromosome number of x = 10 (Goldblatt, 1981). Almost all members of the "*Pterocarpus* clade" have seeds that do not accumulate non-protein amino acids (Beyra and Lavin, 1999). Lavin *et al.* (2001) have shown that *Pterocarpus* and *Platymiscium* are closely related and descendants from a common ancestor having caducous bracteoles. The evolution of wing petals is thought to indicate that *Pterocarpus* is related to the genera *Paramachaerium, Ramorinoa, Tipuana,* and *Platypodium*.

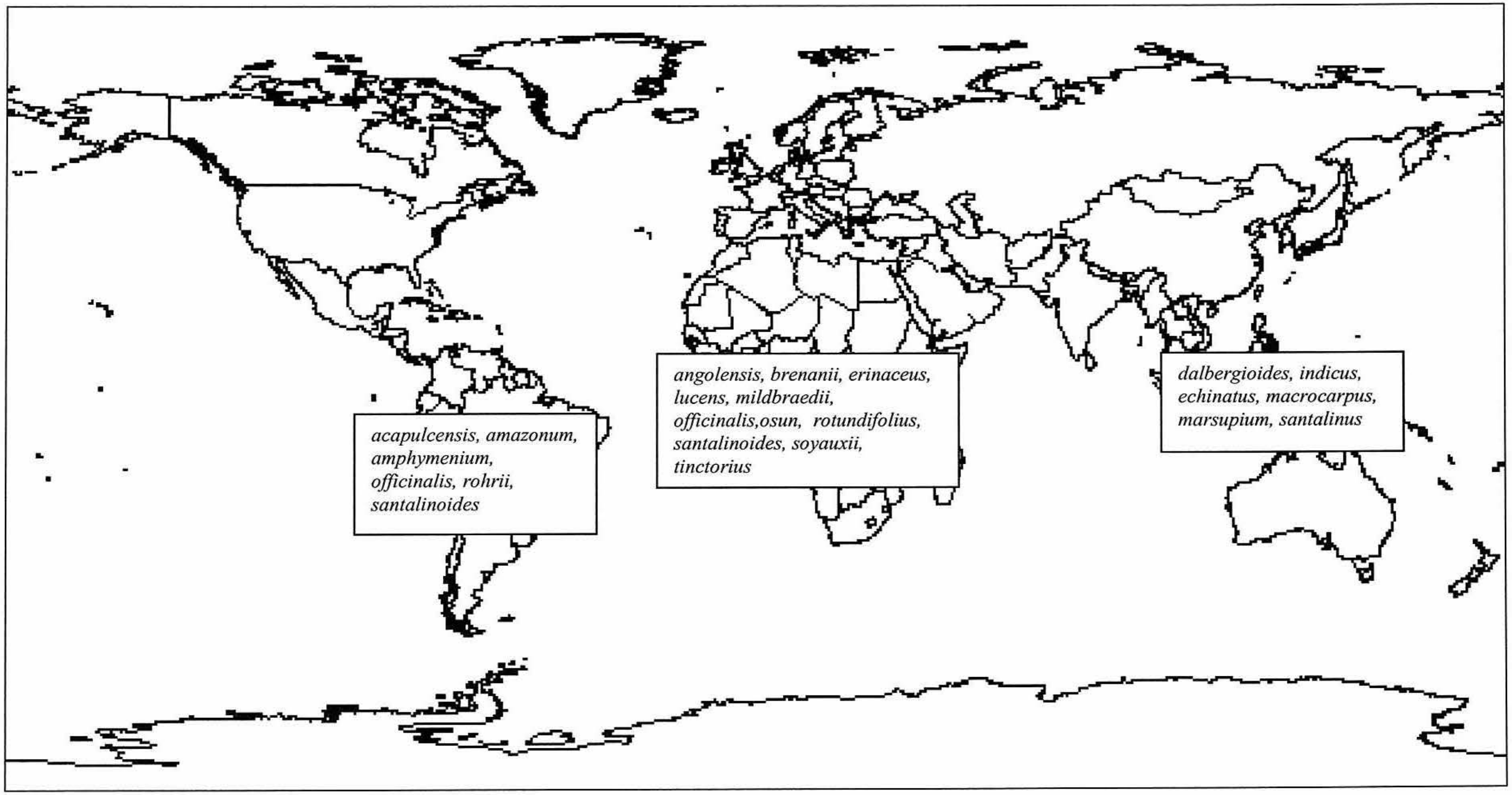


Figure 2.1 Map showing distribution of *Pterocarpus* species in the three geographical regions of the world.
Source: Rojo (1972) adopted and modified.

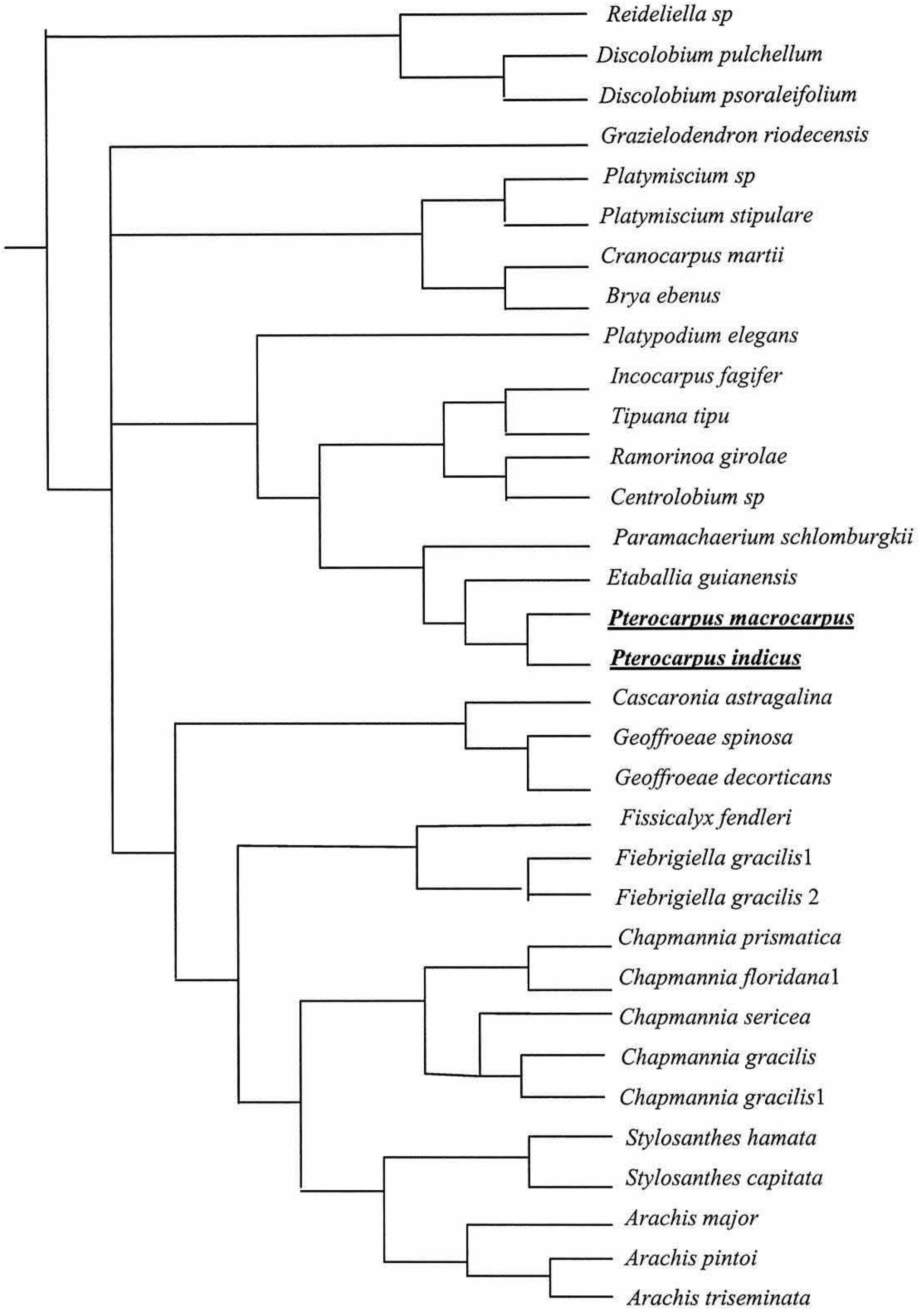


Figure 2.2: Phylogenetic tree of the '*Pterocarpus* clade'

2.2.1.2 Phytochemical context

Several species of *Pterocarpus* are well known for their commercially valuable timber, and as a rich source of flavonoids and related phenolic compounds (Krishnavaneni and

Rao, 2000). A number of species are used medicinally in African societies (Ayensu, 1978; Nagaraju and Rao, 1989; Nagaraju *et al.,* 1991; Iwu, 1993; Ndamba *et al.,* 1994). The phytochemistry of *Pterocarpus* is relatively well-documented, including the bioactivity of the phytochemicals in the cases of certain species (Farboodniay and Ray, 1993; Ebi and Ofoefule, 2000; Groover *et al.*, 2002; Narayan *et al.*, 2005; Dhanabal *et al.*, 2006). A broad class of polyphenols was described in *Pterocarpus* species by Sheshadri (1972) who reported isoflavonoids mainly pterocarpans, isoflavones and deoxybenzoins as major components.

Pterocarpus species are also reported to be rich in such compounds as lupeol (Harborne and Baxter, 1993), β-sitosterol (Ivorra *et al.,* 1989), aurone glycosides (Mohan and Joshi, 1989), (-)epicatechin (Chakravarthy and Gode, 1985), isoflavonoids (Mitra and Joshi, 1983), isoflavonoid phytoalexins including pterocarpans (medicarpin) and isoflavans (vestitol) (Ingham, 1981), terpenoids and related phenolic compounds (Sheshadri, 1972; Kumar *et al.,* 1974; Kumar and Sheshadri, 1976). *P. tinctorius* however, seems to have received little scientific attention compared with other species of the genus.

The phytochemistry of the '*Pterocarpus* clade' reviewed by Harborne and Baxter (1993) and Southon *et al.* (1994a, b) indicates the presence of more flavonoids than alkaloids in the members of this clade (Appendix VIa). Currently, however, knowledge of the phytochemistry of genus *Pterocarpus* (Southon *et al.*, 1994a) is limited to phytochemical observation on thirteen of the 20 species. Most of the 13 species are reported to contain phenolic compounds as their main constituents but indole alkaloids have been reported in one species, *Pterocarpus officinalis* (Appendix VIa). Flavonoids mainly isoflavones, pterocarpans, flavanones, chalcones, isoflavanones, isoflavans and α-methyldeoxybenzoins are the main phytochemicals reported from members of the '*Pterocarpus* clade' (Southon *et al.*, 1994a, b; Dictionary of Natural Products, 2004).

2.2.2 *Strychnos spinosa* Lam.

Strychnos spinosa is a small tree up to 10 m, with a trunk up to 25 cm in diameter, and smooth-grey bark. The species is one of four African species whose branches bear axillary spines (*S. cocculoides, S. congolana* and *S. afzelii*) (Neuwinger, 1996). Leaves are elliptic or obovate. The flowers are pale green or whitish in terminal cymes to about 3 cm across. Fruits are large, yellow and globose, resembling an orange, and 7 – 15 cm in diameter (Beentje, 1994). Locally known as "*Mwage*" in areas around the miombo woodlands of Tabora Region Tanzania, the species grows in savanna forests all over tropical Africa and in open woodland, riverine fringes and on sandy soils along river banks at altitudes from sea level to 1500 m. The species is native to at least 34 countries of mainland Africa as well as to Madagascar, the Comoro Islands, the Seychelles and Mauritius (Leeuwenberg, 1969).

The species has a variety of uses ranging from food to medicine and as an arrow poison additive. The sweet-sour fruit pulp is edible although the seeds and unripe fruit are toxic. The leaves are browsed by livestock (Ogle and Grivetti, 1985), while the hard wood is suitable for timber (Beentje, 1994) being straight-grained and planning well for furniture-making. The species is widely used in traditional medicine (Neuwinger, 1996; *Pers. obs*. 2004), and is sometimes a source of firewood and charcoal and sometimes provides material for charms and traditional musical instruments (Bisset, 1970, von Meydel, 1990, ICRAF, 1992; Hines and Eckman, 1993) and hunting charm (Kokwaro, 1993).

2.2.2.1 Taxonomic context of *Strychnos*

Recent phylogenetic classification circumscribes a 'Loganiaceae clade' (Figure 2.3) of 13 genera (Backlund *et al*., 2000), which share the presence of leaves with stipules, nuclear endosperm formation and prominent occurrence of complex indole alkaloids and seco-iridoids (Jensen, 1991; 1992). Fifteen genera formerly referred to the Loganiaceae family (Leeuwenberg and Leenhouts, 1980) have been excluded from the clade. Four genera (*Strychnos*, *Spigelia*, *Gardneria* and *Neuburgia*) of the 'Loganiaceae clade' out of the thirteen have been shown to be rich in alkaloids (VIIb). The other ten genera: *Antonia, Bonyunia, Geniostoma, Labordia, Logania, Mitrasacme, Mitreola, Neuburgia, Norrisia* and *Usteria* may prove similar but so far seem to have received little or no phytochemical attention. Within the clade, genus *Strychnos* appears related to *Spigelia*, *Neuburgia* and *Gardneria*, and features such as the presence of certain indole alkaloid derivatives support such a relationship. Nevertheless, *Strychnos* seems rather isolated within the clade perhaps partly because of inadequately explained relationships with the majority of other genera in the clade.

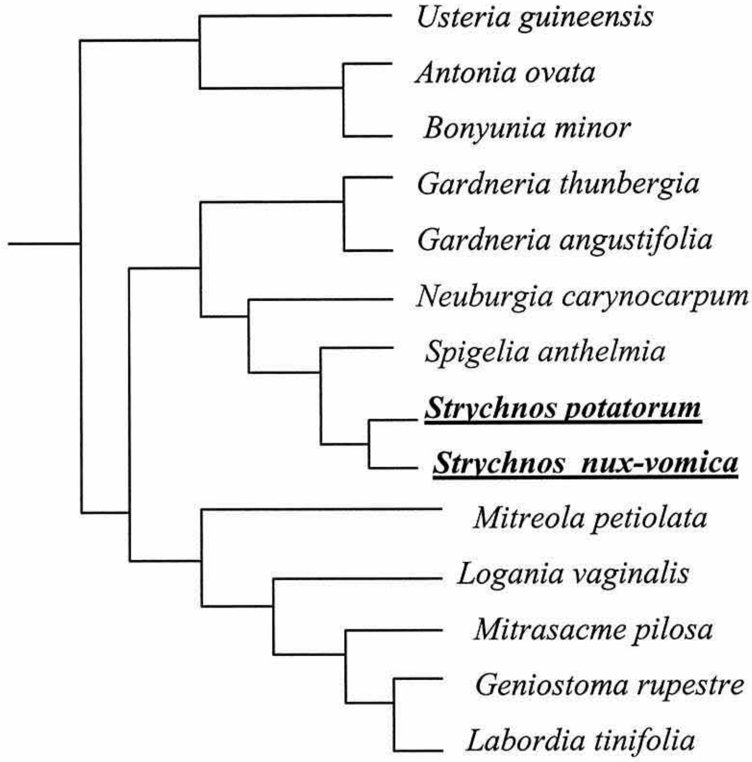


Figure 2.3 Phylogenetic tree of the 'Loganiaceae clade'

In orthodox, classical, taxonomic terms, *Strychnos* belongs to the Loganiaceae, while in conventional taxonomy of the Loganiaceae "family" does not fit current views, although the integrity of *Strychnos* as a genus is not affected. For this study, the key reference point has been the concept of genus *Strychnos* and the concept of *S. spinosa* as a species proposed by Leeuwenberg (1969). Leeuwenberg's views have been followed for the purpose of retrieving relevant information from previous publications relating specifically to *S. spinosa*, regardless of the other names (now treated as synonyms) in the original documents, and to taxa considered more or less closely related to it.

At species level *S. spinosa* is taxonomically close to *S. cocculoides*, *S. congolana* and *S. ternata*, all four species being referred to section Spinosae which occurs only in Africa (Leeuwenberg, 1969). Leeuwenberg regards section Spinosae as morphologically close to sections Aculeatae, Breviflorae, Densiflorae, Penicillatae and Scyphostrychnos.

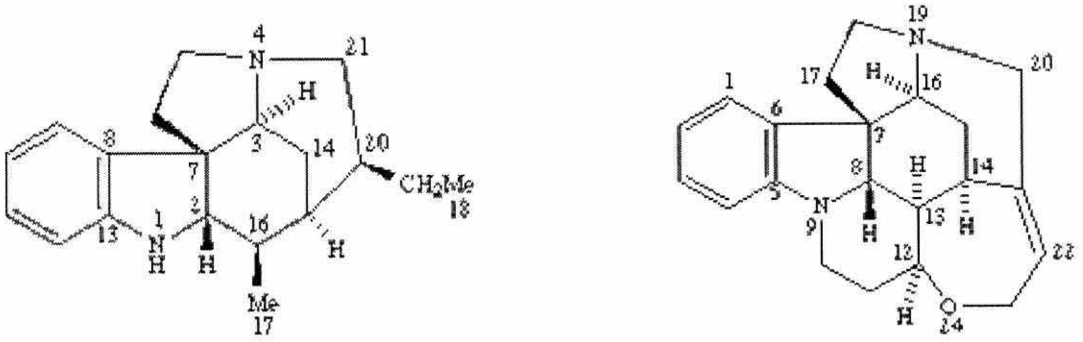
2.2.2.2 Phytochemical context

The phytochemical attention to African *Strychnos* species has a history of some five decades. As far as the literature on *Strychnos* and its alkaloids is concerned noteworthy studies are the works of Rolfsen *et al.* (1979) and Bisset (1980) who organized biogenetic lines and gave accounts of the various types of alkaloids known to occur in the genus (about 200 isolated from various species) commenting, however, that there remain many species about whose alkaloids little or nothing is known.

The genus *Strychnos* is a rich source of monoterpenoid indole alkaloids, the second largest single group of plant bases known today (Thongphasuk *et al.*, 2003) with clinical value in medicine (Harborne *et al.*, 1999). *Strychnos* alkaloids are in fact an example of molecular and pharmacological biodiversity. The main *Strychnos* phytochemicals are indole alkaloids (with more than 300 different alkaloids isolated to date), a class of substance with a wide range of biological activities in several fields: parasitology (*e.g.* amoebiasis) (Wright *et al.*, 1991; Frederich *et al.*, 1999, 2002), cancer (Bonjean *et al.*, 1996, 1998; Lansiaux *et al.*, 2002; Frederich *et al.*, 2003), neurology (*e.g.* tetanizing or curarizing effects) (Sandberg *et al.*, 1969; Quetin-Leclercq *et al.*, 1990; Wins *et al.*, 2003), inflammation (Tits *et al.*, 1991).

The state-of-knowledge summary provided here with regard to phytochemicals previously identified from genus *Strychnos* has been drawn up by consulting relevant past studies on African *Strychnos*: Ohiri *et al.* (1983), Buckingham (1994) and the Dictionary of Natural Products (2004), to develop an overview of the different phytochemicals reported from *Strychnos*, with particular reference to alkaloids reported from *Strychnos spinosa*. There is great variation in the classifications of *Strychnos* alkaloids in past work since the majority of authors (*e.g.* Coune, 1980; Southon and Buckingham, 1989; Sapi and Massiot, 1994) have tried to classify only compounds of immediate concern. Their classifications of the alkaloids of interest have generally been based on the degree of metabolic evolution and on the curan and strychnine skeletons. Recent studies by Biala *et al.* (1998) and Frederich *et al.* (1999) have reported the occurrence of indole alkaloids, iridoids, flavonoids and steroids from *Strychnos* species, broadening the older picture.

For this thesis, the combination classifications of alkaloids in *Strychnos* species of Dictionary of Natural Products (2004), Buckingham (1994), Sapi and Massiot (1994) and Southon and Buckingham (1989) have been adapted and used, since all authors show similarities in describing the monoterpenoid indole alkaloids. Past studies by Sapi and Massiot (1994) suggest *Strychnos* species contain monoterpenoid indole alkaloids of the strychnos type, indoloquinolizine, akuammiline, bisindole, oxindole, yohimbinoid, corynanthe, condylocarpine and ajmalicine-like alkaloids, whose structures incorporate curan or strychnidine skeletons (Figure 2.4).



Curan skeleton Strychnidine skeleton

Figure 2.4: Structures of Strychnos alkaloid skeletons.

A more comprehensive list of indole alkaloids reported to occur in African members of section Spinosae and related sections is presented in Appendix VIIa by indole alkaloid category. Supplementary detail is in Appendix VIIb. Details of the bioactivity of indole alkaloids reported from *Strychnos* species (both closely and less closely related to *S. spinosa*) is in Appendix VIIc.

2.3 Study area description

2.3.1 Location

The study was conducted in the miombo woodlands of Urumwa Forest Reserve in Tabora-Uyui District, Tabora Region (4°-7° S and 31°-34° E). The region forms part of the vast central plateau of the mid-western part of Tanzania (Figure 2.5a), an area of generally low relief most of which lies between 1,100 m and 1,300 m elevation (Acres *et al.*, 1984). It is bordered by Shinyanga Region to the north, Singida to the east, Rukwa and Mbeya to the south and Kigoma Region in the west. The region has a gross land area of 76,151 square kilometres representing 9% of the total land area of Tanzania mainland (URT, 1998).

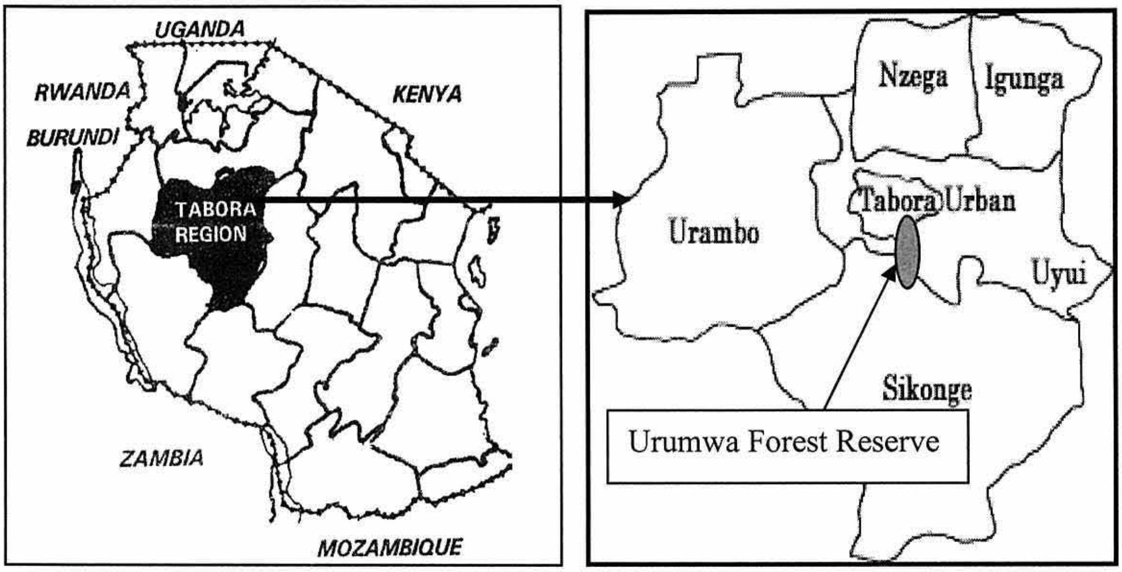


Figure 2.5a Location of the study area in Tanzania.

Source: URT (1998)

Urumwa Forest Reserve and the surrounding villages (5° 08' - 5 ° 14' S, 32 ° 44' - 32° 50'E) are about 15 km south of Tabora municipality (Figure 2.5b) and cover an area of about 13,000 ha. The reserve is bordered by 12 villages collectively with an estimated population of about 22,500 (Mbwambo, 2000). A large proportion (approximately 80%) of Tabora's urban population relies on the reserve for medicinal products. In this study, the six villages most involved in the Joint Forest Management (JFM) programme organized by Tabora-Uyui Forest department were included: Igombanilo, Isukamahela, Kasisi 'A', Masimba, Mtakuja mashariki and Ujerumani.

The choice of the study area is based on the richness of miombo woodlands in the region. About 61% of the vegetation covers of Tabora region is dry Zambezian miombo woodland (White, 1983). Few studies have been done to explore the potential of medicinal plants for the local communities here, while tobacco production as a cash crop currently threatens the survival of miombo woodlands due to the demand for land to cultivate tobacco and demand for fuelwood for curing. Most forest reserves supply closely adjacent villages and are heavily poached or degraded especially when communities experience non timber forest product (NTFPs) shortages (Abdallah, 2001).

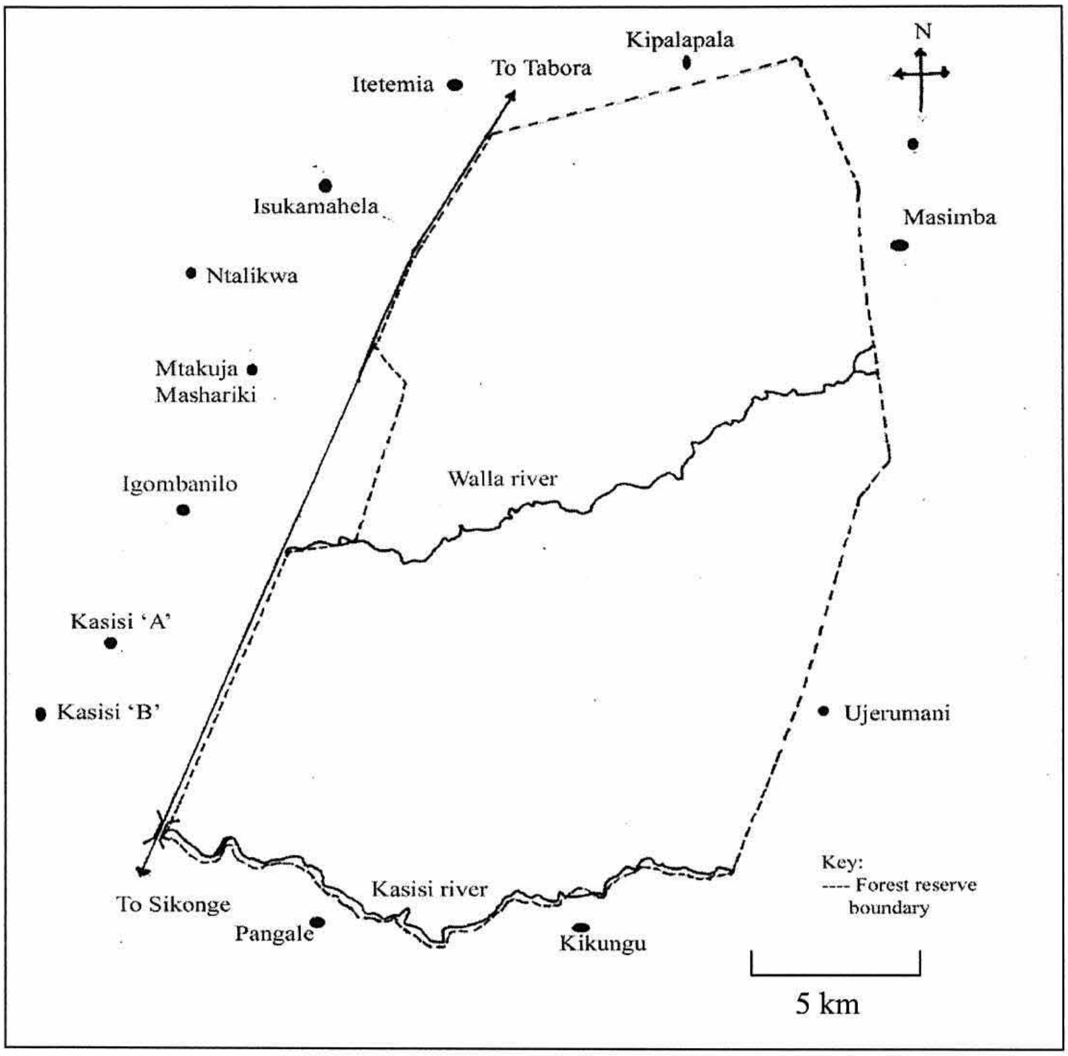


Figure 2.5b Map showing the surveyed and others villages bordering Urumwa Forest Reserve, Tabora Region, Tanzania.
Source: Mbwambo (2000) adopted and modified.

2.3.2 Climate

The climate of Tabora is warm with temperatures reaching a peak in September and October, just before the onset of the rainy season. Monthly means of daily maximum temperature vary from 28°C (January) to 32°C (October), while the corresponding minima range from 13°C (June/July) to 19°C (October). Evapotranspiration demand in the miombo woodlands of Tabora exceeds the mean rainfall every month, resulting in extended water deficit periods depending on the moisture holding capacity of the soil (Acres *et al.*, 1984). Rainfall is seasonal and ranges from an annual average of 1000 mm in the western part to 700 mm in the northeast. The rainfall pattern is characteristically rather variable in space and time with risks of long dry spells even during the rainy season. The rainy season normally starts in October or November and monthly rainfall peaks in December, after which a slight dry spell follows in January or February. There is a lower monthly rainfall peak in February or March and the rains then tail off in April or sometimes May. Thus, the rainfall is broadly monomodal, but with a trend towards a bimodal pattern (Acres *et al.*, 1984). Urumwa Forest Reserve is situated in the high rainfall zone of Tabora Region (Mbwambo, 2000) and receives relatively high rainfall (1000–1100 mm year^{-1}) falling mainly from November to April but with wide year-to-year variation (Mbwambo and Mwiga, 1999; Mbwambo, 2000). Figures 2.6a presents climatic diagrams of three stations neighbouring supporting the climate at Urumwa Forest Reserve. Figure 2.6b shows rainfall distributions of nine stations bordering the reserve, indicating presence of rainfall from November to April especially in the three close stations: Itaga seminary, Tabora observatory and Tabora Airport.

2.3.3 Topography and drainage

The southwest and north-central portions of Tabora Region are divided by a watershed which runs from east to west, and broad defined drainage lines (*mbugas*) drain to Ugalla River in the southwest and Igombe. The Malagarasi River and Lake Sagara form the western boundary of the region. Tabora Region is drained by the two river systems: the Malagarasi and Manonga-Wembere. While the Malagarasi River drains from the southern and western part of the region into Lake Tanganyika and ultimately to the Atlantic, the Manonga drains into the inland Lake Eyasi. Most of the rivers in the region are dry river beds during the dry season. Even during the rainy season the rivers fill for only a very short period, and recede rapidly. This has been attributed in part to the vegetation cover (URT, 1998). Much of the miombo forest floor is bare ground so that rainfall runs off the surface and very little infiltrates (URT, 1998). The two seasonal rivers (Walla and Kasisi) in Urumwa Forest Reserve, which feed into the Malagarasi swamp to the west, form an important seasonal catchment area, for the provision of water for humans, livestock and wild animals immediately after the rainy season (Mbwambo, 2000).

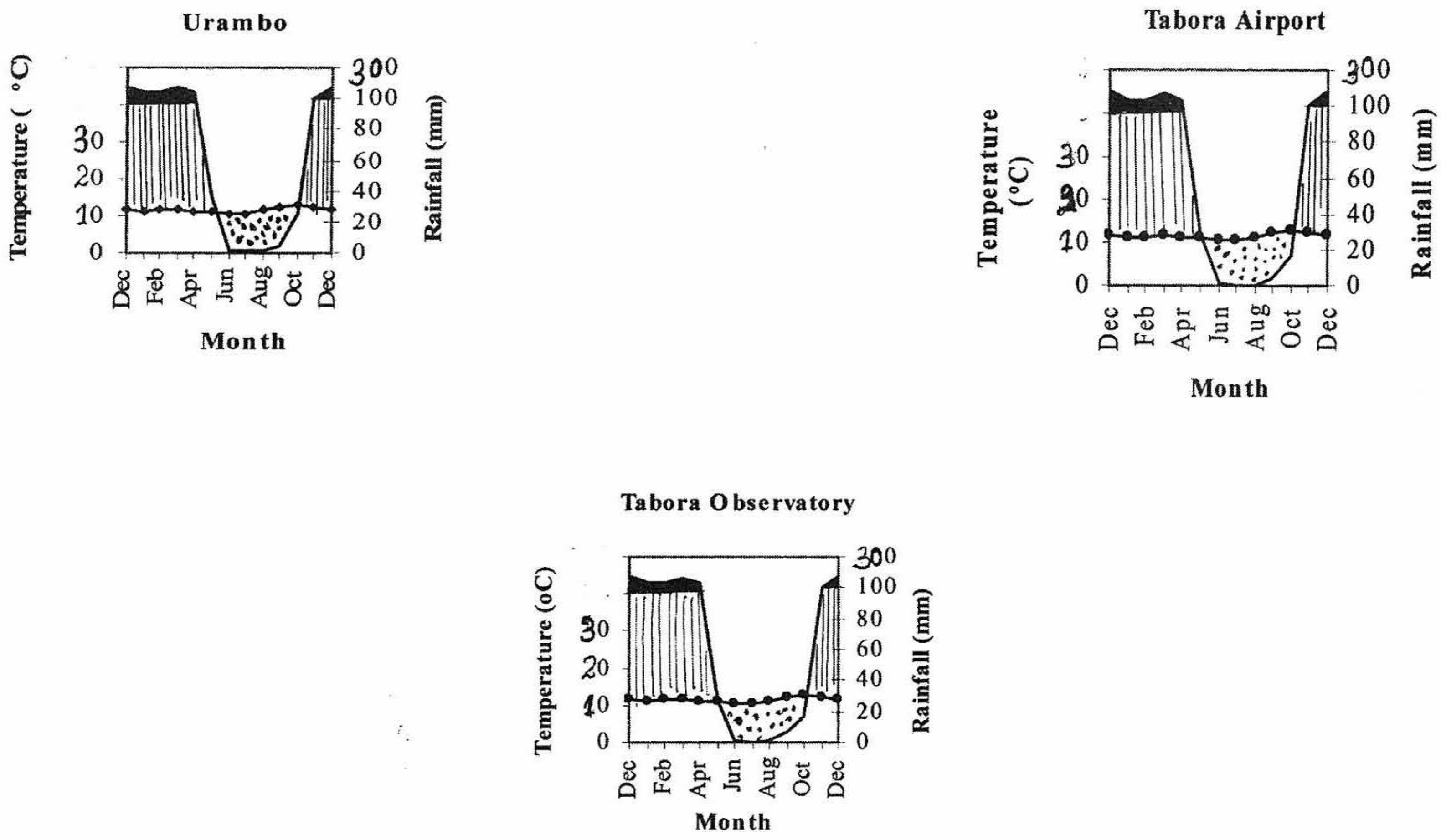


Figure 2.6a Climatic diagrams of three stations bordering Urumwa Forest Reserve, Tabora Region, Tanzania

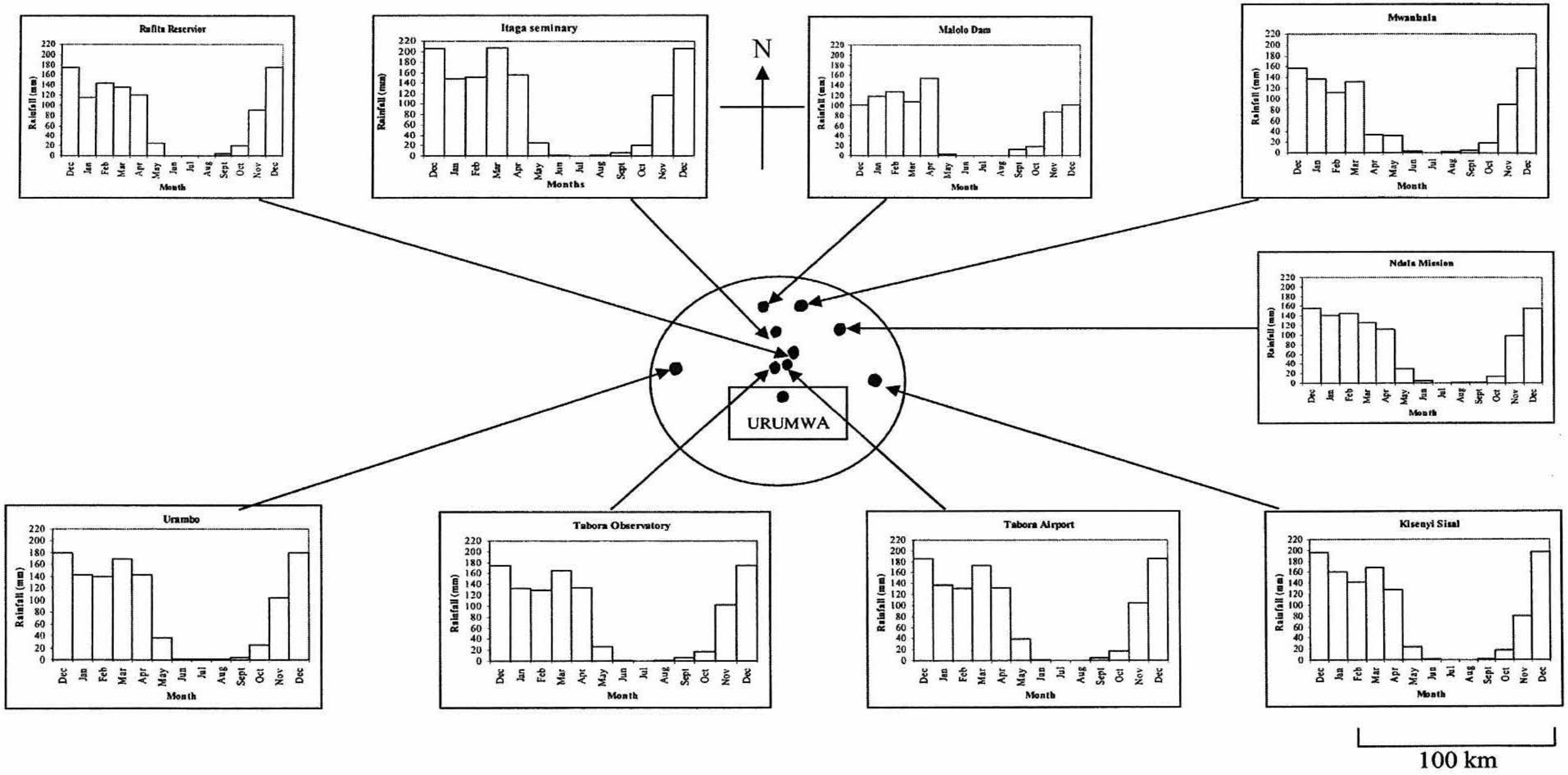


Figure 2.6b Rainfall distributions of nine stations near Urumwa Forest Reserve, Tabora Region, Tanzania

2.3.4 Soil and vegetation

The soils of Tabora Region vary widely, ranging from sandy loams in the south centre and west to heavy (black/dark brown) soils in the poorly drained areas found especially in the north (Acres *et al.*, 1984, Berry, 1995, URT, 1998). The soils are typically red sandy loam (Mbwambo and Mwiga, 1999) and, as in other miombo areas poor in terms of fertility (Lawton, 1982; Stromgaard, 1985). Generally, the soils in Tabora region are mapped as ferric acrisols (FAO-UNESCO, 1977) characterized as being poor and subject to difficult ecological conditions, and supporting mainly dry miombo woodlands and degraded formations Zambezian tree savannas.

The hill vegetation of Tabora Region generally consists of woodland, bushland, thicket and grassland. The valley or wetland vegetation consists of wooded grassland and swamps. Over most of the region, woodland is the natural vegetation cover and is divided into two categories: dry Zambezian miombo woodland (White, 1983) and secondary wooded grassland with *Acacia*, *Combretum* and *Albizia* species (Acres *et al.*, 1984, URT, 1998). A greater proportion of Tabora Region contains natural woodland than any other region in Tanzania.

About half of the woodlands are designated reserves in state land and the rest is land allocated to the public. Most mature miombo woodland in Tabora Region is of secondary regrowth after massive deforestation in the 20th century following an outbreak of sleeping sickness disease (Lawton, 1982). The natural vegetation cover within Urumwa Forest Reserve is drier Zambezian miombo woodland (White, 1983) with the canopy layer dominated by *Brachystegia* and *Jubernaldia* in the hills and the *Acacia/Combretum* communities in the valleys. The reserve has regenerated since people were evacuated in the early 1950's when it was gazetted (Mbwambo, 2000).

2.3.5 Socio-economic activities

The main economic activities of the people in Tabora Region are agricultural production and livestock keeping (about 90% of the population). Other activities are beekeeping, fishing and lumbering. Subsistence farming is the main form of farming with food production dominated by maize as the leading staple food crop to meet family food requirements. Tobacco and cotton are the major cash crops. Livestock keeping is another important activity potentially contributing significantly to the region's economy. Industries, trade and mining activities are undertaken on a small scale and commercial gold mining is under exploration (URT, 1998). Most of those who reside around Urumwa are subsistence farmers and pastoralists. However, pitsawing, charcoal production and beekeeping are undertaken regularly (Mbwambo, 2000) and various non-timber forest products such as wild fruits and medicinal plants are collected and sold.

Ethnobotany and Gender Roles

CHAPTER III

MEDICINAL PLANT ETHNOBOTANY AND GENDER AT URUMWA

This chapter explores the ethnobotanical knowledge and perceptions of gender roles in the utilization and conservation of medicinal plants in the study area. The chapter has four sections subdivided as appropriate. The background (3.1) includes a short state-of-knowledge review. Methodologies used to assemble socio-economic information (3.2.1) and ethnobotanical and conservation attitude data (3.2.2) make up Section 3.2. In the Results (3.3) findings are reported in terms of respondents' profile (3.3.1), ethnobotanical knowledge (3.3.2), perceptions of responsibility (3.3.3) and conservation awareness (3.3.4). Section 3.4 is a discussion.

3.1 Background

3.1.1 Ethnobotany, gender and traditional medicine

The ethnobotany of medicinal plants in the miombo woodlands of western Tanzania is poorly documented creating a need to record the knowledge before the traditional specialists abandon their practices or pass away without imparting their knowledge to a younger generation. Studies such as Ruffo (1990) and Katambo (1999) document plants used as medicine and indigenous knowledge of medicinal plants in the miombo woodlands of western Tanzania, but few make reference to formal pharmacological findings or the status of the resource species. Documentation of medicinal plants is still required especially for the western miombo woodlands of Tanzania which are at increasing risk of habitat loss through anthropogenic activities, threatening the availability of wild plants. Equally, there is the serious problem of traditional medicinal knowledge disappearance in Tanzania (Mahunnah, 1990).

For Tanzania generally, however, two major surveys of plants used in traditional medicine by communities in the eastern and north-eastern parts of the country are noteworthy as models (and because some species found in Tabora Region are included in them). The first is the inventory by Hedberg *et al.* (1982, 1983a, b) of north eastern Tanzania in which, in families Acanthaceae – Vitaceae, 153 plants used in traditional medicine were recorded. The second survey (Chhabra *et al.*, 1989, 1990a, b, 1991, 1993) recorded for the same area 329 angiosperm species used in traditional medicine.

In these major surveys, the medical use, constituents isolated and pharmacological effects of the species are documented.

The use of plants in traditional medicine is widespread in the rural communities of Tanzania where both men and women possess considerable knowledge on ethnomedicine. However, outside the dependent communities, there is lack of understanding of gender role as expressed in traditional medicinal practices, and a need to gain this understanding for effective support through rural initiatives. Such initiatives include strengthening existing (and developing) policies of better management of medicinal plant resources, improving community health and well-being and implementing longer-term plans to integrate traditional and modern medical systems.

In Tanzania, in common with other countries in the miombo ecoregion, the majority of the population lives in rural areas. Women in rural areas make half of the estimated 68% total population (Byers, 2001). The state-of-knowledge of medicinal plants within the gender context, however, is not well described. Variation in information exists from one researcher to another; although it seems that the traditional medicinal practices have been male dominated and women have been much less involved – for example (Urio *et al.*, 1996) for northern Tanzania. Gender-differentiated local knowledge systems have been reported to play a decisive role in the conservation and management of medicinal plants and their use for primary health care (Singhal, 2005).

Medicinal plant species throughout the tropics according to Akerele *et al.* (1991), Balick and Cox (1996), Lange and Schippmann (1997) and Leanman *et al.* (1999) are threatened in the wild due to over-exploitation. The conservation of medicinal plants in miombo woodlands, not only in Tanzania but in the miombo ecoregion generally, amounts to a major gap in knowledge and understanding. Indeed, only in recent years has the need to clarify and understand conservation awareness in communities which use the medicinal plants of miombo woodlands been acknowledged. Unsustainable harvesting and land-use practices for miombo land and products generally are now recognized as serious problems (Bodeker, 2002).

The main threat (Maundu *et al.*, 2004) is unsustainable harvesting practices, particularly ring-barking and uprooting. A well known example is the commercial exploitation of *Warburgia salutaris* (Bertol.f.) Chiov. bark from the miombo woodland of Southern

Africa (Botha *et al*., 2004), which is commercially traded in the markets. The species is among the IUCN's (2001) Red List species categorized as vulnerable and endangered in different countries in southern Africa. Within rural communities the main underlying cause of over-exploitation of medicinal plants is the combination of poverty and high unemployment due to falling per capita income in most African countries. Harvesting and the provision of medicinal plants to meet the urban demand has become an environmentally destructive activity (Williams *et al*., 2000), due to the development of a substantial network of rural commercial gatherers, herb traders, traditional healers, and consumers. In response, non-professionals have turned to herbal harvesting and trading (and even treatment activity). In Kenya and Uganda, *Mondia whitei* (Hook f.) Skeels is becoming rare due to unsustainable root harvesting by unemployed youth (Maundu *et al*., 2004). A study by Makonda *et al.* (2000) in three districts of Tanzania noted in the field that some medicinal plant species were dying in patches following over-exploitation of their roots and bark.

3.1.2 Statement of purpose

The basic objective of the ethnobotanical part of this study was to assess community medicinal plants ethnobotanical knowledge, perceptions of gender roles, and conservation awareness, with respect to the miombo woodlands of Urumwa Forest Reserve, Tabora-Uyui District, Tabora Region, Tanzania (Section 2.3 – Chapter II).

The approach was to record the plants involved and the diseases treated, ascertaining methods for preparing medicines, establishing how remedies are administered and comparing the knowledge held by the men and by the women in the study villages. While, gender roles considered how men and women participated in medicinal plants utilization and conservation in specified categories; conservation awareness explored community views on harvesting methods, priority species and measures to be taken to conserve potential medicinal plants of the study area.

3.2 Methods

Primary data in three sets (socio-economic, ethnobotanical and conservation awareness) were collected from herbalists (*i.e.* traditional healers, medicinal plant sellers and traditional birth attendants), medicinal plant collectors and households residing close to

Urumwa Forest Reserve. Field observation of participants and informal discussion in the village with knowledgeable elders and other informants (mainly forest extension officers, village government leaders and forest protection committee members) supplemented the primary data. Approach and entry to villages for data collection was through the village leadership, generally the Chairmen and Executive Secretaries, to ensure smooth running of day to day activities within the study area.

A preliminary survey was conducted to establish the actual sample size for informants, and assisted the researcher to familiarize with the study area and provide a preliminary focus on plants of particular importance to local communities. The activity helped the village leaders to assist the researcher in explaining to sub-village leaders and villagers the essence of the study and its relevance to communities and the country as a whole.

3.2.1 Socio-economic, ethnobotanical and conservation awareness data

3.2.1.1 Survey rationale and framework

The socio-economic survey was carried out to obtain information on the characteristics of informants, and assisted in ensuring the informants' involvement during face-to-face interviews, helping to build a working relationship between interviewee and interviewer.

The ethnobotanical and conservation awareness survey was to obtain detailed information on the utilization of plant medicine by local communities, on community knowledge about men's and women's involvement in the utilization and conservation of medicinal plant resources, and on men's and women's awareness of conservation and of measures for ensuring the future availability of medicinal plants in the miombo woodlands of Urumwa.

Information was provided by a sample of the population including traditional healers, traditional birth attendants, medicinal plant vendors and collectors, and knowledgeable and other informants representing six villages (Table 3.1). These respondents' were identified during the preliminary survey with the assistance of Chairman in each village considering those who were knowledgeable and use medicinal plants and willing to share information with the researcher.

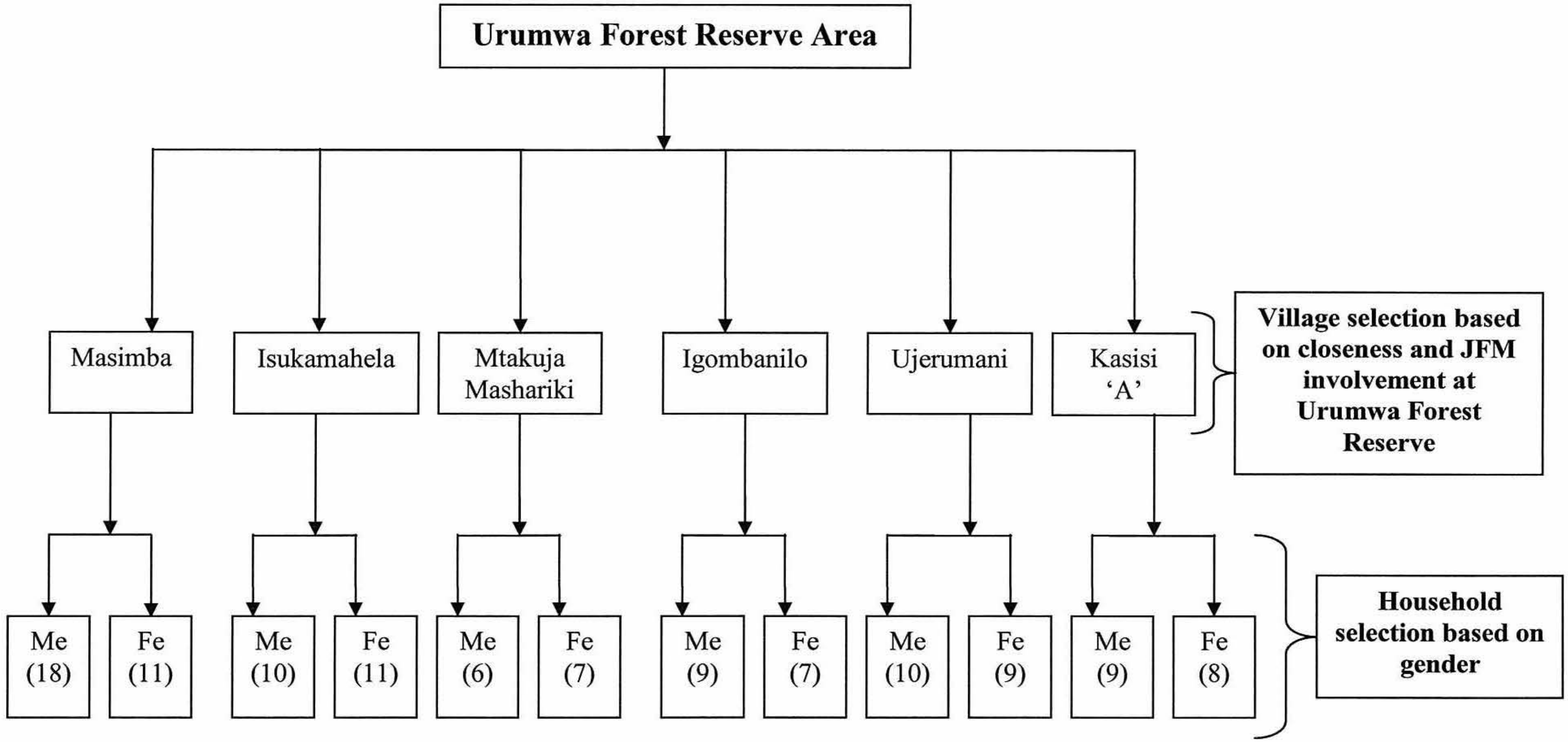
Only mature informants of the age of 18 (as officially recognized adult age) and above were selected to respond to the questions during the survey. An enumerator who was also a staff member at TAFORI-MWRC was given training for two days to assist in the field survey. The person was also tested on his capability to use the data collection instruments during preliminary survey.

3.2.1.2 Data acquisition

Socio-economic, ethnobotanical and conservation awareness data were collected with the use of a questionnaire and through participatory rural appraisal (PRA) survey techniques. A stratified sampling strategy based on gender and households, in the villages close to, and involved in JFM programmes, around Urumwa Forest Reserve (Figure 3.1) was used in data collection. This choice of design is based on its advantage of ensuring that the sample represents adequately all sections of the population at minimal cost while limiting errors in sampling (Temu and Lazaro, 2000).

In each village, traditional healers, traditional birth attendants, and knowledgeable and other informants were sources of information. In four villages, medicinal plant collectors were also consulted and in Masimba village, eight medicinal plant vendors were interviewed (Table 3.1). The intensity of sampling varied with respondent category. While 100% sampling intensity was used for herbalists and medicinal plant collectors, only 20% and 10% of other informants and households respectively were sampled. In all, 115 informants were involved in the survey.

Interviews were conducted in the Swahili language but with provision for use of Nyamwezi whenever a difficulty in language was encountered. A respondent was interviewed only once, due to resource constraints. However, to ensure that answers were provided under consistent conditions, completed questionnaires were cross-checked at the end of each day and when inconsistencies in answers were observed arrangements were made to re-visit and talk with the respondent concerned for a second time. If the second visit did not resolve matters, arrangements were made to interview another person. This situation never arose with herbalists and rarely happened with the sampled households.



Note: Numbers in the parentheses are frequencies; me = 'Male'; Fe = 'Female'

Figure 3.1 Diagrammatic summary of sampling strategy used for ethnobotanical survey in villages around Urumwa Forest Reserve, Tabora Region, Tanzania

Table 3.1 Sampling scale used during ethnobotanical survey in villages around Urumwa Forest Reserve, Tabora Region, Tanzania

Village name	**Sampling units**												**Total sample**
	Traditional healers		Traditional birth attendants		Vendors		Collectors		Households		Other informants		
	Me	Fe	Me	Fe	Me	Fe	Me	Fe	Me	Fe	Me	Fe	
Masimba	3	2	-	7	8	-	2	-	3	2	2	-	**29**
Igombanilo	2	1	-	5	-	-	1	-	4	1	2	-	**16**
Mtakuja mashariki	1	-	-	4	-	-	1	-	3	2	1	1	**13**
Isukamahela	2	1	-	5	-	-	2	-	5	4	1	1	**21**
Ujerumani	6	2	-	3	-	-	-	-	3	3	1	1	**19**
Kasisi 'A'	3	1	-	4	-	-	-	-	4	3	2	-	**17**
Total	**17**	**7**	**-**	**28**	**8**	**-**	**6**	**-**	**22**	**15**	**9**	**3**	**115**

Note: Me, represents 'Male' and Fe, represents 'Female'

Questionnaire survey

This survey generated three data sets in the form of semi-structured question responses with open-ended and closed-ended questions (Appendices IbA, IbB, IbC). With open-ended questions respondents were free to give their own answers and maximum discussion was encouraged (Jackson and Ingles, 1998). For closed-ended questions a number of alternative answers were specified. This two-pointed approach was intended to obtain clearly focussed responses while at the same time deriving reasoning and supporting arguments, as ascribed by Letšela *et al.* (2003). The initial question that was asked of each household member was whether or not he/she has ever used medicinal plants to treat illnesses. If the answer was no, no further information was requested. If the answer was yes, additional questions contained in the questionnaire were asked.

Questions on the socio-economic setting were specific, eliciting respondent's sex, age, marital status, occupation and education level (5 questions). The ethnobotanical setting was explored with seven questions, in two categories: local knowledge on use of medicinal plants, diseases treated and parts used (4 questions), and preparation methods and forms of administering remedies from medicinal plants (3 questions).

Within the ethnobotanical context, gender role knowledge was explored in terms of perceptions of responsibility, with one main question, in two specific categories. A general question revealed either agreement or disagreement on whether gender role difference in utilization and conservation of medicinal plants existed amongst men and women from communities around Urumwa. A more specific question in five sub-categories was put to explore existing roles in utilization (Appendix IbA - question 8, IbB - question 6 and IbC question 2) and conservation (Appendix IbA - question 18, IbB - question 11 and IbC - question 12). It should be noted that when an informant responded negatively by failing to agree on the general question, a conclusion was drawn that no significant difference in gender roles between men and women were recognized in either utilization and/or conservation and the sub-category questions were not put.

To explore awareness on conservation, five questions were used. These solicited information on methods used to harvest the medicinal plants, the status of the plant species in the forest reserve, the threats posed to the plants, the initiatives taken for conservation and the views of local people on conserving medicinal plants at Urumwa (Appendices IbA, IbB, IbC).

Participatory rural appraisal exercise

This exercise was conducted to develop a list of priority species which communities think have relatively high potential and which need future protection more than other plants used. The exercise also provided an opportunity to check if the previous listing of target medicinal plants (Table 4.1, Chapter IV - from Abdallah, 2001) matched with what local people perceived. Thirty six men and women (of different age groups, ethnicity and sex), mainly traditional healers, traditional birth attendants, medicinal plant collectors, knowledgeable elders, forest protection committee members and village leaders from the six villages around Urumwa Forest Reserve, participated. The exercise was conducted in three sessions for easier facilitation; in each session, two villages were involved.

The whole exercise was guided by a PRA checklist (Appendix Ia) to understand local people's preferences and choices in utilizing medicinal plants and on the plants' status and their views about conservation measures to ensure future availability for primary health care. PRA being participatory in nature, allows local people to apply their knowledge, experiences and capacity to share information (Luoga *et al.*, 2000a).

The PRA techniques used in this study included free-listing (where participants were asked to spontaneously list all the plants they knew and used as medicine in their daily life), pair-wise matrix ranking, and participatory mapping. As a research tool, participant observations (Jackson and Ingles, 1998) was used to assist a researcher to clarify misunderstandings that occur if local people provide information that does not match what is seen, and it reduced the number of questions that needed to be asked of local people.

Pair-wise matrix ranking as described by Jackson and Ingles (1998) and Martin (2004) was used to examine local peoples' preferences for potential medicinal plant species which cater for daily primary health care needs. Initially participants from each group (3 different session) were asked to list potential medicinal plants from Urumwa and identify the six most important. These "important" species were supposed to be available in the forest reserve. A matrix was produced with the selected plants being used for rows and columns (Table 3.2), and along each row the species were compared with each counterpart in turn, identifying at each step whether the species labelling the column or the row was more important.

The more favoured of the two was indicated in the relevant cell and a rank list of plants produced at the end in order of preference, according to scores (rank 1 for the highest score descending to 5 for the lowest score at cell level). The plant with highest score was ranked the species of highest priority and the others as of progressively lower priorities as scores decreased.

Table 3.2 Matrix of potential medicinal plant species at Urumwa Forest Reserve, Tabora Region, Tanzania

Local name	Botanical name	A	B	C	D	E	F	Scores	Rank
A. Mlundalunda	*Cassia abbreviata*		A	A	A	A	A	10	1
B. Mshenene	*Xylopia longipetala*	A		B	B	E	B	6	2
C. Mdungwa	*Kigelia africana*	A	B		D	E	C	2	4
D. Mwage	*Strychnos spinosa*	A	B	D		E	D	5	3
E. Msana	*Combretum zeyheri*	A	E	E	D		E	6	2
F. Kafinulambasa	*Dalbergia nitidula*	A	B	C	D	E		0	5

Source: PRA example from Masimba and Mtakuja Mashariki (2004).

In participatory mapping, participants were assisted to draw a map of Urumwa Forest Reserve on a piece of paper and were then asked to indicate areas having abundant or scarce medicinal plants. The aim was to obtain a general picture of how medicinal plant resources are distributed within the reserve to guide 'case study' species inventory.

3.2.1.3 Data processing and analysis

The main tools for data analysis were the Statistical Package for Social Sciences (SPSS) and Microsoft Excel computer softwares. Before data entry relevant variables (from the three data sets) in the questionnaire responses for each question were identified and alternative answers were coded. For open-ended questions where respondents provided unstructured commentary, responses were assigned numerical values ranging from 1 – 3 (or more depending on responses) in a common theme (Appendix Ic). Using SPSS the data were summarized as observed frequencies among the respondents. Cross-tabulations were used to explore pair-wise inter-relations of variables for display as tabular or diagrammatic summaries.

Data collected through PRA techniques were summarized by the researcher and participants from the six villages around Urumwa Forest Reserve, and the results were communicated back to participants.

G-tests of association were carried out to detect any gender differences in utilization and conservation of medicinal plants. *G*-tests were also used to seek differences in ethnobotanical knowledge of medicinal plants between women and men around Urumwa. Assuming that men and women would be represented in equal proportions for each role and would mention same number of medicinal plants, the likelihood ratio statistic (G) was calculated as: $G = 2 \times \sum$ {[(observed frequency) × ln (observed frequency/expected frequency)]}. Calculated values were corrected for continuity by applying the William's correction factor (Sokal and Rohlf, 1995).

Sørensen's index of similarity (Magurran, 2004) was used to indicate the extent of overlap in species spectra reported to be used for treating different disease categories. The index was expressed in percentages and calculated as: [2a/(2a+b+c)] x 100, where; a is number of species shared by the categories compared, b is the number of species reported for only the first category, and c is the number of species reported only for the second category.

3.3 Results

3.3.1 Respondents' profile

A high proportion of male and female respondents in villages around Urumwa Forest Reserve were aged between 38 to 57 years, with more male (32% of 115) than women (26% of 115) respondents (Table 3.3a).

Table 3.3a Frequency distribution of age and occupation of respondents at Urumwa, Tabora Region, Tanzania

Age group	Respondent's occupations										
	Herbalists		Collectors		Households		Other informants*		Total		Combined
	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀+♂
18 - 27	-	4	-	1	1	1	-	1	1	7	8
28 – 37	2	1	-	1	8	5	-	1	10	8	18
38 – 47	9	6	-	2	6	7	-	5	15	20	35
48 – 57	11	10	-	1	3	6	1	-	15	17	32
58 - 67	8	5	-	1	1	-	-	2	9	8	17
68 – 77	3	-	-	-	-	-	-	-	3	-	3
78 – 87	-	1	-	-	-	1	-	-	-	2	2
Totals	**33**	**27**	**0**	**6**	**19**	**20**	**1**	**9**	**53**	**62**	**115**

* Village officials, knowledgeable elders, forest protection committee members; ♀ = Female; ♂ = Male

A high proportion of female and male respondents (42%) around Urumwa are illiterate and have had no access to any form of education, followed by 36% who have attained primary education level and 19% with adult education (part time training for adults who had not attended school when young). Few had benefited from secondary education (Table 3.3b).

Table 3.3b Respondents' education profiles around Urumwa Forest Reserve, Tabora Region, Tanzania

Respondents category	Education profiles				Totals
	Illiterate	Adult education	Primary education	Secondary education	
Female	27(51)	11(21)	14 (26)	1(2)	53(100)
Male	21(34)	11(18)	27(43)	3(50)	62 (100)
Totals	**48(42)**	**22(19)**	**41(36)**	**4(4)**	**115 (100)**

Numbers in parentheses are percentages.

3.3.2 Ethnobotanical knowledge

3.3.2.1 The ethnobotanical data set

The ethnobotanical data set was made up of records. Each record was a report from one of the 115 respondents that a particular species was used for a specified medicinal use. In summarizing the data from the completed questionnaires, 74 medicinal uses (use sub-categories, grouped into 10 use categories) were recognized. Respondents named 111 species when they completed the questionnaires and, in total, approximately 1200 records were assembled.

3.3.2.2 Species reported to be used

A full listing of the 111 species mentioned in the questionnaire responses is appended (Appendices IIIa, IIIb). Out of the reported species, 99 are found inside and 12 outside the forest reserve. As with the different use categories, the numbers of records for different species vary greatly (Figure 3.2), from single records (for 19 species) to 139 records (for *Cassia abbreviata*). For fewer than 40 of the 111 species were 10 or more records gathered, and only 12 species were reported in excess of 20 times, these 12 accounting for 46% of the records. Half of the records are contributed by the top 15 species, suggesting that these are species particularly well-known by the local community. In phylogenetic terms, three orders (Fabales, Myrtales, Sapindales) dominate the records gathered, accounting for more than 60% of the records although containing only 50 of the 111 species.

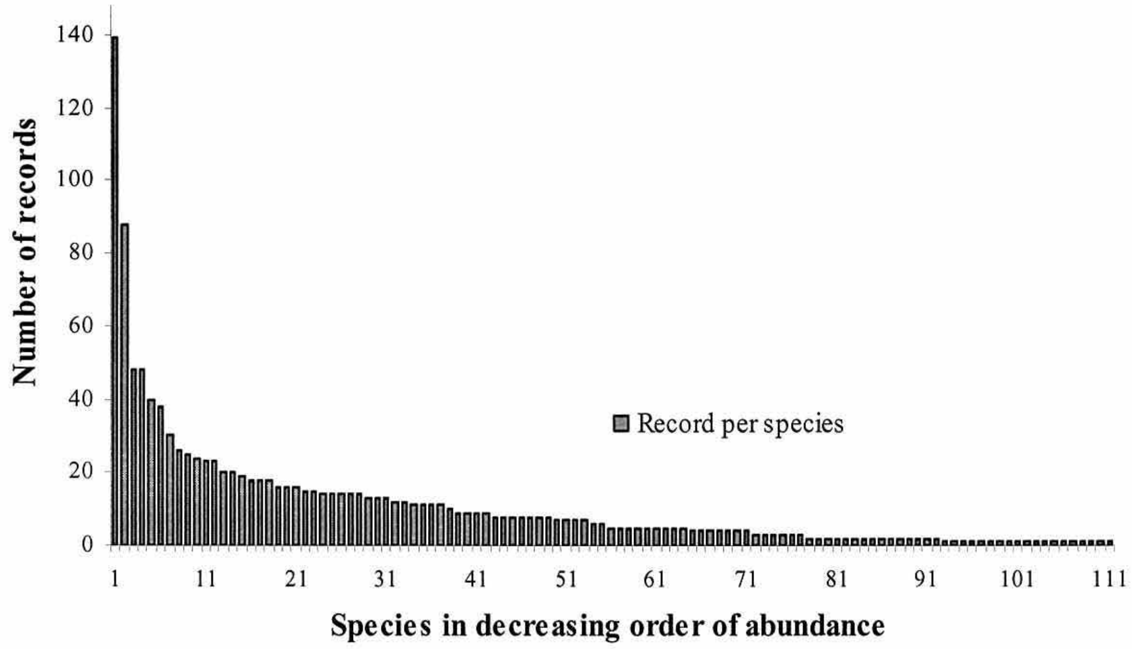


Figure 3.2 Distribution of records against species listed from communities around Urumwa Forest Reserve, Tanzania. The first 15 species are *Cassia abbreviata, Combretum zeyheri, Ekebergia benguelensis, Terminalia sericea, Xylopia longipetala, Kigelia africana, Securidaca longepedunculata, Ozoroa insignis, Friesodielsia obovata, Pterocarpus angolensis, Entada abyssinica, Strychnos spinosa, Schrebera trichoclada, Vepris glomerata and Cajanus cajan.*

3.3.2.3 Reported usage

The numbers of records assembled for use categories and sub-categories varied widely. At category level, numbers range from 33 to 318. At sub-category level, numbers range from 1 to 134 (Table 3.4; Figure 3.3). For most sub-categories the questionnaire responses generated relatively little information (<10 records) – implying that much of the community's traditional medicinal plant use information is sparsely distributed, although quite diverse. However, half of the records refer to the top 8 use sub-categories, and in all but two categories (fevers and skin disorders) at least 30 records were gathered for at least one use sub-category, suggesting a number of medicinal plant usages were commonplace. The familiarity of many local people with treatments for various gastro-intestinal and urino-genital complaints explains the well-reported sub-categories in the rows for these in the Table 3.4, and possibly well-established treatment procedures, although other sub-categories were more rarely mentioned.

Table 3.4 Variation in numbers of records among medicinal plant use categories and sub-categories reported by 115 respondents at Urumwa Forest Reserve, Tanzania

Categories*	**Numbers of sub-categories represented by:**				**Row totals**
	>30 records	21-30 records	11-20 records	1-10 records	
Gastro-intestinal conditions	3	0	3	5	**11**
Urino-genital conditions	2	3	1	7	**13**
Pains and inflammation	1	1	1	14	**17**
Central nervous system	1	2	0	1	**4**
Other human diseases	1	0	2	3	**6**
Rituals/fortune	1	1	1	0	**3**
Fevers	0	1	1	2	**4**
Paediatric conditions	1	0	0	3	**4**
Respiratory conditions	1	0	0	7	**8**
Skin disorders	0	0	2	2	**4**
Column totals	**11**	**8**	**11**	**44**	**74**

* Use categories and sub-categories adopted and modified from Hamisy *et al.* (2000) and Ruffo (1990) respectively.

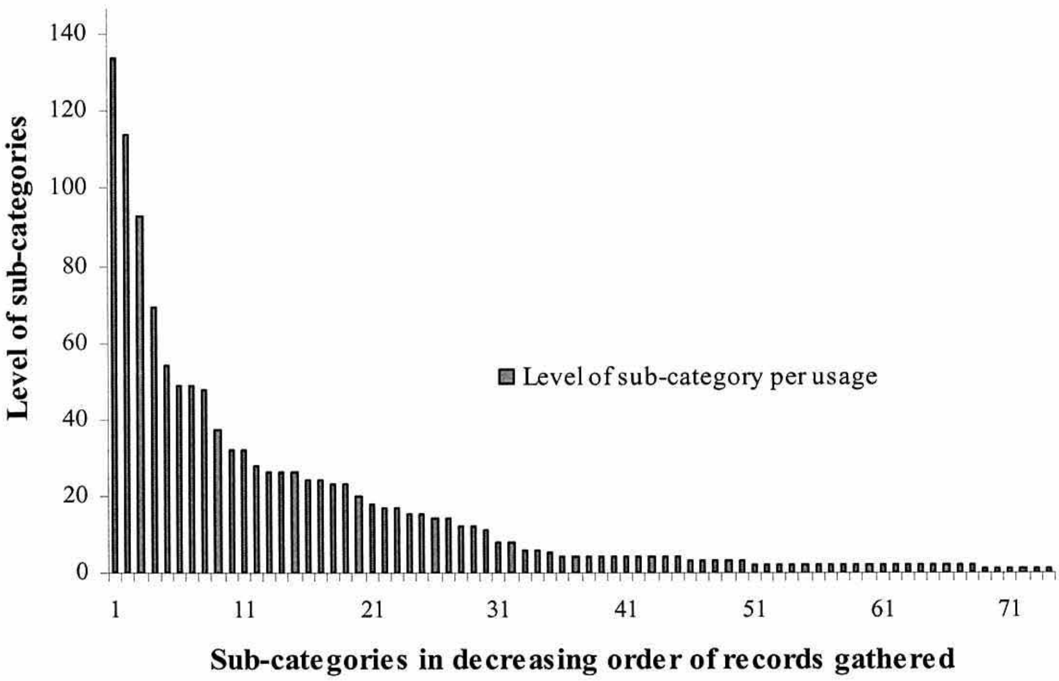


Figure 3.3 Distribution of sub-categories level against use sub-categories of plants from communities around Urumwa Forest Reserve, Tanzania. The first 8 use sub-categories (categories in parentheses) are: infertility (urino-genital), Stomach ache (gastro-

intestinal), diarrhoea (gastro-intestinal), anaemia (other human diseases), snakebite (pains/inflammation), hernia (gastro-intestinal), gonorrhoea (urino-genital), and convulsion (central nervous system).

3.3.2.4 Villages, respondent gender and plant uses

Numbers of records and the corresponding diversity of species are indicated in Table 3.5, as are the numbers of respondents of each gender who provided records from each village. There are marked differences in the information gathered from different villages and in the contributions from women and men.

The most comprehensive set of information was collected from Masimba, with nearly 400 records. At the other extreme, Isukamahela provided only one-third of this number of records. Some of the contrast is a reflection of the higher number of respondents (29) in Masimba (only 21 in Isukamahela) but individually respondents offered less information at Isukamahela (lowest row of Table 3.5): 6 records per respondent compared with 13.55 records per respondent at Masimba. This suggests the villages differ in their collective ethnobotanical knowledge.

Table 3.5 confirms the relatively limited knowledge of species to use for some of the medicinal categories. Information on the treatment of skin disorders is too limited for meaningful interpretation, with almost all records within a village being single reports for the species concerned. In contrast, there is evidence of the communities' general awareness of plants that are useful medicinally for treating gastro-intestinal or urino-genital conditions.

With the exception of Masimba, the numbers of female and male respondents within a village were closely similar, allowing direct comparison of the figures, for reports and species, between genders. In most villages, men provided higher numbers of records and were aware of more species that could be used, although at Isukamahela and Ujerumani little difference between genders is apparent.

Table 3.5 Breakdown of ethnobotanical records from six villages around Urumwa Forest Reserve, Tanzania, by medicinal category, village and gender of respondent

		Igombanilo			Isukamahela			Kasisi 'A'			Masimba			Mtakuja Mashariki			Ujerumani			**Respondents totals**		
Disease category		♀ (7)	♂ (9)	Σ (16)	♀ (11)	♂ (10)	Σ (21)	♀ (8)	♂ (9)	Σ (17)	♀ (11)	♂ (18)	Σ (29)	♀ (7)	♂ (6)	Σ (13)	♀ (9)	♂ (10)	Σ (19)	Σ♀ (53)	Σ♂ (62)	**ΣΣ115**
A	Records	10	29	39	18	17	35	8	36	44	17	82	99	19	29	48	22	31	53	94	224	**318**
	Species	6	17	18	11	13	19	4	20	22	10	31	33	9	19	24	17	21	29	31	56	**61**
B	Records	16	20	36	20	15	35	19	24	43	35	60	95	5	24	38	33	26	59	57	244	**301**
	Species	10	11	19	15	11	21	14	12	21	18	25	35	5	17	25	20	14	28	38	42	**57**
C	Records	1	21	22	0	10	10	2	31	33	3	35	38	1	7	8	4	16	20	11	125	**136**
	Species	1	15	16	0	8	8	2	24	25	3	20	21	1	7	8	4	15	16	10	49	**52**
D	Records	2	19	21	2	1	2	3	6	9	13	32	55	4	10	14	7	3	10	31	80	**111**
	Species	2	9	10	2	1	2	2	5	7	12	15	20	4	8	10	6	2	7	17	23	**27**
E	Records	1	8	9	2	4	6	2	5	7	2	10	12	3	4	7	0	6	6	10	37	**47**
	Species	1	6	7	2	4	5	2	4	6	2	7	9	3	4	7	0	4	4	6	16	**19**
F	Records	2	13	15	10	3	13	2	6	8	7	32	39	1	10	11	11	3	14	33	67	**100**
	Species	2	7	7	7	3	10	2	5	6	5	14	16	1	9	10	7	3	8	12	23	**28**
G	Records	2	12	14	5	3	8	4	4	8	2	25	27	0	3	3	5	6	11	18	53	**71**
	Species	1	6	6	4	3	5	3	3	5	2	11	11	0	3	3	3	4	5	8	13	**16**
H	Records	1	2	3	7	4	11	0	3	3	2	13	15	2	9	11	3	4	10	15	38	**53**
	Species	1	2	2	3	1	3	0	3	3	1	3	3	2	5	7	2	2	5	7	9	**14**
I	Records	0	2	2	2	4	6	0	6	6	1	6	7	2	2	4	3	5	8	16	17	**33**
	Species	0	2	2	2	4	6	0	6	6	1	5	6	1	2	3	3	3	6	6	14	**19**
J	Records	6	4	10	4	2	6	2	2	4	9	7	16	7	1	8	2	3	5	30	19	**49**
	Species	3	3	5	1	2	2	1	2	2	6	4	9	3	1	3	1	3	4	9	8	**13**
Totals	Records	41	130	171	70	63	133	42	121	163	91	302	393	44	101	145	90	103	193	315	904	**1219**
	Species	26	46	60	29	31	47	24	49	58	42	61	76	20	42	50	42	46	63	80	95	**111**
Records/respondent		**6**	**14**	**11**	**6**	**6**	**6**	**5**	**13**	**10**	**8**	**17**	**13**	**6**	**17**	**11**	**10**	**10**	**10**	**6**	**15**	**11**

A, Gastrointestinal disorders; **B**, Urinogenital disorders; **C**, Pains and inflammations; **D**, Central Nervous System; **E**, Respiratory disorders; **F**, Other human diseases; **G**, Ceremonies and fortunes; **H**, Fevers; **I**, Skin disorders; **J**, Paediatric conditions

3.3.2.5 Most-reported species

The concentration of reports in a relatively small proportion of the 111 species mentioned by respondents makes it of interest to look at the species information in the contexts of uses, respondent gender and village. Tabular summaries of information from the ethnobotanical data set were prepared to enable this.

Species x village

In the context of the individual village, species of particular significance can be taken as those ranked up to "10=" (Table 3.6). Because of rank equalities, this means that 12 species are ranked for Mtakuja Mashariki and Ujerumani, and 11 for Isukamahela. Thirty species are included. To complete the table, where a species is not top-ranked an indication is given of presence at lower frequency ("rank <10") or the lack of records ("no report"). The columns in the table are arranged in order of the number of records gathered. The species are grouped according to the number of villages where they are top-ranked, the most widely important species at the top. Within groups, the species more important in the villages with the highest numbers of records are listed first.

There is considerable consistency among the villages in the top-ranked species, and the significance of *Cassia abbreviata* and *Combretum zeyheri* is clear. Seven species are top-ranked in three or more of the six villages: *Cassia abbreviata, Combretum zeyheri, Ekebergia benguelensis, Kigelia africana, Securidaca longepedunculata, Terminalia sericea, Xylopia longipetala.* Four others (*Entada africana, Friesodielsia obovata, Pterocarpus angolensis, Strychnos spinosa*) are used in all the villages and, apart from *Friesodielsia obovata* (top-ranked only for Masimba), are each top-ranked for two of them. This suggests ecologically similar, perhaps overlapping, areas are exploited by the villages for medicinal plants.

There is some indication that different villages use different areas in the absence of any records for *Warburgia salutaris* for four villages, despite top-rankings in the remaining two (Kasisi 'A' and Masimba).

Broadly similar spectra of species are well-reported from the villages. As a consequence, there is good correlation with Table 3.7, which includes only four species (*Cajanus cajan*, *Combretum fragrans*, *Flacourtia indica*, *Vitex mombassae*) that are not in Table 3.6. All the species top-ranked in at least three villages are in both listings, as are three of the six species top-ranked in two villages. *Premna senensis*, *Strychnos spinosa* and *Warburgia salutaris*, included in Table 3.6 because of their significance in two villages, do not appear in Table 3.7.

Species x respondent gender

A number of species were reported by several men but no women, and *Warburgia salutaris* was reported 16 times by men but never by a woman. This could be due to the fact that the species was mentioned by the medicinal plant vendors in the urban market, most of whom were men. When the extent of reporting for the different species is considered, however, a number of marked differences are apparent. Table 3.8 lists all species reported 10 times or more by either women or men. A few species were reported 10 times or more by both women and men. As the respondent ratio was 53:62 (women: men) = 0.85, for the well-reported species, preferential reporting by women (*e.g.* *Cajanus cajan*, *Combretum zeyheri*, *Xylopia longipetala*) suggests gender difference in plant use, as do several extreme contrasts with higher numbers of reports from men.

Table 3.6 Top-ranked species for six villages – based on combined records per species across categories of use and gender at Urumwa, Tanzania

Species/(Number of records)	Masimba (393)	Ujerumani (193)	Igombanilo (171)	Kasisi 'A' (163)	Mtakuja Mashariki (145)	Isukamahela (133)
Cassia abbreviata	**1 (49)**	**1 (20)**	**2 (15)**	**1 (21)**	**1 (18)**	**1 (16)**
Combretum zeyheri	**2 (24)**	**2 (12)**	**3 (12)**	**2 (11)**	**2 (14)**	**2 (15)**
Ekebergia benguelensis	**5 (13)**	**10= (5)**	**1 (16)**	**4= (6)**	**8= (4)**	**6= (4)**
Xylopia longipetala	**6= (11)**	**4= (8)**	**5= (5)**	**9= (5)**	**8= (4)**	**3 (7)**
Terminalia sericea	**3 (20)**	**6= (6)**	**5= (5)**	rank <10	**3 (9)**	**6= (4)**
Kigelia africana	**4 (16)**	**4= (8)**	**4 (8)**	no report	rank <10	**6= (4)**
Securidaca longepedunculata	rank <10	**3 (9)**	**5= (5)**	rank <10	**8= (4)**	rank <10
Ozoroa insignis	**6= (11)**	**6= (6)**	rank <10	rank <10	no report	rank <10
Warburgia salutaris	**9= (9)**	no report	no report	**3 (7)**	no report	no report
Entada abyssinica	rank <10	**10= (5)**	rank <10	**4= (6)**	rank <10	rank <10
Pterocarpus angolensis	rank <10	**10= (5)**	rank <10	**9= (5)**	rank <10	rank <10
Premna senensis	rank <10	rank <10	no report	**4= (6)**	no report	**6= (4)**
Strychnos spinosa	rank <10	rank <10	rank <10	rank <10	**8= (4)**	**4= (5)**
Friesodielsia obovata	**8 (10)**	rank <10	rank <10	rank <10	rank <10	rank <10
Zanthoxylum chalybeum	**9= (9)**	rank <10	no report	no report	rank <10	rank <10
Zanha africana	rank <10	**6= (6)**	rank <10	rank <10	rank <10	no report
Dalbergia melanoxylon	rank <10	**6= (6)**	rank <10	no report	no report	no report
Vepris glomerata	rank <10	rank <10	**5= (5)**	rank <10	rank <10	no report
Schrebera trichoclada	rank <10	no report	**5= (5)**	rank <10	rank <10	rank <10
Erythrina abyssinica	rank <10	no report	**5= (5)**	no report	rank <10	no report
Pterocarpus tinctorius	rank <10	rank <10	no report	**4= (6)**	rank <10	no report
Strychnos potatorum	no report	rank <10	rank <10	**4= (6)**	rank <10	no report
Tamarindus indica	rank <10	rank <10	rank <10	rank <10	**4= (6)**	no report
Albizia harveyi	rank <10	no report	rank <10	no report	**4= (6)**	rank <10
Mundulea sericea	rank <10	no report	rank <10	rank <10	**6= (5)**	rank <10
Aloe vera	no report	rank <10	no report	no report	**6= (5)**	no report
Solanum incanum	no report	rank <10	rank <10	rank <10	**8= (4)**	rank <10
Psidium guajava	rank <10	no report	no report	no report	no report	**4= (5)**
Maytenus galensis	rank <10	rank <10	rank <10	rank <10	no report	**6= (4)**
Combretum obovatum	rank <10	rank <10	no report	no report	rank <10	**6= (4)**

Table 3.7 Key medicinal plants, use categories and sub-categories with records (combined for six villages) by gender for Urumwa Forest Reserve, Tabora Region, Tanzania

Botanical name	Local name	Main use category	Use sub-category	Female reports	Male reports	Total reports
Cajanus cajan	Mbaazi	Urino-genital	Placenta expulsion	15 (23)	0 (0)	15 (23)
Cassia abbreviata	Mlundalunda	Gastro-intestinal	Hernia	1 (3)	18 (46)	19 (49)
		Gastro-intestinal	Stomach ache	6 (35)	18 (79)	24 (114)
		Urino-genital	Gonorrhoea	3 (6)	12 (43)	15 (49)
		Urino-genital	Syphilis	3 (3)	11 (24)	14 (27)
		Fevers	Malaria	3 (5)	12 (21)	15 (26)
		Fevers	Non-malarial fever	3 (4)	7 (11)	10 (15)
Combretum fragrans	Mluzyaminzi	Fevers	Malaria	1 (5)	7 (21)	8 (26)
Combretum zeyheri	Msana	Gastro-intestinal	Diarrhoea	16 (40)	10 (53)	26 (93)
		Gastro-intestinal	Stomach ache	7 (35)	5 (79)	12 (114)
		Other human diseases	Anaemia	7 (25)	7 (44)	14 (69)
		Paediatric conditions	Anal eczema	19 (24)	6 (13)	25 (37)
Ekebergia benguelensis	Mtuzya	Central nervous system	Mental illness	5 (6)	10 (20)	15 (26)
		Rituals and fortune	Love	4 (4)	7 (10)	11(14)
		Rituals and fortune	Luck	5 (8)	9 (24)	14 (32)
Entada abyssinica	Mfutwambula	Urino-genital	Gonorrhoea	1 (6)	8 (43)	9 (49)
		Other human diseases	Anaemia	0 (25)	6 (44)	6 (69)
Flacourtia indica	Msingila	Urino-genital	Infertility	3 (73)	5 (61)	8 (134)
Friesodielsia obovata	Msalasi	Gastro-intestinal	Stomach ache	1 (35)	5 (79)	6 (114)
		Urino-genital	Infertility	5 (73)	6 (61)	11 (134)
Kigelia africana	Mlegea	Central nervous system	Convulsions	1 (10)	11 (38)	12 (48)

		Other human diseases	Anaemia	7 (25)	6 (44)	13 (69)
		Rituals and fortune	Rituals	2 (6)	9 (20)	11 (26)
Maytenus galensis	Mwezya	Rituals and fortune	Luck	2 (8)	8 (24)	10 (32)
Ozoroa insignis	Mwembepori	Gastro-intestinal	Diarrhoea	3 (40)	9 (53)	12 (93)
Piliostigma thonningii	Mtindwambogo	Pain and inflammation	Snakebite	1 (3)	6 (51)	7 (54)
Psidium guajava	Mpera	Gastro-intestinal	Diarrhoea	3 (40)	4 (53)	7 (93)
Pterocarpus angolensis	Mninga	Gastro-intestinal	Diarrhoea	2 (40)	5 (53)	7(93)
		Other human diseases	Anaemia	5 (25)	8 (44)	13 (69)
Pterocarpus tinctorius	Mkulungu	Gastro-intestinal	Diarrhoea	2 (40)	4 (53)	6 (93)
Schrebera trichoclada	Mputika	Pain and inflammation	Snakebite	0 (3)	6 (51)	6 (54)
		Respiratory	Coughs	0 (7)	6 (25)	6 (32)
Securidaca longipedunculata	Mteyu	Urino-genital	Infertility	5 (73)	11 (61)	16 (134)
Terminalia sericea	Mzima	Gastro-intestinal	Diarrhoea	5 (40)	7 (53)	12 (93)
		Gastro-intestinal	Stomach ache	6 (35)	6 (79)	12 (114)
		Paediatric conditions	Anal eczema	3 (24)	4 (13)	7 (37)
Verpis glomerata	Mlungusigiti	Urino-genital	Infertility	4 (73)	5 (61)	9 (134)
Vitex mombassae	Mtalali	Urino-genital	Infertility	5 (73)	4 (61)	9 (134)
		Other human diseases	Diabetes	1 (4)	3 (8)	6 (12)
Xylopia longipetala	Mshenene	Urino-genital	Infertility	21 (73)	10 (61)	31 (134)

Figures in parentheses are number of species reported per use category

Table 3.8 Numbers of reports for most frequently reported species, by gender (villages and use categories combined), at Urumwa Forest Reserve, Tabora Region, Tanzania

Species	Frequncy by gender			Frequncy by gender	
	♀	♂	Species	♀	♂
Albizia harveyi	1	17	*Piliostigma thonningii*	1	10
			Premna senensis	4	10
Cajanus cajan	18	1	*Pterocarpus angolensis*	8	16
Cassia abbreviata	26	113	*Pterocarpus tinctorius*	2	14
Combretum fragrans	1	12	*Schrebera trichoclada*	1	19
Combretum zeyheri	53	35	*Securidaca longepedunculata*	9	21
Dalbergia nitidula	1	12	*Strychnos potatorum*	2	11
Dichrostachys cinerea	10	4	*Strychnos spinosa*	2	21
Ekebergia benguelensis	16	32	*Tamarindus indica*	5	10
Entada abyssinica	2	21	*Terminalia sericea*	19	29
Flacourtia indica	4	14	*Vepris glomerata*	5	15
Friesodielsia obovata	11	14	*Warburgia salutaris*	0	16
Kigelia africana	11	27	*Ximenia caffra*	3	11
Maytenus galensis	4	11	*Xylopia longipetala*	25	15
Ozoroa insignis	7	19	*Zanthoxylum chalybeum*	2	14

Note: ♀ = Female, ♂ = Male

A *G*-test was used to check if gender was independent of the numbers of species reported (Table 3.9) and showed that men reported significantly higher numbers of species than women ($G_{adj} = 8.640$; $p<0.01$).

Table 3.9 Numbers of medicinal plants mentioned by men and women at Urumwa Forest Reserve, Tabora Region, Tanzania

Number of species	Men	Women	Totals
≤ 10 species	45	50	95
>10 species	17	3	20
Totals	62	53	115

There is also a difference in the distribution of records within gender: species reported by men five or more times are around 50% of all the species (n = 95) men reported, compared with about half this proportion for the 80 species reported by women. A relatively low proportion (15%) of the 95 species reported by men were only reported once (36% of the 80 species reported by women were only reported once).

Species x use sub-categories

Every species reported by at least six respondents (5% of the 115 respondents) to have a specific (sub-category) use is listed in Table 3.7. The table lists 21 of the 111 species mentioned by respondents. For several species, reports relate to more than one use sub-category and the top two species, *Cassia abbreviata* and *Combretum zeyheri*, have six and four major uses respectively. Nineteen of the 74 use sub-categories recognized in the survey are represented in the table. Several ailments/conditions are treated regularly with more than one key species, notably diarrhoea (6 species) and infertility (5 species).

As a result, uses for gastro-intestinal (11 entries) and urino-genital conditions (10 entries) are particularly prominent, presumably indicating their regular, familiar and widely-practiced use. In contrast, there are no key species for treating skin disorders and only one (*Schrebera trichoclada*) for treating respiratory complaints.

Figure pairings in the columns to the right indicate the number of records provided (before slash) and the total (all species) numbers of records gathered for the use sub-category (after slash). Only low proportions of respondents share opinions over use. In the case of men, the number of respondents mentioning any species for a particular use sub-category was never greater than 20% of those consulted (62 individuals). There was more convergence of views among the women with over 25% of the 53 female respondents agreeing on species used in relation to placenta expulsion (*Cajanus cajan*), anal eczema in infants and diarrhoea (*Combretum zeyheri*), and infertility (*Xylopia longipetala*).

Species x use categories

It is of interest to examine the spectra of species used for the ten different medicinal use categories recognized. Although the overall list of species reported is long, many are poorly represented: species never reported more than twice for any use category account for 40% of the 111 species listed. For different use categories there are contrasting spectra of species. The most marked contrast is the high number of species reported to be used in treating gastro-intestinal (61) and urino-genital (57) conditions, and pains and inflammation (52), compared with the others. For five use categories, fewer than 20 species were reported to be used. Within use categories, only a small proportion of the species reported to be used were mentioned by ten or more respondents. Sixteen (Table 3.10) are represented strongly (tallies ≥10) in 1-3 use categories. However, none of the species reported to be used in the categories of respiratory conditions and skin disorders belong to this group. These use categories are not well-characterized and the survey has not provided useful insight into them. For five use categories two or three species were frequently reported and four of the species listed were frequently reported for use within more than one category.

Table 3.10 Numbers of reports for most frequently reported species, by medicinal plant use category (genders and villages combined), at Urumwa Forest Reserve, Tabora Region, Tanzania

Species	1*	2	3	4	5	6	7	8	9	10
Cajanus cajan	1	**18**								
Cassia abbreviata	**50**	**42**	9		6	2	1		**29**	
Combretum zeyheri	**45**	1	1	**14**		2				**25**
Ekebergia benguelensis				4	**19**			**25**		
Entada abyssinica		**12**	2	5		4				
Friesodielsia obovata	6	**14**	1	4						
Kigelia africana				**14**	**13**			**11**		
Maytenus galensis		3						**12**		
Ozoroa insignis	**14**	2			2					4
Pterocarpus angolensis	6		1	**13**		1	2			1
Securidaca longipedunculata	6	**18**	4							2
Strychnos spinosa	7	**12**	2		1		1			
Terminalia sericea	**29**		4			7	1			7
Verpis glomerata	3	**12**	1	2			1	1		
Xylopia longipetala	6	**31**		1	1				1	
Zanthoxylum chalybeum	3		**10**			1	1			1

*1, Gastro-intestinal conditions; 2, Urino-genital conditions; 3, Pains and inflammation; 4, Other human diseases; 5, Central nervous system disorders; 6, Respiratory conditions; 7, Skin disorders; 8, Rituals and fortune; 9, Fevers; 10, Paediatric conditions. Species listed were reported ≥10 times for at least one use category (emboldened figures).

3.3.2.6 Similarity assessments based on reported species

The possibility that contrasting assemblages of species are being utilized by different villages and genders, and for different categories of medicinal treatment, were assessed by determining Sørensen's indices of similarity as described in Section 3.2.1.3.

Village similarity

Similarities among villages are high (Table 3.11), indicating similar sets of plants are used as medicinal purposes. The highest similarities involved Masimba.

Table 3.11 Sørensen indices of similarity for all pairs of villages (reported medicinal plant species represented only by single records excluded). Numbers in parentheses are the numbers included for species record at Urumwa Forest Reserve, Tabora Region, Tanzania

	Igombanilo	Isukamehela	Kasisi 'A'	Masimba	Mtakuja Mashariki	Ujerumani
	(36)	(31)	(32)	(54)	(32)	(40)
Igombanilo		45	50	64	50	55
Isukamahela	45		41	54	51	59
Kasisi 'A'	50	41		65	59	53
Masimba	64	54	65		60	60
Mtakuja Mashariki	50	51	59	60		40
Ujerumani	55	59	53	60	40	

Gender similarity

The similarity between female and male spectra of medicinal plants used was 81%. This is a high value but still suggests that each gender possesses knowledge which is not shared by the other gender, and that there are qualitative as well as quantitative knowledge differences between women and men.

Use category similarity

The matrix of indices (Table 3.12) indicates considerable overlapping for the lists of species reported to be used for treating gastro-intestinal and urino-genital complaints, and pains/inflammation. Pains/inflammation, however, shares another set of species with the treatments for respiratory conditions and skin disorders. Other use categories have individually more distinctive lists and consistently low similarity indices.

Table 3.12 Sørensen indices of similarity for all pairs of use categories (reported medicinal plant species represented only by single records excluded) at Urumwa, Tabora Region, Tanzania. Numbers in parentheses are the numbers included for the use category.

Use category	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
	(38)	(41)	(27)	(16)	(18)	(10)	(10)	(9)	(3)	(6)
1. Gastro-intestinal		**48**	37	37	29	29	21	0	10	23
2. Urino-genital	**48**		24	28	17	16	12	12	5	13
3. Pains and inflammation	37	24		23	**40**	38	16	22	7	12
4. Other human diseases	37	28	23		24	23	15	16	0	9
5. Central nervous system	29	17	**40**	24		21	21	22	10	8
6. Respiratory conditions	29	16	38	23	21		10	0	15	25
7. Skin disorders	21	12	16	15	21	10		11	15	13
8. Rituals and fortune	0	12	22	16	22	0	11		0	0
9. Fevers	10	5	7	0	10	15	15	0		0
10. Paediatric conditions	23	13	12	9	8	25	13	0	0	

3.3.2.7 Application of practices

The plant parts most commonly used for medicine at Urumwa were roots (from 101 species out of the 111 recorded species). Bark from 50 species and leaves from 49 species were used. Whole plants, fruits, seeds, twigs and exudates (Table 3.13) were rarely used.

Table 3.13 Medicinal plant parts used for medicine by communities at Urumwa Forest Reserve, Tabora Region, Tanzania

Plant parts	Number of taxa (out of 111)	% of total taxa
Roots	101	91
Bark	50	45
Leaves	49	44
Fruits	3	< 1
Seeds	2	<1
Whole plant	1	<1
Twigs and exudates	1	<1

G-tests of independence showed no gender difference on the preferred methods of preparing medicinal plant remedies at Urumwa. For both males and females boiling combined with grinding (Table 3.14) is the preferred method for preparing remedies; followed by boiling only (32%) and grinding only (10%).

Table 3.14: Plant remedies preparation methods in communities at Urumwa Forest Reserve, Tabora Region, Tanzania.

Respondent category	Response category							Totals
	Boil	Pound	Grind	Boil and Grind	Grind and Pound	Boil and pound	Boil, Grind, Pound	
Female	22 (41)	3 (6)	2 (4)	22 (41)	1 (2)	0	3 (6)	53 (100)
Male	15 (24)	2 (3)	10 (16)	31 (50)	0	0	4 (7)	62 (100)
Totals	**37 (32)**	**5 (4)**	**12 (10)**	**53 (46)**	**1 (1)**	**0**	**7 (6)**	**115 (100)**

Numbers in parentheses are percentages of row totals

Similarly, despite non significant results by *G*-test analysis of independence ($p>0.05$), the majority of respondents (both gendered) at Urumwa indicated that they administered plant medicines in the form of decoctions. A remedy in powder form was reported only once (Table 3.15).

Table 3.15 Forms of remedies used by communities around Urumwa Forest Reserve, Tabora Region, Tanzania

Respondent category	Response category					Totals
	Decoctions	Infusions/ concentrates	Powders	Others*	Mixtures	
Female	35(66)	4(7)	1(2)	10(19)	3(6)	**53(100)**
Male	36(58)	6(10)	0	16(26)	4(6)	**62(100)**
Totals	**71(62)**	**10(9)**	**1(4)**	**26(23)**	**7(6)**	**115(100)**

Numbers in parentheses are percentages of rows totals, * mostly poultices and protective charms

Oral administration through drinking, chewing and or mouthwash (Table 3.16) was typical (48%) for both female and male at Urumwa, followed by mixture of oral and external modes (massage, baths, steaming, smoking).

Table 3.16 Modes of administering remedies used by communities around Urumwa Forest Reserve, Tabora Region, Tanzania

Respondent category	Response category						Totals
	Oral	External	Oral and nasal	Oral and anal	Oral and external	All modes	
Female	23 (43)	1 (2)	2 (4)	8 (15)	13 (25)	6 (11)	53 (100)
Male	32 (52)	0	2 (3)	3 (5)	19 (31)	6 (9)	62 (100)
Totals	**55 (48)**	**1 (2)**	**4 (3)**	**11 (9)**	**32 (28)**	**10 (12)**	**115 (100)**

Numbers in parentheses are frequencies of row totals

Neither female nor male respondents consistently used standardized dosages when administering plant remedies to patients (Table 3.17). Dosage is generally determined subjectively and depends on the severity of the symptoms. Where described as 'standardized', administration of remedies was done as a specific quantity for a specified period of time and the patient had to continue with the dose even if he/she felt better soon after taking the medicine. *E.g.* ½ cup of tea x 3 x 5 days was commonly mentioned for treating diseases like intestinal worms and venereal diseases. In the case of 'informal' dosages, however, no quantity specification was provided, the patient having to estimate a small quantity to take and being expected to stop using the remedy soon after he/she feels recovered from the ailment concerned.

Table 3.17 Dosage knowledge around Urumwa communities, Tabora Region, Tanzania

Respondent category	Response category		Total
	Standardized	Informal	
Female	20 (38)	33 (62)	53 (100)
Male	30 (48)	32 (52)	62 (100)
Total	**50 (43)**	**65 (57)**	**115 (100)**

Note: Numbers in parentheses are percentages

3.3.3 Community perceptions of responsibility

3.3.3.1 Perceptions in utilization

Differences in perceptions of responsibility between female and male respondents from communities around Urumwa in the utilization of medicinal plants were revealed. *G*-tests analyses to compare the proportions of women and men involved in utilization of medicinal plants as perceived (by both genders of respondent) revealed some significant differences (Table 3.18). Men were perceived (by both genders of respondent) to be more involved in traditional healing practices and trading, and as the main specialists providing treatments for various diseases. However, no gender differences in perceived responsibilities were revealed in the processing of medicinal plants or the handling of diseases affecting women and children (Table 3.18).

3.3.3.2 Perceptions in conservation

Differences in perceptions of responsibility between female and male respondents from communities around Urumwa in the conservation of medicinal plants were revealed. *G*-tests analysis to compare the proportion of women and men involved in conservation of medicinal plants as perceived (by both genders of respondent) revealed significant differences (Table 3.19a). Men were perceived as the main harvesters of medicinal plants, to be especially knowledgeable in indigenous conservation practices and to be active participants in decision making to safeguard the reserve. Women were perceived to be the ones primarily involved in domestication activities (Table 3.19a).

Table 3.18 Community perceptions of gender roles in the utilization of medicinal plants at Urumwa Forest Reserve, Tabora Region, Tanzania

Perceiver	**Utilization role response category**														
	Traditional healing practices $G_{adj} = 3.29^{a}$			Medicinal plants processing $G_{adj} = 5.78^{b}$			Medicinal plants trading $G_{adj} = 0.53^{a}$			Speciality various diseases* $G_{adj} = 2.22^{a}$			Speciality women and children diseases $G_{adj} = 4.44^{b}$		
	Actor			Actor			Actor			Actor			Actor		
	Men (0.73)	Women (0.27)	Totals	Men (0.16)	Women (0.84)	Totals	Men (0.74)	Women (0.26)	Totals	Men (0.82)	Women (0.18)	Totals	Men (0.03)	Women (0.97)	Totals
Male	23	13	36	12	38	50	19	8	27	21	7	28	3	40	43
Female	29	6	35	2	34	36	9	2	11	20	2	22	0	46	46
	52	**19**	**71**	**14**	**72**	**86**	**28**	**10**	**38**	**41**	**9**	**50**	**3**	**86**	**89**

Number in parentheses are response ratios; [a] G-test significant at $p<0.05$ probability level; [b] G-test non significant at $p>0.05$ probability level; * all diseases excluding those affecting women and children

Table 3.19a Community perceptions of gender roles in conservation of medicinal plants at Urumwa Forest Reserve, Tabora Region, Tanzania

Perceiver	Conservation role response category											
	Medicinal plants harvesting $G_{adj} = 1.20$ [a]			Domestication activities $G_{adj} = 2.99$ [a]			Knowledge in indigenous conservation practices $G_{adj} = 0.004$ [a]			Decision-making involvement to safeguard Urumwa $G_{adj} = 1.49$ [a]		
	Actor			Actor			Actor			Actor		
	Men (0.99)	Women (0.01)	Totals	Men (0.13)	Women (0.87)	Totals	Men (0.79)	Women (0.21)	Totals	Men (0.98)	Women (0.02)	Totals
Male	58	1	59	6	23	29	11	3	22	28	1	29
Female	49	0	49	2	31	33	4	1	24	32	0	32
	107	**1**	**108**	**8**	**54**	**62**	**15**	**4**	**46**	**60**	**1**	**61**

Number in parentheses are response ratios; [a] G-test significant at $p<0.05$ probability level

The majority of men and women around Urumwa however, failed to adhere to JFM procedures relating to accessing the forest reserve for basic needs like medicinal plants collection as perceived by the majority of gendered respondents (Table 3.19b).

Table 3.19b Gendered respondent perceptions on adherence to JFM rules for accessing Urumwa Forest Reserve, Tabora Region, Tanzania

Respondent category	Response category				Totals
	Men	Women	Both men and women	Nobody adheres to rules	
Male	9 (14)	na	8 (13)	45 (73)	62 (100)
Female	2 (4)	na	1 (2)	50 (94)	53 (100)
Totals	**11 (10)**	**0**	**9 (8)**	**95 (83)**	**115 (100)**

Numbers in parentheses are percentages; na, represents no response

3.3.4 Conservation awareness and measures

3.3.4.1 Medicinal plants harvesting methods

Root digging and bark stripping in combination was the most reported method used for harvesting medicinal plant parts in communities around Urumwa. As a single procedure, root digging was reported most frequently (Table 3.20).

Table 3.20 Medicinal plants harvesting methods used in communities around Urumwa Forest Reserve, Tabora Region, Tanzania

Respondent category	Response category					
	Root digging	Bark stripping	Root digging and leaves collection	Root digging and Bark stripping	All methods	**Totals**
Female	18 (34)	1 (2)	5 (9)	32 (42)	9 (13)	53 (100)
Male	19 (31)	1 (2)	2 (3)	28 (45)	12 (19)	62 (100)
Totals	**37 (32)**	**1 (2)**	**7 (6)**	**50 (43)**	**19 (16)**	**115 (100)**

Numbers in parentheses are percentages.

3.3.4.2 Status of medicinal plants

Medicinal plants in Urumwa Forest Reserve were believed to have decreased in availability in the past two decades according to 56% of respondents (30 female and 35 male). Only 20% of respondents (13 male and 10 female) were of the opinion that availability had not changed (Figure 3.4). Seventy medicinal plants species were reported to be abundant (easy to find) in Urumwa with *Combretum zeyheri* being reported as the most abundant species (Appendix IIa). Seventeen species were mentioned as scarce (difficult to find) with *Ekebergia benguelensis* as the least abundant species (Appendix IIb). No respondent suggested that any species used medicinally had actually disappeared from the miombo woodlands of Urumwa Forest Reserve.

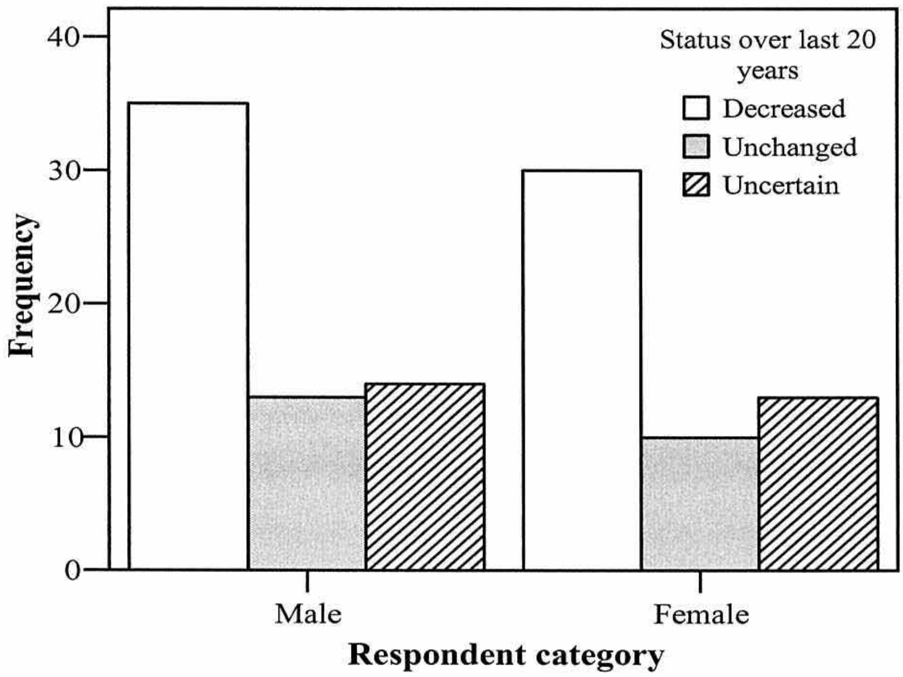


Figure 3.4 Community responses on the status of medicinal plants at Urumwa Forest Reserve, Tabora Region, Tanzania. (Male, N = 62; Female, N= 53)

3.3.4.3 Potential medicinal species

Ten medicinal plants were recorded as high potential species for communities' around Urumwa Forest Reserve judged by their high importance in provision of the daily primary health care needs (Table 3.21). The list was obtained by combining the 3 to 4 most ranked species with highest scores, treating up to two or more ailments, from the three PRA sessions around Urumwa. However, 50% (5 out of 10) of these potential species were reported to be scarce in the miombo woodlands of Urumwa Forest Reserve.

3.3.4.4 Threats to medicinal plants

Increased anthropogenic distrubances (*i.e.* charcoal burning, illegal timber harvesting through pitsawing, unsustainable harvesting of roots and debarking of trees for medicinal purpose and livestock grazing) by people from within and outside the villages to fulfill their basic needs was the main problem perceived to affect the availability of medicinal plants at Urumwa Forest Reserve and was indicated (Figure 3.5) by the majority of female (30) and male (30) respondents (56% of 107 responses). A further 16% of respondents (8 male and 9 female) also referred to disturbances, but in combination with other threats. More than 20% of respondents (14 female and 16 male) mentioned poor cooperation between local communities and the Forest Department in implementing management strategies under JFM regime as a problem, singly or in combination (Figure 3.5).

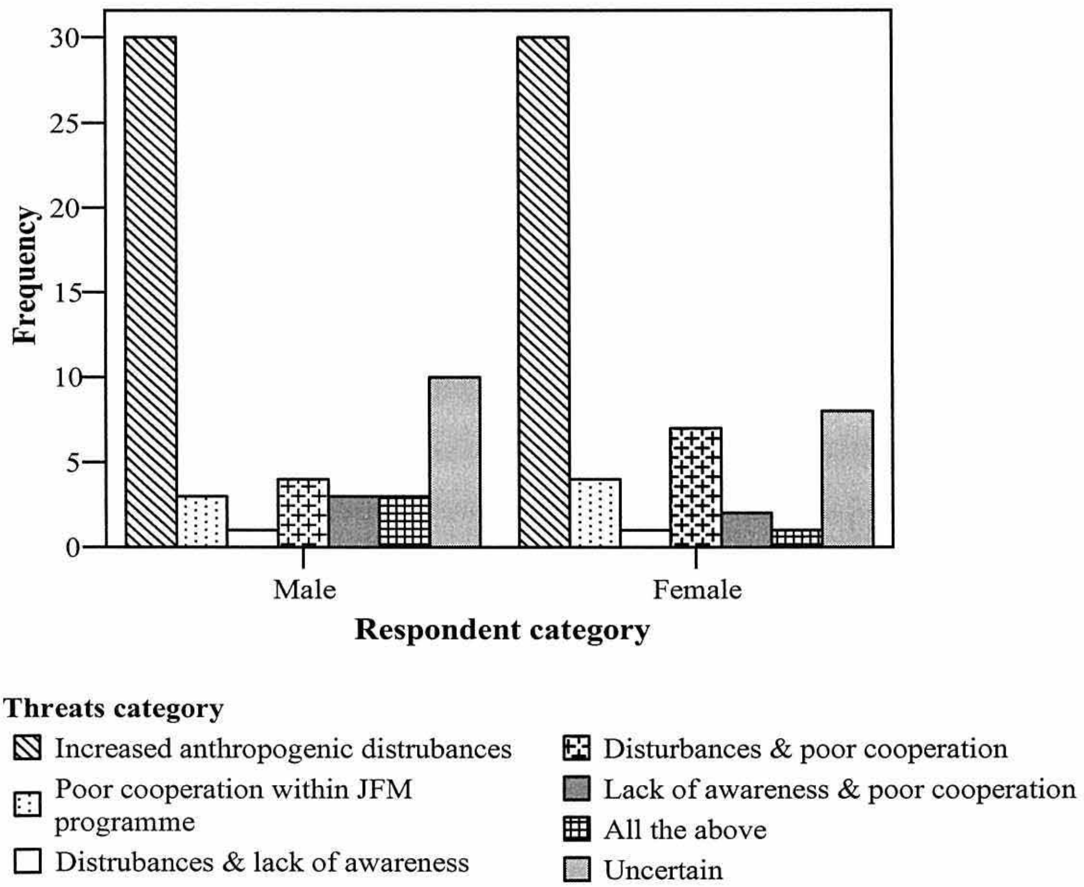


Figure 3.5 Views on threats posed to medicinal plants at Urumwa Forest Reserve, Tabora Region, Tanzania

Table 3.21 Potential medicinal plants of Urumwa Forest Reserve, Tanzania arranged according to their importance to the local communities

S/No	Scientific name	Local name(s)	Plant family (Phylogenetic order)	Status in Urumwa*	Ailment cured	Part(s) used
1.	*Cassia abbreviata* Oliver	Mlundalunda, Mnzoka, Mmulimuli (Nyamwezi)	Papilionoideae (Fabales)	Scarce	abscess, coughs, convulsion, diarrhoea, earache, fever, headache, infertility, jaundice, malaria, schistosomiasis, stomach ache, venereal diseases, vomiting	roots, barks, leaves
2.	*Combretum zeyheri* Sond.	Msana (Nyamwezi)	Combretaceae (Myrtales)	Abundant	anal eczema, anaemia, body pains, coughs, diarrhoea, dysentery, infertility, rectal prolapse, stomach ache	roots, barks, leaves
3.	*Pterocarpus tinctorius* Welw.	Mkulungu (Nyamwezi), Mninga maji (Swahili), Mkula(Sukuma)	Papilionoideae (Fabales)	Abundant	anti-abortion, diarrhoea, snakebite, stomach ache, wounds, eyes problems	roots, barks
4.	*Xylopia longipetala* De Wild. and T. Durand	Mushenene (Nyamwezi)	Annonaceae (Magnoliales)	Scarce	abdominal ulcers, diabetes, epilepsy, fever, infertility, stomachache	roots, barks, leaves
5.	*Strychnos spinosa* Lam.	Mwage (Nyamwezi)	Loganiaceae (Gentiales)	Abundant	convulsion, gonorrhoea, infertility, intestinal worms, snakebite, stabbing pains, stomach ache, syphilis, tumours	roots, barks
6.	*Dalbergia nitidula* Baker	Kafinulambasa, mbelambasa, kapondambasa (Nyamwezi)	Papilionoideae (Fabales)	Abundant	anaemia, diabetes, diarrhoea, gonorrhoea, schistosomiasis, stomach ache, toothache	roots, fruits, barks
7.	*Mundulea sericea* (Willd.) A. Chev.	Mtandala (Nyamwezi)	Papilionoideae (Fabales)	Scarce	anti-abortion, aphrodisiac, epilepsy, hernia, impotency, schistosomiasis, wounds	roots, leaves
8.	*Ozoroa insignis* Delile	Mwembepori, Mkalakala (Nyamwezi)	Anacardiaceae (Sapindales)	Abundant	anal eczema, anti-abortion, diarrhoea, epilepsy, gonorrhoea, stomach ache	roots, leaves, barks
9.	*Vepris glomerata* (Delile) Mziray	Mlungusigiti, Mdimudimu (Nyamwezi), Mju (Sukuma)	Rutaceae (Sapindales)	Scarce	abdominal ulcers, aphrodisiac, constipation, diabetes, hernia, infertility, snakebites, rituals	roots
10.	*Kigelia africana* (Lam.) Benth.	Mvungwa, Mlegea, Msanghwa (Nyamwezi), Mwicha, Ng'wicha (Sukuma)	Bignoniaceae (Lamiales)	Scarce	anaemia, convulsion, hypertension, rituals	fruits, barks

* Status determined through response from PRA surveys in six villages around and field survey inside Urumwa forest reserve.

3.3.4.5 Measures to conserve medicinal plants

A lack of measures in operation to conserve the medicinal plants at Urumwa was indicated in the responses of both female and male respondents to the question "what measures are you taking to conserve the medicinal plants from Urumwa Forest Reserve to ensure future availability?" (Figure 3.6). Some respondents, however, reported involvement in village patrols (weekly patrols to ensure no encroachment in the reserve) and the promotion of sustainable harvesting of the plant parts.

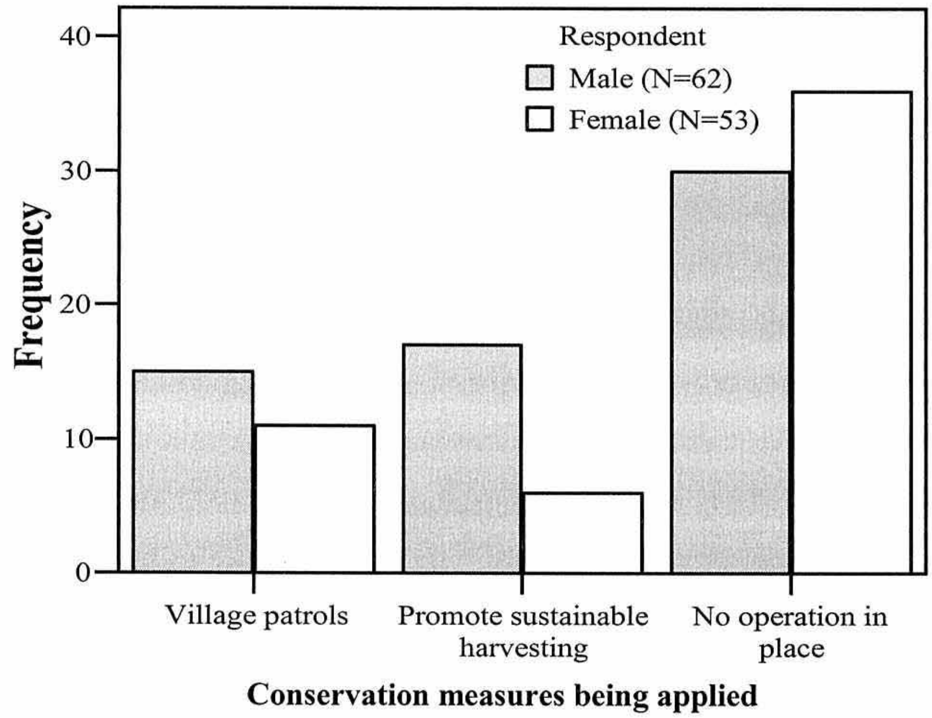


Figure 3.6 Medicinal plants conservation measures in communities around Urumwa Forest Reserve, Tabora Region, Tanzania.

3.3.4.6 Community views on conservation

A *G*-test of independence indicated no significant difference in respondents' views by gender on conservation to ensure future availability of medicinal plants at Urumwa Forest Reserve. Most respondents favoured provision of training (*e.g.* raising awareness on conservation importance, educating herbalists on sustainable ways of harvesting the plants), and research (*e.g.* use of experimental trials through appropriate propagation methods to domesticate potential species) for promoting the conservation of medicinal plants at Urumwa (Table 3.22).

Table 3.22 Community views to promote conservation of medicinal plants at Urumwa Forest Reserve, Tabora Region, Tanzania

Respondents category	**Conservation views**			
	Training and research	Strengthen policies and cooperation	Training, research, strengthen policies and cooperation	Total
Male	40 (64)	6 (10)	15 (24)	61 (100)
Female	32 (60)	10 (9)	8 (15)	50 (100)
Total	**72 (63)**	**16 (14)**	**23 (20)**	**111 (100)**

Numbers in parentheses are percentages of row totals

3.4 Discussion

3.4.1 Medicinal plants ethnobotany and practices

Communities around Urumwa are highly knowledgeable of medicinal plant species (>100 species to treat more than seventy diseases and conditions), with a clear contrast existing in ethnobotany knowledge. Men are ethnobotanically more knowledgeable than women – confirming the existing opinions that, communities' knowledge of plants often differs between women and men. Women were noteworthy for the frequent citing of *Cajanus cajan*, *Combretum zeyheri* and *Xylopia longipetala*, while men frequently cited (compared with women) *Albizia harveyi*, *Cassia abbreviata* and *Warburgia salutaris* – providing an understanding of medicinal plants preference by gender especially about plants that assist in curing diseases of their own sex.

The variations between gender ethnobotanical knowledge at Urumwa arise from men's high interaction with the wild environment while undertaking activities such as hunting and livestock supervision, and the collection of medicinal plants. Similar observations and reasons are reported by Letšela *et al.* (2003) for Lesotho, and Fassil (2003) for rural communities of the north-western Ethiopian highlands. In contrast women showed familiarity with weedy and semi-domesticated plants found around homesteads.

Treatment for gastro-intestinal and urino-genital disorders were particularly common reported, and treated with a wide range of species. Noteworthy in this context were *Cassia abbreviata* (gastro-intestinal conditions – stomach ache, hernia), *Combretum zeyheri* (gastro-intestinal conditions – diarrhoea; paediatric conditions – anal eczema) and *Xylopia longipetala* (urino-genital conditions – infertility) attracting numerous reports from respondents of both genders – suggesting reputation for relieving conditions familiar in households generally. This is consistent with a WHO (2005a) view, that much gastro-intestinal disease is associated with unsafe water and inadequate sanitation and hygiene. These are risks faced by the Urumwa communities.

Medicinal plant practices at Urumwa are dominated by the use of roots to prepare decoctions for oral administration. However, the lack of any standardized dosage noted among users of both gender is striking. On the one hand it implies confidence in the informal limits within which traditional medicines are administered but it also suggests inadequate attention to potential risks in terms of safety and the quality of plant medicines. A measure of complacency may be resulting from the rather high level of illiteracy.

The roots, leaves and bark of many miombo species are reported to be used in health care, both as medicine and for magic (Gelfand *et al.*, 1985). However, the dominant use of roots at Urumwa apparently reflects belief that roots have higher concentrations of remedial elements, a belief also encountered by Makonda *et al.* (2000) in Kilosa, Bagamoyo and Geita Districts. The clear dominance of roots is not always evident; however, Hamisy *et al.* (2000), Uluguru Mountains, observed wide use of leaves as well as roots. Leaves were actually the dominant plant part used in areas studied in Ethiopia (Giday, 2001) and Uganda (Tabuti *et al.*, (2003a).

Earlier studies in Tanzania have also noted the lack of standardized dosages for treatment (Maximillian *et al.,* 2001; Kitula, 2001) administered by most herbalists and by other household members who all tend to rely on long term experience that probably does impose some regulation. Certainly, in Ethiopia, Giday (2001) noted in Zay communities that dosages took account of age, and the physical and health condition of the patient. Nevertheless, potential side effects are sometimes not considered due to lack of knowledge (Augustino, 2002).

3.4.2. Gender role perceptions in utilization

The present study has established that men and women residing around Urumwa Forest Reserve consider that they utilize medicinal plant resources differently. Men are the main traditional practitioners. They specialize in treating certain diseases and they are active traders in medicinal plants products, in both formal and informal markets. This revelation is in line with prevailing opinions on male dominance of these activities persisting in part through gender taboos in the Nyamwezi culture, particularly regarding the inheritance of traditional healing knowledge which tends to be passed to boys rather than girls. Within Africa this is not unusual.

Tsefu *et al.* (1995), in Ethiopia, found men dominant in traditional healing, although Giday *et al.* (2003), also in Ethiopia, did note women healers engaging in family level treatment alongside a high level of 'professional' healing practised by men. Age and illiteracy (Gidef and Hahn, 2003), plus reinforced traditions and taboos (Augustino and Gillah, 2004), have also been identified as influencing traditional healing practices within African communities. In Uganda (Medius, 1998) it is men who handle complicated cases which have failed in hospitals, while it is women who play the key role with emergency cases, including births and acute child sickness, which need urgent attention within the community.

The trading of medicinal plants especially in urban centres, by Urumwa men can be explained in relatively practical terms - firstly by the household gender division of labour considering women's family commitments and, secondly, the need for the vendors of the family to be close to customers in areas offering opportunities for self-employment and higher income-generation as herbalists (Good and Kimani, 1980). Indeed at Urumwa, according to Mbwambo (2000) more men (44%) than women (15%) were found to be involved in trade of miombo products including medicinal plants. This is not unusual in Africa but nor is it ubiquitous, and in the urban areas of Limpopo and Mpumalanga, South Africa (Botha *et al.*, 2004), both men and women participate in the trading of medicinal plants.

3.4.3 Gender role perceptions in conservation

Medicinal plants harvesting activity in communities using the miombo woodlands of Urumwa is male-dominated with little involvement of women. This is probably a consequence of three things: first, very strenuous physical work (especially if roots are involved); second, it may not be possible to combine collection activity with commitments in the home, (especially where bulky collection of plant parts is required); and third, the influence of tradition is sometimes reinforced with taboos that prohibit women from participating. In Ghana, too Naur (2003) found a substantial gender bias related to the collection of plants. Men healers did not send their wives or daughters into the bush to collect medicinal plants, because "people would think they were witches."

Women around Urumwa are dominant in the domestication of medicinal plants, activity manifested in raising herbal plants around homesteads and managing preserved on-farm trees with medicinal value. This means in effect that it is women who by managing and cultivating medicinal plants, operate a mechanism for preserving medicinal plants that are rare in the forest reserve, simultaneously avoiding time-consuming travel to search for wild plants at the expense of household activity. In fact, for sometime it has been acknowledged that in most of the developing world, on-farm and in-situ conservation begins with women as they are largely responsible for providing daily domestic household needs (Bunning and Hill, 1996; Howard, 2003).

Although men in the communities around Urumwa are more knowledgeable of traditional conservation practices than women, they do not implement what they know at present. Taboos and seasonal and social restrictions on gathering medicinal plants used to limit medicinal plant harvesting and hence aid conservation. Now, apparently, respect for customary laws and institutions has been weakened by economic hardship, and harvests of timber and non-timber forest products are being used to maintain families without attention to long-term sustainability. In the past, nobody was allowed to enter Urumwa forest for medicinal plants collection without permission from the elders, and the harvesting of some medicinal tree species as *Sterculia africana* (Mhozya) was prohibited unless permission had been sought from ancestors (*Pers. obs.*, 2004).

Taboos with conservation implications exist in many African societies although, as in Tanzania, their influence is declining. There were taboos against restrictions to collect medicinal plants by women in South Africa and Swaziland as it was believed this would reduce the healing power of plants (Scudder and Conely, 1985). Also, the collection of certain plants in South Africa was restricted to the rainy season after seed set, as summer gathering was believed to cause storms and lightning. In Zimbabwe, clearance has to be obtained from ancestral spirits before entering certain forests where *Walburgia salutaris* occurs (Cunningham, 1993).

Men remain the active decision-makers on all aspects of the protection of the forest reserve and its resources – and gender bias results. A contributory factor is doubtless the reluctance of the majority of women to be assertive, restraint with deep traditional and cultural roots, and illiteracy, deterring participation in meetings, with better educated individuals. According to Karl (1995) women's role in natural resource decision-making is often limited and this is attributable to tradition and culture. Results from the present study indicate only a marginal influence by women in decision-making regarding the conservation and management of the forest reserve and this is a hindrance to the full adoption of operational JFM at Urumwa. Similar findings for the study area are reported by Mbwambo (2000), who noted that, during meetings, women sometimes refused to answer questions about the reserve, reasoning that only men dealt with woodland activities.

Neither women nor men adhere to JFM rules for access to the reserve for basic needs including medicinal plants. From the present study, it appears that the majority of local community members (both genders) in the study villages still violate JFM rules – though perhaps largely from ignorance of the programme (including ignorance of the long-term benefits on their side). The fact that exploitation of medicinal plants is not explicitly included in JFM guidelines implies to many that their significance is minor compared with other products. This omission is thus potentially a negative influence.

3.4.4 Conservation awareness and views at Urumwa

Harvesting of medicinal plants at Urumwa is dominated by the combination of root digging and bark stripping – confirming prevalent use of destructive methods to harvest medicinal plants, and implying that species in high demand at Urumwa will be endangered if harvesting becomes intensive and results in serious resource degradation. Urumwa is not unique. Similar observations were made in Machakos District, Kenya (Musila *et al.,* 2004), where total debarking, uprooting and tree cutting were among destructive harvesting methods employed in collecting medicinal plants.

Generally, a clear relationship exists between the plant part being harvested, the impact on the plant, and the degree of disturbance to the population (Cunningham, 1988), with roots and bark removal having more immediate and more damaging effects than the harvesting of leaves and fruit. According to Zschocke *et al.* (2000), harvesting of leaves for medicinal purpose seems to be more sustainable than harvesting root and stem material, which if over-harvested could threaten the survival of the plant. Bark stripping from an entire tree and ring barking are reported as causes of mortality in medicinal trees (Marcelin *et al.,* 2000).

Medicinal plant resources at Urumwa have been declining for the past two decades due to increased encroachment, but there are no measures taking place to counter this trend – apparently because there is a lack of awareness of needs to conserve the plants to sustain the primary health care system. The results of the present study are consistent with the observations of Hamilton (2004) that in many parts of the world there is virtually no cultivation of medicinal plants taking place on any significant scale and at community level supply continues to be from the wild resource. According to Williams (1996), an estimated 99% of the 400–550 species used in traditional medicine in South Africa originate from wild sources, underlining the trivial proportion of species under any sort of cultivation. Urumwa is similar in its overwhelming reliance on wild-collected medicinal plant material. Nevertheless, both women and men, indicate willingness to domesticate medicinal plants if technically supported, and viewed positively the idea of more training and research, coupled with reinforced and strengthened policies to save the potential medicinal plants at Urumwa from over-exploitation. This indicates the awareness of the Urumwa communities of the overall importance of conserving medicinal plant resources to ensure future availability, and indicates that traditional attitudes will not be a barrier to initiatives to grow medicinal plants.

The current study indicates a need for supporting the cultivation, domestication and sustainable harvesting of medicinal plants to protect and ultimately develop a fully effective traditional medicine system. For this to be made effective there is a role for government, at the very least in formulating policies and legal frameworks to encourage medicinal plant production through appropriate arrangements, and the dissemination of information on key species to be cultivated.

Some medicinal plant species have been identified as of relatively high significance for communities around Urumwa, for their contributions to local health care. Some of these (*e.g. Cassia abbreviata, Securidaca longepedunculata* and *Combretum zeyheri)* have also been ranked as top-ten priority species in a nearby region, Shinyanga (Derry *et al.*, 1999), indicating similarity of use through the western geographical zone of Tanzania's miombo. The species were of similar importance for treating human diseases, matching the usage of medicinal plants in other parts of the Africa (Table 3.23).

Table 3.23 Traditional medicine use, phytochemical and pharmacological evidences relevant to the identified priority medicinal species at Urumwa Forest Reserve, Tabora Region, Tanzania

Botanical name	Reported evidences			References (country)
	Traditional medicine use(s)	**Phytochemical**	**Pharmacological**	
Cassia abbreviata	Roots and bark treat sexual transmitted diseases			Ndubani and Hojer, 1999 (Zambia)
	Roots and leaves used for malaria		Antimalarial activity	Connelly *et al.*, 1996 (Malawi)
		Flavonoids in heartwood		Nel *et al.*, 1999 (South Africa)
			Flowers, leaves, roots and bark contain anthraquinones and triterpenoids	Mutasa and Kahn, 1995 (Tanzania)
Combretum zeyheri	Roots, leaves and bark applied against bacterial infections i.e. gonorrhoea, syphilis and other symptoms like diarrhoea, liver problems, hypertension and even cancer			Fyhrquist *et al.*, 2002 (Tanzania)
		Amino acids in seeds		Mwaluka *et al.*, 1975 (Tanzania)
Dalbergia nitidula		Heartwood with isoflavonoids and Phenolic compounds		Bekker *et al.*, 2002 and Letcher and Shirley, 1976 (South Africa)
Kigelia africana	Fruits for wounds, anaemia, stomach ache		Fruits have antidiabetic activity	Okine *et al.*, 2005 (Ghana)
	Fruits treat sexual transmitted diseases			Ndubani and Hojer, 1999 (Zambia)
	Fruits for urinary schistosomiasis			Ndamba *et al.*, 1994 (Zimbabwe)
Mundulea sericea	Leaves, bark, roots and seed treat aphrodisiac			Arnold and Gulumian, 1984 (Southern tropical Africa)

		Barks contain rotenoids and chalcones		Luyengi *et al.*, 1994 (Kenya)
		Seeds contain imidazole derivatives		Fellows *et al.*, 1977 (Tropical Africa)
Ozoroa insignis	Leaves, bark and roots for malaria, diarrhoea, venereal diseases, tapeworm, hookworms, schistosomiasis, kidney problems, increase lactation in women after child birth			Burkill, 1985; Gelfand *et al.*, 1985; Ndamba *et al.*, 1994; Abrue *et al.*, 1999; Rea *et al.*, 2000; Mølgaard *et al.*, 2001; Asase *et al.*, 2005 (Guinea Bissau, Zimbabwe, Ghana)
			Root bark and leaves showed anthelmintic effects	Mølgaard *et al.*, 2001 (Zimbabwe)
			Leaves, barks and roots have cytotoxic activities	Abrue *et al.*, 1999; Rea *et al.*, 2000 (Guinea Bissau, Zimbabwe)
		Triterpenes from roots		Liu and Abrue, 2006 (Guinea Bissau)
		Leaves, flowers and root extracts contain essential oils, cardanols, anacardic acids		Avedoum *et al.*, 1998; Rea *et al.*, 2000; He *et al.*, 2002 (Benin, Guinea Bissau, Zimbabwe)
Strychnos spinosa	Fruits and roots treat sexual transmitted diseases			Ndubani and Hojer, 1999 (Zambia)
	Leaves and twigs treat malaria			Asase *et al.*, 2005 (Ghana)
			Antitryponönosomal activity in leaves	Hoet *et al.*, 2004 (Benin)
Xylopia longipetala	root decoctions taken for stomach ache root pieces inserted into nostrils for headache relief	Roots and bark extract contain isoquinoline alkaloids	Bark extract with analgesic and antispasmodic activity	Nishiyama *et al.*, 2004 (Kenya and Tanzania)

Medicinal Plants Population Status

CHAPTER IV

POPULATIONS STATUS OF THE 'CASE STUDY' SPECIES: *PTEROCARPUS TINCTORIUS* AND *STRYCHNOS SPINOSA* AT URUMWA

This chapter examines the population status of two 'case study' medicinal plant species in the study area. The chapter has four sections subdivided into subsections; there is a brief account of the state-of-knowledge, a statement-of-purpose and a justification of the choice of species in Section 4.1. Data collection methods are explained in Section 4.2, which outlines the strategic approach used (4.2.1), the sampling and recording activity (4.2.2) and the data processing and analysis (4.2.3). In the results (Section 4.3) findings in terms of population structure by size-class distribution (4.3.1), nearest neighbour distances (4.3.2) and population density by size-class (4.3.3) are reported. Section 4.4 is a discussion.

4.1 Background

4.1.1 Medicinal plants as wild resources

Traditional medicinal plant practices in Africa are widespread and deep rooted, with most medicines from plants coming from wild populations especially those of forests and allied ecosystems (Chikamai and Tchatat, 2004). Almost any type of resource harvesting conducted in a tropical forest has an impact on its ecological functions. The magnitude of this impact depends on the nature and intensity of harvesting, the species and the type of resource under exploitation (Peters, 1994). It has long been suspected (*e.g.* Cunningham, 1993) that intensive harvesting, especially of commercial species in high demand, threatens the wild populations since it is generally vital parts such as roots and bark that are gathered. Thus, in South Africa, efforts to supplement income for daily livelihood needs (Geldenhuys, 2004) have resulted in illegal bark harvesting for traditional medicine from natural forests and, in the process, genetic resources and forest composition and structure have been severely degraded. According to Sheldon *et al.* (1997), the over-exploitation of medicinal plants is economically driven. Harvesters, in need of income, access a free and seemingly abundant resource. Distributors reap enormous profits by packaging and selling large volumes of medicinal plants. Harvest of wild plants on such a massive scale is unsustainable.

The pattern of distribution of a species provides some indication of its sensitivity to harvesting. Widespread species with a continuous distribution are likely to be less sensitive to harvesting or other threats than species with widespread, if fragmented distributions (Rosser and Haywood, 2002). Implementation of sustainable use practices with wild populations of medicinal plants as for other non-timber forest products, however, must take into account distribution, abundance and (ideally) the dynamics of target species (Russell-Smith *et al.*, 2006).

It has been estimated that more than 80% of rural dwellers in miombo woodlands of Tanzania (Oduol *et al.*, 2004) depend on indigenous medicinal plants, but there are concerns that deforestation and increasing human and livestock populations are threatening this resource. In many places the structure of miombo vegetation has been substantially modified through shifting agriculture, harvesting for firewood and charcoal, frequent fires and (in drier areas) heavy grazing by livestock (Fors, 2002).

Tanzania is not unusual in that medicinal plants are generally collected from the wild without any control or regulations. For almost all medicinal plants with rural primary health roles, population status remains poorly understood. With trees, population status is expressed in terms of diameter at breast height (dbh) classes, using these as substitutes for age classes. In healthy populations there is evidence of continual recruitment of regeneration to tree sized individuals and a significant proportion of mature, reproductively active individuals. Additionally, there is a need to ascertain if different size classes are dispersed through the population or localized.

4.1.2 Tree population dynamics

Variations exist within and between tree populations with regard to size class distribution and morphological characteristics due to the influence of both abiotic and biotic factors. The major abiotic factors include water and nutrient availability, soil acidity/alkalinity, soil salinity, presence of heavy metals in the soil and extremes of temperature. The degree of exposure of the population to disturbances like fire, browsing and other human impacts are among the biotic factors which influence plant populations (Crawley, 1996).

Density and size-class structure data are the most fundamental pieces of information needed for the management of forest resources (Peters, 1994). Information on the distribution and abundance of tree species is also of primary importance in the planning and implementation of conservation strategies (Newton *et al.*, 2003). The diameter distribution of species for a particular forest type or a forest in general may indicate whether the species is expanding, stable or declining in terms of population (Geldenhuys, 1993). Information on the size class distribution of plant species is essential for the development of any management and conservation strategy for it, and population structure analysis provides evidence of any impact of harvesting (Dalle and Potvin, 2004). For medicinal plants exploited from the miombo woodlands of Tanzania, population information appears to be completely lacking.

4.1.3 The choice of target species

A choice of two target ("case study") species for population status assessment was made following wide consultation with local people, consideration of the ethnobotanical inventory findings (Chapter III), the current state-of-knowledge at species level of miombo trees used medicinally, and the logistic consideration of the estimated time needed for an indicative population assessment. Before the participatory rural appraisal (PRA) survey was implemented, a list of 12 medicinal tree species (Table 4.1) from the miombo woodlands of Urumwa documented by Abdallah (2001) had been reviewed. Four species from this list (*Albizia harveyi*, *Commiphora africana*, *Dalbergia nitidula* and *Kigelia africana*) were identified as possibilities for detailed attention in this study. However, the PRA outcomes differed from Abdallah's listing and the choices were reconsidered with emphasis shifted to the PRA list of 10 medicinal plant species (Table 3.21 - Chapter III) designated as potential species by the local people. Three species (*Combretum zeyheri, Dalbergia nitidula* and *Kigelia africana*) were in both lists.

Pterocarpus tinctorius and *Strychnos spinosa* are among the 10 PRA listed species as 'potential' medicinal plants to communities around the miombo woodland of Urumwa due to their importance in the daily primary health care needs; and ranked the third and fifth respectively in the main list (Table 3.21–Chapter III). In the general ethnobotanical survey conducted for the present study the two species (*Pterocarpus tinctorius* and *Strychnos spinosa*) were top-ranked species for the six villages–based on combined records per species across categories of use and gender at Urumwa (Table 3.6–Chapter III).

Table 4.1 List of potentially targeted medicinal plants for study from Urumwa Forest Reserve, Tabora Region, Tanzania

S/No	Botanical name	Local name(s)	Family (Phylogenetic order)	Ailment cured	Part(s) used	Study extent		
						a	b	c
1.	*Albizia harveyi*	Mpogolo (Nyamwezi, Sukuma)	Mimosaceae (Fabales)	Stomach ache	Roots	na	+	+++
2.	*Kigelia africana*	Mvungwa, Msangwa (Nyamwezi), Mwicha, Ng'wicha (Sukuma)	Bignoniaceae (Lamiales)	Anaemia, Dysentery	Fruits & Barks	+	+	+++
3.	*Commiphora africana*	Msangasi, Mponda (Nyamwezi), Mponda (Sukuma),	Burseraceae (Sapindales)	Infertility	Roots	+	+	+++
4.	*Dalbergia nitidula*	Kafinulambasa, Mbelambasa, Kapondambasa (Nyamwezi)	Papilionaceae (Fabales)	Anaemia	Roots, Fruits & Barks	na	+	+++
5.	*Pterocarpus angolensis*	Mninga (Nyamwezi), Muhagata (Sukuma)	Papilionaceae (Fabales)	Anaemia	Fruits & Barks	na	+	+++
6.	*Lannea humilis*	Mtinje (Nyamwezi), Ntinje (Sukuma)	Anacardiaceae (Sapindales)	Dysentery	Roots	na	na	+
7.	*Flacourtia indica*	Msingila (Nyamwezi), Nkulwamhuli, (Sukuma)	Salicaceae (Malpighiales)	Dysentery	Roots	+	+	+++
8.	*Grewia villosa*	Msalasi (Nyamwezi)	Malvaceae (Malvales)	Sterility	Roots	+	+	+++
9.	*Combretum zeyheri*	Msana (Nyamwezi), Nsana (Sukuma)	Combretaceae (Myrtales)	Sterility, Diarrhoea	Roots &Leaves	+	+	+++
10.	*Boscia salicifolia*	Mguluka (Nyamwezi)	Capparaceae (Brassicales)	Pneumonia	Barks	++	+	+++
11.	*Terminalia sericea*	Mzima (Nyamwezi), Njimya nkema (Sukuma)	Combretaceae (Myrtales)	Diarrhoea	Leaves	+	+	+++
12.	*Erythrina abyssinica*	Mkalalwanhuba (Nyamwezi), Mpilipili, Nkalalwanhuba, Mungu (Sukuma)	Papilionaceae (Fabales)	Jaundice	Barks	++	+	+++

Source: Abdallah (2001) adopted and modified

Note: **a** = Phytochemistry; **b** = Silviculture; **c** = Inventory information
na = no information available; + = little studied; ++ = intermediate studied; +++ = well studied

- I arranged the tree species in "potentiality" based on the common ailments cured and inadequate or lack of information especially on phytochemical aspects. For the purpose of this study, species number 1 – 4 were proposed for selection and others dropped. However, the final decision depended on resulting species obtained during PRA survey with selected participants in villages surrounding Urumwa Forest Reserve.
- For each of the "potential" species selected, my objective was to screen them for alkaloids and flavonoids composition.

Moreover, *P. tinctorius* was among the key medicinal plant species (Table 3.9 - Chapter III) used to treat gastrointestinal disorders. The final decision to adopt the two as the 'case study' species considered their availability in terms of abundance in the forest reserve as reported by local people.

Phytochemically, these two species are thought to be rich in flavonoids (*P. tinctorius*) and alkaloids (*S. spinosa*), the two types of compound reported to have broad physiological effects in the human body (Harborne, 1994; Saxton, 1994), and partly given attention by this study.

4.1.4 Statement of purpose

The activities reported in this chapter were undertaken to gain an indicative assessment of the population structure of two 'case study' species: *Pterocarpus tinctorius* and *Strychnos spinosa* in the study area. The chapter though lacks detailed ecological aspects, links the ethnobotany and phytochemical parts of this thesis by relating the local communities knowledge on abundance of potential species in Urumwa Forest Reserve, which later formed a basis for phytochemical sampling. The idea was to provide an understanding of the medicinal plant resource base that meet the local stakeholders demand as well as formulating the basis for future planning and development of medicinal plants conservation strategies in the Urumwa Forest Reserve. There were two aspects:

i. to determine the size-class structure in samples of the populations of each 'case study' species in the study area and,

ii. to determine density by size class within these population samples in Urumwa Forest Reserve.

4.2 Data collection methods

4.2.1 Strategic approach

Some references to dryland tree stocking are made in the literature (*e.g.* Schultz and Company, 1973). Low values apply for most species, particularly if attention is restricted to large (≥10 cm dbh) individuals. This makes conventional small-plot work inefficient and a species-centred approach favourable. Except where exports of quality timber species such as *Pterocarpus angolensis* are concerned, there is lack of past attention to small individuals because high minimum sizes have usually been set (Schultz and Company, 1973, use 15 cm dbh).

Data for the present study were collected in the miombo woodland of Urumwa Forest Reserve (described in Section 2.3 – Chapter II).

Prior to the survey, Urumwa Forest Reserve was stratified into two compartments, north and south (Figure 2.5b – Chapter II) using the Walla River as a boundary between the strata. In each stratum, samples of 100 individuals for each species were assessed. A distance of at least 1.5 km separating the centres of different samples of the same species in each stratum was maintained to prevent any sample overlapping. In total seven samples were established; two samples for each target species in the north stratum and two samples for *P. tinctorius* and one sample for *S. spinosa* in the southern stratum. The limited abundance of *S. spinosa* in the south of the reserve did not permit a second sample. To minimize edge effects during measurement, each sample was established starting with an individual large enough for inclusion (often ≥10 cm dbh) at least 500 m from the nearest point on the forest reserve boundary and at least 500 m from the Walla River. This also ensured exclusion of riverine habitat and areas that had suffered serious encroachment.

A diameter threshold of 3 cm was adopted as the minimum size for inclusion in the population samples. This ensured that all individuals of sizes routinely exploited were included and also that juveniles were represented, although there is no knowledge of the typical age of an individual 3 cm diameter at breast height (dbh) in the study area.

4.2.2 Sampling and recording

The sample populations were established following the process used in other multiple-nearest-tree sampling (Boaler, 1966; Hall, 1991). To begin sampling, one *Pterocarpus* or *Strychnos* tree (≥10 cm dbh), identified in an area by a local plant identifier was used as a starting point. Moving away from the starting tree, the 99 nearest other individuals ≥ 3 cm dbh of the target species were then progressively added to the sample. As the sample was expanded by adding more individuals, it was kept as compact as possible. The process was concluded when the sample size reached 100 individuals. Tree positions in each sample were numbered serially. Using coloured masking tape, each tree was tagged with an identification number to avoid repetition in recording and measuring and its position was mapped using a Geographical Positioning System (GPS) facility.

The diameter at breast height (dbh) of every individual *Pterocarpus* or *Strychnos* tree ≥3 cm dbh, (based on the thickest stem if more than one was present), in each sampled population was measured to the nearest centimetre using a calliper and recorded (Appendix V). Tree total height for the largest stems (*i.e.* ≥20 cm dbh for *P. tinctorius* and ≥15 cm dbh for *S. spinosa*) was measured using a clinometer. The nearest neighbour distance from one tree to another was recorded using the GPS odometer in each sampled population. For close distances (*e.g.* 3 m – 10 m) where the odometer signal sometimes failed to record the distances, the alternative option of using measuring tape was taken.

4.2.3 Data processing and analysis

Data were separately processed for each sampled *Pterocarpus* and *Strychnos* tree population. GPS positions were used to prepare maps of each sample. From the maps, summaries of nearest neighbour distances were determined for core trees (trees in the sample excluding those nearer the boundary than to another tree within the sample). From the maps, nearest neighbour distances (assembled from individual distances to nearest meter) were determined (Okullo, 2004) for core trees (trees in the sample excluding those nearer the boundary than another tree within the sample).

For expressing parameters recorded on a per hectare basis, the sampled area for each target species population was estimated. First, the sample was mapped and then trees at the sample margin were taken to be the angles of a convex polygon. The area of the polygon (ha) was estimated using dot grid method.

For data analysis MINITAB 13 and Microsoft Excel computer software tools in form of frequency, mean and standard deviation for tree diameter at breast height, nearest neighbour distances (proximity of core trees) and species density were used. The overall population density estimate was made from: 100/population area (ha). The per hectare tree densities of each target species were calculated for all trees ≥3 cm dbh and, after rounding the nearest whole centimetre for the different size classes (3 – 5 cm; 6 – 10 cm; 11 – 15 cm; 16 – 20 cm; 21 – 25 cm; 26 – 30 cm; 31 – 35 cm and > 35 cm) by dividing the number in each size class by the total area (ha) within which the 100 sampled individuals were assessed.

4.3 Results

4.3.1 Population structure by diameters size-class

Tree diameter frequency of four hundred *Pterocarpus tinctorius* trees: 100 trees in each of the two samples in the north and 100 in each of the two samples in the south of Urumwa Forest Reserve were assessed in eight diameter classes (Table 4.2) to depict the population structure. Overall, in all sampled populations at Urumwa, the species population structure is represented by high frequencies of large trees (size class > 25 cm dbh) with few small trees represented in size classes < 20 cm. There is a total lack of trees ≤ 15 cm dbh for Population II – South of the Walla River (Table 4.2).

Table 4.2 Diameter frequency of *Pterocarpus* tree by size class in sampled populations at Urumwa Forest Reserve, Tabora Region, Tanzania

Dbh size class (cm)	Frequency per sampled populations				
	NW I - Pop 1	NW II – Pop 2	SW I - Pop 3	SW II – Pop 4	Total for all populations
3 – 5	3	13	5	-	21
6 – 10	7	1	12	-	20
11 – 15	8	5	13	-	26
16 – 20	7	2	3	6	18
21 – 25	21	8	10	14	53
26 – 30	22	20	21	28	91
31 – 35	16	16	14	27	73
> 35	16	35	22	25	98
All trees	100	100	100	100	400

Pop = population, NW = North Walla, SW = South Walla

Three hundred *Strychnos spinosa* trees: 100 trees in each of the two samples in the north and 100 in the sample in the south of Urumwa Forest Reserve were assessed in eight diameter classes (Table 4.3). In all sampled populations, the species population structure was represented by many small trees (dbh class ≤ 10 cm), with low representation of large trees (>20 cm dbh). Populations 1 and 2 both in north of the Walla River, lacked trees of size class 31 – 35 cm dbh and only one individual (Population 3) was recorded South of the Walla River (Table 4.3).

Table 4.3 Diameter frequency of *Strychnos* tree by size class in sampled populations at Urumwa Forest Reserve, Tabora Region, Tanzania

Dbh size class (cm)	Sampled populations (Areas)			
	Pop 1 – NW I	Pop2 – NW II	Pop 3 – SW I	Total for all populations
3 – 5	49	50	38	137
6 – 10	45	26	38	110
11 – 15	3	9	11	23
16 – 20	2	10	10	22
21 – 25	1	5	2	8
26 - 30	-	-	-	-
31 – 35	-	-	1	1
> 35	-	-	-	-
All trees	100	100	100	300

Pop = population, NW = North Walla, SW = South Walla.

4.3.2 Nearest neighbour distances

A total of 335 core trees of *P. tinctorius* from the four sampled populations in the north and the south of Urumwa Forest Reserve were assessed to check how close on average, an individual tree was to its neighbour. For *Strychnos spinosa* trees, 260 core trees from the three sampled populations in the north and south of Urumwa Forest Reserve were assessed. Most individuals ≥ 3 cm dbh of both species were > 20 cm from the nearest conspecific neighbour, except in *Strychnos spinosa* Population 1 (Table 4.4, Figures 4.1a, 4.1b, 4.1c. 4.2a, 4.2b) indicating generally sparse distributions.

For *Pterocarpus tinctorius*, Population 2 (North Walla II) had lower mean distance (42 m) between conspecific neighbours than the other populations; while in *Strychnos* *spinosa* Population 1 (North Walla I) had a low mean distance (35 m) between conspecific neighbours and a higher proportion of conspecific individuals within 12 m.

Table 4.4 Proximity (m) of nearest conspecific neighbour for target species at Urumwa Forest Reserve, Tabora Region, Tanzania

Population	N	≤ 4	5 - 8	9 - 12	13 - 16	17 - 20	21 - 24	25 - 28	≥ 29
Pterocarpus tinctorius									
1. NW I (58 m)	86	3	3	5	4	5	11	3	52
2. NW II (42 m)	81	5	6	5	8	4	5	6	42
3. SW I (44 m)	85	12	8	5	9	6	4	9	32
4. SW II (49 m)	83	5	5	11	4	7	2	8	41
Strychnos spinosa									
1. NWI (35 m)	87	8	16	14	5	4	5	3	32
2. NW II (51 m)	85	7	6	9	7	4	5	5	42
3. SW I (46 m)	88	13	6	11	5	4	6	4	39

NW = North Walla; SW = South Walla

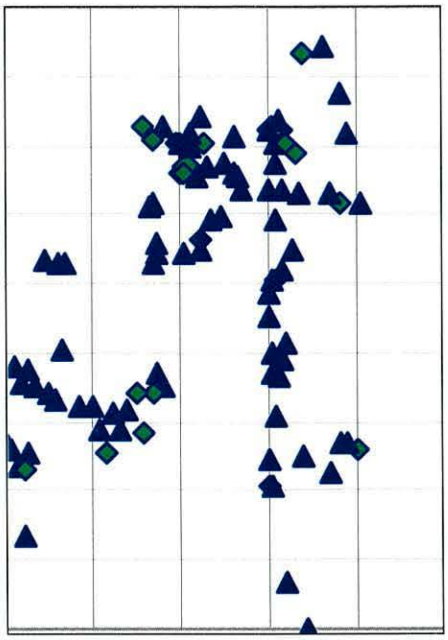


Figure 4.1c Distribution of *Pterocarpus tinctorius* in sampled area of south Walla II at Urumwa Forest Reserve, Tabora Region, Tanzania. (Each cell = 100m x 100m = 1ha).

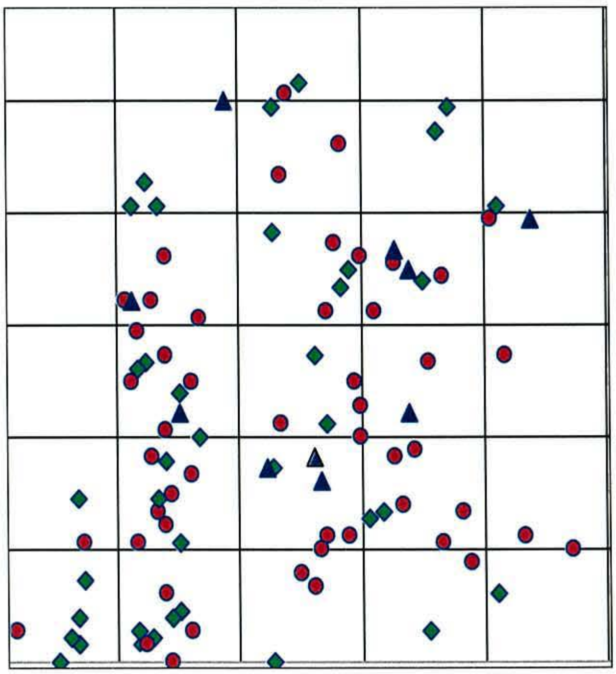


Figure 4.2a Distribution of *Strychnos spinosa* in sampled area of north Walla I at Urumwa Forest Reserve, Tabora Region, Tanzania. (Each cell = 20m x 20 m = 0.4 ha).

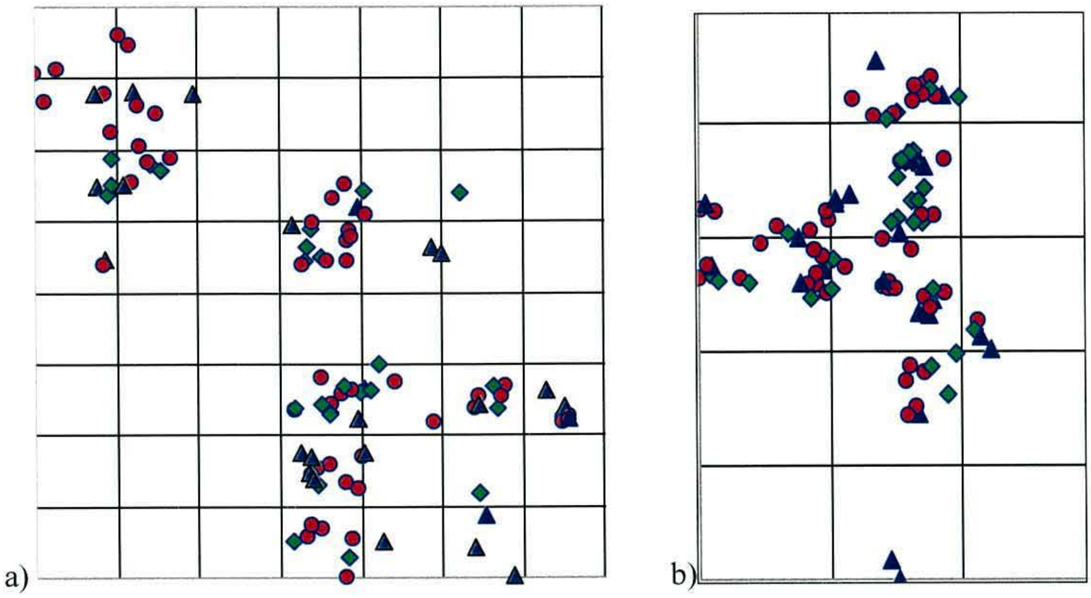


Figure 4.2b Distribution of *Strychnos spinosa* in sampled area of north Walla II (a)- (Each cell = 100 x100 m = 1 ha) and south Walla I (b)- (Each cell = 200 m x 200 m = 4 ha), at Urumwa Forest Reserve, Tabora Region, Tanzania.

4.3.3 Population density by size-class

P. tinctorius stocking (all individuals ≥ 3 cm dbh) size class ranged from just one individual per hectare (Population 2 - North Walla II) to close to five individuals per hectare (Population 1 – North Walla I) (Table 4.5).

Table 4.5 Per hectare *Pterocarpus* tree density by size class in sampled populations at Urumwa Forest Reserve, Tabora Region, Tanzania

Dbh size class (cm)	Sampled populations (Areas)				
	NW I - Pop 1 (21 ha)	NW II – Pop 2 (90 ha)	SW I - Pop 3 (70 ha)	SW II – Pop 4 (72 ha)	All population mean ± SD
3 – 5	0.14	0.14	0.07	-	0.09 ± 0.07
6 – 10	0.33	0.01	0.17	-	0.13 ± 0.16
11 – 15	0.38	0.05	0.18	-	0.15 ± 0.17
16 – 20	0.33	0.02	0.04	0.08	0.12 ± 0. 14
21 – 25	1.00	0.09	0.14	0.19	0.35 ± 0.43
26 – 30	1.05	0.22	0.30	0.39	0.49 ± 0.38
31 – 35	0.76	0.18	0.20	0.37	0.38 ± 0.27
> 35	0.76	0.39	0.31	0.35	0.45 ± 0.21
All trees	4.75	1.10	1.41	1.38	2.61 ± 1.73

Pop = population, NW = North Walla, SW = South Walla

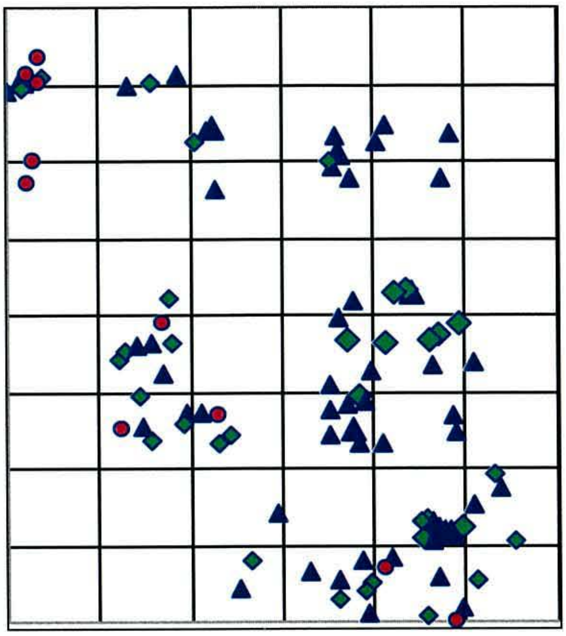
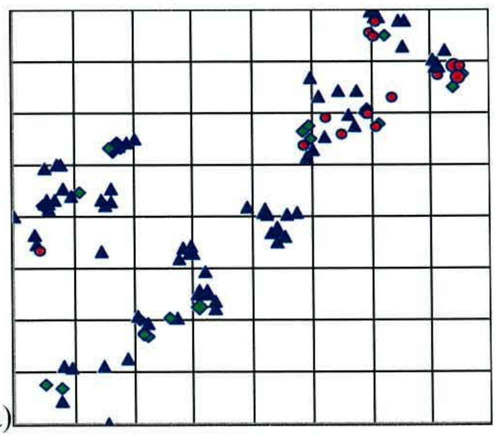


Figure 4.1a Distribution of *Pterocarpus tinctorius* in sampled area of North Walla I at Urumwa Forest Reserve, Tabora Region, Tanzania (Each cell = 100m x 100m = 1ha).

Keys: Red dots = dbh size 3 – 10 cm; diamond-shaped green = dbh size 11 – 25 cm; blue triangles = dbh size > 25 cm.

a)



b)

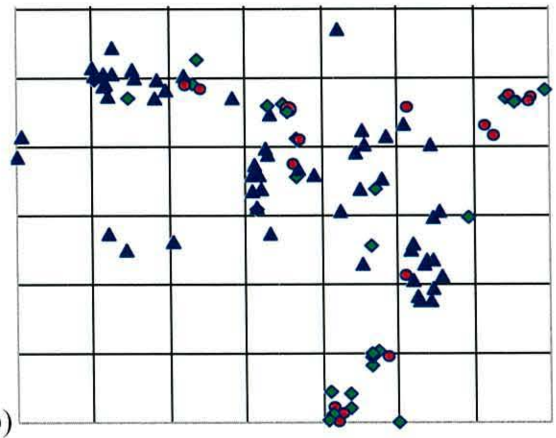


Figure 4.1b Distribution of *Pterocarpus tinctorius* in sampled area of North Walla II (a) and south Walla I (b) at Urumwa Forest Reserve, Tabora Region, Tanzania (Each cell = 100m x 100m = 1ha).

Within all sampled populations in Urumwa Forest Reserve, however, *P. tinctorius* was well-stocked with large individuals (≥ 25 cm dbh) but poorly stocked in terms of trees ≤ 15 cm per hectare (Figure 4.3a).

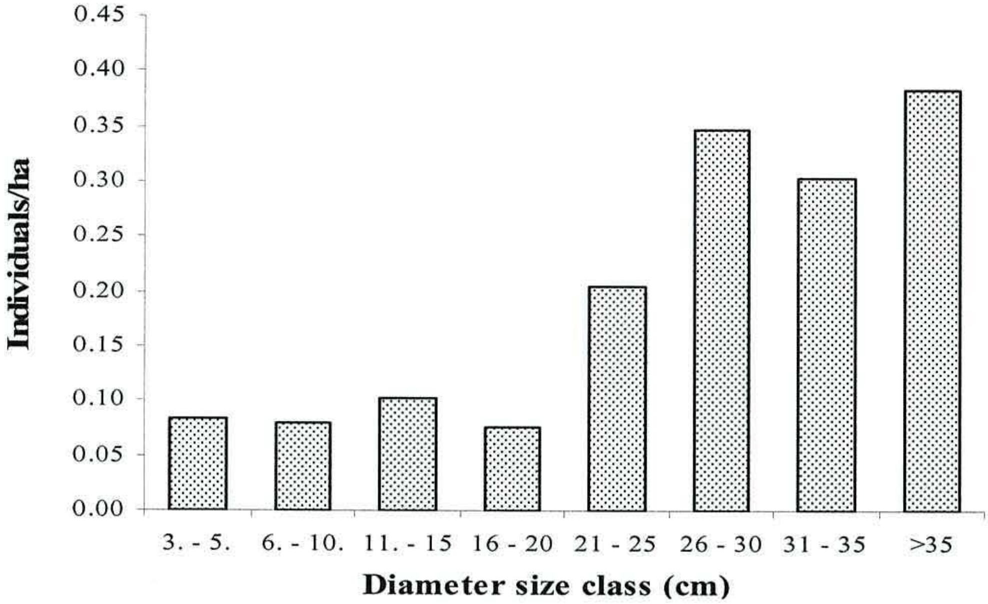


Figure 4.3a Individual per hectare, by size class, all samples combined for *Pterocarpus tinctorius* at Urumwa Forest Reserve, Tabora Region, Tanzania

For *S. spinosa*, stocking mainly with small individual trees, ranged from a little over two individuals per hectare (Population 2 – North Walla II) to as many as 20 individuals per hectare (Population 1 – North Walla I) (Table 4.6).

Table 4.6 Per hectare *Strychnos* tree density by size class in sampled populations at Urumwa Forest Reserve, Tabora Region, Tanzania

Dbh size class (cm)	Sampled populations (Areas)			
	Pop 1 - NW I (5 ha)	**Pop2 - NW II (46 ha)**	**Pop 3 - SW I (21 ha)**	**All population mean ± SD**
3 – 5	9.80	1.09	1.81	4.23 ± 4.83
6 – 10	9.00	0.57	1.81	3.80 ± 4.55
11 - 15	0.60	0.19	0.52	0.41 ± 0.22
16 - 20	0.40	0.22	0.48	0.37 ± 0.13
21 – 25	0.20	0.11	0.09	0.13 ± 0.06
26 - 30	-	0.04	-	0.01 ± 0.02
31 – 35	-	-	0.05	0.02 ± 0.03
> 35	-	-	-	-
All trees	20.00	2.18	4.76	8.98 ± 9.63

S. spinosa represents a well-stocked species in Urumwa Forest Reserve with many small trees (size ≤ 10 cm dbh) although has few individual > 25 cm dbh (Figure 4.3b).

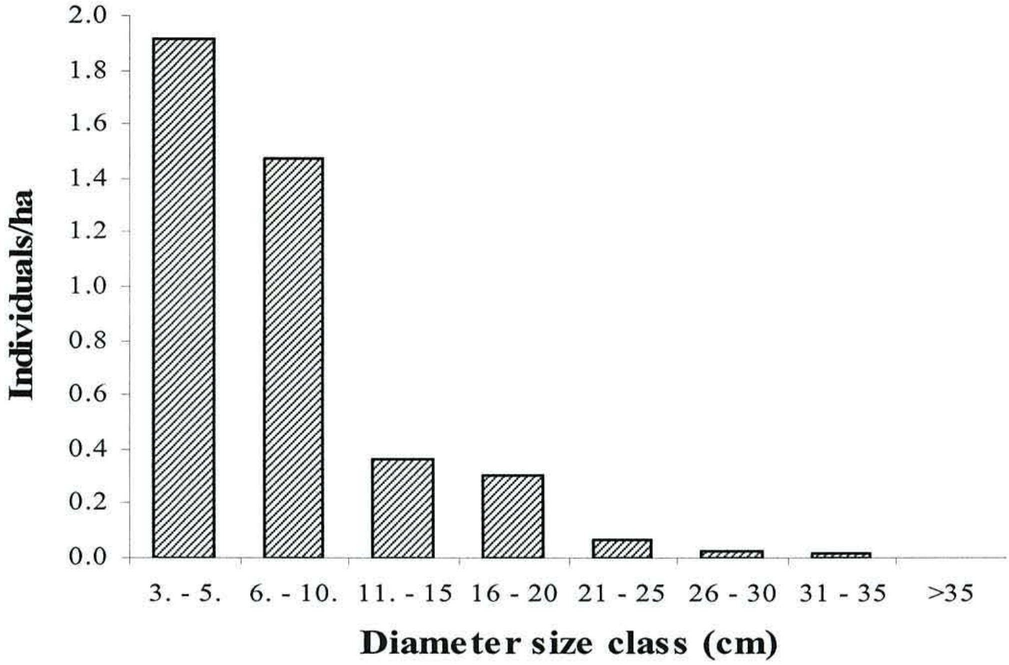


Figure 4.3b Individual per hectare, by size class, all samples combined for *Strychnos spinosa* at Urumwa Forest Reserve, Tabora Region, Tanzania.

4.4 Discussion

For the miombo woodlands of Urumwa Forest Reserve, the present study has indicated differences in the population structure of the two 'case study' species. The population of *Pterocarpus tinctorius* is structurally characterized by larger trees (> 25 cm dbh) with poor representation of smaller trees (≤ 20 cm dbh), indicating a population at risk of elimination. The population of *S. spinosa* at Urumwa is mainly of trees less than 10 cm dbh, indicating its higher recruitment capacity or it might be a species with constant rejuvenation (Lykke, 1998), having a healthy population which is stable and self-maintaining. Interpretation of the results from a survey on a single occasion must, however, be continuously. A single survey does not offer a useful view for the long-term prospects of a population. In the case of *P. tinctorius*, which has many large individuals, it can be argued that, as long as seed sources survive and management can undertake appropriate interventions, the population can be sustained. A more difficult issue with this species is the potential genetic erosion or thinning of the large tree part of population, isolating individuals from cross-pollination. For *S. spinosa*, it is difficult to differentiate the juveniles and adult trees. Probably the species has old individuals which are still quite small and even ones are <3 cm dbh, below the survey threshold may be older than *P. tinctorius* individuals of the same size.

The massive deforestation reported to have occured in the miombo woodlands of central Tanzania particularly Tabora Region (Lawton, 1982) might have affected the population structures and distribution of the two 'case study' species in Urumwa Forest Reserve. Nevertheless, the observed difference in population structures by size classes between 'case study' species at Urumwa, could still reflect other factors that have previously been reported to affect the structure and composition of dry woodland or miombo in south-central Africa, including disturbances such as fire (Kikula, 1986; Chidumayo, 1988a) and anthropogenic factors including commercial charcoal production (Monela, *et al.*, 1993) which is non-selective on what size of tree to fell, and cutting of building poles (Luoga *et al.*, 2000c). All these types of disturbances were noted inside Urumwa Forest Reserve and additionally, the impact of overgrazing by domestic livestock (Figure 4.4).

Figure 4.4 Some of the disturbances encountered inside Urumwa Forest Reserve, Tabora Region, Tanzania.

In terms of the density of the two 'case study' species, the study has demonstrated a lower stocking of *P. tinctorius* compared with *S. spinosa* which seem to be well-stocked, even though with smaller trees. At the same time, both species are, overall sparsely distributed (Figures 4.3a – 4.3d; 4.4a – 4.4c) in the miombo woodlands of Urumwa Forest Reserve. On would need to travel long distance within the reserve to collect medicinal materials of these species, if large quantities were required. This highlights the need to pay attention to the species in future, if possible considering their cultivation in home gardens, taking advantage of the existing agroforestry techniques or domestication in community woodlots, reducing pressure on vulnerable (and probably declining) natural populations, and ensure availability of the resources nearer users especially women. It has been suggested that, domestication of indigenous plants in agroforestry systems (Teklehaimanot, 2004), could provide not only continuous tree cover and contribute to plant material supply, but also improve productivity and sustainability of farming system through maintained soil fertility, while reducing pressure from the wild sources.

Isoflavonoids & other bioactives in *Pterocarpus tinctorius*

CHAPTER V

BIOACTIVE COMPOUNDS IN *PTEROCARPUS TINCTORIUS* WITH SPECIAL REFERENCE TO ISOFLAVONOIDS

This chapter deals with the determination of bioactive compounds in *Pterocarpus tinctorius* with special reference to isoflavonoids. A background section (5.1) gives a brief state-of-knowledge review of the research. Section 5.2 describes the materials and methods employed, and considers the sampling strategy (5.2.1), experimentation and data analysis (5.2.2). In the results section (5.3), findings are reported in terms of confirming presence in crude extracts of the plant parts (5.3.1), their concentration there (5.3.2) and other associated compounds isolated and identified from parts of the tree species (5.3.3) providing evidence for their bioactivity. Section 5.4 is a discussion.

5.1 Background

The choice of studying *Pterocarpus tinctorius* was made in part because ethnomedical data from local communities around the miombo woodlands of Urumwa indicate extensive utilization in traditional medicine. *Pterocarpus tinctorius* has, however, received very little scientific attention compared with other species in the genus, although over 50 years ago King *et al.* (1953) reported the presence of simple aliphatic natural products (mainly pterostilbenes) in the heartwood of the species. Awareness that bioactive compounds, notably isoflavonoids, have been isolated from other *Pterocarpus* species, and other members of the *Pterocarpus* clade, and that there is evidence of their bioactivity in human body physiology (Appendix VIb), suggested this investigation of *Pterocarpus tinctorius* would be of interest.

An updated phytochemical context, expressed as reports of compounds reported for genus *Pterocarpus* is given by Southon *et al.* (1994a, b). There is information for thirteen species. Flavonoids, particularly isoflavonoids such as isoflavones, pterocarpans, isoflavans and isoflavanones are reported (Table 5.1) as principal constituents. Isoflavonoids constitute a large and very distinctive subclass of the flavonoids and can be categorized into several groups: isoflavones (*e.g.* formononetin, genistein and prunetin), isoflavanones, rotenoids, pterocarpans (*e.g.* homopterocarpin), isoflavans (*e.g.* vestitol), isoflavanols, isoflav-3-enes and 3-arylcoumarins (Dewick, 1993).

Table 5.1 List of flavonoids and other compounds reported to occur in the genus *Pterocarpus*

Compound name	**Compound parent group** (Southon *et al*., 1994a, b)	***P. soyauxii* Taubert****	***P. angolensis* DC. ***	***P. dalbergioides* DC.**	***P. erinaceus* Poiret***	***P. indicus* Willd.**	***P. macrocarpus* Kurz.**	***P. marsupium* Roxb.**	***P. officinalis* Jacq.****	***P. osun* Craib***	***P. santalinus* L. f.**
Isoflavan	Flavonoid	10									
Isoflavone	Flavonoid	10	9, 33, 34, 52	57	11	12, 20		4, 27, 46, 49, 50, 66		2, 5	35
Isoflavanone	Flavonoid						69	29			
Simple pterocarpan	Flavonoid	10, 11, 35		35, 57, 60		12, 20	7, 35, 60			2, 5	5
α-Methyldeoxybenzoin	Flavonoid		8, 34		2	20					
Flavanone	Flavonoid		9				69	4, 10, 46, 60, 66			35
Chalcone	Flavonoid					22	69	4, 10, 46			35
Aurone	Flavonoid							4, 10, 41, 46			32
Flavone	Flavonoid							10, 46			
Flavan-3-ol	Flavonoid							17			
Flavonol	Flavonoid	10						4, 10			
Flavan	Flavonoid							13			
Diarylpropane	Flavonoid							41, 65			
Biflavonoid	Flavonoid									5	4, 40, 64
Hypaphorine	Alkaloid								30		

Note: ** = Closely related to *P. tinctorius* Welw.; * = moderately closely related to *P. tinctorius* Welw; Numbers inside the cells are references in appendixVIa

Over 95% of known isoflavonoids are present in legumes (Fabaceae), in particular, in the subfamily Papilionoideae (Dewick, 1993; Harborne, 1994). They have a limited distribution in plants, and are almost restricted to the legumes, where they perform various functions including roles in *Rhizobium* nodulation and antimicrobial phytoalexin formations (Bohm, 1998; Dixon and Paiva, 1999). Many isoflavonoids exhibit medicinal properties and they are common constituents in human diets (Bohm, 1998; Davis *et al.*, 1999). Recently, increased attention has been paid to isoflavones such as genistein, formononetin and prunetin due to their importance for human health (Cos *et al.,* 2003), and especially in the mammalian health-promoting effects of isoflavonoids to prevent bone loss and several cancers (Dixon and Steele, 1999; Dixon *et al.,* 1999).

Initially nine isoflavonoids (Table 5.2) were targeted for studies based on reported bioactivity and the fact that the compounds have never been reported in *Pterocarpus tinctorius*. However, due to limitations in obtaining reference standard materials from commercial sources, the number was narrowed to five isoflavonoids: formononetin, genistein, prunetin, vestitol and homopterocarpin.

The present exercise therefore seeks to ascertain and provide an understanding of the presence of these five isoflavonoids in material of *Pterocarpus tinctorius* from the miombo woodlands of the study area. Specifically the study aims to: (i) isolate and identify the isoflavonoids if they are present in the leaves, stem bark and root bark of the tree species, (ii) quantify and compare the composition of the five isoflavonoids in different parts of the plant and (iii) identify additional compounds - where possible including other isoflavonoids present.

Table 5.2 List of initially targeted compounds of interest for *Pterocarpus tinctorius* analysis

Isoflavonoids category	**Compounds name(s)** (Harborne and Baxter, 1993, Southon *et al.*, 1994b)	***Pterocarpus* species and other species from the "*Pterocarpus* clade"**	**Evidence of biological activity**
Isoflavones	Formononetin	*Pterocarpus soyauxii, P. indicus, Tipuana tipu, Centrolobium robustum, C. sclerophyllum, C. tomentosum*	antifungal, antihypolipidaemic (Harborne and Baxter, 1993)
	Prunetin	*P. soyauxii, P. angolensis, P. santalinus*	antiviral (Southon *et al.*, 1994b)
	Genistein	*P. angolensis*	antifungal, oestrogenic, antiperoxidative (Harborne and Baxter, 1993)); weak antibacterial and oestrogenic, induce cell differentiation(Southon *et al.*, 1994b); oestrogenic, antioxidant, anticarcinogenic, anti-atherogenic, anti-osteoporotic (Barnes and Peterson, 1995; Wei *et al.*, 1995; Wang *et al.*, 1996; Lamartiniere, 2000)
Isoflavan	Vestitol	*P. soyauxii, Centrolobium tomentosum*	antifungal (Harborne and Baxter, 1993)
Simple pterocarpans	Homopterocarpin	*P. soyauxii, P. dalbergioides, P. indicus, P. macrocarpus, P. osun, P. santalinus*	antifungal(Harborne and Baxter, 1993)
	Maackian	*P. dalbergioides*	antifungal (Harborne and Baxter, 1993; Southon *et al.*, 1994b)
	Pterocarpin	*P. dalbergioides, P. indicus, P. macrocarpus, P. osun, P. santalinus*	antifungal (Harborne and Baxter, 1993)
	Vesticarpan	*Platymiscium trinitatis*	antifungal (Harborne and Baxter, 1993)
	Medicarpin	*Platymiscium trinitatis, Centrolobium robustum, C. sclerophyllum, Arachis hypogaea*	antifungal (Harborne and Baxter, 1993)

5.2 Materials and methods

5.2.1 Sampling strategy

5.2.1.1 Plant selection and identification

An ethnobotanical approach (Martin, 2004) was used in sampling. In this approach, the species is selected based on its daily use for traditional medicine to cure different ailments by local communities. Prior to actual collection, a list of more than 10 medicinal plant species drawn by local communities around Urumwa was taken as an indication of "potential species". These "potential species" were identified with the assistance of a local plant identifier and collector, during a reconnaissance survey to develop a general scenario of where the species grow and their abundance in the reserve (Table 3.21 - Chapter III). The Institute of Traditional Medicine, Tanzania, was then consulted for information on on-going phytochemical studies and the scientific state-of-knowledge of the medicinal plants in the miombo woodlands of Tabora, particularly Urumwa Forest Reserve.

Individual plants of *P. tinctorius* were provisionally identified using Mbuya *et al.* (1994), and then collected specimens were compared with voucher specimens at TAFORI-MWRC, Tabora. Finally, identification was confirmed by an experienced taxonomist. Three sets of voucher specimens were prepared. One set designated ITM-3712, was deposited at the Institute of Traditional Medicine, Muhimbili University College of Health Sciences, Dar es Salaam, and a second at the TAFORI-MWRC herbarium in Tabora. A third set will be deposited at National Herbarium of Tanzania, Arusha.

Having established its suitability in terms of availability in the reserve and the scientific state-of-knowledge, *Pterocarpus tinctorius* was selected as a 'case study' species. Final selection was confirmed on the basis of its abundance in the reserve as demonstrated by local communities, and the perceived need for scientific information regarding its phytochemical characteristics.

5.2.1.2 Plant materials collection

Three types of *P. tinctorius* material (root bark, stem bark and leaves) were collected in the natural habitat at Urumwa Forest Reserve in September/October 2004. Collecting was early in the morning (6.00–10.00 h, local time), in relatively cool ambient temperature. The different plant materials were collected from healthy trees apparently free from fungal and bacterial infections. The source tree positions were recorded using a Global Position System (GPS) facility.

From each tree, two or three roots (2 to 5 cm diameter; 15 cm to 100 cm long) were collected. For bark, two pieces (5 cm – 10 cm long) were stripped from the stem 1.3 m above the ground while in the case of leaves, a mixture of young and mature leaves (50% each) was collected following the local practice for selecting and removing material intended for local medicinal use. After collection, samples were pooled by plant organ before processing.

5.2.1.3 Sample field treatment and processing

The sample field treatment, and processing employed, followed procedures recommended by Harborne (1998). Before packaging roots, stem bark and leaves were cleaned to remove debris and other unwanted materials like soil and sand. Within 60 minutes of collection, roots were peeled using a sharp knife to detach the bark, which was retained for analysis. The root cores were discarded. Stem bark was chopped into small pieces to enable quick drying.

After preparation, samples were weighed, packed in labelled plastic mesh bags and temporarily stored (up to 4 h) under shade in a cool, dry place before transportation out of the field. Field quantities of approximately 2 kg of cleaned root bark, 2 kg of stem bark and 2.5 kg of leaves were collected. Transportation from the field took place as soon as the collection of samples from the tree species was completed.

The drying process started an hour later, after field collection and treatment, by spreading them separately on wide plastic mats. A seven days time-period was taken to dry leaves and a 14 days time-period to dry root and stem bark samples. Material was turned four times a day to ensure uniform drying and prevent decay. After drying the material was stored in a cool, dry dark place in plastic mesh bags for 5 days before processing further into fine powder for long term storage. Grinding of dry plant material into fine powder was done in the Forest Biology Department laboratory, Sokoine University of Agriculture, Tanzania using a micro-mill grinder. The ground fine powders were stored in labelled air-tight plastic containers, in a cool and dry dark place for 30 days before transportation to University of Wales, Bangor, UK, for further analysis. On arrival at Bangor, the samples were freeze-dried at -4 °C, while awaiting laboratory analysis.

5.2.2 Laboratory procedures and data analysis

5.2.2.1 Chemicals and standards preparation

The chemicals mainly methanol, acetonitrile, phosphoric acid, formic acid and water, used for HPLC (high performance liquid chromatography) were of analytical grade from Fisher Scientific (Fairlawn, UK). Isoflavonoid standard reference chemicals (98.9% purity) were of formononetin, prunetin, genistein, homopterocarpin and vestitol, purchased from Apin Chemicals Company Ltd (Oxon, UK).

Standard stock solutions were prepared in small quantities at various concentrations in 10 ml methanol: water (90:10, v/v), stored in a dark place at 4°C and brought to room temperature before use. Working solutions were prepared each day of analysis by diluting 0.50 ml of standard stock solution with the required quantity of methanol: water (90:10, v/v) depending on the concentration of the compound to be analysed. The aim was to have a solution of minimum concentration for better peak resolution during chromatographic analysis.

5.2.2.2 Plant materials preparations and extractions

Extraction of bioactive compounds from plant tissue is the most important step in the preparation of crude extracts for chromatographic analysis. The technique and solvents used must assure a good transfer of compounds from solid to liquid matrix in order to obtain a representative, selective and pure extract. For isolation of plant constituents, the commonly used methods have been maceration, shaking and soxhlet extraction for stable substances (Hostettmann *et al.*, 1998). For this study, maceration was adopted as the method of extraction.

Sample preparation followed a modification of the method used by Xiao *et al.* (2004) where approximately 2 g of freeze-dried powdered root bark, stem bark and leaves of *P. tinctorius* were extracted by cold maceration at room temperature using 20 ml methanol: water (90:10, v/v) for 48 h. Prior to maceration, the freeze-dried plant materials were brought to room temperature by placing them in a desiccator for at least 18 h, care being taken to avoid undesirable chemical changes by ensuring that the materials were not exposed to light. The macerated plant extract in aqueous methanol was then separated from the plant material powder by centrifuging at 5000 rpm for 5 minutes. The supernatant solution was filtered using a Whatman 0.2 µm nylon filter into an amber glass vial prior to HPLC analysis.

5.2.2.3 Analytical procedures

Generally, no single analytical method provides sufficient visualization of the metabolite in plants; hence different techniques are suggested (Hall *et al.*, 2002) for comprehensive profiling. The selection of most suitable technique is generally a compromise between speed, selectivity and sensitivity (Sumner *et al.*, 2003). Therefore, for this case study, the reversed-phase HPLC commonly used for separation of complex mixtures of phenolic compounds and other natural products in plant extracts (Suárez *et al.*, 1996) was used to analyse the plant material samples with threefold replication.

Most of the methods for the analysis of isoflavonoids have been based on HPLC use (Dewick, 1993; Abhyanka *et al.*, 2005). However, the use of HPLC coupled with UV/VIS detector according to Prasain *et al.* (2003) fails to detect unknown compounds in a crude extract in contrast with mass spectrometry which allows detection of both known and unknown compounds. Therefore, for the detection of other compounds and possibly isoflavonoids whose standards had not been available from the commercial sources, the use of high performance liquid chromatography coupled on-line to mass spectrometry (HPLC-MS) was used in this study.

High performance liquid chromatography/ultraviolet/visible spectrometry

The HPLC system, ProStar 800 (Varian, UK) equipped with a binary pump (ProStar 230) and an autosampler (ProStar 410), coupled on-line to the ultraviolet visible spectrum (UV/VIS) detector (ProStar 310) and controlled by Hercule 2000-chromatography interface from JMBS software for scientists, was used. A Phenomenex, Hypersil C18 (ODS) (250 mm × 4.6 mm; 5 µm particle size) analytical column was used.

The modified gradient elution adapted from Brolis *et al.* (1998) and Xiao *et al.* (2004) was used. The mobile phase consisted of water containing a volume fraction of 0.1%

phosphoric acid (99.9:0.1, v/v)-(A), and acetonitrile also with a volume fraction of 0.1% phosphoric acid (99.9:0.1, v/v)-(B). The flow rate was maintained at 1 ml/min and the column oven at room temperature. A linear gradient programme was used as follows:

Time (minutes)	Solvent A(%)	Solvent B (%)
0	10	90
10	15	85
20	20	80
25	75	25
28	0	100
33	0	100

A sample injection volume of 10 μl was used. Before and after the batch samples a standard stock solution of a particular isoflavonoid was analysed and the data produced recorded. The column was rinsed with a 15:85 (v/v) mobile phase for 5 minutes and equilibrated for 3 minutes before injecting another sample, in order to clean and get rid of the remaining compounds within the column.

The chromatographic profile was recorded at a fixed wavelength of 254 nm and identification of substances in the plant extracts was achieved by comparing their retention times (t_R) and the peak areas with those of authentic isoflavonoids reference standards. The relative concentrations were calculated on the basis of peak areas. In matching retention times of plant extracts with standards, an allowable error of ±30 seconds was used to overcome experimental errors which might have arisen during analysis.

High performance liquid chromatography – mass spectrometry

Chromatographic conditions similar to those applied in HPLC-UV/VIS analyses were adopted for qualitative analysis of plant extracts. However, a change was made to the mobile phase, due to the incompatibility of phosphoric acid with mass spectrometry. The detection method also incorporated a method modification by Lapcik *et al.* (2005). For the HPLC-MS work, the mobile phase consisted of water (98%) with a volume fraction of 2% formic acid (A), and 100% acetonitrile (B). The flow rate was maintained at 1 ml/min and the column oven operated at room temperature. The chromatographic profile was recorded at 254 nm. The column was rinsed with a 15:85

(v/v) mobile phase for 5 min and equilibrated for 3 minutes before injecting another sample. The effluent from the liquid chromatograph was introduced directly into the quadrupole mass spectrometer (for mass measurements and ion detection) operating in the positive ESI (Echellette Spectrograph Imager) mode. The nebulizer gas pressure was 413.70 kPa, the drying gas was set at 121 per minute at temperature of 300°C and the capillary voltage was 2150 V. Individual compounds were identified by comparison of their retention times and molecular ion fragments with mass spectra library data and published literature.

5.2.2.4 Data generation

The external standard method described by Rouessac and Rouessac (2000) was used. In this method, firstly a solution of known composition (C_{Ref}) of the reference compound is prepared of which a known volume (V) is injected. Secondly, the corresponding area (A_{Ref}) in the chromatogram is measured and recorded. Without changing the chromatographic conditions of analysis, the same volume (V') of the sample containing an unknown composition of analyte, C_{unk}, is injected on the same column. The eluting peak that corresponds to the analyte has an area, A_{unk}. Lastly, because an identical volume of both samples has been injected, the ratio of the area is proportional to the composition with areas dependent on the injected quantity; $m_i = C_iV$, where; m_i = quantity of compound i injected on the column and C_i = composition of compound i. Using the two chromatograms and the equation; $m_i = K_iA_i$, (where K_i is the absolute response factor for compound i and A_i is the area of the eluting peak for compound i) the following relationships are obtained:

$$C_{Ref} = K.\ A_{Ref} \quad \text{and} \quad C_{unk} = K.\ A_{unk}$$

From which, $C_{unk} = C_{Ref} \times (A_{unk}/A_{Ref})$.

For area determination, the upper limit (vertical-axis above zero value) was ≤ 1 absorbance (or ≤ 1000 micro absorbance), and the lower limit (vertical-axis) was not supposed to be below zero absorbance on the chromatogram. The final concentration of the unknown analyte (C_{unk}) was in mg/ml. The conversion to mg/g of dry weight of sample material dissolved was done and later all the figures multiplied by 1000 to obtain concentrations in parts per million (ppm).

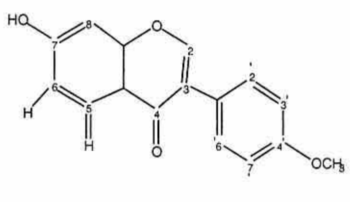
Qualitatively, the identification of other unknowns in different parts of *P. tinctorius* was using NIST 05 (Version 2.0d) mass spectra library and comparison of the spectra results with data in the literature (Harborne and Baxter, 1993; Southon *et al.*, 1994a, b; Harborne *et al.*, 1999; Dictionary of Natural products, 2004).

The contents of each isoflavonoid in three samples each of leaf extract, stem bark extract and root bark extracts were statistically tested for significance with the data expressed as means ± standard deviation (SD). The significant difference between extract sources were determined by one-way analysis of variance (ANOVA) using MINITAB 13 computer software. Whenever a significant difference was observed between tested means, Fishers' least significant difference (LSD) test (Ashcroft and Pereira, 2003) was used for separation. A *p*-value of 0.05 or lower was considered significant.

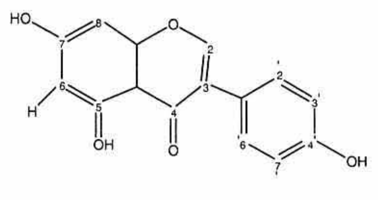
5.3 Results

5.3.1 Isoflavonoid in crude extracts

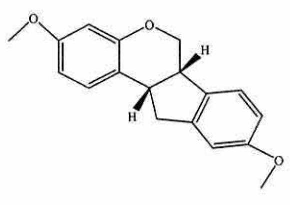
Chromatographic analysis of isoflavonoids from crude extracts of leaves, stem bark and root bark of *P. tinctorius* confirmed the presence of formononetin, prunetin, genistein, vestitol and homopterocarpin (Figure 5.1).



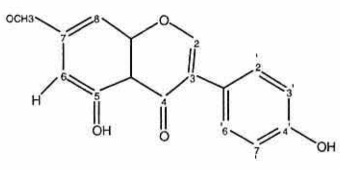
Formononetin



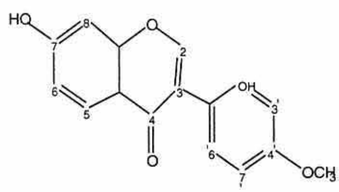
Genistein



Homopterocarpin



Prunetin



Vestitol

Figure 5.1 Structures of isoflavonoids analysed in parts of *Pterocarpus tinctorius*

The mean retention times for all plant part extracts especially stem bark were related to those of the entire standard reference compounds (Table 5.3), although the leaf extracts mean retention times was less than 1 minute for formononetin, prunetin and vestitol.

Table 5.3 Mean retention times of standard references versus plant extracts of *Pterocarpus tinctorius* from Urumwa Forest Reserve, Tanzania

Reference compound	**Mean retention time (minutes) (N = 3)**			
	Standard reference	Leaves	Stem bark	Root bark
Formononetin	2.73	0.85	2.53	2.53
Genistein	2.66	2.46	2.52	2.45
Homopterocarpin	3.29	2.22	3.28	1.10
Prunetin	2.87	0.84	2.54	2.52
Vestitol	2.69	0.84	2.54	2.53

N = number of independent analyses per sample

Large poorly separated peaks for almost all of the analysed isoflavonoids can be noted in leaf, stem bark and root bark chromatograms (Figures 5.2a – 5.2e), sometimes rising above the vertical-axis upper detection limit. It can also be noted that the peaks had no correlation with quantification of the isoflavonoids, but their appearance implied presence of other dominant compounds in extracts of *P. tinctorius*, which prompted the use of the mass spectrometer approach to qualitatively identify those compounds.

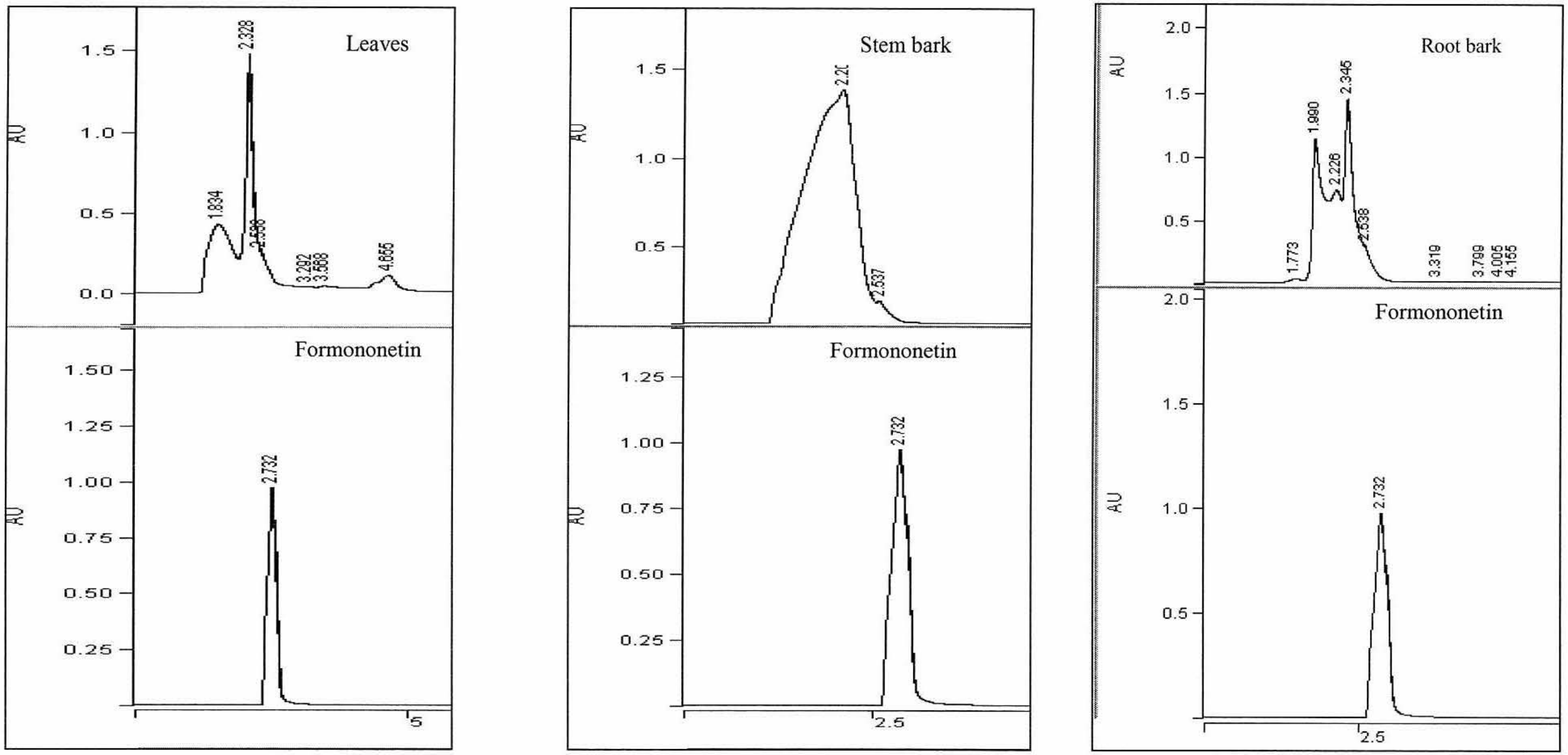


Figure 5.2a HPLC-UV/VIS chromatograms of standard formononetin versus methanolic plant extracts of *Pterocarpus tinctorius* from Urumwa Forest Reserve, Tanzania. (AU = Absorbance value; Horizontal lines represent retention time in minutes)

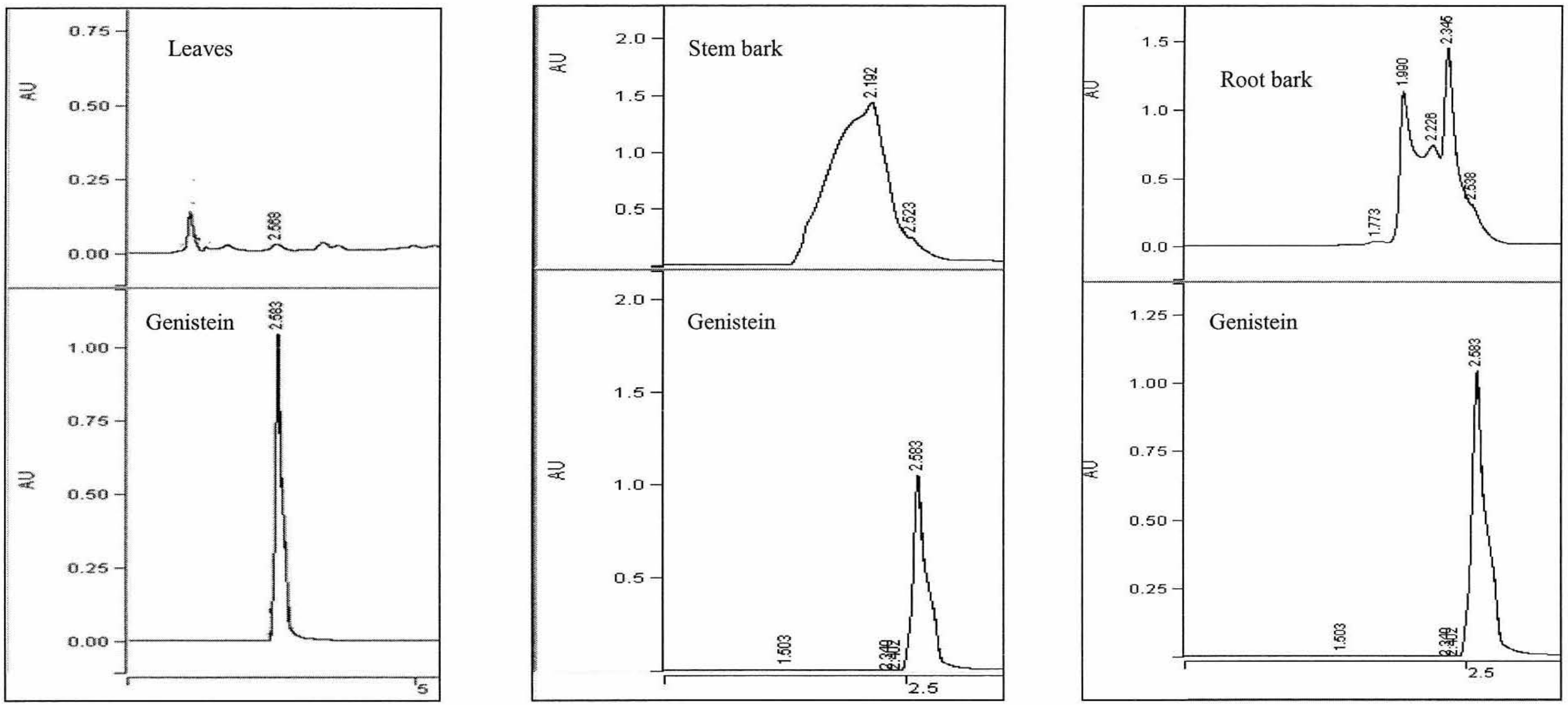


Figure 5.2b HPLC-UV/VIS chromatograms of standard genistein versus methanolic plant extracts of *Pterocarpus tinctorius* from Urumwa Forest Reserve, Tanzania. (AU = Absorbance value; Horizontal lines represent retention time in minutes)

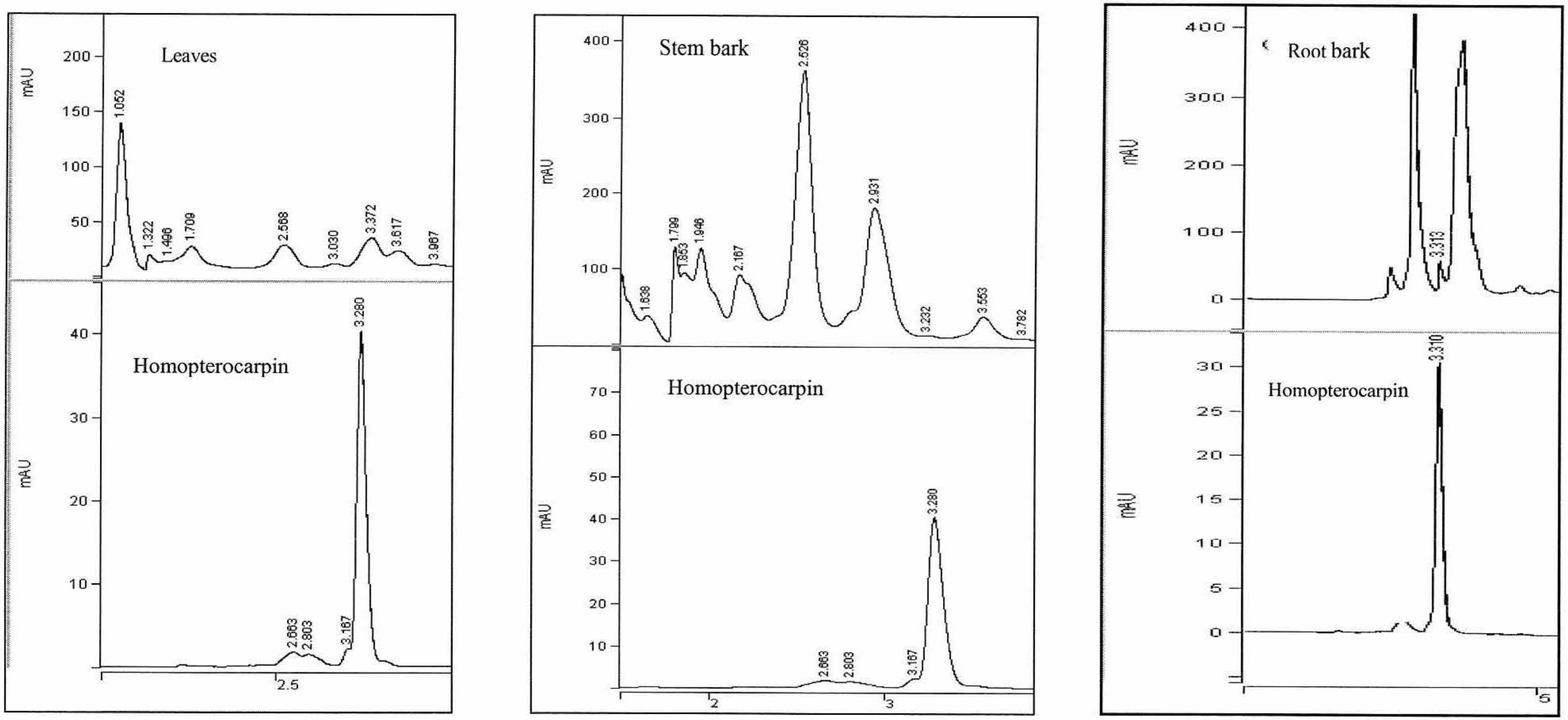


Figure 5.2c HPLC-UV/VIS chromatograms of standard homopterocarpin versus methanolic plant extracts of *Pterocarpus tinctorius* from Urumwa Forest Reserve, Tanzania. (mAU = micro absorbance value; Horizontal lines represent retention time in minutes)

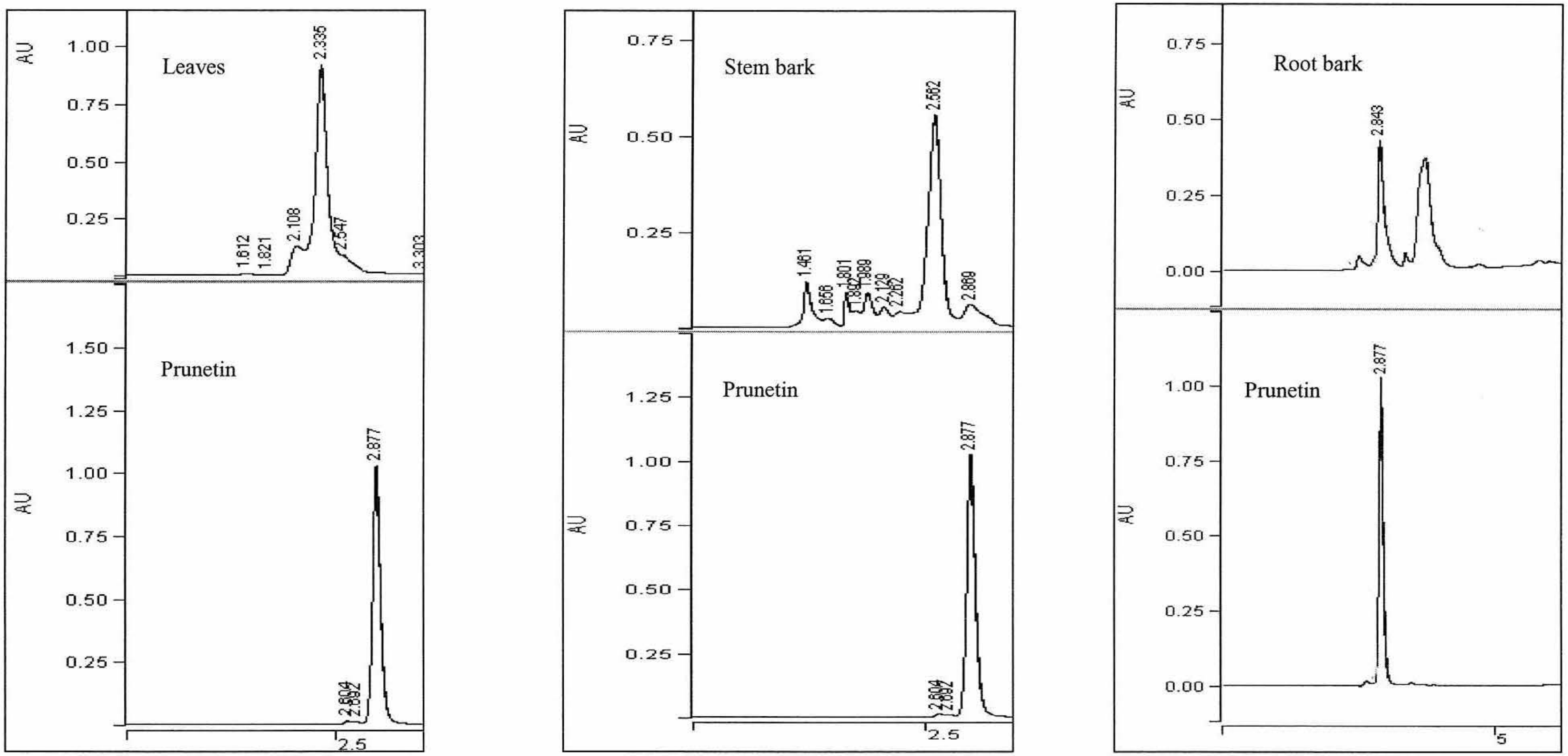


Figure 5.2d HPLC-UV/VIS chromatograms of standard prunetin versus methanolic plant extracts of *Pterocarpus tinctorius* from Urumwa Forest Reserve, Tanzania. (AU = Absorbance value; Horizontal lines represent retention time in minutes)

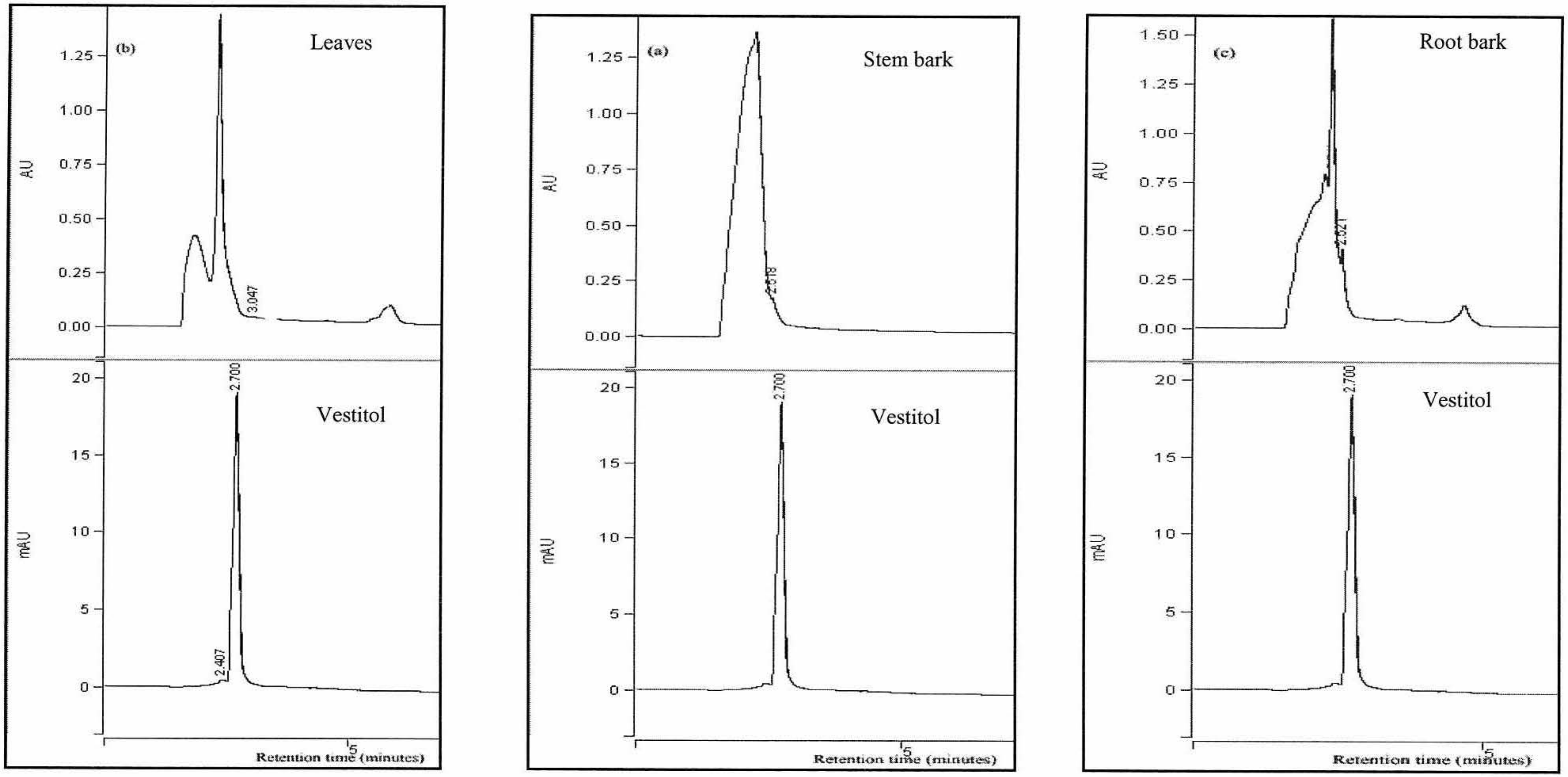


Figure 5.2e HPLC-UV/VIS chromatograms of standard vestitol versus methanolic plant extracts of *Pterocarpus tinctorius* from Urumwa Forest Reserve, Tanzania (AU = Absorbance value; mAU = micro absorbance value)

5.3.2 Isoflavonoids concentrations

Analysis of the three crude extract samples of leaves, stem bark and root bark of *P. tinctorius* in three-fold replication revealed no significant difference in isoflavone (formononetin, genistein and prunetin) concentrations. On the other hand, simple pterocarpan (homopterocarpin) concentration varied significantly (Figure 5.3) with the material analysed ($F = 10.63$, $p<0.05$). The concentration was significantly higher in the stem bark (mean ± SD = 25.83 ± 2.36) than in leaves (mean ± SD = 7.3 ± 1.20) or root bark (mean ± SD = 0.87 ± 1.50) and significantly higher in the leaves when compared to root bark. Isoflavan (vestitol) concentration also varied significantly ($F = 59.52$, $p<0.05$) with a significantly lower concentration (mean ± SD = 1.0 ± 1.73) in the leaves.

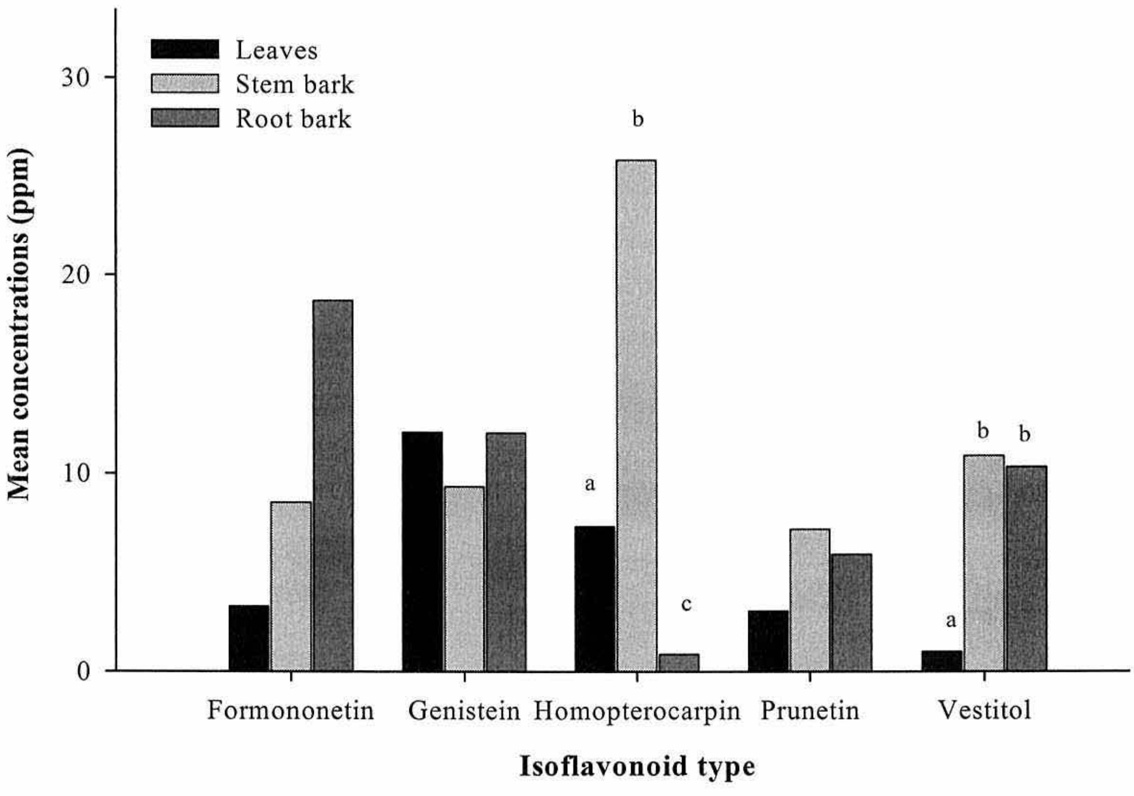


Figure 5.3 Mean isoflavonoid concentration in parts of *Pterocarpus tinctorius* from Urumwa Forest Reserve, Tabora Region, Tanzania. Plant parts having same letter superscript in each isoflavonoid type are not significantly difference in mean concentration (LSD test, $p<0.05$).

5.3.3 Other compounds isolated from parts of *P. tinctorius*

Several other compounds representing nine main categories (Table 5.4), recognized in the Dictionary of Natural Products (2004) were isolated and identified from the crude extracts of *Pterocarpus tinctorius* using the mass spectrometer. Root bark extracts contained all of the identified compounds (Table 5.4). Stem bark extracts lacked the carbohydrates, while leaf extracts lacked isoquinoline-type alkaloids, carbohydrates and terpenoids. Details of individual compounds from each category reported from Table 5.4 are presented in Appendices VIIIa, VIIIb and VIIIc.

Table 5.4 Other compounds isolated from leaves, stem bark and root bark of *Pterocarpus tinctorius* from Urumwa Forest Reserve, Tabora Region, Tanzania.

Compound category	**Plant parts analysed**		
	Leaves	Stem bark	Root bark
Flavonoids: Coumarins	+	+	+
Isoflavonoids	+	+	+
Alkaloids: Simple acyclic amine	+	+	+
Miscellaneous acyclic amine	+	+	+
Indole-type	+	+	+
Isoquinoline-type	-	+	+
Quinoline-type	-	+	+
Colchicine-type	+	+	+
Lupine-type	+	+	+
Steroids	+	+	+
Stilbenoids	+	+	+
SANP	+	+	+
PANP	+	+	+
Polyketides	+	+	+
Carbohydrates	-	-	+
Terpenoids	-	+	+

(+), denotes presence of a compound category; (-), denotes absence of a compound category

5.4 Discussion

The present study reports for the first time the presence of five isoflavonoids in *Pterocarpus tinctorius*: three isoflavones (formononetin, prunetin and genistein), an isoflavan (vestitol) and a simple pterocarpans (homopterocarpin). One or more of these compounds could explain the perceived efficacy of the species as a medicinal plant used by the Urumwa communities since almost all of the detected isoflavonoids have been reported to have physiological effects on human body.

The findings are consistent with what past researchers have observed in terms of the presence of isoflavonoids in *Pterocarpus* species, but differ in that most previous reports are of isoflavonoid occurrences in heartwood or sapwood. Thus, formononetin, prunetin, homopterocarpin and vestitol have been reported in the heartwood of *P. soyauxii* (Appendix VIa), and genistein and prunetin in the heartwood of *P. angolensis*. Homopterocarpin has been reported in the heartwood of *P. dalbergioides*, *P. osun,* and *P. macrocarpus* (Appendix VIa) and in the sapwood of *P. santalinus*. Homopterocarpin and formononetin have also been reported in the heartwood of *P. indicus*.

Results from the present study show that in *P. tinctorius* concentrations of the isoflavonoids detected are low (less than 50 ppm), and that in the cases of homopterocarpin and vestitol they vary with plant part. Homopterocarpin concentration was maximal in stem bark. Vestitol concentration was much lower in leaf material than in stem bark and root bark. The reason for these variations in the different parts of *P. tinctorius* has not been explored in the present study but, a study by Mazur *et al.* (1998) speculated that, differences in the specificity of analytical method might sometimes be cause of such results. It should be kept in mind that any comparisons between results and techniques applied do not hold true without analysis of the same samples.

There are past studies which provide evidence of bioactivity for the isoflavonoids studied here, supporting the use of *P. tinctorius* in the traditional health care system of the Urumwa communities. In a leguminous plant, *Platymiscium floribundum*, Militão *et al.* (2005) observed homopterocarpin among isolated pterocarpans which showed antimitotic properties. Homopterocarpin is among the simple pterocarpans which

Falcão *et al.* (2005) observed to show cytotoxic activity against five human cancer cell lines *in vitro*. Similarly, anticancer activity of homopterocarpin from root extracts of the medicinal plant *Glycyrrhiza pallidiflora*, from China, has been observed by Wei-dong *et al.* (2001). Those authors found that homopterocarpin could inhibit (at lower concentration) or kill (at higher concentration) human's liver cancer cells under cultured condition.

Vestitol is among six natural phenolic components isolated from roots of *Dalbergia odorifera* T. Chen, which have been observed to show antioxidant activities (Wang *et al.*, 2000). From the debarked stem of a leguminous plant, *Millettia racemosa*, Rao and Krupadanam (1994) found vestitol to have promising bactericidal activity. Vestitol from extracts of a leguminous medicinal plant, *Glycyrrhiza uralensis* from China, have been found to exhibit strong antibacterial activity against *Helicobacter pyroli*. This bacterium is found in the stomach and duodenum, and recognized as an agent of peptic ulcers in human beings (Fukai *et al.*, 2002).

Potent anti-tumour promoter activity attributable to formononetin and other isoflavonoids has been reported by Konoshima *et al.* (1988). A recent study by Nestel *et al.* (2006) has found that oral consumption of formononetin, among other isoflavones can help to reduce blood pressure and central arterial stiffness in overweight men and postmenopausal women, indicating potential for reducing cardiovascular risk.

Genistein is a phytoestrogen with a wide variety of pharmacological effects in animal cells, including chemoprevention of breast and prostate cancers, cardiovascular disease and post-menopausal ailments (Polkowski and Mazurek, 2000; Dixon and Ferreira, 2002). Additionally, genistein has been observed to induce differentiation of leukaemia cells (Katagiri *et al.*, 1992), and to inhibit endothelial cell angiogenesis relevant to tumour metastasis (Fortis *et al.*, 1993), and there is evidence of anti-inflammatory properties of the compound in granulocytes, monocytes and lymphocytes of the human body (Verdrengh *et al.*, 2003).

Indole alkaloids & other bioactives in *Strychnos spinosa*

CHAPTER VI

BIOACTIVE COMPOUNDS IN *STRYCHNOS SPINOSA* WITH SPECIAL REFERENCE TO INDOLE ALKALOIDS

This chapter is concerned with the bioactive compounds of *Strychnos spinosa*, with special reference to two monoterpenoid indole alkaloids. The chapter is in four sections. The background section (6.1) provides a brief state-of-knowledge review. The materials and methods section (6.2) describes the sampling strategy (6.2.1) and the laboratory procedures and data analysis (6.2.2). The analytical results are reported in section 6.3 and discussed in Section 6.4, in terms of the presence of the indole alkaloids in crude extracts of the plant parts, their concentration there and other associated compounds isolated and identified.

6.1 Background

Strychnos spinosa (Loganiaceae) was investigated due to awareness that bioactive compounds, notably indole alkaloids, have been isolated from *Strychnos* species, and other members of the Loganiaceae clade (Appendix VIIb). *S. spinosa* is used by communities depending on the miombo woodland of Urumwa in western Tanzania, to treat various ailments (Table 3.21 – Chapter III).

The phytochemical context, expressed as reports of compounds reported for genus *Strychnos* overall is given by Buckingham (1994), while relevant past studies on African *Strychnos* are reviewed by Ohiri *et al.* (1983). Together, these sources document information for fourteen African species. Monoterpenoid indole alkaloids, particularly Strychnos-alkaloids, indoloquinolizidine, condylocarpan, akuammiline, bisindole, ajmalicine and corynanthe are reported (Table 6.1) as principal constituents.

Table 6.1 Indole alkaloids reported to occur in African members of section Spinosae and related sections of the genus *Strychnos*

Section	Species	Indole alkaloid categories						
		Strychnos-alkaloids	Indoloquinolizidine	Condylocarpan	Akuammiline	Bisindole	Ajmalicine	Corynanthe
Spinosae	*S. cocculoides*	Diaboline derivatives Henningsamine derivatives	nr	nr	nr	nr	nr	nr
Aculeatae	*S. aculeata*	Strychnofendlerine and derivatives, Spermostrychnine, Splendine and derivatives	nr	nr	nr	nr	nr	nr
Breviflorae	*S. afzelii*	Bisnordihydrotoxiferine and derivatives, Bisnor C-alkaloid H, WGA, Diaboline, Caracurine V and derivatives, Longicaudatine	nr	nr	nr	nr	nr	nr
	S. angolensis	Diaboline and derivatives, WGA and derivatives, Caracurine V	Angustine Angustidine	Tubotaiwine	nr	nr	nr	nr
	S. dolichothyrsa	WGA and derivatives, Bisnor C-curacurine, Bisnor C-alkaloid D, Bisnodihydrotoxiferine, and derivatives, Caracurine V and derivatives, Diaboline derivatives, Dolichocurine Dolichothine, Longicaudatine	nr	Tubotaiwine Condylocarpine	Nor-C-fluorocurarine	nr	nr	nr

	S. henningsii	Holstine, Holstiline, Condensamine, Retuline and derivatives, Rindline, Diaboline and derivatives, Henningsamine, Henningsoline and derivatives, Henningsamide, Henningsiine, Splendoline Strychnine and derivatives	nr	nr	Tsilanine Tsilambine	nr	nr	nr
	S. icaja	Vomicine, Icajine, Strychnine + derivatives Novacine, Bisnordihydrotoxiferine, Sungucine and derivatives, Strychnohexamine	nr	nr	nr	nr	nr	nr
	S. urceolata	Bisnordihydrotoxiferine, Bisnor C-alkaloid H, Diaboline derivatives, Caracurine V, Longicaudatine	nr	nr	nr	nr	nr	nr
	S. malacoclados	Diaboline derivatives	nr	nr	nr	nr	nr	nr
Penicillatae	*S. diplotricha*	Strychnobrasiline, Malagashanine	nr	nr	nr	nr	nr	nr
	S. longicaudata	Strychnovoline, Bisnor C-alkaloid H, Longicaudatine	nr	nr	nr	nr	nr	nr
	S. tchibangensis	nr	nr	nr	nr	Usambarine and derivatives	nr	nr
	S. trichoneura	nr	Angustine, Angustidine, Angustoline	nr	nr	nr	nr	nr
Scyphostrychnos	*S. camptoneura*	Retuline and derivatives, Akagerine, Camptoneurine	nr	nr	Alstovine	Nr	Serpentine	Antirhine and derivatives

WGA = Wieland Gumlich Aldehyde alkaloids; nr, no report seen; *Sapi and Massiot (1994)   Sources: Buckingham (1994); Southon and Buckingham (1989).

The monoterpenoid indole alkaloids are a large group of structurally diverse molecules found in various species belonging to the Apocynaceae, Loganiaceae, Rubiaceae and Nyssaceae (Collu *et al.,* 2001). They create a family of approximately 3000 compounds, that include the antineoplastic agents vinblastine and camptothecin, the antimalarial drug quinine, and the rat poison strychnine (Facchini, 2001). A number of monoterpenoid indole alkaloids have been isolated from botanical sources, and many of them have been found to possess significant pharmacological activity: anti-contraceptive, anti-tumour, anti-inflammatory, anti-malarial, bactericidal and leishmanicidal in addition to stimulatory or toxic effects on the central nervous system (Chaturvedula *et al.*, 2003; Pace *et al.*, 2004). The potent biological activity of some alkaloids has led to their exploitation as pharmaceuticals, stimulants, narcotics, and poisons. Plant-derived alkaloids currently in clinical use include the analgesics morphine and codeine, the anticancer agents vinblastine and taxol, the gout suppressant colchicine, the muscle relaxant (+)-tubocurarine, the anti-arrythmic ajmaline, the antibiotic sanguinarine, and the sedative scopolamine (Facchini, 2001).

Previous phytochemical studies on the African *Strychnos spinosa* from Malawi and Nigeria have resulted in the isolation of some indole alkaloids, pyridine derivatives, lignan, monoterpenoids, triterpenoids and fatty acids from root bark, stem bark, leaves, fruits and seeds (Oguakwa *et al.*, 1980; Andesogan and Morah, 1981; Ohiri *et al.*, 1984; Msonthi *et* al., 1985; Delaude *et al.,* 1992; Morah, 2000). Recently, Itoh *et al.* (2005) isolated and characterized three new secoiridiod glucosides (stryspinoside and strychosides A and B) from dried branches of *Strychnos spinosa* cultivated in Japan after introduction from Africa.

Initially ten indole alkaloids (Table 6.2) were targeted for investigation in the present study considering reported bioactivity and the fact that the compounds had not been reported in *S. spinosa*. However, as a result of limitations on obtaining reference standard materials from commercial sources, the number was reduced to two. The present exercise thus seeks to establish, and provide an understanding of, the presence of these two monoterpenoid indole alkaloids, strychnine and brucine, in material of *Strychnos spinosa* from the miombo woodland of the study area. Specifically the study aims to: (i) isolate and identify the indole alkaloids if they are present in the stem bark and root bark of the tree species, (ii) quantify and compare the concentrations of the two indole alkaloids in parts of the plant and (iii) identify additional compounds-where possible including other monoterpenoid indole alkaloids present. When the material for analysis was collected (September/October 2004), the trees were not in leaf, so leaf material has not been studied.

Table 6.2 List of initially targeted compounds of interest for *Strychnos spinosa* analysis

Bioactivity	Alkaloid category*	Name of compound(s)	Name(s) of species with compound
antiplasmodial	Strychnos	Vomicine, Malagashanine, Longicaudatine	*Strychnos icaja*[1], *S. henningsii*[1], *S. diplotricha*[2], *S. myrtoides*[2], *S. afzelii*[1], *S. dolichothyrsa*[1], *S. longicaudata*[2], *S. urceolata*[1], *S. afzelii*[1], *S. dolichothyrsa*[1], *S. longicaudata*[2], *S. urceolata*[1]
anticonvulsant/central nervous system stimulant	Strychnos	Icajine, Strychnine, Brucine	*S. afzelii*[1], *S. dolichothyrsa*[1], *S .icaja*[1], *S. henningsii*[1], *S. urceolata*[1]
neuromuscular blocking agent	Strychnos	Caracurine V	*S. afzelii*[1], *S. dolichothyrsa*[1], *S. henningsii*[1], *S. urceolata*[1]
Anti-diarrhoeal	Strychnos	Bisnordihydrotoxiferine	*S. afzelii*[1], *S. dolichothyrsa*[1], *S icaja*[1], *S. urceolata*[1]
Analgesic	Strychnos	Isoretuline	*S. henningsii*[1]
spasmolytic /antiamoebic	Bisindole	Usambarensine	*S. tchibangensis*[2]

[1] = Section Breviflorae, [2] = Section Penicillatae, [3] = Section Scyphostrychnos, *category based on Sapi and Massiot (1994)

Among the estimated 190 species, worldwide of *Strychnos*, only seven have been reported to contain strychnine, brucine or both: *Strychnos nux-vomica* L. – root bark and leaves from Tropical Asia (Basser and Bisset, 1982; Bisset, 1976), *Strychnos ignatii* P. Bergius – stem bark from Eastern Malaysia (Bisset and Walker, 1974) and *Strychnos wallichiana* Steud ex DC – rootbark and leaves from Tropical Asia (Bisset, 1976) and leaves from Bangladesh (Bisset and Coudhury, 1974); *Strychnos lucida* R. Br – rootbark and leaves (Bisset, 1976) from Australia, *Strychnos icaja* Baillon – stem, root bark and leaves (Kambu *et al.,* 1980; Sandberg *et al.*, 1968; 1969b) from Tropical

Africa, and *Strychnos panamensis* – stem bark, root bark, fruits, stem and branches (Krukoff *et al.*, 1972; Marini-Bettolo *et al.*, 1972) from Tropical America.

6.2 Materials and methods

6.2.1 Sampling strategy

6.2.1.1 Plant selection and identification

An ethnobotanical approach (Martin, 2004) was used in sampling. In this approach, the species is selected based on its daily use for traditional medicine to cure different ailments by local communities. Prior to actual collection, a list of more than 10 medicinal plant species was selected as "potential species" by local communities around Urumwa. These "potential species" were identified with the assistance of a local plant identifier and collector during a reconnaissance survey to develop a general scenario of where the species grow and their abundance in the reserve (Table 3.21 - Chapter III). The Institute of Traditional Medicine, Tanzania, was then consulted for information on on-going phytochemical studies and the scientific state-of-knowledge of the medicinal plants in the miombo woodlands of Tabora Region, particularly Urumwa Forest Reserve.

Individual plants of *Strychnos spinosa* were provisionally identified using Mbuya *et al.* (1994), and then collected specimens were compared with voucher specimens at TAFORI-MWRC, Tabora. Finally, identification was confirmed by an experienced taxonomist. Three sets of voucher specimens were prepared. One set designated ITM-3704, was deposited at the Institute of Traditional Medicine, Muhimbili University College of Health Sciences, Dar es Salaam, and a second at the TAFORI-MWRC herbarium in Tabora. A third set will be deposited at National Herbarium of Tanzania, Arusha.

Having established its suitability in terms of availability in the reserve and the scientific state-of-knowledge, *Strychnos spinosa* was selected as a 'case study' species. Final selection was confirmed on the basis of its abundance in the reserve as demonstrated by local communities, and the perceived need for scientific information regarding its phytochemical characteristics.

6.2.1.2 Plant material collection

Two types of *S. spinosa* material (root bark and stem bark) were collected in the natural habitat at Urumwa Forest Reserve in September/October 2004. Collecting was early in the morning (6.00–10.00 h, local time), in relatively cool ambient temperature. The different plant materials were collected from healthy trees apparently free from fungal and bacterial infections. The source tree positions were recorded using a Global Position System (GPS) facility.

From each tree, two or three roots (2 to 4 cm diameter; 15 cm to 50 cm long) were collected. For bark, two pieces (5 cm – 10 cm long) were stripped from the stem 1.3 m above the ground. After collection, samples were pooled by plant organ before processing.

6.2.1.3 Sample field treatment and processing

The sample field treatment and processing employed followed procedures adviced by Harborne (1998). Before packaging roots and stem bark were cleaned to remove debris and other unwanted materials like soil and sand. Within 60 minutes of collection, roots were peeled using a sharp knife to detach the bark, which was retained for analysis. The root cores were discarded. Stem bark was chopped into small pieces to enable quick drying.

After preparation, the samples were weighed, packed in labelled plastic mesh bags and temporarily stored (up to 4 h) under shade in a cool, dry place before transportation out of the field. Field quantities of approximately 2 kg of cleaned root bark and 2 kg of stem bark were collected. Transportation from the field took place as soon as the collection of samples from the tree species was completed.

The drying process started an hour later, after field collection and treatment, by spreading them separately on wide plastic mats. A 14 days time-period was taken to dry root and stem bark samples. Material was turned four times a day to ensure uniform drying and prevent decay. After drying the material was stored in a cool, dry dark place in plastic mesh bags for 3 days or more before processing further into fine powder for long term storage. Grinding of dry plant material into fine powder was done in the Forest Biology Department laboratory, Sokoine University of Agriculture, Tanzania using a micro-mill grinder. The ground fine powders were stored in labelled air-tight plastic containers, in a cool and dry dark place for 30 days before transportation to University of Wales, Bangor, UK, for further analysis. On arrival at Bangor, the samples were freeze-dried at -4 °C, while awaiting laboratory analysis.

6.2.2 Laboratory procedures and data analysis

6.2.1.1 Chemicals and standards preparations

The principal chemicals used were methanol, acetonitrile, phosphoric acid, formic acid and water used for HPLC (High Performance Liquid Chromatography) and all were of analytical grade from Fisher Scientific (Fairlawn, UK). Indole alkaloids standard reference chemicals (98.9% purity): strychnine and brucine were purchased from Sigma Aldrich (UK). Phosphate buffer solution (100 m*M*) was freshly prepared in the laboratory by dissolving 13.8 g of sodium dihydrogen phosphate monohydrate in 1000 ml deionised distilled water and the pH was adjusted to 2.0 with phosphoric acid.

Standard stock solutions were prepared in small quantities by dissolving approximately 0.07 g of strychnine and 0.05 g of brucine in 10 ml methanol (100%), stored in a dark place at 4°C and brought to room temperature before use. Working solutions were prepared each day of analysis by diluting 0.50 ml of standard stock solution with the required quantity of methanol: water (90:10, v/v) depending on the concentration of the compound to be analysed. The aim was to have a solution of minimum concentration for better peak resolution during chromatographic analysis.

6.2.2.2 Plant materials preparations and extractions

Extraction of bioactive compounds from plant tissue was done using maceration as adopted for *P. tinctorius* (5.2.2.2), to obtain a representative, selective and pure extract sample for further analysis.

Sample preparation followed a modification of the method used by Tikhomiroff and Jolicoeur (2002) where approximately 2 g of freeze-dried powdered root bark and stem bark of *S. spinosa* were extracted by cold maceration at room temperature using 20 ml methanol:water (90:10, v/v) for 48 h. Prior to maceration, the freeze-dried plant materials were brought to room temperature by placing them in a dessicator for at least 18 h, care being taken to avoid undesirable chemical changes by ensuring that the materials were not exposed to light. The macerated plant extract in aqueous methanol was then separated from the plant material powder by centrifuging at 5000 rpm for 5 minutes. The supernatant solution was filtered using a Whatman 0.2 μm nylon filter into an amber glass vial prior to HPLC analysis.

6.2.2.3 Analytical procedures

High performance liquid chromatography/ultra violet-visible spectrometry

A HPLC system similar to that described in Chapter V (5.2.4.1) was used with appropriate modification of solvents and the method of analysis. For *S. spinosa* sample extracts, chromatographic separation was carried out using 100 m*M* phosphate buffer (pH 2) – acetonitrile (85:15, v/v) as mobile phase in an isocratic elution (*i.e.* solvent composition remained constant throughout the analysis) for 30 minutes. The concentration of phosphate in the mobile phase was higher, to minimize peak tailing during analysis. A flow-rate of 1.8 ml/min was maintained. The column was rinsed with a 15:85 (v/v) mobile phase for 5 minutes and equilibrated for 3 minutes prior to the start of another analysis. The detection of strychnine and brucine was by UV/VIS detection at a fixed wavelength of 254 nm. Retention time and wavelength were noted and recorded for all analyses.

The identification of the two compounds in plant extracts was achieved by comparing their retention times (t_R) and the peak areas (eluted plant extracts) with authentic standards. Similarly to the *Pterocarpus* analyses (Chapter V), the relative concentrations of strychnine and brucine were calculated on the basis of peak areas. In matching retention times for plants extracts with standards, an allowable error of ± 30 seconds was used to overcome any associated instrumental errors.

High performance liquid chromatography-mass spectrometry

Chromatographic conditions similar to those applied in HPLC-UV/VIS were adopted for qualitative analysis of plant extracts. However, a change was made to the mobile phase, due to the incompatibility of phosphoric acid with mass spectrometry. The detection method also incorporated a method modification by Stahl *et al.* (2004). The separation was carried out using two solvents: A (water with 2% formic acid) and B (acetonitrile) as mobile phase in a gradient elution for 25 minutes. The flow rate of 1.0

ml/minutes was used, starting with 90% A and 10% B for 23 minutes, ramping to 20% A:80% B over 2 minutes. This ratio was maintained for an additional 5 minutes making the total run time be 30 minutes. The separation was performed under ambient temperature conditions. The column was rinsed with a 15:85 (v/v) mobile phase for 10 minutes and equilibrated for 5 minutes before injecting another sample. The elution from the column was monitored at $\lambda = 254$ nm with multiwavelength detector.

The electrospray ionization inlet of mass spectrometer was configured with a capillary having a temperature of 220 °C, the capillary voltage was 2150 V. The sheath and auxiliary gas was N_2, with flow rates of 1.3 and 0.3 l/min, respectively. Individual compounds were identified by comparison of their retention times and molecular ion fragments with mass spectra library data and published literature.

6.2.2.4 Data generation

Quantitatively, data were analysed using the external standard method described by Rouessac and Rouessac (2000). In this method, initially a solution of known composition (C_{Ref}) of the reference compound is prepared for which a known volume (V) is injected. Thereafter, the corresponding area (A_{Ref}) in the chromatogram is measured and recorded. Without changing the chromatographic conditions of analysis, the same volume (V') of the sample containing an unknown composition of analyte, C_{unk}, is injected into the same column. The eluting peak that corresponds to the analyte has an area, A_{unk}. Because an identical volume of each sample has been injected, the ratio of the area is proportional to the composition, with area dependent on the injected quantity; $m_i = C_iV$, where; m_i = quantity of compound i injected on the column and C_i = composition of compound i. Using the two chromatograms and the equation; $m_i = K_iA_i$, (where K_i is the absolute response factor for compound i and A_i is the area of the eluting peak for compound i) the following relationships are obtained:

$$C_{Ref} = K.\ A_{Ref}$$

$$C_{unk} = K.\ A_{unk}$$

From which, $C_{unk} = C_{Ref} \times (A_{unk}/A_{Ref})$.

For area determination, the upper limit on vertical scale (above zero value) of the chromatogram was ≤1 absorbance (or 1000 micro absorbance), and the lower limit on the same vertical scale was supposed not to exceed zero. The final concentration of the unknown analyte (C_{unk}) was in mg/ml. The conversion to mg/g of dry weight of sample material dissolved was done and later all the figures multiplied by 1000 to obtain concentrations in parts per million (ppm).

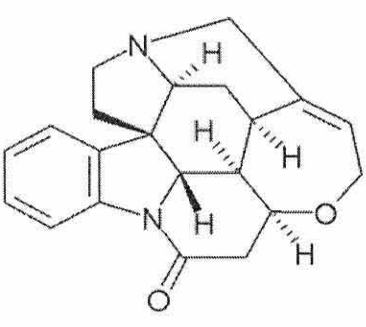
Qualitatively, the identification of other compounds in the different materials of *S. spinosa* was done using NIST05 (Version 2.0d) mass spectra library and comparison of the spectra results with data in the literature (Harborne and Baxter, 1993; Buckingham, 1994; Harborne *et al.*, 1999; Dictionary of Natural Products, 2004).

The contents of strychnine and brucine in three samples each of stem bark extract and root bark extract were statistically tested for significance with the data expressed as means ± standard deviation (SD). The significant difference between extract sources was determined by one-way analysis of variance using MINITAB 13 program. A *p*-value of 0.05 or less was considered significant.

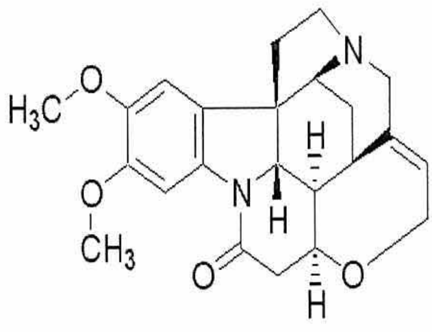
6.3 Results

6.3.1 Strychnine and brucine in crude extracts

HPLC-UV/VIS analysis of indole alkaloids from crude extracts of stem bark and root bark of *S. spinosa* confirmed the presence of strychnine and brucine (Figure 6.1).



Strychnine



Brucine

Figure 6.1 Structures of indole alkaloids analysed in parts of *Strychnos spinosa*

The mean retention times for stem bark and root bark extracts were related to those of the standard reference compounds (Table 6.3) indicating the presence of the two monoterpenoid indole alkaloids in *S. spinosa*.

Table 6.3 Mean retention times of standard reference compounds versus plant extracts of *S. spinosa* from Urumwa Forest Reserve, Tabora Region, Tanzania (N = number of independent analyses per sample)

Reference compound	**Mean retention time (minutes) (N = 3)**		
	Standard reference	Root bark	Stem bark
Strychnine	6.58	6.21	6.52
Brucine	6.01	6.17	6.02

Many poorly separated peaks for the analysed strychnine and brucine compounds appear in the stem bark and root bark chromatograms (Figures 6.2a – 6.2b), below the vertical-axis upper detection limit. The peaks had no correlation with quantification of the two indoles, but their appearance denoted presence of other dominant compounds in extracts of *S. spinosa*, which prompted the use of mass spectrometer in order to qualitatively identify those compounds.

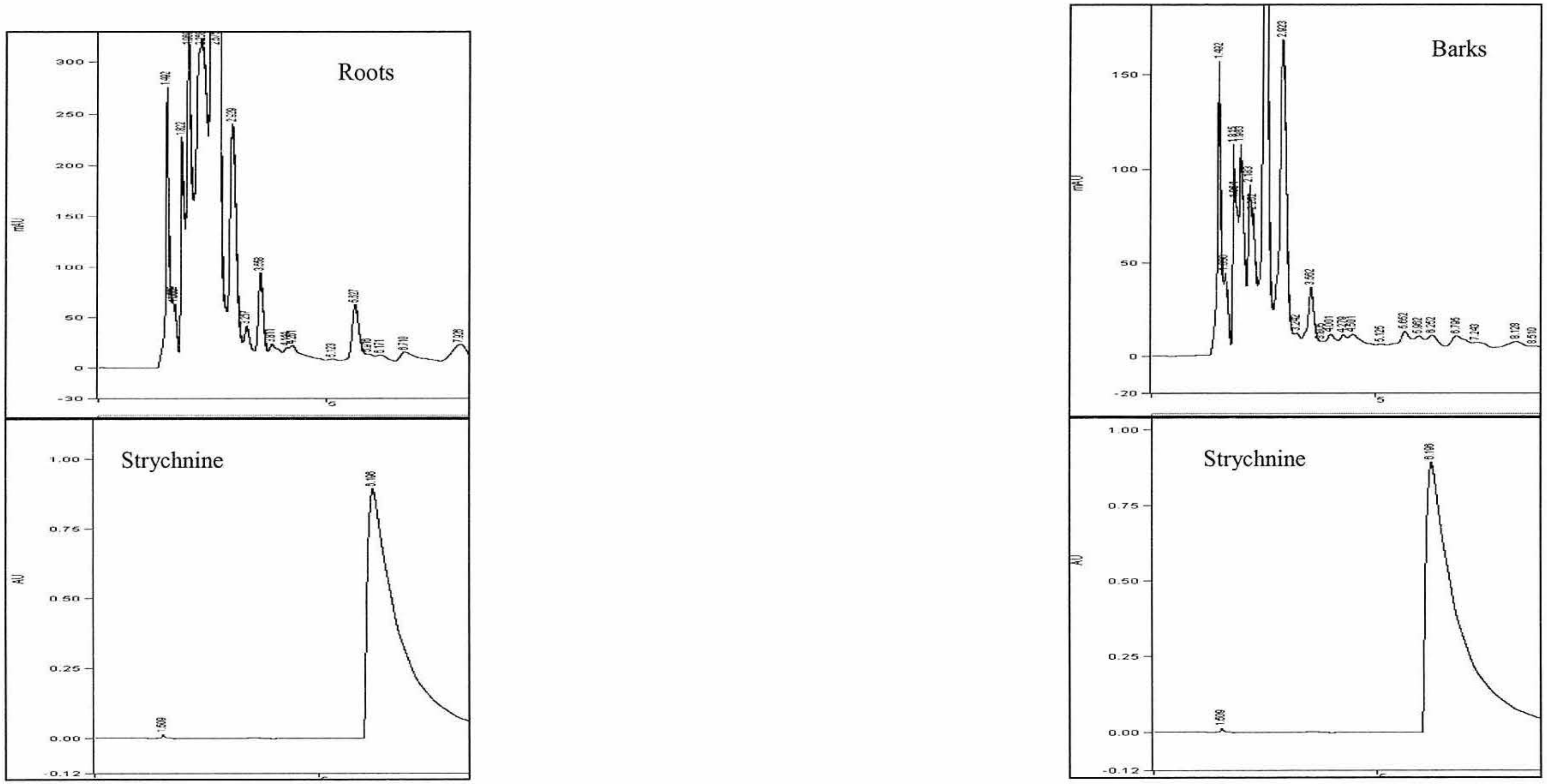


Figure 6.2a HPLC-UV/VIS chromatograms of strychnine and methanolic extracts of roots and barks of *S. spinosa* from Urumwa forest reserve, Tabora region, Tanzania (Figures in X-axis represent retention times (minutes); Y-axis represent absorbance value).

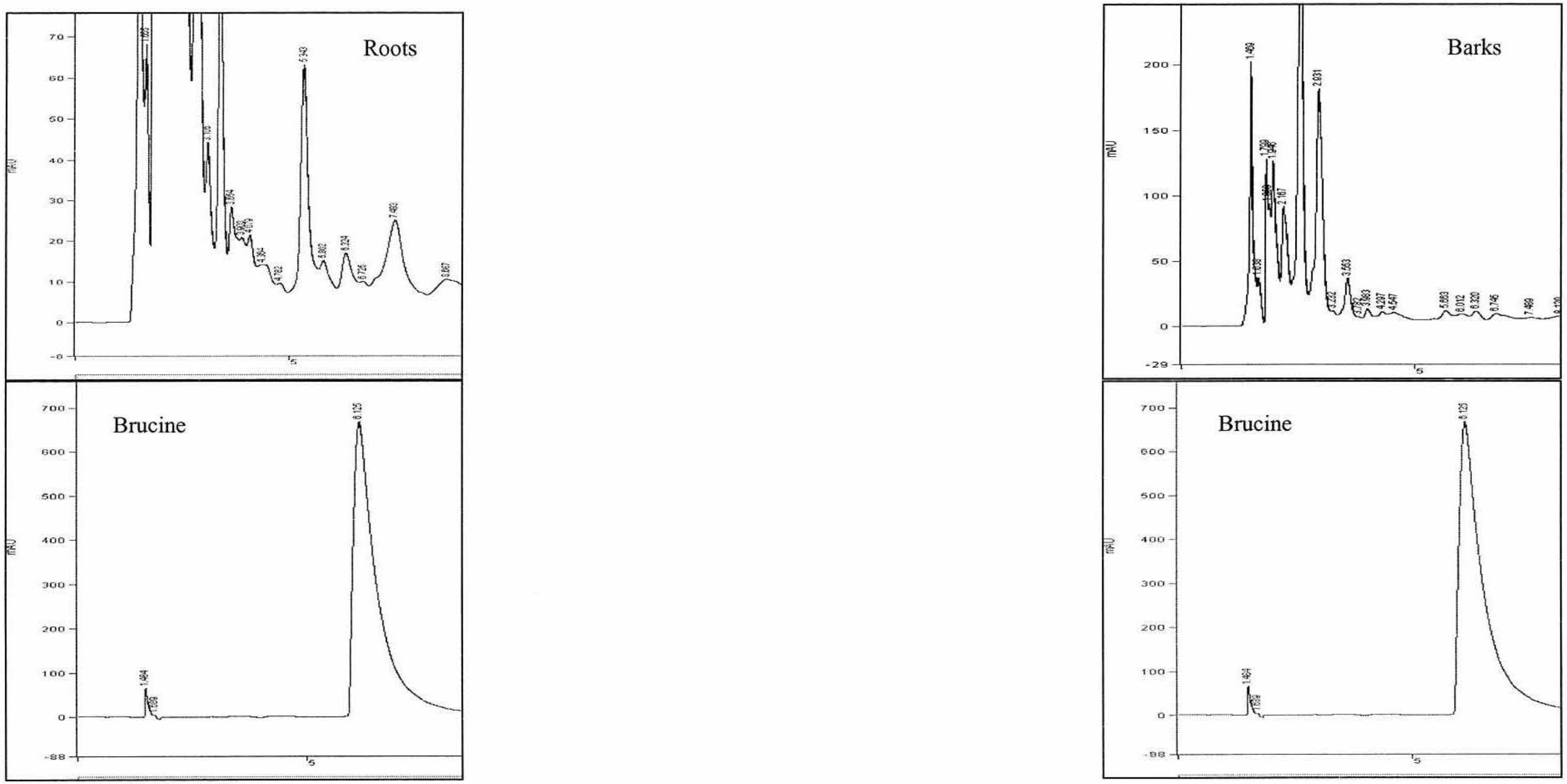


Figure 6.2b HPLC-UV/VIS chromatograms of brucine and methanolic extracts of roots and barks of *S. spinosa* from Urumwa Forest Reserve, Tabora Region, Tanzania (X-axis represent retention times (minutes); Y-axis represent micro absorbance value).

6.3.2 Indole alkaloids concentrations

Analysis of two crude extract samples of stem bark and root bark of *S. spinosa* in three-fold replication revealed no significant difference in strychnine and brucine concentrations ($p>0.05$), but the concentrations was vey low (< 1 ppm dry weight) (Figure 6.3).

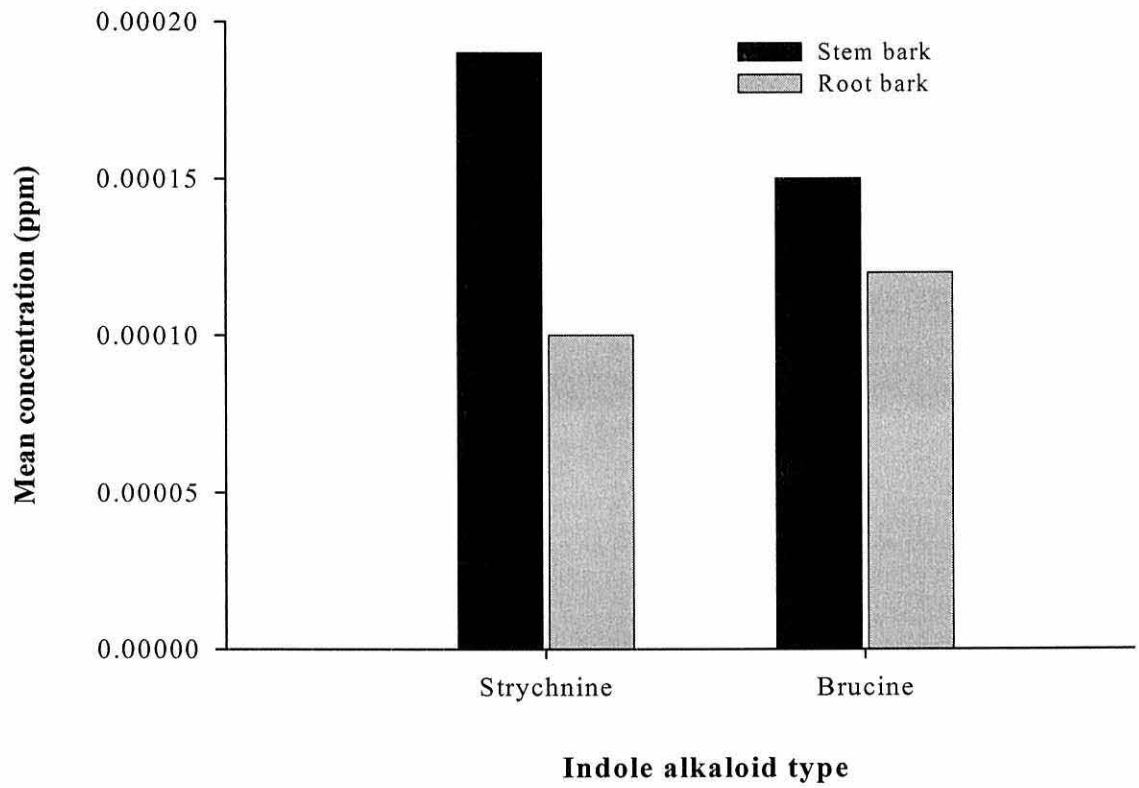


Figure 6.3 Mean concentrations of strychnine and brucine in *Strychnos spinosa* from Urumwa Forest Reserve, Tanzania.

6.3.3. Other compounds isolated from *S. spinosa*

Several other compounds representing six main categories (Table 6.4), recognized in the Dictionary of Natural Products (2004) were isolated and identified from the crude extracts of *Strychnos spinosa* using the mass spectrometer. Strychnine and brucine compounds were also not detected by mass spectrometer in the root bark extracts of *S. spinosa* probably due to its low concentration in the extract or experimental conditions. Stem bark extracts contained all of the identified compounds (Appendix IXa), except the polycyclic aromatic natural products (Table 6.4). Root bark extracts lacked the alkaloids of indole and isosteroidal types and miscellaneous nitrogen compounds. Details of individual compounds from each category reported from Table 6.4 are presented in Appendices IXa and IXb.

Table 6.4 Other compounds identified in stem bark and root bark extracts of *Strychnos spinosa* from Urumwa Forest Reserve, Tabora region, Tanzania.

Compound main category	**Plant parts analysed**	
	Stem barks	Root bark
Simple aromatic natural products	+	+
Aromatic carboxylic acids	+	+
Alkaloids: Simple acyclic amine	+	+
Indole-type	+	-
Isoquinoline-type	+	+
Isosteroidal – type	+	-
Polycyclic aromatic natural products	-	+
Steroids	+	+
Miscellaneous nitrogen compounds	+	-

(+), denotes presence of a compound category; (-), denotes absence of a compound category

6.4 Discussion

In the present study a successful attempt has been made to detect two indole alkaloids, strychnine and brucine, in the stem bark and root bark of *Strychnos spinosa*. The presence of these two compounds in addition to other bioactives detected, may explain the use of the species in traditional medicine due to the fact that strychnine and brucine are reported to have effects on human body physiology including toxicity at high dosage.

Though statistically no differences in concentrations were observed, the study findings overall revealed low concentrations of strychnine and brucine in both (the stem bark and root bark) parts of *S. spinosa*. Results are in agreement with Bisset (1980) argument that strychnine and brucine are major alkaloids in *Strychnos* species but forming quite a small proportion of the total alkaloids compared to others. Bisset (1980) explained this to be due to their oxidative transformation in the plant forming corresponding bases of pseudo-series of the compounds. A study by Bisset and Chondury (1974) observed smaller amounts of strychnine and brucine in leaves of *Strychnos waliachii* from Bangladesh. Similarly, according to Sandberg *et al.* (1968), Marini-Bettolo *et al.* (1972) and Bisset and Phillipson (1976), strychnine and brucine are quite rare in the genus *Strychnos* with only few species known to contain them.

Results from this study differ from those Sandberg *et al.* (1969b) and Duke (1992) found in Tropical Africa and Tropical America respectively in the relatively low concentrations detected in the present study. Strychnine to-date, has been reported to occur nearly in all parts of only one African species, *S. icaja* which contains (Sandberg *et al.*, 1969b) approximately 6600 ppm in its bark dry weight, a figure several orders of magnitude higher than the <1 ppm observed in this study. Within the genus *Strychnos* however, only one species, *Strychnos nux-vomica* (Duke, 1992) is known to contain high amount of strychnine in almost every part (with 15,800 ppm in bark, 400 – 12,000 ppm in seeds, 8,000 ppm in leaves and 7030 ppm in roots). *Strychnos nux-vomica* also has the higher reported concentration of brucine (48,000 ppm in bark, 16,000 ppm in seeds, 8,000 ppm in leaves, 2,770 ppm in roots and 300–650 ppm in fruits).

There are evidences of bioactivity for the two monoterpenoid indole alkaloids supporting the use of *S. spinosa* in the traditional medicine system. Generally, strychnine and brucine are known as central nervous system stimulants, and are often used in anti-inflammatory and analgesic drugs to relieve arthritic and traumatic pains (Zhang *et al.*, 2005). Strychnine was one of the first substances used to enhance sporting performance although it is now listed as a prohibited substance in sports (Verroken, 2000), and a substance for which an individual minimum required performance limit (MRPL) has been specified (200 ng/ml) (World Anti-Doping Agency, 2005).

Strychnine is known to be toxic and deaths related to incorrect dosage of the drug have been reported (Zhang and Huang, 1988). However, while larger doses of strychnine are known to be deadly, leading to violent convulsions, small doses can give subjective feelings of stimulation to human beings (Samulesson, 1992). Recently, a study by Deng *et al.* (2006) revealed the anti-tumour effect of strychnine and brucine from seeds of *S. nux-vomica* on hepatocellular carcinoma, one of the most common malignant tumours worldwide. This evidence could probably provide support for the use of *S. spinosa* roots and barks to treat tumours (Table 3.21 – Chapter III) as mentioned by communities around the miombo woodlands of Urumwa in Tanzania.

Brucine has been reported to act on the peripheral nervous system as a local anaesthetic agent and as a paralytic substance. Small quantities of brucine may have an extremely bitter taste in the mouth and cause reflex gastric secretion resulting in nausea and vomiting (Gosselin *et al.*, 1984). Communities around Urumwa use *S. spinosa* for a person bitten by a snake to induce vomitting as first aid before treatment. This could be explained by the presence of brucine in the species.

General Discussion

CHAPTER VII

GENERAL DISCUSSION

In this chapter, the findings from the present study are re-examined in a general context. The chapter has three sections: An overview of the current ethnobotany and gender roles (Section 7.1), reflections on the status of medicinal plants in relation to local utilization (Section 7.2), and consideration of the phytochemical potential of medicinal plants as illustrated by the 'case study' species (Section 7.3).

7.1 Ethnobotany and gender roles

The present study has revealed a significant contribution of medicinal plants knowledge to the livelihood health security of communities around the miombo woodland of Urumwa. The wealth of this ethnobotanical knowledge is evidenced by the great number of plants recorded, for treating various diseases, and offering a basis for future phytochemical and pharmacological studies of miombo trees. The number of plants and diseases recorded from the present study at Urumwa, is higher compared to what Ruffo (1990) reported for survey of a whole Tabora Region including some villages around Urumwa. The scale of survey and purpose for this study differ from that of Ruffo, but the comparison highlights a situation of how local people around the miombo of Urumwa are endowed with ethnobotanical information especially on plants of their immediate local dependency for primary health care needs.

Gender bias is strong in ethnobotanical knowledge around Urumwa, (favouring male more than female) and this is a threat if knowledge has to be conserved and equal participation between male and female in the primary health care system, is to be assured. To resolve the situation in future, communities around Urumwa especially men need to be sensitized through public education and seminars, raising awareness on the importance of equal transfer to the entire younger generations including the girls; this would be a major departure from tradition.

The present study has also provided an understanding of communities' gender responsibilities in the utilization and conservation of medicinal plants, indicating the potential of both men and women in improving and sustaining the primary health care system. Thus, for successful design of any intervention to develop the medicinal plant resources at Urumwa, these differences should be taken into account. Nevertheless, gender bias has been noted in some responsibilities which will require attention in the near future, if proper use and management of medicinal plant resources is to be sustained at Urumwa and other places where the miombo woodland vegetation is dominant. For instance, when considering the domestication of potential medicinal plant species around Urumwa, men as the main harvesters should not be isolated in the process as their diversity of plant knowledge could help women to broaden and add new knowledge of the species domesticated around homesteads.

In the earlier review of literature, gender aspects in medicinal plant resource use and conservation are revealed as not well covered and reference to gender are biased towards natural resource use and women. In studies by Howard (2003b), although gender differences and relations in plant use and management are described targeting women as the most disadvantaged group in most societies, successful interventions which included both men and women are reported from some parts of Africa. From the approach in the present study towards gender studies, it is argued that soliciting information on gender roles from both men and women (independent of their sexual status) individually or in small groups, provides a good indication of how these roles are differentiated and structured within the domain of medicinal plants. Understanding gender differences in medicinal plants use and conservation aspects could be an essential part of developing policies aimed at both better management of these resources and improved health and well-being of communities.

7.2 Medicinal plant status in relation to utilization

The present study has established that, a relationship exists between tree diameter and medicinal plant part utilization in the miombo woodland of Urumwa. Through informal discussion with herbalists and collectors of medicinal plant materials around Urumwa, it was revealed that, trees $\geq$10 cm diameter are normally preferred for the collection of medicinal plant material though under certain circumstances smaller individuals are considered. In terms of the availability of individual trees of this size, the two 'case study' species (*P. tinctorius* and *S. spinosa*) are meeting the local need at least in the short-term, especially when only small quantities of plant parts such as roots or bark are required. However, where, for commercial purposes, large quantities are required there is a risk of extensive areas being systematically harvested, possibly without attention to longer-term sustainability.

The wild population status of medicinal plants in the miombo woodlands of Urumwa appears to be at some risk high levels of disturbance including unsustainable use of harvesting methods, which has been noted in the present study (Chapter III). Due to the spatial distribution of potential medicinal plants, as shown by *P. tinctorius* and *S. spinosa,* in certain circumstances collectors (mostly those commercially oriented) do uproot the whole tree of a species to conveniently collect the amount required. For Urumwa Forest Reserve, due to its proximity to Tabora town, urbanization as reported by Williams *et al.* (1997) and Mander (1998) in South Africa, seems to create a huge demand for traditional medicines and an extensive informal commercial trade in bark and roots to supplement income for daily livelihood needs. Since there is no legal instrument that exists specifically to protect medicinal plants from uncontrolled use and degradation in Tanzania, major loss potential medicinal plants in future is possible, if the situation is not addressed.

The prevailing poverty situation among communities surrounding Urumwa Forest Reserve and beyond seems to fuel the degradation of miombo resources (including medicinal plants) since communities have no alternative sources for meeting their basic demands and they are not motivated to conserve the species to ensure future sustainability. The prevailing situation is not unique to Urumwa but common in most of the miombo ecoregion. There is a need therefore, for the government to strengthen and reinforce laws which could govern and control the harvesting of medicinal plants from wild sources aiding to conservation. According to Perrings and Lovett (1999), poverty and social conditions are among the factors which affect the way people respond to policy options for biodiversity conservation. As the key to conservation, the authors go further by suggesting construction of economic and financial incentives to capture and internalize the benefits of conservation to local communities. As with the case of Urumwa, the government should technically and materially support the domestication of medicinal plants in the initial stages as a way of building capacity but at the same time motivating the conservation of beneficial resources. Provision of training in nursery establishment, propagation methods, development of market channels for medicinal plants including adding value to final products, will all stimulate communities to embark on conservation.

The above strategy should also go hand in hand with the establishment of databases on medicinal plants with higher market demand, and their status in the forests. Immediate sensitization of all herbalists to sustainable ways of harvesting medicinal plants, applying the sustainable harvesting technologies recommended by Geldenhuys and Mitchell (2006) in Southern Africa is desirable. Those authors have argued that, for harvesting of medicinal plants to be sustainable, market demand must be balanced with the availability of the species in the wild, and recovery rates after harvesting.

7.3 Phytochemical potential of medicinal plants

The phytochemical potential of the two 'case study' species; *Pterocarpus tinctorius* and *Strychnos spinosa*, from the miombo woodland of Urumwa Forest Reserve has been revealed and established by the present study. Results indicate the worth of the ethnopharmacological approach (Martin, 2004) in revealing plants as potential drug sources. The presence of bioactive compounds (both isoflavonoids and monoterpenoid indole alkaloids) with proven bioactivity suggests the local communities' good judgement in using the species as medicines for primary health care as medicines.

The study has also revealed that local people's use of plants, especially the preferences of plant parts to use, is influenced by speculation on the concentration of remedies to effect treatment. In the case of *P. tinctorius* at Urumwa, it is not surprising that communities rarely use the leaves to cure ailments-assuming their ineffectiveness compared with root and bark material. The present study, however, does support claims that leaves do contain isoflavonoids, but in lower concentration than other parts of the plant.

The presence of these bioactive compounds in mixture with the other phytochemicals detected, need further attention in terms of validating efficacy and safety. Similar cautions would extend to the other identified priority species at Urumwa. Generally, it is recommended that, before validation of medicinal plants several types of evidence need to be taken into account (WHO Monographs, 1999, 2002), including ethnobotanical claims, pharmacological studies, and observational and clinical studies. Provision of this evidence in most developing countries, Tanzania included, has been retarded by resource constraints. In most of Sub-Saharan Africa, there is a shortage of this essential part of ethnopharmacological research (Mulholland, 2005), resulting in most research centres (*e.g.* ITM, Tanzania) relying on well-equipped laboratories in other parts of the world to assist, and this leads to research delays and sometimes frustrations and possible IPR conflict. A considerable input of expensive capital equipment is therefore required to achieve the target of proving efficacy and the safety of plant medicines in-country.

Currently medicinal plant researchers in Tanzania and other parts of the world increasingly favour are shifting direct pharmacological screening to prove the efficacy of plant extracts against bacterial, fungal and other harmful micro-organisms rather than combination with chemical screening. Phytochemical screenings are still desirable, however to establish the concentrations of compounds present before effects on human body or human behaviour are realized. As with *Strychnos spinosa* in this study, strychnine (known worldwide for its toxicity) has been quantified at very low concentrations in the bark and roots (Chapter VI), possibly making the species potential as medicine.

The main problem hindering phytochemical screening especially in developing countries, is the expense involved in terms of availability of commercial standard reference materials and the long and tedious extraction time before results can be realized. As the literature reviewed earlier (Chapter II) reveals, there is also a debate on the sustainability of plant materials supply for screening due to the rate of destruction of wild resources. Issues of intellectual property rights add further complexity to all planned initiatives but should not be seen as a disincentive to action.

Conclusions & Future Directions

CHAPTER VIII

CONCLUSIONS AND FUTURE DIRECTIONS

In this chapter the conclusions of the study findings are discussed (Section 8.1) taking into account the ethnobotanical knowledge, the relevance of gender responsibilities in utilization and conservation, and medicinal plant resource base quantity and quality at Urumwa. Outlined future implications (Section 8.2) are suggested aiming to the overall improvement of the primary health care system at Urumwa and Tanzania as a whole, while ensuring sustainability of the medicinal plant resources in future.

8.1 Conclusions

8.1.1 Medicinal plants knowledge

From ethnobotanical survey of medicinal plants, it can be concluded that, communities around Urumwa are knowledgeable of medicinal plant species - with men being ethnobotanically knowledgeable than women. This indicates their knowledge potential in the daily performance of traditional medicine system at Urumwa, in addition to identification of a "top ten" set of medicinal plant species of high potential for them, needing attention in future due to their contribution to primary health needs.

Nevertheless, the traditional medicinal practice by men and women at Urumwa is dominated by the use of roots, harvested unsustainably, and by the lack of standardized dosage for most of plant remedies administered. These are sensitive matters which could hinder the development of traditional medicine system unless serious actions are taken.

8.1.2 Gender roles in use and conservation of medicinal plants

From the study survey it can be concluded that significant differences exist between men's and women's responsibilities in utilizing and conserving medicinal plant resources at Urumwa. In terms of utilization, men dominate the traditional healing system, medicinal plant trade in formal and informal markets and as specialists treating diseases different from those women treat. However, both men and women equally share responsibilities in processing of plant remedies, and treating diseases affecting women and children.

In terms of conservation, men are indicated as the main harvesters of medicinal plants and are active decision-makers in aspects pertaining to the protection of Urumwa Forest Reserve, whereas women are indicated as domesticators of medicinal plants (on a small scale) around homesteads. Both men and women, however, do not respect the JFM rules for access to the reserve for medicinal plants collection, viewing the reserve as an open access property – and contribute to threats to the resources due to higher pressure in utilization.

8.1.3 Population status of 'case study' species

From the survey to establish the medicinal plant population status as reflected from the 'case study' species it can be concluded that, the species are sparsely distributed in Urumwa and differ in status. *P. tinctorius* is poorly stocked but has many large individual trees while; *S. spinosa* is well stocked with many smaller individual trees.

The two species seem to meet the immediate medicinal plant material needs of the local people in short-term, but strategies (*e.g.* encourage coppicing of species, and cultivation in homegardens) need to be developed for ensuring long-term supply, and could be extended to other potentially identified medicinal plants of high local significance. Luoga *et al.* (2004) for the eastern miombo woodlands of Tanzania have recommended the use of coppice rotations as a management system for the woodlands. However, as well as cultivation of medicinal trees in homegardens, the "*Ngitili*" agrosilvopastoral system (Kamwenda, 2002) of *ex-situ* conservation and promoting resprouting from roots and stumps (Boaler and Sciwale, 1966; Strang, 1974; Grundy, 1995; Frost, 1996), which makes use of the resilience and vegetative regeneration capacity of miombo trees, could be applied in communal woodlots. Vegetatively regenerating shoots often grow faster than newly established seedlings because they already have a well-established root system with stored reserves (Chidumayo, 1993a; Grundy, 1995).

The inventory approach used in this study is not new, but there are shortcomings especially in estimating population parameters such as sample area and density. It has been noted that bias in estimating sample area may be introduced if distances from conspecific neighbours are not well measured. The approach also is difficult to follow and establish a circular plot, especially when sampling of extensive areas is required and the species concerned is not well-stocked (*e.g.* the case of Urumwa).

This necessitates covering long distances to obtain the required sample. All in all, however, considering the method's simplicity, and its suitability for use under constrained resources, it is adequate as a first consideration of the conservation context.

8.1.4 Phytochemical status of 'case study' species

The study has confirmed the presence of five isoflavonoids (formononetin, genistein, homopterocarpin, prunetin and vestitol) in the leaves, stem bark and root bark of *P. tinctorius*, with the only differences in concentration between homopterocarpin and vestitol. Overall, the concentration of all studied isoflavonoids is low (<50 ppm dry weight). Similarly the study has also confirmed the presence of strychnine and brucine in *S. spinosa*, but with no significant differences in concentrations between the stem bark and root bark (both very low <1 ppm dry weight).

8.2 Future directions

From the present study, the following actions to be implemented by the government, scientists, policy-makers and or other medicinal plants stakeholders can be made:

Firstly, it is recommended that the ethnobotanical knowledge and existing gender role differences in utilization and conservation of medicinal plant resources at Urumwa be valued, recognized and taken into account when developing strategies to improve the primary health care system and conserve the plant resources for future generations. This can be implemented by the government and all stakeholders involved on developing the traditional medicine sector.

Secondly, there is a need for communities around Urumwa to change taboos and culture which hinder women's participation in traditional healing to sustain the primary health care system. Knowledge should be transferred to both young generations' without excluding girls. This can be achieved through community sensitization using both seminars and mass media from the government and other NGOs with common research interest.

Thirdly, it is recommended that, communities be sensitized on the importance of having standardized dosages and on sustainable ways of harvesting medicinal plant parts to improve their work performance and ensure plant resource availability in future. This could be implemented by all medicinal plant stakeholders under the government ministries of health and natural resources to provide trainings, seminars and field demonstrations.

Fourthly, there is a need to assist local communities to develop their own conservation initiatives including training and technical assistance on how to go about domesticating potential medicinal plants from the miombo using appropriate methods both *in-situ* and *ex-situ*. This could be facilitated by either the Forestry and Beekeeping Division - Tanzania or any other partners having similar interest (*e.g.* ICRAF, ITM). This will ensure not only future availability of the plants, but also sustain the primary healthcare of rural populations.

The existing JFM policy applied to Urumwa Forest Reserve in addition to other policies emphasizing sustainable use of resources should be reinforced and strengthened to ensure proper implementation of the programme and forest management. The need also to sensitize, educate and encourage women's participation in decision-making process especially in JFM and other forestry-related committees around Urumwa Forest Reserve is essential. This can be achieved through education and extension services to empower women in building their own self-esteem and hence ensure their participation.

The 'case study' species (*P. tinctorius* and *S. spinosa*) need further attention in terms of phytochemical, pharmacological and toxicological qualities in future followed by clinical trials using standard protocols to provide proof of their safety in traditional medicine and to increase confidence among other users. For the two species (*P. tinctorius* and *S. spinosa* respectively), there is also a need for structural characterization studies to separate isoflavonoids and monoterpenoid indole alkaloids, from other compounds detected. These would, at present, necessitate the government taking advantage of available institutions like ITM in collaboration with other scientists from recognized institutions within and outside Tanzania.

It is strongly recommended that an intensive ecological survey of the two 'case study' species and other potential medicinal plants in Urumwa be implemented in future to provide a greater insight to the species dynamics in the miombo and assist in forest management and conservation.

References

REFERENCES

Abdallah, J.M. (2001). Assessment of the impact of non timber forest products utilization on sustainable management of miombo woodlands in Urumwa Forest Reserve, Tabora, Tanzania. MSc. (Forestry) dissertation, Sokoine University of Agriculture, Morogoro, Tanzania. 99 pp.

Abreu, P.M., Martins, E.S., Kayser, O., Bindseil, K.U., Siems, K., Seemann, A. and Frevert, J. (1999). Antimicrobial, anti-tumour and antileishmania screening of medicinal plants from Guinea-Bissau. Phytomedicine, 6: 187–195.

Abhyanka, G., Reddy, V.D., Giri, C.C., Rao, K.V., Lakshmi, V.V.S., Prabhakar, S., Vairamani, M. Thippeswamy, B.S. and Bhattacharya, P.S. (2005). Amplified fragment length polymorphism and metabolomic profiles of hairy roots of *Psoralea corylifolia* L. Phytochemistry, 66: 2441–2457.

Acres, B.D., Barrett, A.T., Corker, I.R., Davies, K., Manfield, J.E., Myers, C.N., Rackham, L.J. and Walton, R.K. (1984). Tabora rural integrated development project. Land use component. In: Land evaluation and land use planning in Tabora region. Final report (ed. by A.J.B. Mitchell), pp 147 – 206. Land Resource Development Centre, Tolworth Tower, England.

Akerele, O., Heywood, V. and Synge, H. (1991). Conservation of medicinal plants. Cambridge University Press, UK.

Andesogan, E.K. and Morah, F.N. (1981). Strychnolactone, an unusual monoterpene lactone from *Strychnos spinosa*. Phytochemistry, 20: 2585 – 2586.

Anyinam, C. (1995). Ecology and ethnomedicine: exploring links between current environmental crisis and indigenous medical practices. Social Science and Medicine, 4: 321–329.

Arnold, H.J. and Gulumian, M. (1984). Pharmacopoeia of traditional medicine in Venda. Journal of Ethnopharmacology, 12: 35 – 74.

Ashcroft, P. and Pereira, C. (2003). Practical statistics for the biological sciences: simple pathways to statistical analyses. Basingstoke: Palgrave. 167 pp.

Augustino, S. (2002). Gender roles in sustainable use and practices of medicinal plants in urban districts of Morogoro and Iringa, Tanzania. MSc. (Forestry) thesis, Sokoine University of Agriculture, Morogoro, Tanzania. 117 pp.

Augustino, S. and Gillah, P.R. (2004). Medicinal plants and gender: practices and sustainable use in urban districts of Morogoro and Iringa, Tanzania. Proceedings of the 2nd Worldwide Symposium on Gender and Forestry: challenges to livelihoods and sustainable management, held at Mweka Wildlife College from 1st – 10th August 2004, Kilimanjaro, Tanzania.

Asase, A., Oteng-Yeboah, A.A., Odam, H.G.T. (2005). Ethnobotany study of some Ghanaian antimalarial plants. Journal of Ethnopharmacology, 99: 273 – 279.

Ayedoun, M.A., Moudachirou, M., Garneau, F.X., Gagnon, H., Jean, F.I., Tomi, F. and Casanova, J. (1998). Constituents of the leaf and flower oils of *Heeria insignis* Del. from Benin. Journal of Essential Oil Research, 10: 529–530.

Ayensu, E. S. (1978). Medicinal plants of the West Indies. Unpublished manuscript. 110 pp.

Barnes. S. and Peterson, T.G. (1995). Biochemical targets of the isoflavone genistein in tumour cell lines. Proceedings of the Society for Experimental Biology and Medicine, 208:103-108.

Backlund, M., Bengt, O. and Bremer, B. (2000). Phylogenetic relationships within the Gentianales based on *ndhF* and *rbcL* sequences, with particular reference to the Loganiaceae. American Journal of Botany, 87:1029-1043.

Balakrishnan, R. (2000). Gender-defined strategies for biodiversity management for household food security. In: Gender dimensions in biodiversity management and food security: policy and programme strategies for Asia – A report. M.S. Swaminathan Research Foundation, Chennai.

Balick, M.J. and Cox, P. (1996). Plants, people and culture. The science of ethnobotany. Scientific American Library, USA, 228 pp.

Baker, E.G. (1929). The Leguminosae of tropical Africa. Part II. Suborder Papilionaceae. Unitas Press, Ostend. pp 216 - 607.

Baser, K.H.C. and Bisset, N.G. (1982). Alkaloids of Sri Lankan *Strychnos nux-vomica*. Phytochemistry, 21: 1423–1429.

Bekker, M., Milan, E., Steekamp, J.A. and Brandt, E.V. 2002. An isoflavonoid-neoflavonoid and an O-methylated isoflavone from the heartwood of *Dalbergia nitidula*. Phytochemistry, 59: 415 – 418.

Beentje, H.J. (1994). Kenya tree, shrubs and lianas. National Museums of Kenya, Nairobi, Kenya. 722 pp.

Berry, L. (1995). Physical and social geography. In: Africa south of the Sahara, 24th edition (ed by J.A. Allan and K. Amanor). Staples Printer Rochester Ltd, Kent, UK. 1057 pp.

Beyra-M., A. and Lavin, M. (1999). Monograph of *Pictetia* (Leguminosae—Papilionoideae) and review of the Aeschynomeneae. Systematic Botany Monographs 56: 1–93.

Biala, R.G., Tits, M., Penelle, J., Frederich, M., Brandt, V., Prosperi, C., Llabres, G. and Angenot, L. (1998). Strychnochrysine, a new Bisindole alkaloid from the roots of *Strychnos nux-vomica*. Journal of Natural Products, 61: 139 – 141.

Bisset, N.G. (1980). Phytochemistry. In: Engler and Prantl's Die natürlichen Pflanzenfamilien, Angiospermae: Ordnung Gentianales, Fam. Loganiaceae, vol. 28b (1). (ed by A.J.M. Leeuwenberg), pp 211–237. Duncker and Humblot, Berlin, Germany.

Bisset, N.G. (1976). The Asian species of *Strychnos*. Part IV. The alkaloids. Lloydia, 39: 263–315.

Bisset, N.G. (1970). African species of *Strychnos*. Part I. The ethnobotany. Lloydia, 33: 201 – 243.

Bisset, N.G. and Phillipson, J.D. (1971). African species of *Strychnos* II. Alkaloids Lloydia, 34: 1–60.

Bisset, N.G. and Choudhury, A.K. (1974). Alkaloids from the leaves of *Strychnos wallichiana*. Phytochemistry, 13: 259–263.

Bisset, N.G. and Walker, M.D. (1974). Alkaloids from the stem bark of *Strychnos ignatii*. Phytochemistry, 13: 525–526.

Boaler, S.B. (1966). The ecology of *Pterocarpus angolensis* DC in Tanzania. H.M. Stationery Office, London.

Boaler, S.B. and Sciwale, K.C. (1966). The ecology of a miombo site, Lupa North Forest Reserve, Tanzania: III. Effects on the vegetation of local cultivation practices. The Journal of Ecology, 54: 577 – 587.

Bodeker, G. (2002). Medicinal plants: towards sustainability and security. MedPlant Discussion Paper, Oxford University. 11 pp.

Boer, H.J. de, Kool, A., Bromberg, A., Mziray, W.R., Hedberg, I. and Levenforsd, J.J. (2005). Anti-fungal and anti-bacterial activity of some herbal remedies from Tanzania. Journal of Ethnopharmacology, 96: 461 – 469.

Bohm, B.A. 1998. Introduction to flavonoids. Harwood Academic Publishers. Australia. 503 pp.

Bonjean, K.A., Pauw-Gillet, M.C., Defresne, M.P., Colson, P., Houssier, C., Dassonneville, L., Bailly, C., Greimers, R., Wright, C., Quetin-Leclercq, J., Tits, M. and Angenot, L. (1998). The DNA-intercalating alkaloid cryptolepine interferes with topoisomerase II and inhibits primarily DNA synthesis in B16 melanoma cells. Biochemistry, 37: 5136–5146.

Bonjean, K.A., Depauw-Gillet, M.C., Quetin-Leclercq, J., Angenot, L. and Bassleer, R.J. (1996). In vitro cytotoxic activity of two potential anticancer drugs isolated from *Strychnos*: strychnopentamine and usambarensine. Anticancer Research, 16: 1129-1137.

Botha, J., Witkowski, E.T.F. and Shackleton, C.M. 2004. Market profiles and trade in medicinal plants in the Lowveld, South Africa. Environmental Conservation, 31: 38–46.

Bougatsos, C., Ngassapa, O., Runyoro, D.K B., Chinou, I.B. (2004). Chemical composition and *in vitro* antimicrobial activity of the essential oils of two *Helichrysum* species from Tanzania. Zeitschrift für Naturforschung. Section C, Biosciences, 59: 368-372.

Bradley, P.N. and McNamara, K. (1993). Living with trees: policies for forest management in Zimbabwe. World Bank Technical Paper 210. Washington DC. 327 pp.

Brolis, M., Gabetta, B., Fuzzati, N., Pace, R., Panzeri, F. and Peterlogo, F. (1998). Identification by high performance liquid chromatography-diode array detection-mass spectrometry and quantification by high performance chromatography-UV absorbance detection of active constituents of Hyperricum perforatum. Journal of Chromatography A, 825: 9–16.

Buckingham, J. (1994). Dictionary of natural products. Volume 1-7. Chapman and Hall, London. 8584 pp.

Bunning, S.E. and Hill, C.L.M. (1996). Farmer's right in the conservation of plant genetic resources: a gender perspective. Paper presented at a seminar during the second extraordinary session of the FAO commission on genetic resources for food and agriculture, 22 – 27 April 1996, Rome, Italy.

Brush, S.B. (1996). Whose knowledge, whose genes, whose rights? In: Valuing local knowledge: indigenous people and intellectual property rights (ed by S.B. Brush and D. Stabinsky), pp 41 – 67. Island Press, Washington, DC. 337 pp.

Burkill, H.M. (1985). The useful plants of West Tropical Africa, vol. 1. 2nd ed., Royal Botanic Gardens, Kew.

Byers, B. (2001). Miombo ecoregion: Reconnaissance synthesis report draft review. WWF, SARPO, Harare, Zimbabwe.

Chhabra, S.C., Mahunnah, R.L.A. and Mshiu, E.N. (1993). Plants used in traditional medicine in Eastern Tanzania. VI. Angiosperms (Sapotaceae-Zingiberaceae). Journal of Ethnopharmacology, 3: 83-103.

Chhabra, S.C., Mahunnah, R.L.A., Mshiu, E.N. (1991). Plants used in traditional medicine in Eastern Tanzania. V. Angiosperms (Passifloraceae to Sapindaceae). Journal of Ethnopharmacology 33, 143–157.

Chhabra, S.C., Mahunnah, R.L.A. and Mshiu, E.N. (1990a). Plants used in traditional medicine in Eastern Tanzania. IV. Angiosperms (Mimosaceae to Papilionaceae). Journal of Ethnopharmacology, 29: 295-323.

Chhabra, S.C., Mahunnah, R.L.A. and Mshiu, E.N. (1990b). Plants used in traditional medicine in Eastern Tanzania. III. Angiosperms (Euphorbiaceae to Menispermaceae). Journal of Ethnopharmacology, 28: 255-283.

Chhabra, S.C., Mahunnah, R.L.A. and Mshiu, E.N. (1989). Plants used in traditional medicine in Eastern Tanzania. II. Angiosperms (Capparidaceae to Ebenaceae). Journal of Ethnopharmacology, 25: 339–359.

Chhabra, S.C., Uiso, F.C. and Mshiu, E.N. (1984). Phytochemical screening of Tanzania medicinal plants. Journal of Ethnopharmacology 11: 157 – 179.

Chakravarthy, B.K and Gode, K.D. (1985). Isolation of (−)epicatechin from *Pterocarpus marsupium* and its pharmacological action. Planta Medica, 1: 56–59.

Chalk, L., Burtt Davy, J. and Desch, H.E. (1932). Forest trees and timbers of the British Empire. I. Some East African coniferae and Leguminosae. Clarendon Press, Oxford. 68 pp.

Chaturvedula, V.S.P., Sprague, S., Schilling, J.K. and Kingston, D.G.I. (2003). New cytotoxic indole alkaloids from *Tabernaemontana calcarea* from the Madagascar Rainforest. Journal of Natural Products, 66: 528-531.

Chidumayo, E.N. (1993a). Silvicultural characteristics and management of miombo woodlands. In: The ecology and management of indigenous forests in Southern Africa. (ed. by G.D. Pierce and D.J. Gumbo), pp. 124 – 133. Zimbabwe Forestry Commission/SAREC, Harare.

Chidumayo, E.N. (1988a). A re-assessment of effects of fire on miombo regeneration in the Zambeziana Copper belt. Journal of Tropical Ecology, 4: 361 – 372.

Chikamai, B. and Tchatat, M. (2004). Forest management for non-wood forest products and services in Africa: lessons learnt on forest management in Africa. A report prepared for a project by AFRONET/FAO. 35 pp.

Collu, G., Unver, N., Peltenburg-Looman, A.M.G., van der Heijden, R., Verpoorte , R. and Memelink, J. (2001). Geraniol 10-hydroxylase, a cytochrome P450 enzyme involved in terpenoid indole alkaloid biosynthesis. FEBS Letters, 508: 215 – 220.

Connelly, M.P., Fabiano, E., Patel, I.H., Kinyanjui, S.M., Mberu, E.K. and Watkins, W.M. (1996). Antimalarial activity in crude extracts of Malawian medicinal plants. Annals of Tropical Medical Parasitology, 90: 597 – 602.

Cos, P., De Bruyne, T., Apers, S., Berghe, D., Peiters, L. and Vlietinck, A.J. (2003). Phytoestrogens: recent developments. Planta Medica, 69: 589 – 592.

Coune, C.A., Angenot, L.J.G. and Denoel, J. (1980). 13C NMR of *Strychnos* alkaloids: harmane and usambarensine derivatives. Phytochemistry, 19: 2009 – 2011.

Crawley, M.J. (1996). The structure of plant communities. In: plant ecology (ed by M.J. Crawley), pp 475 – 531. Blackwell Scientific Publications, Oxford. 717 pp.

Cunningham, A.B. (1993). African medicinal plants: setting priorities at the interface between conservation and primary health care. People and Plants Working Paper 1: 1-50. UNESCO, Paris.

Cunningham, A.B. (1991). The herbal medicinal trade: resource depletion and environmental management for a 'hidden economy'. In: South Africa's Informal Economy (ed. by E. Preston-Whyte and C. Rogerson), pp 196–206. Oxford University Press.

Cunningham, A.B. (1988). An investigation of the herbal medicine trade in Kwazulu-Natal. Investigation Report No. 29. Institute of Natural Resources, University of Natal, Pietermaritzburg.

Dalle, S.P. and Potvin, C. (2004). Conservation of useful plants: an evaluation of local priorities from two indigenous communities in Eastern Panama. Economic Botany, 58: 38 – 57.

Dallu, A.I.M. (2003). Tanzania country paper. Proceedings of the workshop on tropical secondary forest management in Africa: reality and perspectives, in collaboration with ICRAF and CIFOR, Nairobi, Kenya, 9 – 13 December 2002. 19 pp.

Davis, S.R., Dalais, F.S., Simpson, E.R. and Murkies, A.L. (1999). Phytoestrogens in health and disease. Recent Progress in Hormone Research, 54: 185–210.

Dhanabal, S.P., Kokate, C.K., Ramanatham, M., Kumar, E.P. and Suresh, B. (2006). Hypoglycaemic activity of *Pterocarpus marsupium* Roxb. Phytotherapy Research, 10: 4 – 8.

Delaude, C., Thepenier, P., Jacquier, M.J., Massiot, G. and Le men-Oliver, L. (1992). Contribution a l'etude des *Strychnos* africains. alcaloides de *Strychnos cocculoides, S. lucens, S. madagascariensis, S. minfiensis, S. mitis, S. pungens* et *S. spinosa*. Bulletin de Societe du Royale des Sciences de Liege, 61: 429 – 440.

Delevoy, G. (1929). La question forestière au Katanga (Congo Belge). Tome II Les Essences forestière du Katanga. Office De Publicitè, Bruxelles. 525 pp.

Deng, X.K., Yin, W., Li, W., Yin, F., Zhang, X., Hua, Z. and Cai, B. (2006). The anti-tumour effects of alkaloids from the seeds of *Strychnos nux-vomica* on HepG2 cells and its possible mechanisms. Journal of Ethnopharmacology, 106: 179–186.

Derry, B.B., Otysina, R., and Ngatiwa C. (1999). Indigenous knowledge of medicinal trees and setting priorities for their domestication in Shinyanga region, Tanzania. ICRAF report 87 pp.

Dewees, P.A. (1994). Social and economical aspects of miombo woodland management in Southern Africa: options and opportunities for research. CIFOR Occasional Paper No. 2, Bogor, Indonesia.

Dewick, P.M. (1993). Isoflavonoids. In: The Flavonoids. Advances in research since 1986 (ed by J.F. Harborne), pp 117 – 238. Chapman and Hall, London.

Dictionary of Natural Products (2004). Combined dictionary of natural products on CD-ROM – version 5.2. Chapman and Hall/CRC Press. London

Dixon, R.A. and Ferreira, D. (2002). Genistein. Phytochemistry, 60: 205 – 211.

Dixon, R.A. and Steele, C.L. (1999). Flavonoids and isoflavonoids - a gold mine for metabolic engineering. Trends Plant Science, 4: 394-400.

Dixon, R.A., Canovas, P., Guo, ZJ, He, X.Z., Lamb, C. and McAlister, F. (1999). Molecular controls for isoflavonoid biosynthesis in relation to plant and human health. In: Phytochemicals in Human Health Protection, Nutrition and Plant Defence (ed by J.T. Romeo), 133 – 159. Lower Academic, New York.

Dixon, R.A. and Paiva, N.L. (1995). Stress-induced phenylpropanoid metabolism. Plant Cell, 7: 1085–1097.

Duke J.A. (1992). Handbook of phytochemical constituents of grass, herbs and other economic plants. CRC Press Inc., London. 690 pp.

Ebi, G.C. and Ofoefule, S.I. (2000). Antimicrobial activity of *Pterocarpus osun* stems. Fitoterapia, 71: 433- 435.

Elujoba, A.A., Odeleye, O.M. and Ogunyeni, C.K. (2005). Traditional medicine development for medical and dental primary health care delivery system in Africa. African Journal of Traditional, Complementary and Alternative Medicines, 2: 46 – 61.

Facchini, P.J. (2001). Alkaloid biosynthesis in plants: Biochemistry, cell biology, molecular regulation, and metabolic engineering applications. Annual Review of Plant Physiology and Plant Molecular Biology, 52:29– 66.

Falcão, M.J.C., Poulquem, Y.M.B., Lima, M.A.S., Gramosa, L.V., Militão, G.C.G., Pessoa, C., Moraes, M.O. and Silveira, E.R. (2005). Cytotoxic flavonoids from *Platymiscium floribundum*. Journal of Natural Products, 68: 423 – 426.

FAO (2004). Understanding the interface of natural woodlands and HIV/AIDS-affected communities in Southern Africa. FAO seminar proceedings, Harare, Zimbabwe 1 – April, 2004. FAO, Rome Italy. 64 pp.

FAO (2001). State of the world's forests 2001. Rome, Italy: FAO, 181 pp.

FAO (1986). Some medicinal forest plants of Africa and Latin America. FAO Forestry Paper, 67: 1 – 252.

FAO-UNESCO (1977). Soil map of the World 1:5000,000. Volume VI. Africa. UNESCO, Paris.

Farboodniay, M.A. and Ray, A.B. (1993). Antihyperlipidemic effects of isoflavonoids from *Pterocarpus marsupium*. Journal of Natural Products, 56: 989 – 994.

Farnsworth, N.R. (1988). Screening plants fro new medicines. In: Biodiversity (ed. by E.O. Wilson), pp 83 – 97. National Academy Press, Washington, DC.

Fassil, H. (2003). A qualitative understanding of local traditional knowledge and medicinal plant use: Ethiopia. Indigenous Knowledge Note, 52: 1 – 4.

Fellows, L.E., Bell, E.A. and King, G.S. (1977). 2-Aminoimidazole in seeds of *Mundulea sericea*. Phytochemistry, 16: 1399 – 1400.

Fors, L. (2002). Tree seed survival across a miombo fragmentation gradient in Tanzania. MSc dissertation, Uppsala University, Uppsala. 26 pp.

Fotsis, T., Pepper, M., Adlercerutz, H., Fleischmann, G., Hase, T., Montesano, R. and Schweigerer, M.(1993). Genistein, a dietary-derived inhibitor of *in vitro* angiogenesis. Proceedings of National Academy of Sciences USA, 90: 2690–2694.

Frédérich, M., Bentires-Alj, M., Tits, M., Angenot, L., Greimers, R., Gielen, J., Bours, V. and Merville, M.P. (2003). Isostrychnopentamine, an indolomonoterpenic alkaloid from *Strychnos usambarensis*, induces cell cycle arrest and apoptosis in human colon cancer cells. Journal of Pharmacology and Experimental Therapy, 304: 1103–1110.

Frederich, M., Jacquier, M.J., Thepenier, P., De Mol, P., Tits, M., Philippe, G., Delaude, C., Angenot, L. and Zeches-Hanrot, M. (2002). Journal of Natural Products, 65: 1381.

Frédérich, M., Tits, M.P., Hayette, V., Brandt, J., Penelle, P., De Mol, P., Llabrès, G. and Angenot, L. (1999). 10′-Hydroxyusambarensine, a new antimalarial bisindole alkaloid from the roots of *Strychnos usambarensis*. Journal of Natural Products, 62: 619–621.

Frost, P. 1996. The ecology of miombo woodlands. In: The miombo in transition: woodlands and welfare in Africa (ed. B. Campbell), pp 11 - 55. CIFOR, Bogor. 273 pp.

Fukai, T., Marumo, A., Kato, K., Kanda, T., Terada, S. and Nomura, T. (2002). Anti-*Helicobacter pyroli* flavonoids from Licorice extract. Life Sciences, 71: 1449 – 1463.

Fyhrquist, P., Mwasumbi, L., Hæggstrom, C.-A., Vuorela, H., Hiltunen, R. and Vuorela, P. (2002). Ethnobotanical and antimicrobial investigation on some species of *Terminalia* and *Combretum* (Combretaceae) growing in Tanzania. Journal of Ethnopharmacology, 79: 169 – 177.

Gadi-Biala, R., Tits, M., Waiters, J.N. and Angenot, L. (1996). A new HPLC method for the assay of alkaloids in *Strychnos nux-vomica* and *Strychnos ignatii*. Fitoterapia, 67: 163–165.

Garí, J.O. (2002). Agrobiodiversity, food security and HIV/AIDS mitigation in Sub-Saharan Africa: strategic issues in agricultural policy and programme responses. FAO: Sustainable Development Dimensions Report. 10 pp.

Gauslaa, Y. (1988). Management and regeneration of tropical woodlands with special reference to Tanzanian condition. A literature review. Report to NORAGRIC. 57 pp.

Geldenhuys, C. And Mitchell, D. (2006). Sustainable harvesting technologies. In: Commercialising medicinal plants: a southern African guide (ed. by N. Diederichs), pp. 21 – 40. Sun Press, Stellenbosch. 216 pp.

Geldenhuys, C.J. (2004). Bark harvesting for traditional medicine: from illegal resource degradation to participatory management. Scandinavian Journal of Forest Research, 19: 103 – 115.

Geldenhuys, C.J. (1993). Reproductive biology and population structures of *Podocarpus falcatus* and *P. latifolius* in Southern Cape forests. Botanical Journal of the Linean Society, 112: 59 – 74.

Gelfand, M., Mavi, S., Drummond, R.B. and Ndemera, B. (1985). The traditional medical practitioner in Zimbabwe. Mambo Press, Harare.

Giday, M., Asfaw, Z., Elmqvist, T. and Woldu, Z. (2003). An ethnobotanical study of medicinal plants used by the Zay people in Ethiopia. Journal of Ethnopharmacology, 85: 43 – 52.

Giday, M. (2001). An ethnobotanical study of medicinal plants used by the Zay people in Ethiopia. CBM: Skriftserie 3: 81 – 99.

Gidef, T. and Hahn, H. (2003). The use of medicinal plants in self-care in rural central Ethiopia. Journal of Ethnopharmacology, 87: 155 – 161.

Goldblatt, P. (1981). Cytology and phylogeny of the Leguminosae. In: Advances in legume systematics. Part 2 (ed by R.M. Polhill and R.H. Raven), pp.427 – 464. Royal Botanic Gardens, Kew. 1050 pp.

Good, C. M. and Kimani, V. N. (1980). Urban traditional medicine: A Nairobi case study. East African Medical Journal, 57: 301-316.

Gosselin, R.E., Smith, R.P. and Hodge, H.C. (1984). Clinical toxicology of commercial product. 5th ed. Williams and Wilkins: Baltimore, London.

Groover, J.K., Yadav, S. and Vats, V. (2002). Medicinal plants of India with anti-diabetic potential. Journal of Ethnopharmacology, 81: 81 – 100.

Grundy, I.M. (1995). Regeneration and management of *Brachystegia spiciformis* Benth. and *Julbernardia globiflora* (Benth.) Troupin in miombo woodlands, Zimbabwe. PhD Thesis, University of Oxford, Oxford.

Hall, R., Beale, M., Fiehn, O., Hardy, N., Sumner, L., Bino, R. (2002). Plant metabolomics as the missing link in functional genomics strategies. Plant Cell, 14: 1437–1440.

Hall, J.B. (1991). Multiple-nearest-tree sampling in an ecological survey of Afromontane catchment forest. Forest Ecology and Management, 42: 245 – 266.

Hamilton, A. (2004). Medicinal plants, conservation and livelihoods. Biodiversity Conservation, 13: 1477 – 1517.

Hamilton, A. (2003). Medicinal plants and conservation: issues and approaches. International Plant Conservation Unit, WWF, UK. 51 pp.

Hamisy, W.C., Mwaseba, D., Zilihona, I.E. and Mwihomeke, S.T. (2000). Status and domestication potential of medicinal plants in the Uluguru mountain area, Tanzania. Project report submitted to Wildlife Conservation Society of Tanzania (WCST), Morogoro Tanzania. 62 pp.

Harborne, J.B., Baxter, H. and Moss, G.P. (1999). Phytochemical dictionary: a handbook of bioactive compounds from Plants. 2nd Edition. Taylor and Francis, London. 893 pp.

Harborne, J.B. (1998). Phytochemical methods: a guide to modern techniques of plant chemical analysis. Chapman and Hall, London. 295 pp.

Harborne, J.B. (1994). The flavonoids: advances in research since 1986. Chapman and Hall/CRS Press Inc., London. 688 pp.

Harborne, J.B. and Baxter, H. (1993). Phytochemical dictionary: a handbook of bioactive compounds from plants. Taylor and Francis, London. 791 pp.

Harms, H. (1915). *Pterocarpus*. In: Die Végétation der Erde. IX. Die Pflanzenwelt Afrikas. 3.1. Charakter pflanzen Afrikas. Die dikotyledonen Angiospermen Casuarinaceae bis Dichapetalaceae (ed by A. Engler), pp 632 – 638. Engelman, Leipzig. 689 pp.

Hauman, L. (1954). Quelques Papilionaceae – Dalbergieae du Congo Belge. Bulletin du Jardin Botanique de l'Ètat, 24: 223 – 228.

He, W., Puyvelde, L.V., Bosselaers, J., De Kimpe, N., Flaas, M.V.D., Roymans, A., Mathenge, S.G., Mudida, F.P. and Mutiso, P.B.C. (2002). Activity of 6-pentadecylsalicyclic acid from *Ozoroa insignis* against marine crustaceans. Pharmaceutical Biology, 40: 74–76.

Hedberg, I., Hedberg, O., Madati, P.J., Mshigeni, K.E., Mshiu, E.N. and Samuelsson, G. (1983a). Inventory of plants used in traditional medicine in Tanzania. II. Plants of the families Dilleniaceae–Opiliaceae. Journal of Ethnopharmacology, 9: 105–182.

Hedberg, I., Hedberg, O., Madati, P.J., Mshigeni, K.E., Mshiu, E.N. and Samuelsson, G. (1983b). Inventory of plants used in traditional medicine in Tanzania. III. Plants of the families Papilionaceae–Vitaceae. Journal of Ethnopharmacology, 9: 237–260.

Hedberg, I., Hedberg, O., Madati, P.J., Mshigeni, K.E., Mshiu, E.N. and Samuelsson, G. (1982). Inventory of plants used in traditional medicine in Tanzania. I. Plants of families Acanthaceae – Cucurbitaceae. Journal of Ethnopharmacology, 6: 29 – 60.

Hines, D.A. and Eckman, K. (1993). Indigenous multipurpose trees of Tanzania: uses and economic benefits for people. Cultural Survival Canada and Development Services Foundation of Tanzania.

Hoet, S., Opperdoes, F., Brun, R., Adjakidje, V. and Quetin-Leclercq, J. 2004. In vitro-antitryponosomal activity of ethnopharmacologically selected Beninese plants. Journal of Ethnopharmacology, 91: 37 – 42.

Howard, P.L. (2003a). Women in the plant world: the significance of women and gender bias for biodiversity conservation. IUCN-ORMA. San José, Costa Rica.

Howard, P. L. (2003b). Women and plants: gender relations in biodiversity management and conservation. Zed Books, London and New York. 298 pp.

ICRAF (1992). A selection of useful trees and shrubs for Kenya: notes on their identification, propagation and management for use by farming and pastoral communities. International Centre for Research in Agroforestry, Nairobi, Kenya.

Iddi, S. (2002). Community participation in forest management in the United Republic of Tanzania. Paper presented at the second workshop on participatory forestry in Africa, 18-22 February 2002, Arusha, Tanzania.

Ingham, J.L. (1981). Phytoalexin induction and its taxonomic significance in the Leguminosae (subfamily Papilionoideae). In: Advances in legumes systematics. Part 2 (ed by R.M. Polhill and R.H. Raven), pp. 599 – 626. Royal Botanic Gardens, Kew. 1050 pp.

IRDP (1997). Integrated rural development project. Soil Surveys Reports. Tabora region.

Ishengoma, R.C. and Gillah, P.R. (2002). The role of medicinal plants in Northern Tanzania. A poster presented during the first Plant Resources of Tropical Africa (PROTA) International workshop 23rd – 25th September 2002, Nairobi, Kenya. 7 pp.

Ishengoma, R.C., Gillah, P.R. and Chihongo, A.W. (1997). Properties of lesser utilized *Trichilia emetica* (*T. rocka*) and *Pterocarpus stolzii* timber species of Tanzania. Annals of Forestry, 5: 10 – 15.

Itoh, A., Oya, N., Kawaguchi, E., Nishio, S., Tanaka, Y., Kawachi, E., Akita, T., Nishi, T. and Tanashi, T. (2005). Secoiridoid glucosides from *Strychnos spinosa*. Journal of Natural Products, 68: 1434 – 1436.

IUCN (2001). IUCN Red List categories. Version 3.1. Prepared by the IUCN Species Survival Commission. World Conservation Union, Gland, Switzerland and Cambridge

Ivorra, M.D., Paya, M. and Villar, A. (1989). A review of natural products and plants as potential antidiabetic drugs. Journal of Ethnopharmacology, 27: 243–275.

Iwu, M.M. (1993). Handbook of African medicinal plants. CRC Press Inc., Florida, USA. 435 pp.

Jackson, W.J. and Ingles, A.W. (1998). Participatory techniques for community forestry: a field manual. IUCN, Gland, Cambridge. 124 pp.

Jensen, S.R. (1992). Systematic implications of the distribution of iridoids and other chemical compounds in the Loganiaceae and other families of the Asteridae. Annals of the Missouri Botanical Garden, 79: 284–302.

Jensen, S.R. (1991). Plant iridoids, their biosynthesis and distribution in angiosperms. In: Ecological chemistry and biochemistry of plant terpenoids (ed by H.B. Harborne and F. A. Tomas-Barberan). Clarendon Press, Oxford.

Joseph, C.C., Moshi, M.J., Sempombe, J. and Nkunya, M.H.H. (2006). (4-methoxy-benzo[1,3]dioxol-5-yl)-phenylmethanone: an antibacterial benzophenone from *Securidaca longepedunculata*. African Journal of Traditional, Complementary and Alternative Medicine, 3: 80 – 86.

Kambu, K., Coune, C. and Angenot, L. (1980). Nouveaux alcaloïdes des racines du *Strychnos icaja*. Planta Medica, 37: 161–164.

Kano, T. (1972). Distribution and adaptation of the chimpanzee on the eastern shore of Lake Tanganyika. Kyoto University African Studies, 7: 37 – 129.

Kamuhabwa, A., Nshimo, C. and Witte, P.de. (2000). Cytotoxic of some medicinal plant extracts used in Tanzanian traditional medicine. Journal of Ethnopharmacology, 70: 143 – 149.

Kapingu, M.C., Guillaume, D., Mbwambo, Z.H., Moshi, M.J., Uiso, F.C., Mahunnah, R.L.A. (2000). Diterpenoids from the roots of *Croton macrostachys*. Phytochemistry 54: 767–770.

Karl, M. (1995). Women and empowerment: participation and decision making. Zed Books Ltd., London.

Katagiri, K., Katagiri, T., Kajiyama, K., Uehara, Y., Yamaoto, T. and Yoshida, T. (1992). Modulation of monocytic differentiation H-60 cells by inhibitor of protein tyrosine kinase. Cell Immunology, 140: 282–294.

Katambo, M.L.M. (1999). Indigenous knowledge and biodiversity conservation: a case of medicinal plants and Nyamwezi people in Tabora, Tanzania. MSc. Thesis, Addis Ababa University, Ethiopia.

Kamwenda, G.J. (2002). *Ngitili* agrosilvipastoral systems in the United Republic of Tanzania. Unasylva, 53: 46 – 50.

Kerman, M.R., Amarquaye, A., Chen J., Chan, J., Sesin, D.F., Parkinson, N., Ye ZhiJun, Barrett, M., Bales, C., Stoddart, C.A., Sloan, B., Blanc, P., Limbach, C., Mrisho, S., Rozhon, E.J. (1998). Antiviral phenylpropanoid glycosides from the medicinal plant *Markhamia lutea*. Journal of Natural Products, 61: 564-570.

Kikula, L.S. (1986). The influence of fire on the composition of miombo woodland of south-western Tanzania. Oikos, 46: 317 – 324.

King, F.E., Cotterill, C.B., Godson, D.H., Jurd, L. and King, T.J. (1953). The chemistry of extractives from hardwoods. Part XIII. Colourless compounds of *Pterocarpus* species. Journal of Chemical Society, 1950: 3693 – 3697.

Kitula, R.A. (2001). The use of medicinal plants for maternal care and child survival: a case study of villages around Zaraninge forest reserve in Bagamoyo, Tanzania. MSc (MNRSA) thesis, Sokoine University of Agriculture, Morogoro, Tanzania. 143 pp.

Kiunsi, R.B. (1994). Vegetation loss in rural settlements causes and remedies: with examples from Tanzania. Dar es Salaam University Press, Tanzania.

Kokwaro, J.O. (1993). Medicinal plants of East Africa. 2nd Ed. Kenya Literature Bureau, Nairobi, Kenya. 401 pp.

Kokwaro, J.O. (1991). Conservation of medicinal plants in Kenya. In: Conservation of medicinal plants (ed. by O. Akerele, V. Heywood and H. Synge), pp 315 - 319. Cambridge University Press.

Konoshima, T., Okamoto, E. and Kozuka, M. (1988). Studies of skin tumour III. Inhibitors effects of isoflavonoids from *Wisteria brachybotrys* of epstein-barr virus activation. Journal of Natural Products, 51:1266-1270.

Kothari, B. (2003). The invisible queen in the plant Kingdom: gender perspectives in medical ethnobotany. In: Women and plants: gender relations in biodiversity conservation and management (ed. by P.L. Howard), pp 150 – 164. Zed Book Ltd, London. 298 pp.

Krishnavaneni, K.S. and Rao, J.V.S. (2000). An isoflavone from *Pterocarpus santalinus*. Phytochemistry, 53: 605 – 606.

Kumar, N. and Seshadri, T.R. (1976). A new triterpene from *Pterocarpus santalinus* bark. Phytochemistry, 15: 1417 – 1418.

Kumar, N., Ravindernath, B. and Seshadri, T.R. (1974). Terpenoids of *Pterocarpus santalinus* heartwood. Phytochemistry, 13: 633 – 636.

Krukoff, B.A., Marini-Bettolo, G.B. and Bisset, N.G. (1972). American species of *Strychnos*. Lloydia, 35: 193–271.

Lamartiniere, C.A. (2000). Protection against breast cancer with genistein: a component of soy. American Journal of Clinical Nutrition, 71:1705-1707.

Lambert, J., Srivastava, J. and Vietmeyer, N. (1997). Medicinal plants: rescuing a global heritage. World Bank Technical Paper, 025-7494, 355: 1 – 61.

Lange D. (1998). Europe's medicinal and aromatic plants: their use, trade and conservation: an overview. TRAFFIC International, Cambridge, UK.

Lange, D. and Schippmann, U. (1997). Trade survey of medicinal plants in Germany: a contribution to international plant species conservation. Bundesamt für Naturschutz, Bonn.

Lansiaux, A., Bailly, C., Houssier, C., Colson, P., Pauw-Gillet, M.C., Frederich, M., Tits, M. and Angenot, L. (2002). Apoptosis of HL-60 Leukemia cells induced by the bisindole alkaloids sungucine and isosungucine from *Strychnos icaja*. Planta Medica, 68: 591 – 595.

Lapcik, O., Klejdus, B., Kokoska, L., Davidova, M., Afandi, K., Kuba, V. and Hampl, R. (2005). Identification of *Acca sellowiana* and two *Psidium* species (Myrtaceae). Biochemical Systematics and Ecology, 33: 963 – 992.

Lavin, M., Pennington, R.T., Klitgaard, B.B., Sprent, J.I., Lima, H.C. & Gasson, P.E. (2001). The dalbergioid legumes (Fabaceae): delimitation of a pantropical monophyletic clade. American Journal of Botany, 88: 503 – 533.

Lawton, R.M. (1982). Natural resources of miombo woodlands and recent changes in agricultural and land use practices. Forest Ecology and Management, 4: 285–297.

Leanman, D.J., Fassil, H. and Thornmann, I. (1999). Conserving medicinal plant species identifying the contribution of international plants genetic resource institute (IPGRI). IPGRI unpublished report.

Leeuwenberg, A.J.M. (1969). The Loganiaceae of Africa VIII. *Strychnos* III. Revision of the African species with notes on the extra-African. Meded. Landbouwhogescholl Wageningen, 69: 1 – 316.

Leeuwenberg, A.J.M. and Lenhouts, P.W. (1980). Loganiaceae In: Engler and Prantl's Die natürlichen Pflanzen-familien, fam. Loganiaceae, volume 28b (1), pp 211 – 237. Duncker and Humblot, Berlin, Germany.

Letcher, R.M. and Shirley, I.M. (1976). Phenolic compounds from the heartwood of *Dalbergia nitidula*. Phytochemistry, 15: 353 – 354.

Letšela, T., Witkowski, E.T.F. and Balkwill, K. (2003). Plant resources used for subsistence in Tsehlanyane and Bokong in Lesotho. Economic Botany, 57: 619 – 639.

Lewis, G.P. (1987). Legumes of Bahia. Royal Botanic Gardens, Kew. 369 pp.

Liu, Y. and Abreu, P.J.M. (2006). Long chain akyl and alkenyl phenols from the roots of *Ozoroa insignis*. Journal of Brazilian Chemical Society, 17: 527–532.

Luoga, E. J., Witkowski, E. T. F. and Balkwill, K. (2004). Regeneration by coppicing (resprouting) of miombo (African savanna) trees in relation to land use. Forest Ecology and Management, 189: 23 – 25.

Luoga, E. J., Witkowski, E. T. F. and Balkwill, K. (2000a). Differential utilization and ethnobotany of trees in Kitulanghalo forest reserve and surrounding communal lands. Eastern Tanzania. Economic Botany, 54: 328 – 343.

Luoga, E.J., Witkowski, E.T.F. and Balkwill, K. (2000c). Subsistence use of wood products and shifting cultivation within miombo woodland of Eastern Tanzania, with some notes on commercial uses. South African Journal of Botany, 66: 72 – 85.

Luyengi, L., Lee., I., Mar, M., Fong, H.H.S., Pezzuto, J.M. and Kinghorn, A.D. (1994). Rotenoids and chalcones from *Mundulea sericea* that inhibit phorbol ester-induced orthinine decarboxylase activity. Phytochemistry, 36: 1523 – 1526.

Lykke A.M. (1998). Assessment of species composition and change in savanna vegetation by means of woody plants' size class distributions and local information. Biodiversity and Conservation, 7: 1261–1275.

Magurran, A.E. (2004). Measuring biodiversity. Blackwell Publishers. Malden. 256 pp.

Mahunnah, R.L.A. and Mshigeni, K.E. (1996). Tanzania's policy on biodiversity prospecting and drug discovery programs. Journal of Ethnopharmacology, 51: 221–228.

Mahunnah, R.L.A. (1992). Utilization and conservation of medicinal plants in Tanzania. Proceedings of the first national workshop on plant genetic resources and biotechnology, Arusha, Tanzania. Benedictine Publications Ltd., Peramiho, Tanzania. pp 280 –290.

Mahunnah, R.L.A. (1990). Utilization and conservation of medicinal plants in Tanzania. Proceedings of the Workshop on Plants Genetic Resources and Biotechnology. Benedict Publications, Peramiho, Tanzania. pp 280 – 289.

Makaranga, J.J., Henry, L., Jonker, S.A. and Nkunya, M.H.H. (2003). The caulindoles: dimeric prenylindoles from *Isolona cauliflora*. Phytochemistry, 65: 227-232.

Makonda, F.B.S., Ishengoma, R.C. and Hamza, K.F.S. (2000). Traditional Medicinal Plants of Geita, Bagamoyo and Kilosa districts, Tanzania. Paper presented to the African Academy of Sciences, 2nd symposium on Recent Advances in Forestry Research and Management in Africa, 16 – 20th September 2000. Addis Ababa, Ethiopia. 5 pp.

Mander, M. (1998). Marketing of indigenous medicinal plants in South Africa: a case study of Kwazulu Natal. FAO, Rome. 151 pp.

Marcelin, T.M., Ndam, N. and Bell, J.M. (2000). Medicinal tree needs sustainability cure. ITTO Newsletter, 99: 16 – 17.

Marini-Bettolo, G.B., Ciasca, M.A., Galeffi, C., Bisset, N.G. and Krukoff, B.A. (1972). The occurrence of strychnine and brucine in an American species of *Strychnos*. Phytochemistry, 381–384.

Martin, G.J. (2004). Ethnobotany: a people and plants conservation manual. Earth scans Publications, UK. 292 pp.

Mathabe, M.C., Nikolova, R.V., Lall, N. and Nyazemac, N.Z. (2006). Antibacterial activities of medicinal plants used for the treatment of diarrhoea in Limpopo Province, South Africa. Journal of Ethnopharmacology, 105: 286–293.

Maundu, P., Kariuk, P. and Eyog-Matig, O. (2004). Threats to medicinal plant species: an African perspective. Proceedings of a global synthesis on 'Biodiversity loss and species extinction: managing the risk in a changing World'. Sub theme: conserving medicinal species- securing a health future, 17^{th} – 25^{th} November, 2004. Bangkok, Indonesia. 17 pp.

Maximillian, J.R., Luoga, E.J., O'kting'ati, A. and Monela, G.C. (2001). Value of medicinal plants and role in primary health care of local communities: a case of Kongowe ward, Kibaha District, Tanzania. Tanzania Journal of Forestry and Nature Conservation, 74: 117 – 133.

Mazur, W.M., Duke, J.A., Wahala, K., Rasku, S. and Herman, A. (1998). Isoflavonoids and lignan in legumes: nutritional and health aspects in humans. Journal of Nutritional Biochemistry, 9: 193 – 200.

Mbuya, L.P., Msanga, H.P., Ruffo, C.K., Birnie, A. and Tengnas, B. (1994). Useful trees and shrubs for Tanzania. Regional Soil Conservation Unit (RSCU), Swedish International Development Authority.

Mbwambo, R.L. (2000). Species utilization preferences and resource potential of miombo woodlands: a case of selected villages in Tabora, Tanzania. MSc Thesis, University of Stellenbosch, South Africa. 100 pp.

Mbwambo, R.L. and Mwiga, G. (1999). Botanical survey in the Miombo woodlands: a case of Urumwa and Igombe Forest Reserves, Tabora. TAFORI Newsletter 2: 10 – 13.

Mbwambo, Z.H., Apers, S., Moshi, M.J., Kapingu, M.C., van Miert, S, Claeys, M., Brun, R., Cos, P., Pieters, L. and Vlietinck, A. (2004). Anthranoids compounds with antiprotozoal activity from *Vismia orientalis*. Planta Medica, 70:706-710.

Meadows, K. And Sutherland, A. (2000). Addressing gender in renewable natural resources knowledge strategies. Socio-economic methodologies for natural resources research best practices guidelines. Natural Resources Institute, UK. 18 pp.

Medius, K. (1998). Medicinal plants and herbalist preferences around Bwindi Impenetrable Forest, Uganda. A dissertation submitted for award of Master of Science (Botany) at Makerere University, Uganda. 71 pp.

Mhame, P.P. (2000). The role of traditional knowledge (TK) in the national economy: importance and scope of TK particularly traditional medicine in Tanzania. A poster presented to the expert meeting on systems and national experiences for protecting traditional knowledge, innovations and practices, 30th October to 1st November, 2000, Geneva, France. 4pp.

Militão, G.C.G, Jimenez, P.C., Wilke, D.V., Pessoa, C., Falcão, M.J.C., Lima, M.A.S., Silveira, E.R., de Moraes, M.O. and Costa-Lutufo, L.V. (2005). Antimitotic properties of pterocarpans isolated from *Platymiscium floribundum* on Sea Urchin eggs. Planta Medica, 71: 683 – 685.

Millogo, A., Ratsimbazafy, V., Nubukpo, P., Barro, S., Zongo, I. and Preux, P.M. (2004). Epilepsy and traditional medicine in Bobo-Dioulasso (Burkina Faso). Acta Neurologica Scandinavica, 109: 250 – 254.

Mitra, J. and Joshi, T. (1983). Isoflavonoids from the heartwood of *Pterocarpus marsupium*. Phytochemistry, 22: 2326–2327.

MNRT (1998). National forest policy. Government Printer, Dar es salaam, Tanzania. 59pp.

Mohan, P. and Joshi, T. (1989). Two anthochlor pigments from heartwood of *Pterocarpus marsupium*. Phytochemistry, 28: 2529–2530.

Mølgaard, P., Nielsen, S.B., Rasmussen, D.E., Drummond, R.B., Makaza, N. and Andreassen, J. (2001). Anthelminthic screening of Zimbabwean plants traditionally used against Schistosomiasis. Journal of Ethnopharmacology, 74: 257–264.

Monela, G.C., O'kting'ati, A. and Kiwele, P.M. (1993). Socio-economic aspects of charcoal consumption and environemental consequences along Dar es salaam-Morogoro highway, Tanzania. Forest Ecology and Management, 58: 249 – 258.

Morah, F.N. (2000). Fruits terpenoids and fatty acids of *S. spinosa*. Global Journal of Pure and Applied Sciences, 6: 57-59.

Moshi, M.J. and Mbwambo, Z.H. (2005). Some pharmacological properties of extracts of *Terminalia sericea* roots. Journal of Ethnopharmacology, 97: 43 – 47.

Moshi, M.J., Mbwambo, Z.H., Nondo, R.S.O., Masimba, P.J., Kamuhabwa, A., Kapingu, M.C., Thomsa, P. and Richard, M. (2006). Evaluation of ethnomedical claims and brine shrimp toxicity of some plants used in Tanzania as traditional medicines. African Journal of Traditions, Complementary and Alternative Medicine, 3: 48 – 58.

Moshi, M.J., Kagashe, G.A.B. and Mbwambo, Z.H. (2005). Plants used to treat epilepsy in Tanzania by traditional healers. Journal of Ethnopharmacology, 97: 327 – 336.

Moshi, M.J., Joseph, C.C., Innocent, E. and Nkunya, M.H.H. (2004). *In vitro* antibacterial and antifungal activities of extracts and compounds from *Uvaria scheffleri*. Pharmaceutical Biology, 42: 269 – 273.

Msonthi, J.D., Galeffi, C., Nicoletti, M., Messana, I. and Marini-Bettolo, G.B. (1985). Kingside aglucone, a natural secoiridoid from unripe fruits of *Strychnos spinosa*. Phytochemistry, 24: 771-772.

Mulholland, D.A. (2005). The future of ethnopharmacology: a southern African perspective. Journal of Ethnopharmacology, 100: 124–126.

Müller-Jakic, B., Müller, M., Pröbstle, A., Johns, T.A. and Bauer, R. (1993). Anti-inflammatory activity of *Zanthoxylum chalybeum* extracts and identification of protoberberine and benzoberberine alkaloids by GC-MS and HPLC. Planta Medica, 59: 664.

Musila, W., Kisangau, D. and Muema, J. (2004). Conservation status and use of medicinal plants by traditional medical practitioners in Machakos District, Kenya. Proceedings of the International Indigenous Knowledge Conference: transforming the academy, held from 27th – 29th May 2004 at the Pennyslvania State University. 8 pp.

Mutasa, S.L. and Khan, M.R. (1995). Phytochemical investigations of *Cassia abbreviata*. Fitoterapia, 66: 184.

Mutasa, S.L. and Khan, M.R. (1993). Constituents of *Cassia petersiana*. Fitoterapia, 64:186-187.

Mutayabarwa, C.K., Sayi, J.G.M. and Dade, M. (2003). Hypoglycaemic activity of *Centella asiatica* (L) Urb. East and Central African Journal of Pharmaceutical Sciences, 6: 30 – 35.

Mwaluka, K., Arthur Bell, E, Barry, V, Charlwood, B.V. and Briggs, J.M. (1975). *N*-methyl-L-tyrosine from seeds of *Combretum zeyheri*. Phytochemistry, 14: 1657 – 1658.

Nabhan, G.P., Joaquin Jr. A., Loney, N. and Dahl, K. (1996). Sharing the benefits of plant resources and indigenous scientific knowledge. In: Valuing local knowledge: indigenous people and intellectual property rights (ed by S.B. Brush and D. Stanbisky), pp 186 – 208. Island Press, Washington DC. 323 pp.

Nagaraju, N. and Rao, K.N. (1989). Folk medicine for diabetes from Rayalaseema of Andhra Pradesh. Ancient Science of Life, 91: 31–35.

Nagaraju, N., Prasad, M., Gopalakrishna, G. and Rao, K.N. (1991). Blood sugar lowering effect of *Pterocarpus santalinus* (red sanders) wood extracts in different at models. International Journal of Pharmacognosy, 29: 141–144.

Narayan, S., Devi, R.S., Srinivasan, P. and Shymala, D.C.S. (2005). *Pterocarpus santalinus*: a traditional herbal drug as a protectant against ibuprofen induced gastric ulcers. Phytotherapy Research, 19: 958 – 962.

Naur, M. (2003). Indigenous knowledge and HIV/AIDS: Ghana and Zambia. Indigenous Knowledge (IK) Notes, 30: 1 – 4.

Ndamba, J., Nyazema, N., Makaza, N., Anderson, C. and Kaondera, K.C. (1994). Traditional herbal remedies used for the treatment of urinary schistosomiasis in Zimbabwe. Journal of Ethnopharmacology, 42: 125-132.

Ndubani, P. and Hojer, B. (1999). Traditional healers and the treatment of sexually transmitted illnesses in rural Zambia. Journal of Ethnopharmacology, 67: 15–25.

Nel, R.J.J., Mthembu, M., Coetzee, J., van Rensburg, H, Malan, E. and Ferreira, D. (1999). The novel Flavan-3-ol, (2R, 3S)-guibourtinidol and its diastereomers. Phytochemistry, 52: 1153 – 1158.

Nestel, P., Fuji, A. and Zhang, L. (2006). An isoflavone metabolite reduces arterial stiffness and blood pressure in over weight men and postmenopausal women. Arteriosclerosis *(In Press)*.

Neuwinger, H.D. (1996). African ethnobotany: poisons and drugs: chemistry, pharmacology and toxicology. Chapman and Hall, London. 941 pp.

Newton, A., Oldifield, S., Fragoso, G., Mathew, P. Miles, L. and Edwards, M. (2003). Towards a global tree conservation Atlas: mapping the status and distribution of the world's threatened tree species. UNEP-WCMC/FFI, Banson Production, UK. 20 pp.

Nishida, T. and Uehara, S. (1983). Natural diet of chimpanzees (*Pan Troglodyte's schweinfurthii*): long-term record from the Mahale Mountains, Tanzania. African Studies Monographs, 3: 109 – 130.

Nishiyama, Y., Moriyasu, M., Ichimaru, M., Iwasa, K., Kato, A., Mathenge, S.G., Mutiso, P.C.B. and Juma, F.D. (2004). Isoquinoline alkaloids from *Xylopia parviflora*. Phytochemistry, 65: 939 – 944.

Nkunya, M.H.H., Jonker, S.A., Gelder, R.de, Wachira, S.W., Kihampa, C. (2004). (±) Schefflone: a trimeric monoterpenoid from the root bark of *Uvaria scheffleri*. Phytochemistry, 65: 399 - 404.

Nkunya, M.H.H., Weenen, H., Renner, C., Waibel, R., Achenbach, H. (1993). Benzylated dihydrochalcones from *Uvaria leptocladon*. Phytochemistry, 32: 1297 - 1300.

Oduol, P.A., Swai, R. and Mbwambo, L. (2004). Valualization of miombo biodiversity for poverty alleviation and food security. Paper presented at the 4th Regional session of the global biodiversity forum for Africa: biodiversity and livelihoods in Africa – delivering on the millennium development goals, 11th June 2004. 6 pp.

Ogle, B.M. and Grivetti, L.E. (1985). Edible wild plants in the Kingdom of Swaziland, Southern Africa: a cultural, ecological and nutritional study. Ecology of Food and Nutrition, 16: 193-208.

Oguakwa, J., Galeffi, C., Nicoletti, M., Messana, I., Patamia, M., Marini-Bettelo, G.B. (1980). On the alkaloids of *Strychnos*. 34. The alkaloids of *Strychnos spinosa* Lam. Gazzetta Chimica Italiana, 110: 97 – 100.

Ohiri, F.C., Verpoorte, R. and Baerheim, S.A. (1984). 12-Hydroxy-11-methoxydiaboline: a new alkaloid from *Strychnos spinosa* (stem bark). Planta Medica, 50: 446 – 447.

Ohiri, F.C., Verpoorte, R. and Baerheim Svendsen, A. (1983). The African *Strychnos* species and their alkaloids. Ethnopharmacology, 9: 167 – 223.

Okine, L.K.N., Nyarko, A.K., Osei-Kwabena, N., Oppong, I.V., Barnes, F. and Ofosuhene, M. (2005). The antidiabetic activity of the herbal preparation ADD-199 in mice: a comparative study with two oral hypoglycemic drugs. Journal of Ethnopharmacology, 97: 31 – 38.

Okullo, J.B.L. (2004). *Vitellaria paradoxa* in Uganda: population structures and reproductive characteristics. PhD thesis, University of Wales, Bangor, UK. 303 pp.

Pace, C.J., Glick, S.D., Maisonneuve, I.M., He, L.W., Jokiel, P.A., Kuehne, M.E. and Fleck, M.W. (2004). Novel iboga alkaloid congeners block nicotinic receptors and reduce drug self-administration. European Journal of Pharmacology, 492: 159-167.

Padua, L.S. de, Bunyapraphatsara, N. and Lemmens, R.H.M.J. (1999 – 2003). Medicinal and poisonous plants 1. Plant resources of South-East Asia, 12(1-3). Pudoc, Wageningen.

Palgrave, K.C. (1988). Tree of Southern Africa. 2nd Edition. Struik Publishers. 959 pp.

Pank, F. (1998). Der Arznei- und Gewürzpflanzenmarkt in der EU. Zeitschrift für Arznei- und Gewürzpflanzen, 3: 77-81.

Pauli, N.M. and Séquin, U. (1996). Synthesis of Flavonol Glycosides isolated from the leaves of *Boscia salicifolia* Oliv. Molecules, 1: 15 – 22.

Perrings, C. and Lovett, J. (1999). Policies for biodiversity conservation: the case of Sub-Saharan Africa. International Affairs, 75: 281 – 305.

Peters, C.M. (1994). Sustainable harvest of non-timber plant resources in tropical moist forest: an ecological primer. Biodiversity Support Program, Washington, DC. 26 pp.

Polhill, R.M. (1971). Dalbergieae. In: Flora of tropical East Africa: leguminosae subfamily Papilionoideae (ed by J.B. Gillett, R.M. Polhill and B. Verdcourt), pp 61- 121. Crown Agents, London. 1109 pp.

Polkowski, K. and Mazurek, A.P. (2000). Biological properties of genistein. A review of in vitro and in vivo data. Acta Poloniae Pharmaceutica, 57: 135-55.

Prasain, J.K., Jones, K., Kirk, M., Wilson, L., Smith-Johnson, M., Weaver, C., Barnes, S. (2003). Profiling and quantification of isoflavonoids in kudzu dietary supplements by high performance liquid chromatography and electrospray ionization tandem mass spectrometry. Journal of Agriculture and Food Chemistry, 51: 4213–4218.

Quetin-Leclercq, J., Angenot, L. and Bisset, N.G. (1990). Southern American *Strychnos* species. Ethnobotany (except curare) and alkaloids screening. Journal of Ethnopharmacology, 28: 1 – 52.

Rao, C.P. and Krupadanam, G.L.D. (1994). An isoflavans from *Milletia racemosa*. Phytochemistry, 35: 1597 – 1599.

Rea, A.I., Schmidt, J.M., Setzer, W.N., Sibanda, S., Taylor, C. and Gwebu, E.T. (2000). Cytotoxic activity of *Ozoroa insignis* from Zimbabwe. Fitoterapia, 74: 732–735.

Rojo, J.P. (1977). Pantropic speciation of *Pterocarpus* (Leguminosae-Papilionaceae) and the Malesia-Pacific species. Pterocarpus, 3: 19 – 31.

Rojo, J. P. (1972). *Pterocarpus* (Leguminosae - Papilionaceae) revised for the world. Phanerogamarum Monographiae, 5: 1 - 120. Cramer, Lehre.

Rojo, J.P. and Alonzo, D.S. (1993). *Pterocarpus* Jacq. In: Timber trees: major commercial timbers (ed by I. Soerianegara and R.H.M.J. Lemmens), pp. 374 – 379. Plant resources of south-east Asia, 5(1). Pudoc, Wageningen. 610 pp.

Rolfsen, W., Kakizadeh, Z.A., Sandberg, F. and Strombom, J. (1979). Pharmacological and phytochemical screening of *Strychnos* species from Gabon. Acta Pharmaceutica Seucica, 16: 47.

Rosser, A.M. and Haywood, M. (2002). Guidance for CITES scientific authorities: checklist to assist in making non-detriment findings for Appendix II Experts. Occasional Paper of the IUCN Species Survival Commission No. 27. Gland/Cambridge. 145 pp.

Rouessac, F. and Rouessac, A. (2000). Chemical Analysis: Modern Instrumental Methods and Techniques. John Wiley and Sons Ltd. Chichester, New York. 445 pp.

Ruffo, C.K., Birnie, A. and Tengnas, B. (2002). Edible wild plants of Tanzania. Technical Handbook No 27. Regional Land Management Unit (RELMA)/Swedish International Development Coorperation Agency (SIDA). 766 pp.

Ruffo, C.K. (1990). A survey of medicinal plants in Tabora Region, Tanzania. Proceedings of a workshop on traditional medicine in developing countries held from 9 – 10 March 1990, Arusha, Tanzania. pp 155 – 168.

Ruffo, C.K., Mwasha, I.V. and Marie, C. (1989). Medicinal plants in the East Usambara. In: Forest Conservation in the East Usambara Mountains, Tanzania (ed. by A.C. Hamilton and R. Bensted-Smith), pp 195-206. Switzerland and Cambridge Press, UK.

Rulangaranga, Z.K. (1991). Some important indigenous medicinal and aromatic plants in the wild flora of Tanzania Mainland. Tropical Forestry Action Plan, Working Paper 24. Tanzania Ministry of Lands, Natural Resources and Tourism. Dar es salaam, Tanzania.

Runyoro, D.K.B., Ngassapa, O.D., Matee, M.I.N., Joseph, C.C. and Moshi, M.J. (2006). Medicinal plants used by Tanzania traditional healers in the management of Candida infections. Journal of Ethnopharmacology, 106: 158 – 165.

Russell-Smith, J., Karunaratne, N.S. and Mahindapala, R. (2006). Rapid inventory of wild medicinal plants population in Sri-Lanka. Biological Conservation, 132: 22 – 32.

Samulesson, G. (1992). Drugs of natural origin. Swedish Pharmaceutical Press, Stockholm. 282 pp.

Sandberg, F., Roos, K., Ryrberg, K. and Kristianson, K. (1968). A new alkaloid 4-hydroxy-strychnine from African species *Strychnos icaja* Baill. Tetrahedron Letters, 59: 6217 – 6218.

Sandberg, F., Lunnel, E. and Ryrberg, K.J. (1969b). Pharmacological and phytochemical investigations of African *Strychnos* species. Acta Pharmaceutica Suecica, 6: 79 – 102.

Sapi, J. and Massiot, G. (1994). The *Strychnos* alkaloids. In: Monoterpenoid indole alkaloids: supplementary to part 4 (ed. by J.E. Saxton), pp 279 – 355. Wiley, Chichester. 848 pp.

Saxton, J.E. (1994). Monoterpenoid indole alkaloids. Supplement to part 4. John Wiley and Sons, Chichester. 848 pp.

Scudder, T. and Conelly, T. (1985). Management systems for fisheries. IDA Report.

Seshadri, T.R. (1972). Polyphenols of *Pterocarpus* and *Dalbergia* woods, Phytochemistry, 11: 881–898.

Shackleton, S. and Willis, C. (2000). Community involvement in forestry management: whose stake in forest management? The case of South Africa. A background paper. Division of Water, Environment and Forestry Technology, CSIR, Pretoria, South Africa. 56 pp.

Sheldon, J.W., Balick, M.J. and Laird, S.A. 1997. Medicinal plants: can utilization and conservation coexist? Advances in Economic Botany, 12: 1 – 104.

Schultz, C.D. and Company (1973). Indigenous forest inventory of five areas of the Republic of Tanzania. Volume 2. Tables of project data. C.D. Schultz and Company, Vancouver. 369 pp.

Singhal, R. (2005). Medicinal plants and primary health care: the role of gender. Journal of Health Management, 7: 277 – 293.

Sofowora, A. (1993). Recent trends in research into African medicinal plants. Journal of Ethnopharmacology, 38:197 – 208.

Sokal, R. and Rohlf, F.J. (1995). Biometry. W.H. Freeman and Company, New York

Southon, I.W. and Buckingham, J. (1989). Dictionary of alkaloids. Chapman and Hall, London. 1850 pp.

Southon, I.W., Brisby, F.A., Buckingham, J. and Harborne, J.B. (1994a). Phytochemical dictionary of the Leguminosae.Volume I. Plants and their constituents. Chapman and Hall, London. 1051 pp.

Southon, I.W., Bisby, F.A., Buckingham, J. and Harborne, J.B. (1994b). Phytochemical dictionary of the Leguminosae.Volume II. Chemical constituents. Chapman and Hall, London. 573 pp.

Strang, R.M. (1974). Some man-made changes in successional trends on the Rhodesian Highveld. Journal of Applied Ecology, 11: 249 – 263.

Srivastava, J., Lambert, J. and Vietmeyer, N. (1996). Medicinal plants. An expanding role in development. World Bank Technical Paper No. 320. Washington, DC, USA, World Bank.

Stahl, R.S., Arjo, W.M., Wagner, K.K., Furcolow, C., Nolte, D.L. and Johnston, J.J. (2004). Development of a high performance liquid chromatography/mass spectroscopy method for the determination of strychnine in insects used to assess potential risks to insectovores. Journal of Chromatography B, 811: 257–262.

Stromgaard, P. (1985). Biomass, growth and burning of woodlands in a shifting cultivation area of southern-central Africa. Forest Ecology and Management, 12: 163 – 175.

Sumner, L.W., Mendes, P., Dixon, R.A. (2003). Plant metabolomics: large scale phytochemistry in the functional genomics era. Phytochemistry, 62: 817–836.

Suzuki, A. (1969). Ecological study of Chimpanzees. Primates, 10: 103 – 148.

Tabuti, J.R.S., Lye, K.A. and Dhillion, S.S. (2003a). Traditional herbal drugs of Bulamogi, Uganda: plants, uses and administration. Journal of Ethnopharmacology, 88: 19 – 44.

Talhouk, S.N., Lorbach, I. and Karmann, M. (2001). Gender knowledge about NTFPs. European Tropical Forest Research Network (ETFRN) Newsletter, 32: 27-29.

Teklehaimanot, Z. (2004). Exploiting the potential of indigenous agroforestry trees: *Parkia biglobosa* and *Vitellaria paradoxa* in sub-Saharan Africa. Agroforestry Systems, 61: 207 – 220.

Temu, A.E. and Lazaro, E. A. (2000). Introduction to research and survey methodology. A teaching compendium for BSc. (Agribusiness). Sokoine University of Agriculture, Morogoro, Tanzania. 31 pp.

Tesfu, B.C., Mengistu, B., Welde-Aregay, G. (1995). Women lead in protecting food germplasm and herbs for health in Ethiopia. Report submitted to Earth Care Africa, Nairobi, Kenya.

Thongphasuk, P., Suttisri, R., Bavovada, R. and Verpoorte, R. (2003). Alkaloids and a pimarane diterpenoid from *Strychnos vanprukii*. Phytochemistry, 64: 897-901.

Tikhomiroff, C. and Jolicoeur, M. (2002). Screening of *Catharanthus roseus* secondary metabolites by high-performance liquid chromatography. Journal of Chromatography A, 955: 87-93.

Tits, M., Damas, J., Quetin-Leclercq, J. and Angenot, L. (1991). From ethnobotanical uses of *Strychnos henningsii* to anti-inflammatory, analgesics and antispasmodics. Journal of Ethnopharmacology, 34: 261–267.

Tutuariana, J. and Tauran, C. (1997). Women's participation in sustainable forestry development in Indonesia. In: Proceedings. of the XI World Forestry Congress 13 – 22 October 1996. Antalya, Turkey. Vol. 5. 137pp.

Tyler, V.E. (2000). Herbal medicine from the past to the future. Public Health Nutrition, 3: 447 – 452.

UNCTAD (2000). Systems and national experiences for protecting traditional knowledge, innovations and practices. United Nations Conference on Trade and Development. Background note by the UNCTAD Secretariat. Geneva.

UNEP-WCMC (2005). Species database: CITES-listed species. Available online at http://www.cites.org/. Accessed April 2005.

Uniyal R.C. (2000). Research for 'medicinal plants cultivation in India – a reference book'. In: Medicinal plants stakeholders' meeting. TRAFFIC-India, New Delhi, India.

Urio, R.M.E., Gillah, P.R. and Ishengoma, R.C. (1996). Medicinal trees and practices in north eastern Tanzania. A poster presented at FAO workshop, on domestication of indigenous trees, Nairobi, Kenya.

URT (1998). Social economic profile of Tabora Region. The Planning Commission, Dar es salaam, Tanzania. 183 pp.

URT (1991). Population census national profile. Bureau of Statistics, President's Office Planning Commission, Dar es Salaam

van Wyk, B. and Wink, M. (2004). Medicinal plants of the World: an illustrated scientific guide to important medicinal plants and their uses. BRIZA Publications, Pretoria, South Africa. 480 pp.

Verdrengh, M., Jonsson, I.M., Holmdahl, R. and Tarkowski, A. (2003). Genistein as an anti-inflammatory agent. Biomedical and Life Sciences and Medicine, 52: 341 – 346.

Verroken, M. (2000). Drug use and abuse in sports. Bailliere's Clinical Endocrinolgy and Metabolism, 14: 1 -23.

von Maydell, H.J. (1990). Trees and shrubs of the Sahel: their characteristics and uses. Verglaf Josef Margraf Sceintfic books, Germany. 525 pp.

Wang, T.T., Sathyamoorthy, N. and Phang, J.M. (1996). Molecular effects of genistein on oestrogen receptor mediated pathways. Carcinogenesis, 17:271-275.

Walter, A. and Séquin, U. (1990). Flavonoids from leaves of *Boscia salicifolia*. Phytochemistry, 29: 2561-2563.

Wei, H., Bowen, R. and Cai, Q. (1995). Antioxidant and antipromotional effects of the soybean isoflavone genistein. Proceedings of the Society for Experimental Biology and Medicine, 208: 124-130.

Wei-dong, L., Yu-ming, K., Miu, H. and Quan, Z. (2001). The inhibitory effects of homopterocarpin and medicarpin on human liver cancer cells in vitro. Journal of Shenyang Pharmaceutical University, 18: 211 - 212.

White, F. 1983. The vegetation of Africa. UNESCO Natural Resources Research No. 20. UNESCO, Paris. 356 pp.

WHO (2005). National policy on traditional medicine and regulation of herbal medicine. Report of WHO global survey. World Health Organization, Geneva. 168 pp.

WHO (2002). WHO traditional medicine strategy 2002 – 2005. World Health Organization. Geveva, Switzerland. 74 pp.

WHO Monographs (1999). WHO Monographs of selected medicinal plants, vol. 1. WHO, Geneva, Switzerland.

WHO Monographs (2002). WHO Monographs of Selected Medicinal Plants, vol. 2. WHO, Geneva, Switzerland.

World Anti-Doping Agency (WADA) (2005). Prohibited list and Minimum required performance limits for detection of prohibited substances, TD2004MRPL, version number 1.0. Available at: http://www.wada-ama.org

Williams, V.L.W., Balkwill, K. and Witkowski, E.T.F.W. (2000). Unravelling the commercial markets for medicinal plant and plant parts on the Witwatersrand, South Africa. Economic Botany, 54: 310 – 327.

Williams, V.L., Balkwill, K. and Witkowski, E.T.F. (1997). Muthi traders on the Witwatersrand, South Africa: an urban mosaic. South African Journal of Botany, 63: 378 - 381.

Williams, V.L. (1996). The Witwatersrand muti trade. Veld and Flora, 82: 12 – 14.

Wins, P., Margineanu, I., Penelle, J., Angenot, L., Grisar, T. and Bettendorff, L. (2003). Bisindole alkaloids from *Strychnos guianensis* are effective antagonists of nicotinic acetylcholine receptors in cultured human TE671 cells. Naunyn-Schmiedeberg's Archives of Pharmacology, 367: 253 – 259.

Wrangham, R.W. (1977). Feeding behaviour of Chimpanzees in Gombe national park, Tanzania. In: Primate ecology: studies of feeding and ranging behaviour in Lemurs, Monkeys and Apes (ed by T.H. Clutton-Brock), pp. 481 – 501. Academic Press, New York. 643 pp.

Wright, C.W., Bray, D., O'Neill, H., Warhurst, D., Phillipson, J., Quetin-Leclerq, J. and Angenot, L. (1991). Antiamoebic and antiplasmodial activities of alkaloids isolated from *Strychnos usambarensis*. Planta Medica, 57: 337–340.

Wyk, V.B.E., Van O.E. and Gericke, N. (1997). Medicinal plants of South Africa. Briza, Pretoria. 304 pp.

Xiao, H.B., Krucker, M., Albert, K. and Liang, X.M. (2004). Determination and identification of isoflavonoids in *Radix astragali* by matrix solid-phase dispersion extraction and high-performance liquid chromatography with photodiode array and mass spectrometric detection. Journal of Chromatography, 1032: 117-124.

Zschocke, S., Rabe, T., Taylor, J.L.S., Jäger, J. and van Staden, J. (2000). Plant parts substitution–a way to conserve endangered medicinal plants? Journal of Ethnopharmacology, 71: 281 – 292.

Zhang, Y.G. and Huang, G.Z. (1988). Poisoning by toxic plants in China. Report of 19 autopsy cases. American Journal of Forensic Medicine and Pathology, 9: 313 – 319.

Zhang, Q.L., Xu, J.J., Lian, H.Z., Li, X.Y. and Chen, Y.H. (2005). Rapid separation of strychnine and brucine on a dynamically modified poly (dimethylsiloxane) microchip followed by electrochemical detection. Analytical and Bioanalytical Chemistry, 384: 265 – 270.

REFERENCES TO APPENDIX VIa

1. Akisanya, A., Bevan, C.W.L. and Hirst, J. (1959). West African timbers. Part II. Heartwood constituents of the genus *Pterocarpus*. Journal of Chemical Society, 1959: 2679 – 268.

2. Alegrio, L.V., Braz-Filho, R. and Gottlieb, O.R. (1989). Diarylheptanoids and isoflavonoids from *Centrolobium* species. Phytochemistry, 28: 2359 – 2362.

3. Arnone, A., Camarda, L., Merlini, L. and Nasini, G. (1975). Structures of the red sandalwood pigment santalins A and B. Journal of Chemical Society Perkin Transactions, 1: 186 -193.

4. Arnone, A., Camarda, L., Merlini, L., Nasini, G. and Taylor, D.A.H. (1977). Colouring matters of the West African red woods *Pterocarpus osun* and *P. soyauxii*. Structures of santarubins A and B. Journal of Chemical Society Perkin Transactions, 1: 2116 – 2118.

5. Ayensu, E. S. (1978). Medicinal plants of the West Indies. Unpublished manuscript. 110 pp.

6. Bahl, C.P., Parthasarathy, M.R.and Seshadri, T.R. (1968). Constitution of pterocarpol. Tetrahedron, 24: 6231 – 6235.

7. Bezuidenhoudt, B.C.B., Brandt, E.V., Roux, D.G. and van Rooyen, P.H. (1980). Novel a-methyldeoxybenzoins from the heartwood of *Pterocarpus angolensis* D.C.: absolute configuration and conformation of the first sesquiterpenylangolensis, and *X*-ray crystal structure of 4-*O*-a-cadinylangolensin. Journal of Chemical Society Perkin Transactions, 1: 2179 – 2183.

8. Bezuidenhoudt, B.C.B., Brandt, E.V. and Roux, D.G. (1981). A novel a-hydroxydihydrochalcone from the heartwood of *Pterocarpus angolensis* D.C.: absolute configuration, synthesis, photochemical transformations, and conversion into a-methyldeoxybenzoins. Journal of Chemical Society Perkin Transactions, 1: 263 – 269.

9. Bezuidenhoudt, B.C.B., Brandt, E.V. and Ferreira, D. (1987). Flavonoid analogues from *Pterocarpus* species. Phytochemistry, 26: 531 – 535.

10. Bevan, C.W.L. Ekong, D.E.U. and Okogun, J.I. (1966). West African timbers. Part XIII. Extracts from the heartwood of *Amphimas pterocarpoides* and *Pterocarpus erinaceus*. Journal of Chemical Society, 5C: 509 – 510.

11. Bhrara, S.C., Jain, A.C. and Seshadri, T.R. (1964). A new examination of the special components of *Pterocarpus indicus* heartwood. Current Science, 33: 303-303.

12. Biggs, R.P., Cooper, W.L., Hazleton, E.O., Nierenstein, M.and Price, P.H. (1931). Stereoisomeric catechins. Journal of American Chemical Society, 53: 1500 – 1505.

13. Braga O.A., Gottlieb, O.R. and Leite A.M.E. (1971). Extractives of *Tipuana tipu*. Phytochemistry, 10: 2552 – 2553.

14. Braga O.A., Fonseca S.L.G. and Gottlieb, O.R. (1972). Flavonoids and coumarins from *Platymiscium praecox*. Phytochemistry, 11: 3515 – 3519.

15. Burkill, J.D. (1966). A dictionary of the economic products of the Malay Peninsula. Ministry of Agriculture and Co-operatives, Kuala Lumpur. 2444 pp.

16. Chakravarthy, B.K. and Gode, K.D. (1985). Isolation of (-)-epicatechin from *Pterocarpus marsupium* and its pharmacological actions. Planta Medica, 1: 56 – 59.

17. Dictionary of Natural Products (1996). The dictionary of natural products on CD-ROM – version 2. Chapman and Hall/CRC Press. London.

18. Cooke, R.G. and Rae, I.D. (1964). Isoflavonoids. I. Some new constituents of *Pterocarpus indicus* heartwood. Australian Journal of Chemistry, 17: 379 – 384.

19. Daigle, D.J., Conkerton, E.J., Hammons, R.O. and Branch, W.D. (1985). The presence of 5, 7-dihydroxyisoflavone in peanuts by high performance liquid chromatography analyses. Peanut Science, 12: 60 - 62.

20. Douglass, C.D., Howard, W.L. and Wender, S.H. (1950). The isolation of quercitrin from peanut hulls. Journal of American Chemical Society, 72: 4177 – 4178.

21. Ebi, G.C. and Ofoefule, S.I. (2000). Antimicrobial activity of *Pterocarpus osun* stems. Fitoterapia, 71: 433- 435.

22. Ferreira, M.A., Moir, M. and Thomson, R.H. (1974). New pterocarpenes from Brya ebenus. Journal of Chemical Society Perkin Transactions, 1974: 2429 – 2435.

23. Gupta, V.N. and Seshadri, T.R. (1956). Special chemical components of commercial woods and related materials: Part III- *Pterocarpus indicus*. Journal of Scientific and Industrial Research, 15B: 146 – 149.

24. Groover, J.K., Yadav, S. and Vats, V. (2002). Medicinal plants of India with anti-diabetic potential. Journal of Ethnopharmacology, 81: 81 – 100.

25. Iwu, M.M. (1993). Handbook of African medicinal plants. CRC Press Inc. Florida, USA. 435 pp.

26. Jain, S.C., Sharma, S.K., Kumar, R., Rajwanshi, V.K. and Babu, B.R. (1970). A homoisoflavanone from *Pterocarpus marsupium*. Phytochemistry, 44: 765 – 766.

27. Janzen, D.H., Lynn, D.G., Fellows, L.E. and Hallwachs, W. (1982). The indole alkaloid, Hypaphorine and *Pterocarpus* seed protection. Phytochemistry, 21: 1035 – 1037.

28. Kesari, A.N., Gupta, R.K. and Watal, G. (2004). Two aurones glycosides from heartwood of *Pterocarpus santalinus*. Phytochemistry, 65: 3125 – 3129.

29. King, F.E. and Jurd, L. (1952). The chemistry of extractives from hardwoods. Part VIII. The isolation of 5,4'-dihydroxy-7-methoxyisoflavone (prunetin) from the heartwood of *Pterocarpus angolensis* and a synthesis of 7,4'-dihydroxy-5-methoxyisoflavone hitherto known as prunusetin. Journal of Chemical Society, 3693: 3211 – 3215.

30. King, F.E., King, T.J. and Warwick, A.J. (1952). The chemistry of extractives from hardwoods. Part VI. Constituents of Muninga, the heartwood of *Pterocarpus angolensis*, A.:6, 4'-dihydroxy-5, 7 - dimethoxyisoflavone (Muningin). Journal of Chemical Society, 1920: 96 – 100.

31. King, F.E., Cotterill, C.B., Godson, D.H., Jurd, L. and King, T.J. (1953). The chemistry of extractives from hardwoods. Part XIII. Colourless compounds of *Pterocarpus* species. Journal of Chemical Society, 1192: 3693 – 3697.

32. Krisha, M.A. (1969). The Wealth of India VIII. CSIR, New Delhi, India.

33. Krishnaveni, K.S. and Rao, J.V.S. (2000). An isoflavone from *Pterocarpus santalinus*. Phytochemistry, 53: 605 – 606.

34. Krishnaveni, K.S. and Rao, J.V.S. (2000). A new isoflavone glucoside from *Pterocarpus santalinus*. Journal of Asian Product Research, 2: 219 – 223.

35. Krishnaveni, K.S. and Rao, J.V.S. (2000). A new acylated isoflavone glucoside from *Pterocarpus santalinus*. Chemical and Pharmaceutical Bulletin, 48: 1373 – 1374.

36. Kumar, N. and Seshadri, T.R. (1974). Chemical components of *Pterocarpus santalinus* sapwood. Current Science, 43: 611 – 612.

37. Mathew, J. and Subba R.A.V. (1983). Carpusin: a novel 2-hydroxy-2-benzylcoumaranone from *Pterocarpus marsupium*. Phytochemistry, 22: 794 – 795.

38. Mathew, J. and Subba R.A.V. (1984). Propterol B, a further 1,3-diarylpropan-2-ol from *Pterocarpus marsupium*. Phytochemistry, 23: 1814 – 1815.

39. Mathew, J., Subba, R.A.V. and Rambhav, S. (1984). Propterol - an antibacterial agent from *Pterocarpus marsupium*. Current-Science, 53: 576-577.

40. Maurya, R., Ray, A.B., Duah, F.K., Slatkin, D.J. and Schiff Jr., P.L. (1984). Constituents of *Pterocarpus marsupium*. Journal of Natural Products 47: 179 – 181.

41. Maurya, R., Singh, R., Deepak, M., Handa, S.S., Yadav, P.P. and Mishra, P.K. (2004). Constituents of *Pterocarpus marsupium*: an ayuvendic crude drug. Phytochemistry, 65: 915 – 920.

42. Mitra, J. and Joshi, T. (1982). An isoflavone glycoside from the heartwood of *Pterocarpus marsupium*. Phytochemistry, 21: 2429 – 2430.

43. Mitra, J. and Joshi, T. (1983). Isoflavonoids from the heartwood of *Pterocarpus marsupium*. Phytochemistry, 22: 2326 – 2327.

44. Mohan, P. and Joshi, T. 1989. Two aurone glycosides from the flowers of *Pterocarpus marsupium*. Phytochemistry, 28: 1287 – 1288.

45. Morgan, J.W.W. and Orsler, R.J. (1967). Isolation of 7-methyltectorigenin from the heartwood of Muninga (*Pterocarpus angolensis*). Chemical Industry, 27: 1173 – 1174.

46. Nagaraju, N. and Rao, K.N. (1989). Folk medicine for diabetes from Rayalaseema of Andhra Pradesh. Ancient Science of Life, 91: 31–35.

47. Nagaraju, N., Prasad, M., Gopalakrishna, G. and Rao, K.N. (1991). Blood sugar lowering effect of *Pterocarpus santalinus* (red sanders) wood extract in different rat models. International Journal of Pharmacognosy 29: 141–144.

48. Ndamba, J., Nyazema, N., Makaza, N., Anderson, C. and Kaondera, K.C. (1994). Traditional herbal remedies used for the treatment of urinary schistosomiasis in Zimbabwe. Journal of Ethnopharmacology, 42: 125-132.

49. Parthasarathy, M.R. and Seshadri, T.R. (1965). Occurrence of β-Eudesmol and Pterocarpol in the heartwoods of *Pterocarpus indicus* and *P.macrocarpus*. Current Science, 34: 115 -115.

50. Parthasarathy, M.R., Puri, R.N. and Seshadri, T.R. (1969). New components of *Pterocarpus dalbergioides* heartwood. Indian Journal of Chemistry, 7: 118 – 120.

51. Perry, L.M. (1980). In: Medicinal plants of East and Southeast Asia: attributed properties and uses. MIT Press, Cambridge, Massachusetts and London. 224 pp.

52. Sawhney, P. L.. and Seshadri, T.R. (1954). Special chemical components of commercial woods and related plant materials: part I. The neutral components from heartwoods and sapwoods of *Pterocarpus dalbergioides* (Andaman Padauk) and *Pterocarpus macrocarpus* (Burma Padauk). Journal of Scientific and Industrial Research, 13B: 5 – 8.

53. Seshadri, T.R. (1972). Polyphenols of *Pterocarpus* and *Dalbergia* woods, Phytochemistry 11: 881–898.

54. Steenkamp, V., Mathivha, E., Gouws, M.C. and van Rensburg, C.E.J. (2004). Studies on antibacterial, antioxidant and fibroblast growth stimulation of wound healing remedies from South Africa. Journal of Ethnopharmacology, 95: 353-357.

55. Subba, R.A.V. and Mathew, J. (1982). Marsupol: a novel isoflavonoid glycol from *Pterocarpus marsupium.* Phytochemistry, 21: 1837 – 1838.

56. Subba, R.A.V., Mathew, J. and Sankaram, A.V.B. (1984). Propterol: A 1,3-diarylpropan-2-ol from *Pterocarpus marsupium.* Phytochemistry, 23: 897 – 898.

57. Tripathi, J and Joshi, T. (1988). Flavonoids from *Pterocarpus marsupium.* Planta Medica, 54: 371 – 372.

58. Uphof, J.C.T. (1968). Dictionary of economic plants. 2nd ed. Verlag von J. Cramer, Gebundene Ausgabe. 591 pp.

59. Verma, K.S., Jain, A.K., Nagar, A. and Gupta, S.R. (1986). Macrocarposide, a new isoflavone C-glucoside from *Pterocarpus macrocarpus* heart wood. Planta Medica 4: 315 – 317.

60. Yadav, R.N. and Singh, R.K. (1998). 6-Hydroxy-3,5,7,4'-tetramethoxyflavone;6-rhamnoside from roots of *Pterocarpus marsupium.* Phytochemistry, 48: 1259 – 1261.

REFERENCES TO APPENDIX VIb

1. Barnes. S. and Peterson, T.G. (1995). Biochemical targets of the isoflavone genistein in tumour cell lines. Proceedings of Society for Experimental Biology and Medicine, 208:103-108.

2. Ebi, G.C. and Ofoefue, S.I. (2000). Antimicrobial activity of *Pterocarpus osun* stems. Fitoterapia, 71: 433- 435.

3. Gotoh, T., Yamada, K. and Yin, H. (1998). Chemoprevention of N-nitroso-N-methylurea-induced rat mammary carcinogenesis by soy foods or biochanin A. Japanese Journal of Cancer Research, 89:137-142.

4. Harborne, J.B. and Baxter, H. (1993). Phytochemical dictionary: a handbook of bioactive compounds from plants. Taylor and Francis, London. 791 pp.

5. Lamartiniere, C.A. (2000). Protection against breast cancer with genistein: a component of soy. American Journal of Clinical Nutrition, 71:1705S-1707S.

6. Lee, Y.S., Kim, T.H., Cho, K.J. and Jang, J.J. (1992). Inhibitory effects of biochanin A on benzo[a]pyrene induced carcinogenesis in mice. In vivo, 6: 283-286.

7. Manickam, M., Ramanathan, M., Farboodniay, J.M.A., Chansouria, J.P.N. and Ray, A.B. (1997). Antihyperglycemic activity of phenolics from *Pterocarpus marsupium*. Journal of Natural Products, 60: 609-610.

8. Marles, R.J.and Farnsworth, N.R. (1995). Antidiabetic plants and their active constituents. Phytomedicine, 2:137-189.

9. Rimando, A.M., Pezzulo, J.M, Farnsworth, N.R., Santisuk, T. and Reutrakul, V. (1994). Revision of the NMR assignments of pterostilbenes and of dihydrodiconiferyl alcohol: cytotocic constituents from *Anogeissus acuminata*. Natural Product Letters, 4: 267–272.

10. Rimando, A.M., Cuendet, M., Desmarchelier, C., Mehta, R.G., Pezzuto, J.M. and Duke, S.O. (2002). Cancer chemo preventive and antioxidant activities of

pterostilbene, a naturally occurring analogue of resveratrol. Journal of Agriculture and Food Chemistry, 50: 3453–3457.

11. Rimando, A.M., Kalk, W., Magee, J.B., Ballington, J.R. and Dewey, J. (2004). Resveratrol, pterostilbene and piceatannol in Vaccinium berries. Journal of Agriculture and Food Chemistry, 52: 4713 – 4719.

12. Saloniemi, H., Wàhàlà, K. and Nykà nen-Kurki, P. (1995). Phytoestrogen content and estrogenic effect of legume fodder. Proceedings of Society for Experimental Biology and Medicine, 208: 13-17.

13. Southon, I.W., Brisby, F.A., Buckingham, J and Harborne, J.B. (1994b). Phytochemical dictionary of the Leguminosae.Volume II. Chemical constituents. Chapman and Hall, London. 573 pp.

14. Tolomeo, M., Grimaudo, S., Di Cristina, A., Roberti, M., Pizzirani, D., Meli, M., Dusonchet, L., Gebbia, N., Abbadessa, V. and Crosta, L. (2005). Pterostilbene and 3′-hydroxypterostilbene are effective apoptosis-inducing agents in MDR and BCR-ABL-expressing leukaemia cells. The International Journal of Biochemistry and Cell Biology, 37: 1709-1726.

15. Wang, T.T., Sathyamoorthy, N. and Phang, J.M. (1996). Molecular effects of genistein on oestrogen receptor mediated pathways. Carcinogenesis, 17:271-275.

16. Wei, H., Bowen, R. and Cai, Q. (1995). Antioxidant and antipromotional effects of the soybean isoflavone genistein. Proceedings of Society of Experimental Biology and Medicine, 208: 124-130.

17. Yanagihara, K., Ito, A., Toge, T. and Numoto, M. (1993). Antiproliferative effects of isoflavones on human cancer cell lines established from the gastrointestinal tract. Cancer Research, 53:5815-5821.

18. Dictionary of Natural Products, 1996. Dictionary of natural products on CD-Rom version 5:1. Chapman and Hall, London.

REFERENCES TO APPENDIX VIIb

1. Achenbach, H., Hubner, H., Vieling, W., Brandt, W. and Reiter, M. (1995). Constituents of tropical medicinal plants 68. Spigathine, the cardioactive principle of *Spigelia anthelmia*. Journal of Natural products-Lloydia, 58 : 1092 – 1096.

2. Angenot, L. and Bisset, N.G. (1971). Isolement et structure de nouveaux alcaloïdes extraits du *Strychnos usambarensis* Gilg du Rwanda. Journal de Pharmacie de Belgique, 26 : 585 – 588.

3. Angenot, L. and Denoel, A. (1973). Alcaloïdes des Loganiacées: sur l'isolement d'un nouvel alcaloïde á partir du *Strychnos usambarensis*. Planta Medica, 23 : 226 – 234.

4. Angenot, L., Bisset, N.G. and Denoel, A. (1973). Alcaloïdes des Loganiacées: sur l'isolement de l'harmane á partir du *Strychnos usambarensis* Gilg. Plantes Médicinales et Phytothérapie, 7: 33 – 36.

5. Angenot, L. (1975). De nouveau alcaloïdes quaternaires du *Strychnos usambarensis*. Planta Medica, 27: 24 – 30.

6. Angenot, L., Bisset, N.G. and Franz, M. (1975a). La desacetylretuline extraite du *Strychnos variabilis*. Phytochemistry, 14: 2519 – 2520.

7. Angenot, L, Dideberg, O. and Dupont, L. (1975b). Isolation and structure of akagerine: a new type of indole alkaloid. Tetrahedron Letters, 16: 1357 – 1358.

8. Angenot, L., Dubois, M., Ginion, C., Van Dorser, W. and Dresse, A. (1975c). Chemical structure and pharmacological (curarizing) properties of various indole alkaloids extracted from an African *Strychnos*. Archives Internationales de Pharmacodynamie et de Thérapie, 125: 246 – 258.

9. Angenot, L., Coune, C. and Tits, M. (1978a). Nouveaux alcaloïdes des feuilles du *Strychnos usambarensis*. Journal de Pharmacie de Belgique, 33 : 11 – 23.

10. Angenot, L. and Tits, M. (1981). Isolement d'un nouvel alcaloïde (O-acetylretuline) et d'un triterpenoide (Friedeline) á partir du *Strychnos henningsii* du Zaire. Planta Medica, 41: 240 – 243.

11. Biemann, K., Grossert, J.S., Hugo, J.M., Occolowitz, J. and Warren, F.L. (1965a). The indole alkaloids Part V: the structure of henningsoline. Journal of the Chemical Society, 2818 – 2822.

12. Bisset, N.G. (1965b). Vomicine et N-methyl-pseudo-strychnine (icajine), alcaloïdes retirés des feuilles du *Strychnos icaja* Baill. Compte Rendus de l'Académie des Sciences, 261: 5237 – 5238.

13. Bisset, N.G. (1968). 21, 22-α-Epoxy-N-methyl-sec-pseudobrucine, an alkaloid from *Strychnos icaja* Baill. Tetrahedron Letters, 27: 3107 – 3110.

14. Bisset, N.G. (1970). The African species of *Strychnos.* Part I. The ethnobotany. Lloydia, 33: 201 – 239.

15. Bisset, N.G., Das, B.C. and Parella, J. (1973a). Alkaloids from the leaves of *Strychnos icaja* Baill. Tetrahedron, 29: 4137 – 4148.

16. Bisset, N.G. and Phillipson, J.D. (1974). Antirhine and antirhine methosalt from the leaves of *Strychnos camptoneura*. Phytochemistry, 13: 1265 – 1267.

17. Bisset, N.G., Bosly, J., Das, B.C. and Spiteller, G. (1975). Alkaloids fro *Strychnos henningsii*: revised structures for holstiine and rindline, proposed structure for holstiline. Phytochemistry, 14: 1411 – 1414.

18. Bisset, N.G. and Khalil, A.A. (1976). New alkaloids from Strychnos icaja. Phytochemistry, 15: 1973 – 1976.

19. Bohlin, L., Rolfsen, W., Strömbom, J. and Verpoorte, R. (1979). Alkaloids and biological activity of *Strychnos angolensis*. Planta Medica, 35: 19 – 30.

20. Bosly, J. (1951). Contribution á l'étude des alcaloïdes du *Strychnos holstii* (Gilg.) var. reticulata, fo. condensata. Journal de Pharmacie de Belgique, 6: 150 – 177; 243 - 266.

21. Brasseur, T. and Angenot, L. (1985). Flavonol glycosides from leaves of *Strychnos variabilis*. Phytochemistry, 25: 563 – 564.

22. Buckingham, J. (1994f). Dictionary of natural products. Volume 7: Type of compound and species index. Chapman and Hall, London.

23. Caprasse, M. and Angenot, L. (1981). Les alcaloïdes majoritaires du *Strychnos scheffleri* du Zaire. Planta Medica, 42: 364 – 370.

24. Caprasse, M., Coune, C. and Angenot, L. (1981). Isolement par DCCC (Droplet-Counter Current Chromatography) de la fluorocurarine á partir du *Strychnos usambarensis* Gilg. du Rwanda. Journal de Pharmacie de Belgique, 36: 243 - 248.

25. Caprasse, M. and Angenot, L. (1982). Cytotoxic anhydronium bases from *Strychnos usambarensis*. Planta Medica, 45: 149

26. Coune, C. (1978). Sur les alcaloïdes nouveaux du *Strychnos gossweileri* Exell. Plantes Médicinales et Phytothérapie, 12: 106 – 111.

27. Coune, C. and Angenot, L. (1978a). Le Dolichantoside, un Alcaloïdes nouveau du *Strychnos gossweileri* Exell. Planta Medica, 34 : 53 – 56.

28. Coune, C. and Angenot, L. (1978b). La Diploceline, alcaloïde nouveau du *Strychnos gossweileri*. Phytochemistry, 17: 1447 – 1448.

29. Coune, C. (1980). Contribution á l'étude du *Strychnos gossweileri* du Zaire : isolement et détermination de structure de nouveaux alcaloïdes. Ph.D Thesis, Université de Liège.

30. Coune, C.A., Angenot, L.J.G., and Denoel, J. (1980). 13C NMR of *Strychnos* alkaloids: harmane and usambarensine derivatives. Phytochemistry, 19: 2009 – 2011.

31. Delaude, C., Thepenier, P., Jacquier, M.J., Massiot, G. and Le men-Oliver, L. (1992). Contribution a l'etude des *Strychnos* africains. alcaloides de *Strychnos cocculoides, S. lucens, S. madagascariensis, S. minfiensis, S. mitis, S. pungens* et *S. spinosa*. Bulletin de Société Royal Des Sciences de Liege, 61: 429 – 440.

32. Dideberg, O., Dupont, L. and Angenot, L. (1975). Détermination de la structure cristalline et de la configuration absolue d'un dérive de l'usambarensine. Acta Crystallographica, B31: 1571 – 1575.

33. Dideberg, O., Lamotte-Brasseur, J., Dupont, L., Campsteyn, H., Vermeire, M. and Angenot, L. (1977). Structure cristalline et moléculaire d'un nouvel alcaloïde bisindolique : complex moléculaire 1 : 2 strychnofoline-ethanol (C_{30} H_{34} N_4 $O_2.2C_6$ H_6 O). Acta Crystallographica, B33: 1796 – 1801.

34. Dubois, M., Ginion, C., Angenot, L., Van Dresser, W. and Dresse, A. (1974). Caractères chimiques et propriétés pharmacologiques de plusieurs alcaloïdes extraits de *Strychnos usambarensis*. Archives Internationales de Physiologie et de Biochimie, 82: 823 – 830.

35. Dupont, L., Lamotte-Brasseur, J., Dideberg, O., Campsteyn, H., Vermeire, M. and Angenot, L. (1977). La structure cristalline et moléculaire d'un nouvel alcaloïde bisindolique : la strychnopentamine $C_{35}H_{43}N_5O$. Acta Crystallographica, B33: 1801 - 1807.

36. Frédérich, M. , Pauw, M. C. de , Prosperi, C. , Tits, M. , Brandt, V. , Penelle, J. , Hayette, M. P. , DeMol, P. and Angenot, L. (2002). Strychnosugucines A and B, two new antiplasmodial bisindole alkaloids from *Strychnos icaja*. Journal of Natural Products, 64: 12-16.

37. Frédérich, M. , Choi YoungHae , Angenot, L. , Harnischfeger, G. , Lefeber, A. W. M. and Verpoorte, R. (2004). Metabolomic analysis of *Strychnos nux-vomica, Strychnos icaja* and *Strychnos ignatii* extracts by ^{1}H nuclear magnetic resonance spectrometry and multivariate analysis techniques. Phytochemistry, 65: 1993 – 2001.

38. Garnier, J., Koch, M. and Plat, M. (1974). Loganiacées de la Côte d'Ivoire X : alcaloïdes du *Strychnos camptoneura* Gilg et Busse. Plantes Médicinales et Phytothérapie, 8: 281 – 286.

39. Goonetilleke, A., Rolfsen, W. and Rajapakse, L. (1980). Tertiary indole alkaloids of *Strychnos aculeata*. Planta Medica, 39: 208

40. Grossert, J.S., Hugo, J.M., Von Klemperer, M.E. and Warren, F.L. (1965). The indole alkaloids. Part III. The isolation of diaboline and three new alkaloids, henningsamine, henningsoline and rindline from *Strychnos henningsii* Gilg. Journal of Chemical Society, 1965 :2812 – 2814.

41. Hubner, H., Vielring, W., Brandt, W., Reiter, M. and Achenbach, H. (2001). Constituents of tropical medicinal plants part 91 – minor constituents of *S. anthelmia* and their cardiac activities. Phytochemistry, 57 : 285 – 296.

42. Iwu, M.M. (1993). Handbook of African medicinal plants. CRC Press Inc. Florida, USA. 435 pp.

43. Janot, M.-M., Goutarel, R. and Bosly, J. (1951). L'Holstiine : alcaloïde du *Strychnos holstii* Gilg. *var. reticulata* fo. condensata. Compte Rendus de l'Académie des Sciences, 232: 853 – 858.

44. Kambu, K., Coune, C. and Angenot, L. (1979). Nouveaux alcaloïdes des racines du *Strychnos icaja*. Planta Medica, 37: 161 – 164.

45. Koch, M., Plat, M., Das, B.C. and Le Men, J. (1966). Loganiacées de Côte d'Ivoire III. Alcaloïdes du *Strychnos splendens* Gilg.: isolement et structure de la strychnosplendine. Tetrahedron Letters, 21: 2353 – 2359.

46. Koch, M., Plat, M., Das, B.C. and Le Men, J. (1967). Loganiacées de Côte d'Ivoire IV. Alcaloïdes du *Strychnos splendens* Gilg.: isolement et structure de la splendoline. Tetrahedron Letters, 33: 3145 – 3148.

47. Koch, M., Plat, M., Das, B.C. and Le Men, J. (1968). Loganiacées de Côte d'Ivoire V. Alcaloïdes du *Strychnos splendens* Gilg.: stéréochimie de la strychnosplendine et de la splendoline : isolement et structure de l'isostrychnosplendine, isosplendoline et N_a-acetyl-isostrychnosplendine. Bulletin de la Société Chimique de France, 8: 3250 – 3252.

48. Koch, M., Plat, M., Das, B.C., Fellion, E. and Le Men, J. (1969). Loganiacées de Côte d'Ivoire VI. Alcaloïdes des écorces et des fruits du *Strychnos splendens* Gilg. Annales Pharmaceutique Françaises, 27: 229 – 238.

49. Koch, M., Plat, M. and Janot, M.M. (1971). Structure de l'usambarine, nouvel alcaloïde du *Strychnos usambarensis* Gilg. (Loganiaceae). Compte Rendus de l'Académie des Sciences, 273: 753 – 754.

50. Koch, M., Garnier, J. and Plat, M. (1972). Loganiacées de la Côte d'Ivoire IX. Alcaloïdes du *Strychnos camptoneura* Gilg. Annales Pharmaceutique Françaises, 30: 299 – 306.

51. Koch, M., Fellion, E. and Plat, M. (1973). Loganiacées de la Côte d'Ivoire XI. Alcaloïdes du *Strychnos usambarensis* Gilg. Annales Pharmaceutique Françaises, 31: 45 – 48.

52. Koch, M., Fellion, E. and Plat, M. (1976). Cinq alcaloïdes nouveaux de *Strychnos henningsii*. Phytochemistry, 15: 321 – 324.

53. Lamotte, J., Dupont, L., Dideberg, O., Kambu, K. and Angenot, L. (1979). Isolation and structure of sungucine: a new type of bisindoline alkaloid. Tetrahedron Letters, 43: 4227 – 4228.

54. Martin, M.T., Rasoanaivo, P., Palazzino, G., Galeffi, C., Nicoletti, M., Trigalo, F. and Frappier, F. (1999). Minor N_b C(21)-secocuran alkaloids of *Strychnos myrtoides*. Phytochemistry, 51 : 479 – 486.

55. Massiot, G., Zèches, M., Thépenier, P., Jacquier, M,-J., Le Men-Oliver, L. and Delaude, C. (1982). Structure of ngouniensine: an indole alkaloid of a new type from *Strychnos ngouniensis*. Journal of Chemical Society, 768 – 769.

56. Massiot, G., Zèches, M., Mirand, C., Le Men-Oliver, L., Delaude, C., Baser, K., Bovovada, R., Bisset, N.G., Hylands, P.J., Strömbom, J. and Verpoorte, R. (1983). Occurrence of Longicaudatine, a new type of bisindole base and bisno-C-alkaloid H in *Strychnos* species. Journal of Organic Chemistry, 48: 1869 – 1872.

57. Massiot, G., Thepenier, P., Jacquier, M. J., Henin, J., Men-Olivier, L. le. and Delaude, C. (1991). Alkaloids from *Strychnos henningsii*. Phytochemistry, 30: 3449 – 3456.

58. Massiot, G., Thepenier, P., Jacquier, M.J., Men-Olivier, L. le, Delaude, C. (1992). Alkaloids from roots of *Strychnos potatorum*. Phytochemistry, 31: 2873 – 2876.

59. Michel, S., Tillequin, F. and Koch, M. (1980a). L'Ellipticine, alcaloïde majeur des écorces de *Strychnos dinklagei*. Journal of Natural Products, 43 : 294 – 295.

60. Michel, S., Tillequin, F. and Koch, M. (1980b). L'Oxo-17ellipticine : nouvel alcaloïde de *Strychnos dinklagei*. Tetrahedron Letters, 21: 4027 – 4030.

61. Michel, S., Tillequin, F., Koch, M. and Assi, L.A. (1982). Alcaloïdes des écorces de tiges *Strychnos dinklagei*. Journal of Natural Products, 45: 489 – 494.

62. Mirand, C., Delaude, C., Levy, J., Le Men-Oliver, L. and Le Men, J. (1979). Alcaloïdes du *Strychnos aculeata* Sol. Plantes Médicinales et Phytothérapie, 13: 84 – 86.

63. Msonthi, J.D., Galeffi, C., Nicoletti, M., Messana, I. and Marini-Bettolo, G.B. (1985). Kingside aglucone, a natural secoiridoid from unripe fruits of *Strychnos spinosa*. Phytochemistry, 24: 771-772.

64. Nicoletti, M., Oguakwa, J.U. and Messana, I. (1980). On the alkaloids of two African *Strychnos*: *Strychnos nigritana* Bak. and *Strychnos barteri* Sol, Carbon-13 NMR spectroscopy of nigritanins. Fitoterapia, 3: 131 – 134.

65. Nuzillard, J.M., Thépenier, P., Jacquier, M.J., Massiot, G., Men-Olivier, L.le, Delaude, C. (1996). Alkaloids from root bark of *Strychnos panganensis*. Phytochemistry, 43: 897 – 902.

66. Neuwinger, H.D. (1996). African ethnobotany. Poisons and drugs: chemistry, pharmacology and toxicology. pp 590 – 599. Chapman and Hall, London

67. Occolowitz, J., Biemann, K. and Bosly, J. (1965). The structures of the *Strychnos* alkaloids condesamine and retuline. Farmaco (Ed.Sc.), 20: 751 – 756.

68. Oguakwa, J.U., Galeffi, C., Messana, I., La Bua, R., Nicoletti, M. and Marini-Bettòlo, G.B. (1978). On the alkaloids of *Strychnos* XXX: The structure of the

nigritanins; the alkaloids of *Strychnos nigritana* Bak. Gazzeta Chimica Italiana, 108: 615 – 618.

69. Oguakwa, J.U., Galeffi, C., Nicoletti, M., Messana, I., Patamia, M. and Marini-Bettòlo, G.B. (1980). On the alkaloids of *Strychnos* XXXIV: the alkaloids of *Strychnos spinosa* Lam. Gazzeta Chimica Italiana, 110: 97 – 100.

70. Ohiri, F.C., Verpoorte, R. and Baerheim, S.A. (1983). Alkaloids of *Strychnos soubrensis* Hutch. et Dalz (Loganiaceae). Journal of Natural Products, 146: 369 – 373.

71. Ohiri, F.C., Verpoorte, R. and Baerheim, S.A. (1984). 12-hydroxy-11-methoxydiaboline: a new alkaloid from *Strychnos spinosa* (stem bark). Planta Medica, 50: 446 – 447.

72. Olaniyi, A.A. and Rolfsen, W. (1980). Two new tertiary indole alkaloids from *Strychnos decussata*. Journal of Natural Products, 43: 595 – 597.

73. Olaniyi, A.A., Rolfsen, W. and Verpoorte, R. (1981). Quaternary indole alkaloids of *Strychnos decussata*. Planta Medica, 43: 353 – 359.

74. Petitjean, A., Rasquarnairo, P. and Razafintsalama, J. (1977). Nouveau gluco-alcaloïdes de *Strychnos decussata*. Phytochemistry, 16: 154 – 155.

75. Philippe, G., Mol, P.de, Zèches-Hanrot, M., Nuzillard, J.M., Tits, M.H., Angenot, L. and Frédérich, M. (2003). Indolomonoterpenic alkaloids from *Strychnos icaja* roots. Phytochemistry, 62: 623 – 629.

76. Phillipson, J.D., Hemingway, S., Bisset, N.G., Houghton, P. and Shellard, E. (1974). Angustine and related alkaloids from species of *Mitragyna, Nauclea, Uncaria* and *Strychnos*. Phytochemistry, 13: 973 – 978.

77. Rasoanaivo, P., Ratsimamanga-Urverg, S. and Frappier, F. (1996). Recent results on pharmacodynamics of alkaloids from *Strychnos* in Madagascar. Cahiers d'Etudes et de Recherches Francophones sante, 6: 249 – 253.

78. Rasoanaivo, P. , Palazzino, G. , Nicoletti, M. and Galeffi, C. (2001). The occurence of C(3) epimer N_b,C(21)-secocuran alkaloids from *Strychnos diplotricha* and *Strychnos myrtoides*. Phytochemistry, 56: 863 – 865.

79. Richard, C., Delaude, C., Le Men-Oliver, L. and Le Men, J. (1978). Alcaloïdes du *Strychnos tchibangensis*. Phytochemistry, 17: 539 – 541.

80. Rolfsen, W., Bohlin, L., Yeboah, S., Geevaratne, M. and Verpoorte, R. (1978). New indole alkaloids of *Strychnos dale* and *Strychnos elaeocarpa*. Planta Medica, 34: 264 – 273.

81. Rolfsen, W., Bresky, A.-M., Anderson, M. and Strömbom, J. (1980a). Isolation, synthesis and pharmacological activity of strychnocarpine, a new *β*-carboline alkaloid from *Strychnos alaeocarpa*. Acta Phramaceutica Seucica, 17: 333 – 340.

82. Rolfsen, W., Olaniyi, A. and Hylands, P. (1980b). New tertiary alkaloids from *Strychnos decussata*. Journal of Natural Products, 43: 97 – 101.

83. Sandberg, F., Roos, K., Ryrberg, K. and Kristianson, K. (1968). A new alkaloid 4-hydroxy-strychnine from African species *Strychnos icaja* Baill. Tetrahedron Letters, 59: 6217 – 6218.

84. Sandberg, F., Roos, K., Ryrberg, K. and Kristiansson, K. (1969b). The pharmacologically active alkaloids of *Strychnos icaja* Baill: strychnine and a new alkaloid, 4-hydroxy-strychnine. Acta Pharmaceutica Seucica, 6: 103 – 108.

85. Sakai, S., Aimi, N., Yamaguchi, K., Yamanaka, E. and Haginiwa, J. (1975b). Gardneria alkaloids -X structure of gardmultine, a novel the bisindole alkaloid. Tetrahedron Letters, 16: 719 – 722.

86. Sarfati, R., Pais, M. and Jarreau, F.-X. (1970). Nouveaux alcaloïdes isolés d'un *Strychnos henningsii* d'origine malgache. Phytochemistry, 9 : 1107 – 1113.

87. Singh, H. and Kapoor, V.K., Phillipson, J.D. and Bisset, N.G. (1975). Diaboline from *Strychnos potatorum*. Phytochemistry, 14: 587 – 588.

88. Spiteller-Friedmann, M. and Spiteller, G. (1968b). Über alcaloïde aus *Strychnos henningsii* Gilg. Annals of Chemistry, 712: 179 – 194.

89. Takayama, H., Nitta, W., Kitajima, M., Aimi, N. and Sakai, S. (1994). A new *Gardneria* alkaloid, gardenoquinoline having a novel 4-quinolone skeleton. Journal of Natural Products, 57 : 521 – 523.

90. Thépenier, P., Jacquier, M.J., Massiot, G., Men-Olivier, L.le. and Delaude, C. (1988). Alkaloids from *Strychnos staudtii*. Phytochemistry, 27: 657 – 659.

91. Thépenier, P., Jacquier, M.J., Hénin, J., Massiot, G., Men-Olivier, L.le. and Delaude, C. (1990). Alkaloids from *Strychnos pungens*. Phytochemistry, 27 : 2384 – 2386.

92. Thépenier, P., Jacquier, M.J., Massiot, G., Men-Olivier, L. le. and Delaude, C. (1990). Alkaloids from seeds of *Strychnos variabilis* and *S. longicaudata*. Phytochemistry, 29: 686 – 687.

93. Tits, M. and Tavernier, D. (1978). Nouveaux alcaloïdes du *Strychnos variabilis*. Plantes Médicinales et Phytothérapie, 12: 92 – 95.

94. Tits, M. and Angenot, L. (1980). Alcaloïdes des feuilles du *Strychnos variabilis*. Plantes Médicinales et Phytothérapie, 14: 213 – 217.

95. Tits, M., Angenot, L. and Tavernier, D. (1980a). New indole aldehydic alkaloids of *Strychnos variabilis*. Tetrahedron Letters, 21: 2439 – 2442.

96. Tits, M., Tavernier, D. and Angenot, L. (1980b). Alcaloïdes indoliniques du *Strychnos variabilis*. Phytochemistry, 19: 1531 – 1534.

97. Tits, M., Franz, M., Tavernier, D. and Angenot, L. (1981). Les alcaloïdes quaternaires majoritaires du *Strychnos variabilis* du Zaire. Planta Medica, 42: 371 – 374.

98. Tits, M. (1982). Contribution á l'étude du *Strychnos variabilis*, plant toxique du Bas-Zaire : isolement et détermination de structure de nouveaux alcaloïdes. Ph.D. Thesis, Université de Liège.

99. Tits, M., Damas, J., Quetin-Leclerca, J. and Angenot, L. (1991). From ethnobotanical uses of *S. heningsii* to anti-inflammatory, analgesics and antispasmodic. Journal of Ethnopharmacology, 34 : 261 – 267.

99. Verpoorte, R. and Sandberg, F. (1971). Alkaloids of *Strychnos camptoneura*. Acta Pharmaceutica Seucica, 8: 119 – 122.

100. Verpoorte, R. and Baerheim, S.A. (1974). 11-Methoxy-diaboline in *Strychnos malacoclados*. Phytochemistry, 13: 2011 – 2012.

101. Verpoorte, R., Baerheim, S.A. and Sandberg, F. (1975). Alkaloids of *Strychnos camptoneura*. Acta Pharmaceutica Seucica, 12: 455 – 460.

102. Verpoorte, R. and Baerheim, S.A. (1976). The alkaloids of *Strychnos dolichothyrsa*. Lloydia, 39: 357 – 362.

103. Verpoorte, R., Kodde, E., Van Doorne, H. and Baerheim, S.A. (1978a). Antimicrobial effect of the alkaloids from *Strychnos afzelii* Gilg. Planta Medica, 33: 237 – 242.

104. Verpoorte, R., Kodde, E., Van Doorne, H. and Baerheim, S.A. (1978b). A chromatographic comparison of *Strychnos dolichothyrsa* and *Strychnos urceolata*. Planta Medica, 34: 62 – 65.

105. Verpoorte, R., Groenink, H. and Baerheim, S.A. (1980). Minor alkaloids and sterols in *Strychnos afzelii*. Planta Medica, 38: 388 – 390.

106. Verpoorte, R., Verzijl, M. and Baerheim, S.A. (1982). Further alkaloids from *Strychnos dolichothyrsa*. Planta Medica, 44: 21 – 27.

107. Weeratunga, G. (1984). Alkaloids in *Strychnos aculeata*. Acta Pharma. Suecica, 21: 135- 140.

108. Sapi, J. and Massioti, G. (1994). The *Strychnos* alkaloids. In: Monoterpenoid indole alkaloids. Supplement to Part 4. (ed. by J.E. Saxton), pp 279 – 355. Wiley Interscience Publication. 848 pp.

109. Mathias, M.E. (1982). Some medicinal plants of the Hehe (Southern Highlands Province, Tanzania). Taxon, 31: 488 – 494.

111. Sakai, S., Aimi, N., Yamaguchi, K., Ogata, K. and Haginiwa, J. (1987). *Gardneria* alkaloids. 14. The structure of Gardfloramine and 18-demethoxygardfloramine. Chemical and Pharmaceutical Bulletin, 35: 453 – 455.

112. Hubner, H., Vierling, W., Brandt, W., Reiter, M. and Achenbach, H. (2001). Constituents of tropical medicinal plants part 91 - Minor constituents of *Spigelia anthelmia* and their cardiac activities. Phytochemistry, 57: 285-296.

113. Aimi, N., Yamaguchi, K., Sakai, S., Haginiwa, J. and Kubo, A. (1978). *Gardneria* alkaloids. 12. Carbon magnetic-resonance spectra of *Gardneria* alkaloids – study on configuration of side chain double-bonds of indole alkaloids. Chemical and Pharmaceutical Bulletin, 26: 3444 – 3449.

114. Sakai, S., Aimi, N., Yamaguchi, K., Hori, K. and Haginiwa, J. (1977). *Gardneria* alkaloids. 11. Several minor bases of *Gardneria multiflora* Makino. Yakugaku Zasshin – Journal of the Pharmaceutical Society of Japan, 97: 399 – 409.

115. Dictionary of natural products. (2004). Combined dictionary of natural products on CD-ROM – version 5.2. Chapman and Hall/CRC Press. London.

116. Hedberg, I., Hedberg, O., Madati, P. J., Mshigeni, K. R., Mshiu, E. N. and Samuelsson, G. (1983a). Inventory of plants used in traditional medicine in Tanzania. Part II. Plants of the families Dilleniaceae - Opiliaceae. Journal of Ethnopharmacology, 9: 105 – 128.

117. Gills, L.S. (1992). Ethnomedical uses of plants in Nigeria. University of Benin Press, Nigeria. 276 pp.

118. FAO, (1983). Food and fruit-bearing forest species: examples from East Africa. Forestry Paper 44. Food and Agricultural Organization, Rome Italy.

Appendices

APPENDICES

Appendix Ia PRA checklist used for survey of utilized medicinal plants from Urumwa Forest Reserve, Tanzania.

Region…………………… District………………… Ward………..…………………..

Village……………………. Date………………….… Facilitator………………….

1. Could you please mention about fifteen (15) most important medicinal plants that are found in UFR, diseases cured and part(s) used?
2. What is the current status of medicinal plants in the forest reserve? Please give reason(s) for your answer.
3. From the list in question 1 above what medicinal plant species do you think are found in abundant in the forest reserve? Rank to get the most abundant.
4. From the list in question 1 above, what medicinal plant species do you think are becoming rare/difficulty to find in UFR and hence endangered to extinction due to frequency use. Rank to get the rarest/difficulty to find.
5. From the list in question 1 above what medicinal plant species do you think have disappeared (extinct) completely in the forest reserve? Rank to get the most extinct
6. From the list in question 1 above list about six (6) medicinal plant species which you think are of importance for your daily primary health care and hence require further conservation attention. Rank to get the most important with reasons
7. Are there any cultural practices and beliefs that are present or were there in the past to support the conservation and sustainable use of medicinal plants in UFR? Please mention them.
8. What measures do you think should be taken to ensure availability of medicinal plants in UFR in future?
9. Could you please map the medicinal plants basing on their abundance in the forest reserve?

Appendix Ib Questionnaire survey on gender roles in utilization and conservation of medicinal plants from Urumwa Forest Reserve, Tanzania

A Questionnaire to Traditional healers, Traditional birth attendants, Households residing near the reserve and Medicinal plants collectors

i. Socio- economic information

Village................................ Ward.................................
Division.............................. District.........................
Region................................ Ethnic group........................

1. Gender: Male (...)/Female (...) Please put a tick (✔) on appropriate answer).

2. Age of respondent.........(years) 3. Occupation:.................................

4. Marital status (Put a tick (✔) on appropriate answer)

i. Single (....) ii. Married (....)

iii. Separated (....) iv. Widowed (....)

v. Divorced (....)

5. Education profile (Put a tick (✔) on appropriate answer)

i. Illiterate (...) ii. Adult education (...)

iii. Primary education (...) iv. Secondary education (...)

v. Higher education (Please specify)...

Name of respondent .... Respondent code no.........................

Interviewer's name.......................... Date of interview............................

ii. Information on utilization of medicinal plants

1. Mention the different plant species from URF that you know are used for medical purposes

<u>Local name</u> <u>Botanical name</u>

i)..................... ....

ii)...................... ....

(Use separate sheet for more lists)

2. Mention the diseases, which are commonly treated, parts used and mode of application and dosage by the species of medicinal plants you have listed above.

Disease(s)	Part(s)	Application
....	....	....
....	....	....

(Use separate sheet for more lists)

3. To your knowledge are there any other medicinal plants/trees that you know but are not found inside UFR? If answer is YES, Mention them.

Local name	Botanical name
i).....................	....
ii)......................	....

(Use separate sheet for more lists)

4. Where do you obtain the above mentioned medicinal plants? (Please put a tick (✔) to the right answer)

i) Collect from community woodlots (...)

ii) Collect from other villages/districts/regions? (...) Name the place................

iii) Buy from collectors, sellers or other practitioners (...)

iv) From both sources (...)

5. What method do you use to prepare the remedies from different plant/trees parts for different usage? (Put tick (✔) to the right answer)

a) Boiling (...) b) Infusion (...)

c) Pounding (...) c) Grinding (...)

d) Boiling and grinding (...) e) Infusion and grinding (....)

e) Both methods (...)

f) Others (please mention them)..

6. In what form do you give the medicine to the patients? (Please put a tick (✔) on the appropriate answer)

a) Decoction (…) b) Infusion (…)

c) Powder (…) d) Mixtures (…)

e) Two or both methods (…) Mention them………………………………………

7. How do you administer your remedies to the patients (Dosage and frequency?)

a) Standardized dosage based on age and disease extent e.g. one cup, teaspoonful once, for three or seven days etc. (…)

b) Informal dosage, just estimated quantity by the patient as directed by the healer(…)

8. Based on your knowledge, are there any difference in the use of medicinal plants by males and females in the village? YES/NO. If answer is YES, what roles does each group play? Please put in the brackets appropriate number according to the answer *i.e.* 1= Men only; 2 = Women only; 3 = both men and women; 4 = men and boys; 5 = women and girls; 6 = No body participates, 7 = Not sure/don't know

a) Traditional healing activities (…)

b) Medicinal plants trading in local/district/regional markets (…)

c) Processors of medicinal plants (…)

d) Speciality in treating various diseases (…)

e) Speciality in treating women and children diseases (…)

iii. Information on conservation of medicinal plants

9. What methods do you use to harvest the medicinal plants from the forest reserve?

……………………………………………………………………………………

……………………………………………………………………………………

…………

10. Are the medicinal plants in UFR increasing, decreasing or persistent? What is the reason (s) for your answer?

……………………………………………………………………………………………

…

11. What medicinal plant species do you think are found in abundant in UFR?

Local name | Botanical name

i)………………… ………………………

ii)………………….. ………………………

(Use separate sheet for more lists)

12. What medicinal plant species do you think are found in abundant but in UFR but frequently used hence their status endangered?

Local name | Botanical name

i)………………… ………………………

ii)………………….. ………………………

(Use separate sheet for more lists)

13. What medicinal plant species do you think are rare to find in UFR?

Local name | Botanical name

i)………………… ………………………

ii)………………….. ………………………

(Use separate sheet for more lists)

14. What medicinal plant species do you think have disappeared (extinct) completely in UFR?

Local name | Botanical name

i)………………… ………………………

ii)………………….. ………………………

(Use separate sheet for more lists)

15. What measures are you taking to conserve the available medicinal plants from UFR?

i)……………………………………………………………………………………

ii)…………………………………………………………………………………..

16. Are there any problems considered as threats to the availability of medicinal plants at Urumwa which ? (Yes/No). If yes mention them

………………………………………………………………………………………………………

17. What are your own views on conserving the potential medicinal plants from UFR for health care?

....

....

....

18. Based on your knowledge are there any difference in conservation of medicinal plants by male and females in the village? YES/NO. If YES, what roles does each group play? Please put in the brackets appropriate number according to the answer *i.e.* 1= Men only; 2 = Women only; 3 = both men and women; 4 = men and boys; 5 = women and girls; 6 = No body participates, 7 = Not sure/don't know

a) Collection/harvesting of medicinal plant parts (...)

b) Knowledge on traditional conservation practices (...)

c) Participation in domestication of medicinal plants (...)

d) Adherence to JFM set rule to access the reserve (...)

e) Decision-making process to protect Urumwa and its resources (...)

B Questionnaire to Medicinal plant sellers

i. Socio- economic information

Market/Place……………… Ward……………… Division…………………….

District………………. Region……………… Seller's name……………………...

1. Gender: Male (…)/Female (…) Please put a tick (✔) on appropriate answer).

2. Age of respondent………(years)

3. Marital status (Put a tick (✔) on appropriate answer)

   i. Single (….) ii. Married (….)

   iii. Separated (….) iv. Widowed (….) v. Divorced (….)

4. Education profile (Put a tick (✔) on appropriate answer)

   i. Illiterate (…) ii. Adult education (…)

   iii. Primary education (…) iv. Secondary education (…)

   v. Higher education (Please specify)...…………………………………………..

Name of respondent …………………….. Respondent code no……………………..

Interviewer's name……………………… Date of interview..…………………...…

ii. Information on utilization of medicinal plants

1. Mention the different plant species you are selling for medical purposes.

   Local name — Botanical name

   i)…………………. ……………………..

   ii)………………….. ……………………..

   (Please use separate sheet for more list)

2. Mention the diseases, which are commonly, treated and parts used by the species you have mentioned above

Species used	Disease	Parts used
………………	…………………	……………….
………………..	………………….	………………..

(Please use separate sheet for more list)

3. What method do you use to prepare the remedies from different plant/trees parts for different usage? (Put tick (✔) to the right answer)

a) Boiling (…) b) Infusion (...)

c) Pounding (…) c) Grinding (...)

d) Boiling and grinding (…) e) Infusion and grinding (....)

e) Both methods (…)

f) Others (please mention them)………………………………………

4. In what form do you give the medicine to the patients? (Please put a tick (✔) on the appropriate answer)

a) Decoction (…) b) Infusion/concentrates (…)

c) Powder (…) d) Mixtures (…)

e) Two or both methods (…) Mention them………………………………………

5. How do you administer your remedies to the patients (Dosage and frequency?)

a) Standardized dosage based on age and disease extent e.g. one cup, teaspoonful once, for three or seven days etc. (…)

b) Informal dosage, just estimated quantity by the patient as directed by the healer (…)

6. Based on your knowledge, are there any difference in the use of medicinal plants by males and females in the village? YES/NO. If answer is YES, what roles does each group play? Please put in the brackets appropriate number according to the answer *i.e.* 1= Men only; 2 = Women only; 3 = both men and women; 4 = men and boys; 5 = women and girls; 6 = No body participates, 7 = Not sure/don't know

a) Traditional healing activities (…)

b) Medicinal plants trading in local/district/regional markets (…)

c) Processors of medicinal plants (…)

d) Speciality in treating various diseases (…)

e) Speciality in treating women and children diseases (…)

iii. Information on conservation of medicinal plants

7. Where do you obtain the above mentioned medicinal plants? (Please put a tick (✔) to the right answer)

i) Collect from community woodlots (...)

ii) Collect from other villages/districts/regions? (...) Name the place.................

iii) Buy from collectors (...)Name the place where they get plants...................

iv) From both sources (...)

8. Do you have problems on obtaining the medicinal plants you are selling? (Yes/No). If yes mention the problems.

....

....

9. What harvesting methods do you use or other collectors' use to collect the medicinal plants?

....

....

10. What are your own views on conserving the potential medicinal plants from UFR for health care?

....

....

11. Based on your knowledge is there any difference in conservation of medicinal plants by males and females in the village? YES/NO. If YES, what roles does each group play? Please put in the brackets appropriate number according to the answer *i.e.* 1= Men only; 2 = Women only; 3 = both men and women; 4 = men and boys; 5 = women and girls; 6 = No body participates, 7 = Not sure/don't know

a) Collection/harvesting of medicinal plant parts (...)

b) Knowledge on traditional conservation practices (...)

c) Participation in domestication of medicinal plants (...)

d) Adherence to JFM set rule to access the reserve (...)

e) Decision-making process to protect Urumwa and its resources (...)

C Questionnaire to other informants

i. Socio-economic information

Village.. Ward...
Division................................ District...

Region............................... Ethnic group...

1. Gender: Male (...)/Female (...) Please put a tick (✔) on appropriate answer).

2. Age of respondent............. (Years) 3. Occupation:.............................

4. Marital status (Put a tick (✔) on appropriate answer)

i. Single (....) ii. Married (....)

iii. Separated (....) iv. Widowed (....) v. Divorced (....)

5. Education profile (Put a tick (✔) on appropriate answer)

i. Illiterate (...) ii. Adult education (...)

iii. Primary education (...) iv. Secondary education (...)

v. Higher education (Please specify)..

Name of respondent .... Respondent code no.................................

Interviewer's name.................. Date of interview.....................................

ii. Information on utilization of medicinal plants

1. Based on your knowledge, could you please give information on the use of different medicinal plants found in UFR, the diseases which are commonly treated, parts used and mode of application?

<u>Species</u>	<u>Disease(s)</u>	<u>Part(s)</u>	<u>Application</u>
....	....	....	....
....	....	....	....

(Use separate sheet for more lists)

2. Based on your knowledge, are there any difference in the use of medicinal plants by males and females in the village? YES/NO. If answer is YES, what roles does each

group play? Please put in the brackets appropriate number according to the answer *i.e.* 1= Men only; 2 = Women only; 3 = both men and women; 4 = men and boys; 5 = women and girls; 6 = No body participates, 7 = Not sure/don't know

a) Traditional healing activities (...)

b) Medicinal plants trading in local/district/regional markets (...)

c) Processors of medicinal plants (...)

d) Speciality in treating various diseases (...)

e) Speciality in treating women and children diseases (...)

iii. Information on conservation of medicinal plants

3. What methods are known to be used in harvesting the medicinal plants from the forest reserve?

....

....

4. What is the current status of medicinal plants in UFR? Give reasons for your answer?

....

....

5. What medicinal plant species do you think are found in abundant in UFR?

<u>Local name</u> <u>Botanical name</u>

i)........................ ....

ii)....................... ....

(Use separate sheet for more lists)

6. What medicinal plant species do you think are found in abundant in UFR?

<u>Local name</u> <u>Botanical name</u>

i)..................... ....

(Use separate sheet for more lists)

7. What medicinal plant species do you think are becoming rare to find in UFR?

<u>Local name</u> <u>Botanical name</u>

i)......................   ....

(Use separate sheet for more lists)

8. What medicinal plant species do you think have disappeared (extinct) completely in UFR?

<u>Local name</u>   <u>Botanical name</u>

i)......................   ....

Use separate sheet for more lists)

9. What measures do you think should be taken to conserve the available medicinal plants from Urumwa forest reserve?

....

....

10. Are there any problems considered as threats to the availability of medicinal plants at Urumwa which ? (Yes/No). If yes mention them

....

....

11. What are your own views on conserving the potential medicinal plants from UFR for health care?

....

....

12. Based on your knowledge is there any difference in conservation of medicinal plants by males and females in the village? YES/NO. If YES, what roles does each group play? Please put in the brackets appropriate number according to the answer *i.e.* 1= Men only; 2 = Women only; 3 = both men and women; 4 = men and boys; 5 = women and girls; 6 = No body participates, 7 = Not sure/don't know

a) Collection/harvesting of medicinal plant parts (...)

b) Knowledge on traditional conservation practices (...)

c) Participation in domestication of medicinal plants (...)

d) Adherence to JFM set rule to access the reserve (...)

e) Decision-making process to protect Urumwa and its resources (...)

Appendix Ic Variables definitions and coding applied to questions administered to communities around Urumwa Forest Reserve, Tanzania

Question type	Variable name	Variable codes
A. Socio-economic data		
Close-ended	Sex (gender)	**1** = Male; **2** = Female
Open-ended	Age	**1** = 18 – 27 years; **2** = 28 – 37; **3** = 38 – 47; **4** = 48 – 57; **5** = 58 – 67; **6** = 68 – 77; **7** = 78 – 87; **8** = 88 - 97
Open-ended	Occupation	**1** = Herbalist (Traditional healers, Traditional birth attendants, Medicinal plant sellers); **2** = Householder; **3** = Medicinal plant collector; **4** = Other informants
Close-ended	Marital status	**1** = Single; **2** = Married; **3** = Separated; **4** = Widowed; **5** = Divorced
Close-ended	Education profile	**1** = Illiterate; **2** = Adult education; **3** = Primary education; **4** = Secondary education; **5** = Higher education
Open-ended	Ethnic group	**1** = Nyamwezi; **2** = Sukuma; **3** = Other tribes
Open-ended	Village classification	**1** = Masimba; **2** = Igombanilo; **3** = Mtakuja Mashariki; **4** = Isukamahela; **5** = Kasisi 'A'; **6** = Ujerumani
B. Information on utilization of medicinal plants		
Open-ended	Plant parts used	**1** = Roots; **2** = Barks; **3** = Leaves; **4** = Roots & Barks; **5** = Roots & Leaves; **6** = Roots, Leaves & Barks; **7** = Other parts (twigs, seeds, fruits, flowers, stem, exudates/resins); **8** = All the above parts
Close-ended	Other collection sites for medicinal plants	**1** = Village woodlands; **2** = other districts/regions; **3** = Trees left on-farms; **4** = Buy from sellers/collectors; **5** = Both sites
Close-ended	Preparation of remedies	**1** = Boiling; **2** = Pounding; **3** = Grinding; **4** = 1 and 2; **5** = 1 and 3; **6** = 2 and 3; **7** = All methods
Closed-ended	Forms of remedies	**1** = Decoctions; **2** = Infusions/concentrates; **3** = Powders; **4** = Others (protective charms, poultices); **5** = Mixtures
Open-ended	Application methods	**1** = Oral; **2** =Nasal; **3** = Anal; **4** = External; **5** = Oral and nasal; **6** = Oral and anal; **7** = Oral and external; **8** = all modes are used

Close-ended	Dosage knowledge	**1** = Standardized dosage **2** = Informal dosage
Open-ended	Plant knowledge	**1** = 1 – 5 species; **2** = 6 – 10; **3** = 11 - 15; **4** = 16 – 20; **5** = Above 20 species
Open-ended	Existence of gender roles differences	**1** = Yes; **2** = No
Close-ended	Gender roles in utilization	**1** = men only; **2** =women only; **3** = men and women; **4** = Men and boys; **5** = women and girls; **6** = No body participates; **7** = Not sure/ Do not know
C. Information on conservation of medicinal plants		
Open-ended	Harvesting methods used	**1** = Root digging; **2** = Bark stripping; **3** = Leaves collection; **4** = Root digging and leaves collection; **5** = Root digging and bark stripping; **6** = Both 1, 2 & 3; **7** = Other methods (exudates tapping/seeds or flower collection)
Open-ended	Medicinal plants status	**1** = Increasing; **2** = Decreasing; **3** = Persistent/Normal; **4** = Don't know
Open-ended	Threats to medicinal plants	**1** = Encroachment; **2** = Unawareness of conservation options; **3** = Ineffective JFM; **4** = 1 & 2; **5** = 1 & 3; **6** = 2 & 3; **7** = 1, 2 &3; **8** = No threats; **9** = Not sure
Open-ended	Conservation measures	**1** = Village patrols; **2** = Promote sustainable harvesting; **3** = 1 & 2; **4**= No operation in place
Open-ended	Views on conservation	**1** = Training; **2** = Research; **3** = Strengthen policies; **4** = Strengthen local and government cooperation ; **5** = 1 & 2; **6** =1, 2 & 3; **7** = 1, 2, 3 & 4; **8** = 2 & 3; **9** = No comments
Close-ended	Gender roles in conservation	**1** = Men only; **2** =women only; **3** = men and women; **4** = Men and boys; **5** = women and girls; **6** = No body participates; **7** = Not sure/ Do not know

Appendix IIa List by frequency of reports, of medicinal plants species considered abundant at Urumwa Forest Reserve, Tabora Region, Tanzania

Frequency	Botanical name	Local name
47	*Combretum zeyheri*	Musana
24	*Terminalia sericea*	Muzima
21	*Pterocarpus tinctorius*	Mkulungu
18	*Strychnos spinosa*	Mwage
16	*Combretum fragrans*	Muluzyaminzi
	Strychnos pungens	Mkome
	Xylopia longipetala	Mshenene
12	*Friesodielsia obovata*	Musalasi
	Vitex mombassae	Mutalali
11	*Ozoroa insignis*	Mwembepori
9	*Entada abyssinica*	Mufutwambula
	Vepris glomerata	Mulungusigiti
8	*Dichrostachys cinerea*	Mutundulu
	Kigelia africana	Mudungwa
	Schrebera trichoclada	Muputika
	Hymenocardia acida	Mupala
7	*Grewia bicolor*	Mukoma
	Pericopsis angolensis	Muvunga
	Pterocarpus angolensis	Mninga
	Ximenia caffra	Mnembwa
6	*Flacourtia indica*	Musingila
	Tamarindus indica	Musisi
	Dalbergia nitidula	Kafinulambasa
5	*Albizia harveyi*	Mupogolo
	Crossopteryx febrifuga	Msanzambeke
	Diospyros fischeri	Mufubata
	Zanthoxylum chalybeum	Mlungulungu
4	*Boscia salicifolia*	Muguluka
	Isoberlinia angolensis	Muva
	Premna senensis	Mnunhwanhala
3	*Combretum obovatum*	Vugoweko
	Securidaca longependiculata	Mteyu

	Solanum incanum	Mtulantu
	Strychnos innocua	Mmundu
	Strychnos potatorum	Mgwegwe
	Markhamia obtusifolia	Mpapa
2	*Afzelia quanzensis*	Mkola
	Antidesma venosum	Msekela
	Brachystegia spiciformis	Mtundu
	Catunaregam spinosa	Ng'ochangoko
	Combretum molle	Mlama
	Commiphora africana	Mtonto
	Euphorbia grantii	Mdulansongo
	Lannea schimperi	Mgumbu
	Piliostigma thonningii	Mtindwambogo
	Rothmannia engleriana	Mkondokondo
	Sclerocarya birrea	Mng'ongo
	Steganotaenia araliacea	Mnyongampembe
	Sterculia africana	Mhozya
	Tapiphyllum cinerascens	Kambolambola
	Zanha africana	Ng'watya
1	*Acacia senegal*	Kagowole
	Berchemia discolor	Mgwata
	Bridelia duvigneaudi	Mkuni
	Canthium crassum	Muvuzivuzi
	Cissampelos pareira	Mukuluwanti
	Clerodendrum uncinatum	Mukotakipwa
	Cassia abbreviata	Mulundalunda
	Euphorbia hirta	Lonzwe
	Euphorbia tirucalii	Mnyaa
	Mangifera indica	Mwembe
	Maytenus senegalensis	Lweja
	Phyllanthus engleri	Mgogondi
	Physalis peruviana	Sinkini
	Premna senensis	Mununhwanhala
	Pseudolachnostylis glauca	Mtungulu
	Ricinus communis	Mbarika
	Senna occidentalis	Njegenjege
	Xeroderris stuhlmannii	Mnyenye

Appendix IIb List by frequency of reports, of medicinal plants considered scarce at Urumwa Forest Reserve, Tabora Region, Tanzania

Frequency	Botanical name	Local name
34	*Ekebergia benguelensis*	Mutuzya
15	*Cassia abbreviata*	Mulundalunda
12	*Pterocarpus angolensis*	Muninga
11	*Securidaca longependinculata*	Mteyu
9	*Xylopia longipetala*	Mushenene
8	*Kigelia africana*	Mudungwa
6	*Mundulea sericea*	Mutandala
4	*Capparis kirkii*	Mugakamo
4	*Maytenus galensis*	Mwezya
3	*Strychnos potatorum*	Mugwegwe
3	*Afzelia quanzensis*	Mkola
2	*Piliostigma thonningii*	Mutindwambogo
	Sterculia africana	Mhozya
	Vepris glomerata	Mlungusigiti
	Entada abysinica	Ngemwambula
1	*Strychnos potatorum*	Mulungusigiti
	Albizia harveyi	Mpogolo
	Albizia versicolor	Ntindwanzagamba
	Cissampelos pareira	Nkuluwanti
	Capparis kirkii	Mgakamo
	Dalbergia melanoxylon	Mgembe
	Lannea schimperi	Mgumbu
	Premna senensis	Mnunhwanhala
	Pithecellobium dulce	Ilamata
	Turrea fischeri	Mningiwe

Appendix IIIa Combined alphabetical list of medicinal plants with their vernacular names, family, part(s) used, habit, diseases/complications cured and application methods recorded from Urumwa Forest Reserve, Tabora region, Tanzania.

Botanical name	Vernacular name(s)	Family (Phylogenetic order)	Habit	Part(s) used	Disease/ Complication cured	Application method(s)
Abrus precatorius	Kantyentye	Papilionoideae (Fabales)	Herb	Roots	Stomach ache, Aphrodisiac	Oral
Acacia gerrardii	Olng'ong'wenyi	Mimosoideae (Fabales)	Tree	Barks	Haemorrhoids	Oral
Acacia mellifera	Mulugala	Mimosoideae (Fabales)	Tree	Roots, Leaves, Barks	Stomach ache, Menstrual disorder, Diarrhoea, Anaemia	Oral
Acacia nigrescens	Kagowole	Mimosoideae (Fabales)	Tree	Roots	Infertility, Foetus disposition, Stomach ache, Lucky	Oral, Bath
Acacia polyacantha	Livindwe	Mimosoideae (Fabales)	Tree	Roots, Barks	Convulsion, Chronic malaria	Nasal, Oral
Acacia senegal	Mugwata	Mimosoideae (Fabales)	Tree	Roots	Abscess	Massage
Acalypha fruticosa	Mugulumwanguku	Euphorbiaceae (Malpighiales)	Herb	Roots	Hernia	Oral
Adansonia digitata	Mbuyu	Malvaceae (Malvales)	Tree	Barks	General body weakness	Oral, Bath
Afzelia quanzensis	Mkola	Caesalpinioideae (Fabales)	Tree	Roots, Barks	Gonorrhoea, Syphilis, Aphrodisiac, Stroke, Fever, Abdominal swelling, Body swelling	Oral, Massage
Albizia harveyi	Mupogolo	Mimosoideae (Fabales)	Tree	Roots, Leaves	Energy giver, Convulsion, Hypertension, Intestinal worms, Stomach ache, Chest pains, Wounds, Abscess,	Oral, Nasal, Massage
Antidesma venosum	Musekela	Euphorbiaceae (Malpighiales)	Tree	Roots, Leaves	Stomach ache, Snakebite, Lucky	Oral, Massage, Bath
Azanza garckeana	Mutobo	Malvaceae (Malvales)	Tree	Roots	Labour progression	Oral

Bechemia discolor	Mukuni	Rhamnaceae (Rosales)		Roots, Leaves	Snakebite	Massage
Bidens pilosa	Ndasa	Asteraceae (Asterales)	Herb	Leaves	Fever in infants	Oral, Bath
Boscia salicifolia	Muguluka	Capparidaceae (Brassicales)	Tree	Roots, Barks	Scrotal masses, Headache, Backache, Stroke, Rheumatism	Oral, Massage
Brachystegia boehmii	Muyombo	Caesalpiniodeae (Fabales)	Tree	Roots, Leaves	Snakebite	Oral, Massage
Brachystegia spiciformis	Mutundu	Caesalpiniodeae (Fabales)	Tree	Roots, Leaves, Barks	Snakebite, Cough	Oral, Massage, Chew
Bridelia duvigneaudi	Muvuzivuzi	Euphorbiaceae (Malpighiales)	Shrub	Roots, Leaves	Intestinal worms, Love	Oral, Bath, Massage
Burkea africana	Mukarati	Caesalpiniodeae (Fabales)	Tree	Barks	Headache	Oral, Massage
Canthium crassum	Mukumbakumba, Muyogoyogo	Rubiaceae (Gentianales)		Roots	Convulsion, Infertility, Stomach ache	Oral
Capparis kirkii	Mugakamo	Capparidaceae (Brassicales)	Shrub	Roots, Barks	Rituals	Bath, External
Cassia abbreviata	Mulundalunda, Mmulimuli, Munzoka	Caesalpiniodeae (Fabales)	Tree	Roots, Leaves, Barks	Gonorrhoea, Hernia, Syphilis, Stomach ache, Bilharzias, Haemorrhoids, Fever, Jaundice, Diarrhoea, Convulsion, Abortion, Earache, Epilepsy, Aphrodisiac, Vomiting, Cough, Infertility	Oral, Chew, Anal, Nasal
Cassia obtusifolia	Muzegazega	Caesalpiniodeae (Fabales)	Tree	Roots	Jaundice	Oral
Catunaregam spinosa	Mupogole, Ng'ochangoko, Ng'wiwansungu	Rubiaceae (Gentianales)	Shrub	Roots, Barks	Infertility, Gonorrhoea, Hernia, Stomach ache, Convulsion, Abortion	Oral
Cissampelos pareira	Nkuluwanti	Menispermaceae (Ranunculales)	Shrub	Roots	Malaria, Hernia, Stomach ache, Gonorrhoea, Fever	Oral
Cissus quadrangularis	Mutandamwaka,	Vitaceae	Shrub	Roots	Hernia, Rectal prolapse	Oral, Anal

	Vulavwansuwi					
Combretum fragrans	Muluzyaminzi	Combretaceae (Myrtales)	Tree	Roots, Leaves	Malaria, Wounds, Trachoma	Oral, Massage
Combretum molle	Mulama	Combretaceae (Myrtales)	Tree	Roots, Leaves	Earache, Wounds, Love, Rituals	Oral, Massage, Bath
Combretum obovatum	Vugoweko	Combretaceae (Myrtales)	Shrub	Roots	Antiabortion, Abscess, Infertility, Love, Gonorrhoea, Snakebite	Oral, Massage, Bath
Combretum singueana	Musambisambi	Combretaceae (Myrtales)	Tree	Roots, Leaves	Epilepsy, Convulsion, Limbs ache	Oral, Nasal, Massage
Combretum zeyheri	Musana	Combretaceae (Myrtales)	Tree	Roots, Leaves, Barks	Rectal prolapse, Cough, Diarrhoea, Anaemia, Abdominal ulcers, Anal eczema, Body pains, Stomach ache, Wounds, Dysentery, Infertility, Snakebite, Haemorrhoids, Rituals	Oral, Chew, Anal, Massage, External
Commiphora africana	Muntonto, Esilalei	Burseraceae (Sapindales)	Tree	Roots, Barks	Infertility, Diabetes, Trachoma, Snakebite	Oral, Massage
Crossopteryx febrifuga	Musanzambeke	Rubiaceae (Gentianales)	Tree	Roots, Barks	Diarrhoea, Convulsion, Sore throats, Cough, Dysentery, Hernia, Hypertension, Stomach ache	Oral, Chew
Dalbergia melanoxylon	Mugembe	Papilionoideae (Fabales)	Tree	Roots, Twigs	Gonorrhoea, Bilhazia, Wounds, Abscess, Skin rashes	Oral, Massage
Dalbergia nitidula	Kafinulambasa	Papilionoideae (Fabales)	Tree	Roots, Barks	Anaemia, Toothache, Diabetes, Gonorrhoea, Bilhazia, Diarrhoea	Oral
Dichrostachys cinerea	Mutundulu	Mimosoideae (Fabales)	Tree	Roots, Leaves, Barks	Infertility, Wounds, Epilepsy, Rituals, Menstrual disorder, Rectal prolapse, Stomach ache, Diarrhoea, Dizziness	Oral, Anal, Bath, External
Diospyros fischeri	Mfubata	Ebenaceae(Ericales)	Shrub	Roots, Leaves	Placental removal after delivery, Stomach ache, Earache, Snakebite, Wounds	Oral, Massage, External
Ekebergia benguelensis	Mutuzya	Meliaceae (Sapindales)	Tree	Roots, Leaves, Barks	Convulsion, Mental disorders, Low & Hypertension, Stomach ache, Love/Lucky	Oral, Bath, Massage

Entada abyssinica	Mufutwambula, Ngemwambula	Mimosoideae (Fabales)	Tree	Roots, Leaves, Barks	Tonsillitis, Gonorrhoea, Syphilis, Hypertension, Anaemia, Snakebite, Infertility, Tuberculosis, Sore throats	Oral, chew, Massage
Erythrina abyssinica	Mukalalwanhuba	Papilionoideae (Fabales)	Tree	Barks, Leaves	Jaundice, Snakebite	Oral, Massage
Erythroxylum emarginatum	Ndaja	Erythroxylaceae (Malpighiales)	Herb	Roots, Leaves	Tumours, Rituals	Massage, Bath
Euclea divinorum	Mdaa	Ebenaceae (Ericales)	Shrub	Roots, Leaves	Infertility, Wounds, Snakebite	Oral, Massage
Euphorbia grantii	Mudulansongo	Euphorbiaceae (Malpighiales)	Shrub	Roots, Exudate	Epilepsy, Toothache, Snakebite	Nasal, Massage, External
Euphorbia hirta	Lonzwe, Vakikulu	Euphorbiaceae (Malpighiales)	Herb	Roots, Leaves, Barks	Hernia, Hypertension, Convulsion, Epilepsy, Menstrual disorders	Oral, Nasal
Euphorbia tirucalii	Munyala, Myaa	Euphorbiaceae (Malpighiales)	Shrub	Leaves, Exudate	Chicken typhoid, Finger swelling	Oral, Massage
Flacourtia indica	Musingila, Muchongoma, Mubuguswa	Salicaceae (Malpighiales)	Tree	Roots, Leaves	Infertility, Stomach ache, Cough, Hernia, Snakebite	Oral, Chew, Massage
Friesodielsia obovata	Musalasi, Msasi	Annonaceae (Magnoliales)	Tree	Roots	Infertility, Stomach ache, Anaemia, Placenta expulsion, Snakebite	Oral, Massage
Gardenia jovis-tonantis	Kilindilamugunda	Rubiaceae (Gentianales)	Shrub	Roots	Hypertension, Aphrodisiac	Oral
Grewia bicolor	Mukoma	Malvaceae (Malvales)	Shrub	Roots	Infertility, Anaemia	Oral
Grewia conocarpoides	Mudati	Malvaceae (Malvales)	Shrub	Roots	Infertility	Oral
Hymenocardia acida	Mupala	Euphorbiaceae (Malpighiales)	Tree	Roots, Leaves	Infertility, Epilepsy, Rectal prolapse, Hernia, Stomach ache	Oral, Anal, Nasal
Indigofera swaziensis	Igangula	Papilionoideae (Fabales)	Tree	Exudate	Spleen enlargement	Oral, External
Isoberlinia angolensis	Muva	Caesalpiniodeae (Fabales)	Tree	Barks	Cough, Wounds, Snakebite	Chew, Massage

Jatropha curcus	Mubono	Euphorbiaceae (Malpighiales)	Shrub	Roots, Exudate	Anal eczema	Oral, Anal
Jubernadia globiflora	Muba, Muwa	Caesalpiniodeae (Fabales)	Tree	Barks	Cough, Snakebite	Chew, Massage
Justicia salvioides	Muluguti	Acanthaceae (Lamiales)	Shrub	Roots	Infertility	Oral
Kigelia africana	Mudungwa, Mwicha, Mulegea	Bignoniaceae (Lamiales)	Tree	Roots, Barks, Fruits	Anaemia, Convulsion, Hypertension, Rituals	Oral, External
Lannea schimperi	Mugumbu	Anacardiaceae (Sapindales)	Tree	Roots, Leaves, Barks	Anaemia, Tumours, Cough, Mental disorders, Stomach ache, Snakebite, Rituals	Oral, Chew, Massage, External
Lonchocarpus bussei	Mubale	Papilionoideae (Fabales)	Tree	Roots, Leaves	Rituals	External
Mangifera indica	Mwembe	Anacardiaceae (Sapindales)	Tree	Barks	Anal eczema, Diarrhoea, Dysentery	Oral, Anal
Marigaritaria discoidea	Kasenga	Euphorbiaceae (Malpighiales)	Tree	Roots	Infertility	Oral
Markhamia obtusifolia	Mubapa	Bignoniaceae (Lamiales)	Tree	Roots	Infertility, Aphrodisiac, Love, Lucky	Oral, Bath, Massage
Maytenus senegalensis	Mwezya, Lweja	Celastraceae (Celastrales)	Tree	Roots, Barks	Infertility, Stomach ache, Fever Love/Lucky	Oral, Bath, Massage
Mundulea sericea	Mutandala	Papilionoideae (Fabales)	Shrub	Roots, Barks	Antiabortion, Wounds, Aphrodisiac, Hernia, Bilhalzia, Epilepsy, Stomach ache	Oral, Nasal, massage
Oldfieldia dactylophylla	Muliwanfwengi	Euphorbiaceae (Malpighiales)		Roots	Infertility, Aphrodisiac, Hernia, Stomach ache	Oral
Ormocarpum trachycarpum	Mukondwamhuli	Papilionoideae (Fabales)	Shrub	Roots, Leaves	Pneumonia, Snakebite	Oral, Massage
Ozoroa insignis	Mwembepori, Mukalakala	Anacardiaceae (Sapindales)	Tree	Roots, Leaves, Barks	Diarrhoea, Haemorrhoids, Anal eczema, Epilepsy, Gonorrhoea, Antiabortion, Stomach ache	Oral, Nasal, Anal
Parinari curatellifolia	Mumbula	Chrysobalanaceae	Tree	Roots	Infertility	Oral

		(Malpighiales)				
Pennisetum purpureum	Isumbu	Poaceae (Poales)	Herb	Stem	Infertility	Oral
Pericopsis angolensis	Mubanga, Muvunga	Papilionoideae (Fabales)	Tree	Roots, Leaves, Barks	Stroke, Headache, Dizziness, Cough, Fireburn, Limbs ache, Convulsion	Oral, Massage
Phyllanthus engleri	Mugogondi	Euphorbiaceae (Malpighiales)	Shrub	Roots, Leaves	Epilepsy, Hernia	Nasal, Oral
Phyllanthus reticulatus	Mubinzandimi	Euphorbiaceae (Malpighiales)	Shrub	Leaves	Hookworms	Oral
Physalis peruviana	Sinkini	Solanaceae (Solanales)	Herb	Roots	Intestinal worms	Oral
Piliostigma thonningii	Mutindwambogo	Caesalpiniodeae (Fabales)	Tree	Roots, Leaves, Barks	Convulsion, Epilepsy, Snakebite	Oral, Nasal, Massage
Pithecellobium dulce	Ilamata	Mimosoideae (Fabales)	Tree	Roots	Snakebite	Massage
Premna senensis	Mununhwanhala	Lamiaceae (Lamiales)		Roots, Leaves	Epilepsy, Body pains/weakness, Stomach ache, Infertility, Hernia, Aphrodisiac, Abscess, Rituals	Oral, Nasal, Massage, Bath, external
Pseudolachnostylis glauca	Mutungulu	Euphorbiaceae (Malpighiales)	Shrub	Roots, Leaves, Barks	Stabbing sensations, Diarrhoea, Snakebite	Oral, Massage
Pterocarpus angolensis	Muninga	Papilionoideae (Fabales)	Tree	Roots, Barks, Leaves, Fruits	Anaemia, Cough, Diarrhoea, Snakebite	Oral, Chew, Massage
Pterocarpus tinctorius	Mukurungu,	Papilionoideae (Fabales)	Tree	Roots, Leaves, Barks	Anaemia, Diarrhoea, Wounds, Antiabortion, Stomach ache, Eyes ache, Snakebite	Oral, Massage
Ricinus communis	Mbarika, Mkale	Euphorbiaceae (Malpighiales)	Tree	Roots, Leaves	Labour pains, Stroke, Placenta expulsion	Oral, Massage
Rothmannia engleriana	Mukondokondo	Rubiaceae (Gentianales)	Tree	Roots, Leaves, Barks	Infertility, Gonorrhoea, Antiabortion, Placenta expulsion	Oral
Schrebera trichoclada	Muputika	Oleaceae (Lamiales)	Tree	Roots, Leaves,	Headache, Cough, Wounds, Flu, Stabbing	Oral, Chew,

				Barks	sensations, Snakebite	Nasal, Massage
Sclerocarya birrea spp caffra	Mung'ongo	Anacardiaceae (Sapindales)	Tree	Leaves, Barks	Anal eczema, Cough	Anal, Oral, Chew
Securidaca longependinculata	Mteyu, Mteyo, Nengonengo	Polygalaceae (Fabales)		Roots, Leaves	Epilepsy, Headache Infertility, Toothache, Snakebite, Placenta expulsion, Stomach ache	Oral, Chew, Nasal
Senna occidentalis	Muhungajini, Muwangajini, Njegenjege	Caesalpiniodeae (Fabales)	Tree	Roots	Stomach ache, Fever	Oral
Solanum incanum	Ntulantu, Matula, Iditula	Solanaceae (Solanales)	Shrub	Roots, Fruits	Tooth decay, Aphrodisiac, Hernia, Intestinal worms, Pelvic dilation, Stomach ache, Rituals	Oral, Bath
Steganotaenia araliacea	Munyongampembe	Apiaceae (Apiales)		Roots, Leaves, Barks	Snakebite, Rituals	Massage, External
Sterculia africana	Muhozya	Malvaceae (Malvales)	Tree	Roots, Barks	Pain relief, Anaemia, Mental disorder, Infertility, Convulsion, Lucky, Rituals	Oral, Bath, External
Strophanthus eminii	Musungululu	Apocynaceae (Gentianles)		Roots	Epilepsy	Oral, Nasal
Strychnos innocua	Mumundu	Strychnaceae (Gentianales)	Tree	Roots	Aphrodisiac, Infertility	Oral
Strychnos potatorum	Mugwegwe, Mupandepande	Strychnaceae (Gentianales)	Tree	Roots, Leaves	Stomach ache, Toothache, Hernia, Cough, Malaria, Gonorrhoea, Syphilis, Bilhalzia, Snakebite	Oral, Chew, Massage
Strychnos pungens	Mukome	Strychnaceae (Gentianales)	Tree	Roots, Leaves, Fruits	Snakebite, Convulsion, Heart pains	Oral, Massage
Strychnos spinosa	Mwage	Strychnaceae (Gentianales)	Tree	Roots, Leaves, Barks	Infertility, Tumours, Convulsion, Vomiting, Intestinal worms, Stabbing sensations, Gonorrhoea, Syphilis, Cough, Stomach ache, Snakebite	Oral, Chew, Massage
Syzygium cumini	Mudisi	Myrtaceae (Myrtales)	Tree	Barks	Bilhalzia	Oral

Tapiphyllum cinerascens	Kambolambola	Rubiaceae (Gentianlaes)	Herb	Roots	Infertility	Oral
Terminalia sericea	Muzima, Njimya	Combretaceae (Myrtales)	Tree	Roots, Leaves, Barks	Haemorrhoids, Diarrhoea, Anal eczema, Stabbing sensations, Rectal prolapse, Stomach ache, Cough, Measles, Limbs ache, Rituals	Oral, Chew, Anal, Massage
Turraea fischeri	Ningiwe, Muningiwe	Meliaceae (Sapindales)	Tree	Roots	Stomach ache, Infertility, Headache	Oral, Massage
Vepris glomerata	Mulungusigiti	Rutaceae (Sapindales)	Tree	Roots, Leaves	Scrotal masses, Infertility, Aphrodisiac, Hernia, Diabetes, Constipation, Snakebite, Rituals	Oral, Massage, external
Vitex mombassae	Mutalali, Musungwi	Lamiaceae (Lamiales)	Tree	Roots, Leaves	Infertility, Body rashes, Stomach ache, Diabetes, Diarrhoea, Snakebite	Oral, Massage
Xeroderris stuhlmannii	Munyenye	Papilionoideae (Fabales)	Tree	Roots, Leaves	Hookworms, Snakebite	Oral, Massage
Ximenia caffra	Munembwa, Mutundwa	Olacaceae (Santalales)	Tree	Roots, Leaves	Stomach ache, Gonorrhoea, Anaemia, Mental disorder, Abdominal ulcers, Tumours, Abscess, Hernia, Intestinal worms, Snakebite	Oral, Nasal, Massage
Xylopia longipetala	Mushenene	Annonaceae (Magnoliales)	Tree	Roots, Leaves	Infertility, Stomach ache, Diabetes, Abdominal ulcers, Fever, Epilepsy	Oral, Nasal
Zanha africana	Mukalya, Ng'watya, Mdaula	Sapindaceae (Sapindales)	Tree	Roots, Barks	Convulsion, Flu, Headache, Stomach ache, Elephantiasis, Aphrodisiac, Epilepsy	Oral, Nasal, Massage
Zanthoxylum chalybeum	Mulungulungu, Munungu, Oluisuki	Rutaceae (Sapindales)	Tree	Roots, Leaves, Barks	Hernia, Headache, Toothache, Body swelling, Stomach ache, Limb swelling, Malaria, Asthma, Chest pains, Infertility, Heart pains, Abscess	Oral, Nasal, Massage
Ziziphus mucronata	Mugugunu	Rhamnaceae (Rosales)	Tree	Roots, Barks	Foetus disposition, Aphrodisiac, Stomach ache, Chest pains, Hypertension	Oral

Appendix IIIb Alphabetical list of other utilized medicinal plans with their vernacular names, family, part(s) used, habit, diseases/complications cured and application methods from outside* Urumwa Forest Reserve, Tabora Region, Tanzania.

Botanical name	Vernacular name	Family	Habit	Part(s) used	Disease/Complication cured	Application method(s)
Acacia nilotica	Olkiroliti	Mimosoideae (Fabales)	Tree	Barks	Stomach ache, Typhoid fever, Diabetes, Gonorrhoea, Syphilis, Anaemia	Oral
Aloe vera	Lugaka	Asphodelaceae (Asparagales)	Herb	Leaves, Roots	Intestinal worms, Constipation, Stomach ache, Aphrodisiac, Impotency, Spleen enlargement	Oral
Annona senegalensis	Mukonola, Mutopetope	Annonaceae(Magnoliales)	Tree	Roots	Stomach ache, Labour progression	Oral
Azadirachta indica	Mwarobaini	Meliaceae (Sapindales)	Tree	Roots, Leaves, Barks	Stomach ache, Fever, Malaria, Hernia, General body weakness	Oral
Balanites aegyptica	Olng'oswai	Zygophillaceae	Tree	Roots	Typhoid fever, Menstrual disorders	Oral
Cajanus cajan	Mubaazi	Papilionoideae (Fabales)	Shrub	Roots, Leaves, Seeds	Placenta expulsion, Stomach ache, Antiabortion, Infertility, Foetus disposition, Labour progression	Oral
Carica papaya	Limbabayu, Mpapai	Caricaceae (Brassicales)	Tree	Roots, Barks	Hookworms, Typhoid in chicken	Oral
Psidium guajava	Mpera	Myrtaceae (JMyrtales)	Tree	Roots, Leaves, Barks	Dysentery, Malaria, Diarrhoea	Oral
Tamarindus indica	Musisi, Nshishi	Caesalpiniodeae (Fabales)	Tree	Leaves, Barks	Mental disorder, Malaria, Vomiting, Diarrhoea, Stomach ache, Wounds, Dysentery, Snakebite	Oral, Massage
Terminalia brownii	Olbukoi	Combretaceae (Myrtales)	Tree	Barks	Hypertension	Oral
Terminalia cuminii	Mzambarau	Combretaceae (Myrtales)	Tree	Seeds	Diabetes	Chew
Walburgia salutaris	Musokonoi	Canellaceae (Canellales)	Tree	Barks, Roots	Bilhalzia, Gonorrhoea, Syphilis, Hernia, Cough, Asthma	Oral, Chew, Nasal

* Obtained from other districts mainly Sikonge, other regions mainly Arusha and in farms around homesteads

Appendix IV Alphabetical list of diseases and their respective medicinal plants as identified by male and female respondents in communities around Urumwa Forest Reserve, Tabora Region, Tanzania.

Disease(s)Complication(s)	Medicinal Plant(S) Used	Disease/complication frequency by respondents	
Gastrointestinal disorders:		**Male**	**Female**
Abdominal ulcers	*Combretum zeyheri, Ximenia caffra, Xylopia longipetala*	2	2
Constipation	*Aloe vera., Securidaca longipendiculata, Verpis glomerata*	4	-
Diarrhoea	*Acacia mellifera, Cassia abbreviata, Combretum zeyheri, Crossopterix febrifuga, Dalbergia nitidula, Dichrostarchys cinerea, Mangifera indica, Ozoroa insignis, Pseudolachnostylia glauca, Psidium guajava, Pterocarpus angolensis, Pterocarpus tinctorius, Tamarindus indica, Terminalia sericea, Vitex mombassae*	32	23
Dysentery	*Combretum zeyheri, Crossopterix febrifuga, Mangifera indica, Psidium guajava, Tamarindus indica*	7	9
Haemorrhoids	*Cassia abbreviata, Combretum zeyheri, Terminalia sericea*	1	-
Hernia	*Acalypha fruticosa, Aloe vera., Azadrachta indica, Cassia abbreviata, Catunaregam spinosa, Cissampelos pareira, Cissus quadrangularis, Crossopterix febrifuga, Euphorbia hirta, Flacourtia indica, Hymenocardia acida, Mundulea sericea, Oldfieldia dactylophylla, Phyllanthus engleri, Premna senensis, Securidaca longipendiculata, Solanum incarnum, Strychnos potatorum, Warburgia salutaris, Ximenia caffra, Zanthoxylum chalybeum*	34	3
Intestinal worms and Hookworms	*Albizia harveyi, Aloe vera., Bridelia duvigneaudi, Cassia abbreviata, Carica papaya, Phyllanthus reticulates, Physalis peruviana, Solanum incarnum, Strychnos spinosa, Ximenia caffra, Xerodernis stuhlmanii*	8	1
Rectal prolapse	*Cissus quadrangularis, Combretum zeyheri, Dichrostarchys cinerea, Hymenocardia acida, Terminalia sericea*	9	4
Spleen enlargement	*Aloe vera., Clerodendrum uncinatum, Indigofera swaziensis*	3	-
Stomach ache	*Abrus precatorius, Acacia mellifera, Acacia nilotica, Acacia nigrescens, Albizia harveyi, Aloe vera., Annona senegalensis, Antidesma venosum, Azadrachta indica, Cassia abbreviata, Cathium crassum, Catunaregam spinosa, Cissampelos pareira, Combretum zeyheri, Crossopterix febrifuga, Dalbergia nitidula, Dichrostarchys cinerea, Diospyros fischeri, Ekebergia benguelensis, Flacourtia indica, Friesodielsia obovata, Hymenocardia acida, Lannea shimperi, Mundulea sericea, Mytenus senegalensis, Oldfieldia dactylophylla, Ozoroa insignis, Phyllanthus engleri, Premna senensis, Pterocarpus tinctorius, Schrebera trichoclada, Securidaca longipendiculata, Senna occidentalis, Solanum incarnum, Strychnos potatorum, Strychnos spinosa, Tamarindus indica, Terminalia sericea, Turrea fischeri,*	36	26

	Vanguleriopsos lanciflora, Verpis glomerata, Ximenia americana, Xylopia longipetala, Zanthoxylum chalybeum, Ziziphus mucronata		
Typhoid	*Acacia nilotica, Balanites aegyptica*	2	-
Gynaecological, Andrological and Urogenital disorders:			
Abortion	*Cassia abbreviata, Catunaregam spinosa*	2	-
Anti-abortion	*Cajanus cajan, Combretum obovatum, Mundulea sericea, Ozoroa insignis, Pterocarpus tinctorius, Rothmannia engleriana*	1	2
Aphrodisiac	*Abrus precatorius, Afzelia quanzensis, Aloe vera., Asparangus falcatus, Cassia abbreviata, Gardenia jovistonantis, Mundulea sericea, Oldfieldia dactylophylla, Premna senensis, Solanum incarnum, Strychnos innocua, Verpis glomerata, Zanha africana, Ziziphus mucronata*	14	4
Bilharzias/Schistosomiasis	*Cassia abbreviata, Dalbergia melanoxylon, Mundulea sericea, Strychnos potatorum*	5	-
Foetus disposition	*Acacia nigrescens, Cajanus cajan, Ziziphus mucronata*	-	1
Gonorrhoea	*Acacia nilotica, Afzelia quanzensis, Cassia abbreviata, Catunaregam spinosa, Cissampelos pareira, Combretum obovatum, Dalbergia nitidula, Diospyros fischeri, Entada abyssinica, Ozoroa insignis, Rothmannia engleriana, Strychnos potatorum, Strychnos spinosa, Warburgia salutaris, Ximenia caffra*	9	2
Infertility	*Acacia nigrescens, Asparangus falcatus, Cajanus cajan, Cassia abbreviata, Cathium crassum, Combretum obovatum, Combretum zeyheri, Commiphora africana, Dichrostarchys cinerea, Entada abyssinica, Euclea divinorum, Flacourtia indica, Friesodielsia obovata, Grewia bicolour, Grewia conocarpoides, Hymenocardia acida, Justica salvioides, Marigaritaria discoidea, Maytenus galensis, Oldfieldia dactylophylla, Parinari curratellifolia, Pavetta schumanniana, Pennisetum perpureum, Premna senensis, Rothmannia engleriana, Securidaca longipendiculata, Sterculia africana, Strychnos innocua, Strychnos spinosa, Tapiphyllum cinerascens, Turrea fischeri, Verpis glomerata, Vitex mombassae, Xylopia longipetala, Zanthoxylum chalybeum*	29	25
Impotency	*Aloe vera., Mundulea sericea*	2	-
Labour pains progression	*Annona senegalensis, Azanza garkeana, Cajanus cajan, Ricinus communisum*	-	5
Menstrual disorders	*Acacia mellifera, Balanites aegyptica, Dichrostarchys cinerea, Euphorbia hirta, Warburgia salutaris*	4	4

Placenta expulsion	*Cajanus cajan, Diospyros fischeri, Friesodielsia obovata, Ricinus communis, Rothmannia engleriana, Securidaca longipendiculata*	-	17
Scrotal masses	*Boscia salicifolia, Verpis glomerata*	2	-
Syphilis	*Acacia nilotica, Afzelia quanzensis, Cassia abbreviata, Entada abyssinica, Strychnos potatorum, Strychnos spinosa, Warburgia salutaris*	3	-
Pain and Inflammations:			
Abdominal swellings	*Afzelia quanzensis*	1	-
Backache	*Boscia salicifolia*	1	-
Body swelling	*Afzelia quanzensis, Zanthoxylum chalybeum*	6	1
Body pains	*Combretum zeyheri*	1	1
Chest pains	*Albizia harveyi, Zanthoxylum chalybeum, Ziziphus mucronata*	2	-
Ears ache	*Combretum molle, Diospyros fischeri, Cassia abbreviata*	3	1
Elephantiasis	*Zanha Africana*	1	-
Finger swelling	*Euphorbia tirucalii*	1	-
Headache	*Boscia salicifolia, Burkea africana, Cassia abbreviata, Pericopsis angolensis, Securidaca longipendiculata, Solanum incarnum, Turrea fischeri, Zanha africana, Zanthoxylum chalybeum*	13	4
Heart pains	*Strychnos pungens, Zanthoxylum chalybeum*	2	-
Limbs ache	*Combretum singueana, Pericopsis angolensis, Terminalia sericea*	2	-
Pain relief	*Sterculia Africana*	1	-
Stabbing sensations	*Schrebera trichoclada, Strychnos spinosa, Terminalia sericea*	5	-
Rheumatism	*Boscia salicifolia*	4	-

Snakebite	*Antidesma venosum, Bechemia discolour, Brachystegia boehmii, Brachystegia spiciformis, Cassia abbreviata, Combretum obovatum, Commiphora africana, Condylocarpon diplorhynchus, Diospyros fischeri, Entada abyssinica, Erythrina abyssinica, Erythrophleum africanum, Euphorbia grantii, Flacourtia indica, Friesodielsia obovata, Isoberlinia angolensis, Julbernadia globiflora, Lannea schimperi, Ormacarpum trachycarpum, Pericopsis angolensis, Piliostigma thoningii, Pseudolachnostylia glauca, Pterocarpus angolensis, Pterocarpus tinctorius, Schrebera trichoclada, Securidaca longipendiculata, Steganotaenia araliaceae, Sterculia africana, Strychnos potatorum, Strychnos pungens, Strychnos spinosa, Tamarindus indica, Verpis glomerata, Vitex mombassae, Xerodernis stuhlmnii, Ximenia caffra*	25	3
Toothache/Tooth decay	*Dalbergia nitidula, Euphorbia grantii, Securidaca longipendiculata, Solanum incarnum, Strychnos potatorum, Zanthoxylum chalybeum*	4	-
Trachoma and eyes problems	*Combretum fragans, Commiphora africana, Pterocarpus tinctorius*	3	-
Tumours	*Erythroxylum emarginatum, Ximenia caffra*	1	-
Brain and Nervous system:			
Convulsion	*Acacia polyacantha, Albizia harveyi, Albizia versicolor, Cassia abbreviata, Catunaregam spinosa, Crossopterix febrifuga, Euphorbia hirta, Euphorbia grantii, Ekebergia benguelensis, Kigelia africana, Pericopsis angolensis, Piliostigma thoningii, Sterculia africana, Strychnos pungens, Strychnos spinosa, Zanha africana*	22	6
Epilepsy	*Albizia versicolor, Cassia abbreviata, Combretum singueana, Dichrostarchys cinerea, Euphorbia grantii, Mundulea sericea, Ozoroa insignis, Phyllanthus engleri, Piliostigma thoningii, Premna senensis, Securidaca longipendiculata, Strophanthus eminii, Xylopia longipetala, Zanha Africana*	7	11
Mental illness	*Ekebergia benguelensis, Lannea schimperi, Tamarindus indica, Ximenia caffra*	11	5
Stroke	*Afzelia quanzensis, Boscia salicifolia, Pericopsis angolensis, Ricinus communis*	3	1
Respiratory disorders:			
Asthma	*Warburgia salutaris, Zanthoxylum chalybeum*	2	-
Cough	*Brachystegia spiciformis, Cassia abbreviata, Combretum zeyheri, Crossopterix febrifuga, Flacourtia indica, Isoberlinia angolensis, Jubernaldia globiflora, Lannea schimperi, Pericopsis angolensis, Pterocarpus angolensis, Schrebera trichoclada, Sclerocarya birrea, Strychnos potatorum, Strychnos spinosa, Terminalia sericea, Warburgia salutaris,*	21	7
Flu	*Schrebera trichoclada, Zanha africana*	3	-

Measles	*Terminalia sericea, Vernonia glabra*	1	2
Pneumonia	*Ormacarpum trachycarpum,*	1	-
Sore throats	*Crossopterix febrifuga, Entada abyssinica,*	2	1
Tonsillitis	*Entada abyssinica,Solanum incanum*	1	-
Tuberculosis	*Entada abyssinica*	2	-
Other human diseases:			
Anaemia	*Acacia mellifera, Acacia nilotica, Combretum zeyheri, Dalbergia nitidula, Entada abyssinica, Friesodielsia obovata, Grewia bicolour, Kigelia africana, Lannea schimperi, Pterocarpus angolensis, Pterocarpus tinctorius, Sterculia africana, Ximenia caffra*	25	17
Diabetes	*Acacia nilotica, Commiphora africana, Dalbergia nitidula, Terminalia cuminii, Verpis glomerata, Vitex mombassae, Xylopia longipetala*	8	4
Dizziness	*Dichrostarchys cinerea, Pericopsis angolensis*	2	-
Energy giver	*Albizia harveyi*	1	-
General body weakness	*Azadrachta indica, Premna senensis*	3	-
Hypertension	*Albizia harveyi, Borassus ethiopicum, Crossopterix febrifuga, Ekebergia benguelensis, Entada abyssinica, Euphorbia hirta, Gardenia jovistonantis, Kigelia africana, Terminalia brownii, Warburgia salutaris, Ziziphus mucronata*	11	3
Low blood pressure	*Borassus ethiopicum, Ekebergia benguelensis*	2	-
Rituals and fortunes:			
Love	*Antidesma venosum, Combretum molle, Chenopodium album, Ekebergia benguelensis*	10	4
Lucky	*Acacia nigrescens, Antidesma venosum, Chenopodium album, Ekebergia benguelensis*	15	8
Rituals	*Capparis kirkii, Combretum molle, Combretum zeyheri, Dichrostarchys cinerea, Erythroxylum emarginatum, Kigelia africana, Lannea schimperi, Lonchocarpus bussei, Mundulea sericea, Premna senensis, Steganotaenia araliaceae, Sterculia africana, Terminalia sericea, Verpis glomerata,*	16	6

Malaria and fever:			
Malaria	*Acacia polyacantha, Azadirachta indica, Cassia abbreviata, Cissampelos pareira, Combretum fragans, Psidium guajava, Strychnos potatorum, Tamarindus indica, Zanthoxylum chalybeum*	18	5
Fever	*Afzelia quanzensis, Azadirachta indica, Cassia abbreviata, Cissampelos pareira, Senna occidentalis, Xylopia longipetala,*	11	6
Jaundice	*Cassia abbreviata, Cassia obtusfolia, Entada abyssinica*	2	2
Vomitting	*Cassia abbreviata*		1
Skin disorders:			
Abscess	*Acacia senegal, Albizia harveyi, Combretum obovatum, Dalbergia melanoxylon, Premna senensis*	8	3
Fire burn	*Pericopsis angolensis*	-	1
Skin/Body rashes	*Dalbergia melanoxylon, Vitex mombassae*	2	-
Wounds	*Albizia harveyi, Combretum fragans, Combretum molle, Combretum zeyheri, Condylocarpon diplorynchus, Dalbergia melanoxylon, Dichrostarchys cinerea, Diospyros fischeri, Euclea divinorum, Isoberlinia angolensis, Mundulea sericea, Pterocarpus tinctorius, Schrebera trichoclada*	10	6
Infants disorders:			
Anal eczema	*Combretum zeyheri, Jatropha curcus, Mangifera indica, Ozoroa insignis, Sclerocarya birrea, Terminalia sericea*	15	24
Infants fever/Headache	*Biden pilosa, Markhamia obtusifolia, Pterocarpus angolensis, Securidaca longipendiculata*	2	3
Constipation	*Clerodendum capitatum*	2	1
Infants stomach ache	*Dichrostarchys cinerea, Securidaca longipendiculata*	-	1
General body weakness	*Adansonia digitata*	-	1

Appendix V Inventory form used during medicinal plants species survey at Urumwa Forest Reserve, Tabora Region, Tanzania.

Forest area name:.. **Recorder:**...

Date:.. **Species Local name**...

Tree no.	Distance (m)	Dbh (cm)	Height (m) Largest stem	GPS Readings (X,Y)	Tree no.	Distance (m)	Dbh (cm)	Height (m) Largest stem	GPS Readings (X,Y)
1					18				
2					19				
3					20				
4					21				
5					22				
6					23				
7					24				
8					25				
9					26				
10					27				
11					28				
12					29				
13					30				
14					31				
15					32				
16					33				
17					34				

Any disturbance noted:

....

....

....

....

Other observations:

Fruiting evidence ....

Flowering evidence ....

Tree has ever been exploited..............................

....

Appendix VIa The Flavonoids and Alkaloids reported from *Pterocarpus* species and other members of the *Pterocarpus* clade with their medicinal application arranged according to their degree of closeness to *P. tinctorius*.

Species name	Compound(s) reported	Flavonoids/ Alkaloids sub-categories (18)	Species from other genera reported to have compounds known from *Pterocarpus*	Species medicinal application
Pterocarpus tinctorius	na	na	na	Diarrhoea, Anaemia, Wounds, Anti-abortion, Stomachache, Snakebite (Pers. obs. 2004)
P. soyauxii ***	Claussequinone; *(R)-form*(9a)	Flavonoids: Isoflavanquinones	na	Fever, Diarrhoea, Wounds (25)
	Vestitol; *(R)-form*(2a, 9a)	Flavonoids: Isoflavans	*Centrolobium tomentosum* Benth.**	
	Kaempferol (9a)	Flavonoids: Flavonols	*Arachis hypogaea* L.*,	
	Formononetin (9a, 13a, 53a)	Flavonoids: Isoflavones	*Centrolobium tomentosum* Benth.**, *C. robustum* (Vell. Conc.) Benth.**, *C. sclerophyllum* H.C. Lima**,, *Tipuana tipu* (Benth.) Benth**	
	Prunetin (9a)		na	
	Santal (9a)		na	
	3,8-Dihydroxy-9-methoxypterocarpan(9a)	Flavonoids: Simple pterocarpans	na	
	Homopterocarpin (10a, 31a),		na	
P. mildbraedii ***	na	na	na	Diarrhoea, Fever, Urinal antiseptic (25)
*P. angolensis***	Angolesin7a, (30a)	Flavonoids: α-Methyldeoxybenzoins	na	Wounds (54), Schistosomiasis (48), Aphrodisiac (58)
	4-*O*-α-Cadinylangolesin (7a)		na	
	4-*O*-Methylangolesin(7a)		na	
	Genistein(8a)	Flavonoids: Isoflavones	na	

	7-*O*- Methyltectorigenin (8a,45a, 53a)		na	
	Muningin (8a,30a, 53a)		na	
	Prunetin(8a,29a, 53a)		na	
	Liquiritigenin(8a)	Flavonoids: Flavanones	*Centrolobium robustum* (Vell. Conc.) Benth.**	
*P. dalbergioides***	Calycosin (50a)	Flavonoids: Isoflavones	*Centrolobium sclerophyllum* H.C. Lima**, *Centrolobium paraense* Tul. var. *paraense* Benth**	na
	Homopterocarpin (52b) Maackiain; *(±)-form* (50a, 53a) Pterocarpin (31a,50a,52a)	Flavonoids: Simple pterocarpans	na	
*P. erinaceus***	Angolesin (1a)	Flavonoids: α-Methyldeoxybenzoins	na	Diarrhoea, Dysentery, Fever, Leucorrhea, Ringworms, Sores, Tumor, Urethritis, Wounds (5), Skin diseases, Fever (25)
	Pseudobaptigenin (10a)	Flavonoids: Isoflavones	na	
*P. indicus***	Angolesin (18a, 23a,b)	Flavonoids: α-Methyldeoxybenzoins	na	Malaria, Dysentery, Skin disorders, minor wounds (51); Diarrhoea, Mouth thrush, Sore throat (15; 51); Boil, Nephritis, Prickly heat, Stomatitis, Syphilis (5).
	Formononetin (11a,18a)	Flavonoids: Isoflavones	*Centrolobium tomentosum* Benth.**, *Centrolobium robustum* (Vell. Conc.) Benth.**, *Centrolobium sclerophyllum* H.C. Lima**,, *Tipuana tipu* (Benth.) Benth**	
	Homopterocarpin(11a)	Flavonoids: Simple pterocarpans	na	
	Pterofuran (18a)		na	
	Pterocarpin (11a,18a)		na	
	Isoliquiritigenin (20a)	Flavonoids: Chalcones	*Platymiscium praecox* Benth. **	
*P. macrocarpus***	Homopterocarpin (6a,52a,b)	Flavonoids: Simple pterocarpans	na	na
	Pterocarpin (31a,52a)		na	

	Isoliquiritigenin (14a, 59a)	Flavonoids: Chalcones	*Platymiscium praecox* Benth. **	
	Liquiritigenin (14a, 59a)	Flavonoids: Flavanones	*Centrolobium robustum* (Vell. Conc.) Benth.**, *Platymiscium praecox* Benth. **	
	Macrocarposide (59a)	Flavonoids: Isoflavanones	na	
*P. marsupium***	Aureusidin ; 6-*O*- α-L-Rhamnopyranoside (37a)	Flavonoids: Aurones	na	Diabetes mellitus (23, 24); Diarrhoea, Boils, Stomach acid, Sores, Skin disorders(50)
	Carpusin (9a)		na	
	4',6-Dihydroxy-7-methylaurone; 6-*O*- α-L-Rhamnopyranoside(43a)		na	
	4,4'6-Trihydroxy-7-methylaurone; 4-*O*-α-L-Rhamnopyranoside(44h)		na	
	4,4',6-Trihydroxyaurone; 6-*O*- α-L-Rhamnopyranoside(44h)		na	
	Pterosupin (40a,3c)		na	
	Coatline A (9a)	Flavonoids: Chalcones	na	
	Isoliquiritigenin (8a,35a,2c)		*Platymiscium praecox* Benth. **	
	4',7-Dihydroxyflavone (40a)	Flavonoids: Flavones	na	
	8-C-Glucopyranosyl-3,4',7-trihydroxyflavone(9a)		na	
	3,4',5,6,7-Pentamethoxyflavone; 6-rhamnoside (60c)		na	
	Epicatechin (16e)	Flavonoids: Flavan-3-ols	*Arachis hypogaea* L.*	
	Garbanzol (3c)	Flavonoids: Flavonols	na	
	7-Hydroxy-6,8-dimethylflavanone; *(S)*-	Flavonoids: Flavanones	na	

form, 7-*O*- α-L-Arabinopyranoside (52c)		
7-Hydroxyflavanone; *(S)-form* (40a)		na
Liquiritigenin (3c, 9a,40a,22a)		*Centrolobium robustum* (Vell. Conc.) Benth.**
Naringenin (52i)		na
3',4',5',7,8-Pentahydroxyflavanone; *(S)-form*, 3',5'-Di-Me ether, 4'-*O*- β-D-glucopyranoside (57c)		na
Irisolidone 7-rhamnoside(23a)	Flavonoids: Isoflavones	na
Pseudobaptigenin (3c)		na
Retusin 8-arabinoside(57i)		na
3,4',7-Trihydroxyisoflavone(40a,3c)		na
4'7,8-Trihydroxyisoflavone; 4'-Me ether, 7-*O*- α-D- Glucopyranoside(43a)		na
5,6,7-Trihydroxyisoflavone; 6-Me ether, 7-*O*- α-L- rhamnopyranoside (43a)		na
4'5,7-Trihydroxy-8-methylisoflavone; 4',5-Di-Me ether, 7-*O*- α-L-rhamnopyranoside(42a)		na
6-Hydroxy-3,5,7,4'-tetramethoxyflavone, 6-rhamnoside(57c)		na
3,3',4',5,7-Pentahydroxyflavan; *(2RS,3RS)-form*(12i)	Flavonoids: Flavans	na
Propterol (56a), Propterol B (39a, 38a)	Flavonoids: Diarylpropane	na
Homoisoflavanone (26a)	Isoflavanones	na

*P. officinalis***		Alkaloids: indole	na	na
*P. osun***	Homopterocarpin (1a)	Flavonoids: Simple pterocarpans	na	Skin disorders, Wounds, Rheumatism, Sprains, Stiff joints (21)
	Pterocarpin (1a, 4a)		na	
	Santal (4, 1)	Flavonoids: Isoflavones	na	
	Santarubin AandB (5a)	Flavonoids: Biflavonoids	na	
	Santalin A (5a),		na	
*P. santalinoides***	na	na	na	Diarrhoea, Abortion (25)
*P. santalinus***	Homopterocarpin (4b)	Flavonoids: Simple pterocarpans	na	Headache, Bilious, Skin disorder, Dysentery, Diarrhoea(32); Diabetes mellitus (46, 47)
	Pterocarpin (4b, 53a)		na	
	Santalin A, B and C (3a,55a,36b)	Flavonoids: Bioflavonoids	na	
	Liquiritigenin(33a)	Flavonoids: Flavanones	*Centrolobium robustum* (Vell. Conc.) Benth.**	
	Isoliquiritigenin(33a)	Flavonoids: Chalcones	*Platymiscium praecox* Benth.**	
	4',5-Dihydroxy, 7-*O*-methylisoflavone; 3'-*O*-β-D-Glucoside (33a, 34a, 35a)	Flavonoids: Isoflavones	na	
	4',5-Dihydroxy-7-*O*-methylisoflavone,		na	

Note: a = Heartwood; b=Sapwood; c = Roots; d = Stem; e = Barks; f = Seeds/pods; g = Leaves; h = Flowers; i = Unspecified parts; j = other parts (seed coat, shell, pods, whole plant); na = Information not available; Numbers in parentheses followed by letters identify references in accompanying list. *** = Very closely related to *P. tinctorius*; ** = relatively closely related to *P. tinctorius*; * = less closely related to *P. tinctorius*

Appendix VIb Bioactivity of flavonoids and alkaloids reported from genus *Pterocarpus* Jacq. and other related genera of the '*Pterocarpus* clade'

Compound(s) category (18)	**Structural name(s)**	**Compound common name(s)**	**Other genera reported to have compounds known from *Pterocarpus***	**Reported bioactivity**
Flavonoids: α-Methyldeoxybenzoins	1-(2,4-Dihydroxyphenyl)-2-(4-methoxyphenyl)-1-propanone	Angolesin	na	Antifungal(4)
	1-(2,4-Dihydroxyphenyl)-2-(4-methoxyphenyl)-1-propanone; 2-Me ether	Angolesin susbstitute (2-*O*-Methylangolesin, Angolesin; (R)-*form*)		
	1-(2,4-Dihydroxyphenyl)-2-(4-methoxyphenyl)-1-propanone; 4-Me ether	Angolesin substitute (4-*O*-Methylangolesin)		
	4-*O*-T-Cadinylangolesin; (10'R)-*form* 4-α-T-Candylangolesin; (10'S)-*form*	Cadinylangolesin substitutes		Antifungal(4)
Flavonoids: Isoflavones	3',7-Dihydroxy-4'-methoxyisoflavone 3-Hydroxyformononetin	Calycosin	*Centrolobium* Benth**, *Tipuana* (Benth.) Benth**	na
	4',5,6,7-Tetrahydroxyisoflavone	Irisolidone 7-rhamnoside		na
	4,6'-Dihydroxy-5,7-dimethoxyisoflavone	Muningin		na
	4',5,6,7-Tetrahydroxyisoflavanone; 4',5-Dihydroxy-6,7-dimethoxyisoflavone	7-*O*- Methyltectorigenin		na
	7-hydroxy-4'-methoxyisoflavone	Formononentin (Biochanin B; Pratol; Neochanin)		Antifungal, Antihypolipidaemic (4)
	4',5,7-Trihydroxyisoflavone	Genistein (Prunetol; Sophoricol;Genistol)		Antifungal, Oestrogenic, Antiperoxidative (4), weak antibacterial and weak oestrogen, induce cell differentiation(13); Oestrogenic, Antioxidant, Anticarcinogenic, Antiatherogenic, Antiosteoporotic (1, 16, 15, 5)
	4',5-Dihydroxy-7-methoxyisoflavone	Prunetin (Prunusetin)		na

	7-Hydroxy-3',4'-methylenedioxyisoflavone	Pseudobaptigenin (Baptigenin)		na
	7,8-Dihydroxy-4'-methoxyisoflavone	Retusin 8-arabinoside		na
	3',4',5-Trihydroxy-7-methoxyisoflavone	Santal		na
	5,6,7-Trihydroxyisoflavone; 6-Me ether, 7-O- α-L- rhamnopyranoside			na
	4',5,7,8-Tetrahydroxymethylisoflavone			na
	4'5,7-Trihydroxy-8-methylisoflavone; 4',5-Di-Me ether, 7-O- α-L-rhamnopyranoside			
Flavonoids: Aurones	3',4,4',6-Tetrahydroxyaurone	Aureusidin;6-*O*- α-L-Rhamnopyranoside	na	Enzymes inhibitor (4)
	2,4',6-Trihydroxy-4-methylbenzylcoumaranone	Carpusin		na
	4',6-Dihydroxy-7-methylaurone; 6-*O*- α-L-Rhamnopyranoside			na
	4,4',6-Trihydroxyaurone; 6-*O*- α-L-Rhamnopyranoside	Trihydroxyaurone substitutes		
	4,4'6-Trihydroxy-7-methylaurone; 4-*O*- α-L-Rhamnopyranoside	Tetrahydroxyaurone substitute		na
Flavonoids: Isoflavanquinones		Claussequinone; (R)-*form*	na	na
Flavonoids: Chalcones	2',4,4'-Trihydroxychalcone	Isoliquiritigenin	*Platymiscium* Vogel**	Antitumour, Antiinflammatory (13), Antioxidant (4)
	3-C-Glucosyl-α,2',4,4'-tetrahydroxydihydrochalcone	Coatline A		na
	2',4,4'-tetrahydroxydihydrochalcone-8-*β*-Glucopyranosyl	Pterosupin		Antimicrobial, Antifungal, Anthelmintic (11), Antidiabetic (8, 9), Anticancer (10,11), Antitumour (14)
Flavonoids: Simple	3,8,9-Trihydroxypterocarpan		*Arachis* L.**, *Brya* P. Browne**, *Centrolobium*	na

pterocarpans	3,8-Dihydroxy-9-methoxypterocarpan		Benth*, *Platymiscium* Vogel*	
	3,9-Dimethoxypterocarpan	Homopterocarpin; (-)-form		Antifungal(4)
	7-hydroxy-4',5'-methylenedioxypterocarpan	Maackiain; (±)-form (Inermin)		
	7-Hydroxy-4',5'-metheylenedioxypterocarpan, Me ether	Pterocarpin		Antifungal (4)
Flavonoids: Flavonols	3,5,7,4'-Tetrahydroxyflavone or 4',5-Dihydroxy-3,7-dimethylisoflavone	Kaempferol	*Arachis* L.*	Radical scavenger, Anti-inflammatory, Antibacterial, Antimutagenic, enzymes inhibitor (4)
	3,3',4',7-Tetrahydroxyflavone or 8-C-Glucopyranosyl-3,3',4',7-tetrahydroxyflavone or 5-Deoxyquercetin	Fisetin		Antibacterial, enzymes inhibitor, Antismooth muscle contraction (4)
Flavonoids: Flavan-3-ols	3,3',4',5,7-Pentahydroxyflavan	Epicatechin (Epicatechol)	*Arachis* L.*	Antibacterial, Antiinflammatory, antihyperglycaemic, Antianaphylactic, Antimutagenic, Antiperoxidative (4), Antibacterial (8, 7)
	3,3',4',5,7-Pentahydroxyflavan; (2RS,3RS)-*form*	Catechin (Catechol; Biocatechin; Tanningenic acid)		Antiperoxidative, Antihepatotoxic, Antiinflammatory, Antihepatitis (4)
Flavonoids: Dihydroflavonols	8-C-Glucopyranosyl-3,4',7-trihydroxyflavanone 3,7,4'-Trihydroxyflavanone Dihydroflavonols 3,4',7-Trihydroxyflavanone	Garbanzol (Lecontin)	na	na
Alkaloids : indole alkaloids	Tryptophan betaine	Hypaphorine; *(S)-form*	na	Convulsive poison (4)
Flavonoids: Flavanones	3',4',7-Trihydroxyflavavon-8-(*C*- *β*-D-Glucopyranosyl)	Isocoreopsin	*Arachis* L.*, *Centrolobium* Benth,** , *Platymiscium*	Antihepatotoxic, Antihepatitis (4)

			Vogel**	
	Arabinopyranoside; 7-Hydroxy-6,8-dimethylflavanone			na
	7-Hydroxy-6,8-dimethylflavanone; (S)-form, 7-O- α-L-Arabinopyranoside			
	Isoderricidin; 7-Prenyloxyflavanone	7-Hydroxyflavanone; (S)-form		na
	4',7-Dihydroxyflavanone	Liquiritigenin		Weak antifungal, Haemoglobin induction, Acts on Central Nervous System (4), Antidiabetic (8, 7)
	4',5,7-Trihydroxyflavanone	Naringenin (Floribudigenin; Narigetol; Salipurpol)		Antibacterial (4, 13), Antifungal, Antihepatotoxic, Antiperoxidative, Antispasmodic, Antiulcers (4)
	3',4',5',7,8-Pentahydroxyflavanone; (S)-form,			na
Flavonoids: Isoflavanones	2',4',5,7-Tetrahydroxyisoflavanone; 6-C-glucopyranosyl	Macrocarposide	*Centrolobium* Benth**	na
Flavonoids: Isoflavans	2',7-Dihydroxy-4'-methoxyisoflavan	Vestitol; (S; R)-form	*Brya* P. Browne,* *Centrolobium* Benth**	Antifungal (4)
Flavonoids: Diarylpropane	1,3-Bis(4-hydroxyphenyl)-2-propanol	Propterol	na	na
	1-(2,4-Dihydroxyphenyl)-3-(4-hydroxyphenyl)-2-propanol	Propterol B		na
Flavonoids: Biflavonoids		Santalin A, C	na	Antibacterial, Antifungal (2)
		Santarubin A, B	na	Antibacterial, Antifungal (2)

Appendix VIIa Indole alkaloids reported to occur in African members of section Spinosae and related sections of genus *Strychnos*

Section	Species	Indole alkaloid categories						
		Strychnos	Indoloquinolizidine	Condylocarpan	Akuammiline	Bisindole	Ajmalicine	Corynanthe
Spinosae	*S. cocculoides*	Diaboline derivatives, Henningsamine derivatives	nr	nr	nr	nr	nr	nr
Aculeatae	*S. aculeata*	Strychnofendlerine and derivatives, Spermostrychnine, Splendine and derivatives	nr	nr	nr	nr	nr	nr
Breviflorae	*S. afzelii*	Bisnordihydrotoxiferine and derivatives Bisnor C-alkaloid H WGA, Diaboline, Caracurine V and derivatives , Longicaudatine	nr	nr	nr	nr	nr	nr
	S. angolensis	Diaboline and derivatives, WGA and derivatives, Caracurine V	Angustine Angustidine	Tubotaiwine	nr	nr	nr	nr
	S. dolichothyrsa	WGA and derivatives, Bisnor C-curacurine, Bisnor C-alkaloid D, Bisnodihydrotoxiferine and derivatives, Caracurine V and derivatives, Diaboline derivatives, Dolichocurine, Dolichothine, Longicaudatine	nr	Tubotaiwine Condylocarpine	Nor-C-fluorocurarine	nr	nr	nr
	S. henningsii	Holstine, Holstiline, Condensamine Retuline and derivatives, Rindline, Diaboline and derivatives, Henningsamine, Henningsoline and derivatives, Henningsamide, Henningsiine, Splendoline, Strychnine and derivatives	nr	nr	Tsilanine Tsilambine	nr	nr	nr

	S. icaja	Vomicine, Icajine, Strychnine + derivatives, Novacine, Bisnordihydrotoxiferine, Sungucine and derivatives, Strychnohexamine	nr	nr	nr	nr	nr	nr
	S. urceolata	Bisnordihydrotoxiferine, Bisnor C-alkaloid H, Diaboline derivatives Caracurine V, Longicaudatine	nr	nr	nr	nr	nr	nr
	S. malacoclados	Diaboline derivatives	nr	nr	nr	nr	nr	nr
Penicillatae	*S. diplotricha*	Strychnobrasiline Malagashanine	nr	nr	nr	nr	nr	nr
	S. longicaudata	Strychnovoline Bisnor C-alkaloid H Longicaudatine	nr	nr	nr	nr	nr	nr
	S. tchibangensis	nr	nr	nr	nr	Usambarine and derivatives	nr	nr
	S. trichoneura	nr	Angustine Angustidine Angustoline	nr	nr	nr	nr	nr
Scyphostrychnos	*S. camptoneura*	Retuline and derivatives Akagerine Camptoneurine	nr	nr	Alstovine	nr	Serpentine	Antirhine and derivatives

Note: WGA = Wieland Gumlich Aldehyde alkaloids; nr, no report seen

Appendix VIIb The indole alkaloids and medicinal application reported from African *Strychnos* species and other members of "Loganiaceae clade" grouped according to their degree of closeness to *Strychnos spinosa*.

Taxon	**Genera/Species name**	**Monoterpenoid indole alkaloids sub-categories** (22, 108, 115)	**Compound(s) reported**	**Species medicinal application**
Strychnos section: Spinosae	***STRYCHNOS*** *Strychnos spinosa* Lam.	Alkaloids: Strychnos	Akagerine (69bc) 10-Hydroxyakagerine (69c) Kribine (69c) 12-Hydroxy, 11-methoxydiaboline (69c) 11-Methoxydiaboline (71b) 11-Methoxy-12-hydroxydiaboline (71b) 11-Methoxyhenningsamine (31a) 12-Hydroxy-11-methoxyhenningsamine (31a) Kingside aglucone (63f)	dysentery, meningitis, trypanosomiasis, whooping cough, conjunctivitis, diarrhoea, elephantiasis of the scrotum, (66, 14); gonorrhoea , syphilis, intestinal worms, epilepsy, coughs, snakebites, ears ache, convulsion (*Per. obs.* 2004, 66, 14), infertility, tumours, vomiting, stabbing sensations, stomach ache (*Per. obs.* 2004), mental illness (110), fever, wounds (42), venereal diseases, stomach disorders and snake bites (116)
	S. congolana Gilg.	na	na	Snakebites, Headache, Epilepsy (14)
	S. ternata Gilg. ex Leeu.	na	na	na
	S. cocculoidess Baker	Alkaloids: Strychnos	11-Methoxydiaboline (31a) 11-Methoxy-12-hydroxydiaboline (31a) (31a) 11-Methoxyhenningsamine (31a) 12-Hydroxy-11-methoxyhenningsamine (31a)	Sores, Pneumonia, Pulmonary tuberculosis (14), Gonorrhoea (14, 118)
Aculeatae (a)	*S. aculeata* Solered	Alkaloids: Strychnos	Strychnofendlerine (62a)	Oedema, Elephantiasis of the scrotum, Abortion (14).

			N_a-Acetylstrychofendlerine (62a)	
			Spermostrychnine (39b)	
			Isosplendine (107h)	
			Na-Acetylisostrychnosplendine (39b)	
			Na-Acetyl-*O*-methyl-strychnosplendine (39b)	
Breviflorae(a)	*S. afzelii* Gilg.	Alkaloids: Strychnos	Bisnordihydrotoxiferine (104b)	Aphrodisiac, Fever, Stomach ache, (14).
			Bisnor-C-alkaloid H (104b)	
			Wieland-Gumlich aldehyde (104b)	
			Diaboline (106a)	
			Bisnodihydrotoxiferine mono *N*–oxide (106b)	
			Bisnordihydrotoxiferine di-*N*–oxide (106b)	
			Caracurine V mono- *N*–oxide (106b)	
			Longicaudatine (56b)	
			Caracurine V (104b)	
	S. angolensis Gilg.	Alkaloids: Indoloquinolizine	Angustine (76c)	na
			Angustidine (76c)	
		Alkaloids: Condylocarpan	Tubotaiwine (19ab)	
		Alkaloids: Strychnos	11-Methoxy-diaboline(19ab)	
			11-Methoxy-Wieland-Gumlich aldehyde (19ab)	
			11-Methoxy, epi 17-*O*-methyl- Wieland-Gumlich aldehyde (19ab)	

		Caracurine V (19ab)	
S. campicola Gilg. ex Leeu.	na	na	na
S. dolichothyrsa Gilg. ex Onochie et Hepper	Alkaloids: Strychnos	18-Desoxy- Wieland-Gumlich aldehyde (103b)	na
		Bisnor-C-cararine (103b)	
		Bisnor-C-alkaloid D(103b)	
		Bisnordihydrotoxiferine mono- *N* –oxide(103b)	
		Bisnordihydrotoxiferine di- *N* –oxide(103b)	
		Caracurine V mono-*N*-oxide(103b)	
		Bisnordihydrotoxiferine(103b)	
		11-Methoxy-diaboline(107b)	
		Bisnor-C-alkaloid H(103b)	
		Bisnor-C-alkaloid H di-*N*-oxide(107b)	
		Dolichocurine (107b)	
		Dolichothine (107b)	
		Wieland-Gumlich aldehyde(107b)	
		Caracurine V (103b)	
		Bisnor-C-alkaloid H mono-*N*-oxide(107b)	
		Caracurine V di-*N*-oxide(103b)	
		Longicaudatine (56b)	
		18-Desoxy- Wieland-Gumlich aldehyde (103b)	

	Alkaloids: Condylocarpan	Tubotaiwine (107b)	
		Condylocarpine (107b)	
	Alkaloids: Akuammiline	Nor-C-flourocurarine (107b)	
S. henningsii Gilg.	Alkaloids: Strychnos	Holstiine (17b, 20b, 43b, 58abc)	na
		Holstiline (17b, 20b, 88b)	
		Condesamine (20b, 67b)	
		Isoretuline (17b, 20b, 58abc, 67b)	
		Rindline 117b, 43b, 88b)	
		Diaboline (88b)	
		Henningsamine (11b, 43b)	
		Henningsoline (11b, 43b)	
		O-Acetyl-henningsoline (88b)	
		11-Methoxydiaboline (88b)	
		2,16-Dehydrodiaboline(88b)	
		2,16-Dehydro, 11-methoxydiaboline (88b)	
		N_a-Desacetylisoretuline (51i)	
		18-Hydroxyisoretuline (51i)	
		N_a-Desacetyl-18-hydroxyisoretuline (51i)	
		N_a-Desacetyl, 18-hydroxy, 17-*O*-methylisoretuline (51i)	
		O-Acetylretuline (10c)	

		Henningsiine (58abc)	
		Splendoline (58abc)	
		23-Hydroxyspermostrychnine (58abc)	
		19-*epi*-23-hydroxyspermostrychnine (58abc)	
		O – Acetylhenningsiine (58abc)	
		3-Hydroxyhenningsiine (58abc)	
		Henningsiine-N-oxide (58abc)	
		23-Hydroxyspermostrychnine-N(4)-oxide (58abc)	
		17,23-Dihydroxyspermostrychnine (58abc)	
		Spermostrychnine (58abc)	
		Henningsamide (58abc)	
		O-Acetylhenningsamide (58abc)	
	Alkaloids: Akuammiline	Tsilanine (86e)	
		10-methoxytsilanine (86e)	
		O-Demethyltsilanine (86c)	
		O-Demethyl, 10-methoxytsilanine (86c)	
		Tsilanimbine (52i)	
S. icaja Baill.	Alkaloids: Strychnos	Vomicine (12c, 18f)	Skin diseases, gastrointestinal disorders (42)
		Icajine (12c, 18f, 37abcs, 44a)	
		19,20α-Epoxynovacine (13c, 44ac),	

Strychnine (83a, 84a)

12-Hydroxystrychnine (83a, 84a)

Pseudostrychnine (15c, 75a)

19,20α-Epoxy, 10-methoxyvomicine (15c)

19,20α-Epoxy, 11-methoxyvomicine (15c, 18c)

19,20α-Epoxy, 15-Hydroxyicajine (15c, 18c)

19,20α-Epoxy, 15-hydroxyvomicine (15c, 18c)

15-Hydroxyicajine (15c, 18c)

Novacine (18c)

19,20α-Epoxy, 15-hydroxy, 11-methoxyvomicine (18c)

19,20α-Epoxy, 11,12-dimethoxyicajine (18c)

19,20α-Epoxy-12-methoxyicajine (18f)

19,20α-Epoxy, 15-hydroxy-12-methoxyicajine (18f)

Bisnordihydrotoxiferine (44a)

Sungucine (44a, 53a)

Strychnosungucine A and B (36c)

Strychnosungucine C (75a)

Strychnohexamine (75a)

Protostrychnine (75a)

Genostrychnine (75a)

			N_b-Methyl-strychninium (44a)	
	S. urceolata Leeu.	Alkaloids: Strychnos	Bisnordihydrotoxiferine (105b)	na
			Bisnor-C-alkaloid H (105b)	
			11-Methoxydiaboline (105b)	
			Caracurine V (105b)	
			Longicaudatine (56b)	
	S. malchairii De Wild.	na	na	na
	S. mimfiensis Gilg. ex Leeu.	na	na	na
	S. mitis S. Moore	na	na	na
	S. malacoclados C.H.Wright	Alkaloids: Strychnos	11-Methoxydiaboline (101b)	na
			19,20-Dihydro, 11-methoxydiaboline (103b)	
	S. bifurcata Leeu.	na	na	na
	S. diplotricha Leeu.	Alkaloids: unclassified	3-epi-myrtoidine (78b)	na
			11-demethoxy-3-epi-myrtoidine (78b)	
			11-demethoxy,12-hydroxy-3-epi-myrtoidine (78b)	
			Myrtoidine (78b)	
			11-demethoxymyrtoidine (78b)	
Penicillatae(a)		Alkaloids: Strychnos	Strychnobrasiline (77h)	
			Malagashanine (77h)	
	S. longicaudata Gilg.	Alkaloids: Strychnos	Strychnovoline (92e)	Chest pains (14)

		Bisnor-C-alkaloid H (56a)	
		Longicaudatine (56a)	
S. matopensis S. Moore	na	na	na
S. mostueoides Leeu.	na	na	na
S. myrtoides Gilg. and Busse	Alkaloids: unclassified	3-*epi*-myrtoidine (78abc)	na
		11-demethoxy-3-epi-myrtoidine (78abc)	
		11-demethoxy,12-hydroxy-3-epi-myrtoidine (78abc)	
		Myrtoidine (54b)	
		11-demethoxymyrtoidine (54b)	
	Alkaloids: Strychnos	Strychnobrasiline (77b)	
		Malagashanine (77b)	
		Malagashanol (77b)	
		12-hydroxy, 19-epi-malagashanine (77b)	
S. tchibangensis Pellegr.	Alkaloids: Bisindole	5',6'-Dihydrousambarensine(79abc)	na
		Usambarensine derivatives (30a)	
	Alkaloids: unclassified	Harmane derivatives (30a)	
S. trichoneura Leeu.	Alkaloids: Indoloquinolizine	Angustine (76c)	na
		Angustidine (76c)	
		Angustoline (76c)	
S. camptoneura Gilg. et	Alkaloids: Akuammiline	Alstovine (100ab)	na

	Busse	Alkaloids: Ajmalicine-like	Serpentine (100ab)	
		Alkaloids: Strychnos	Retuline N-oxide (50b)	
			Camptoneurine (50b)	
			Retuline (38b)	
Scyphostrychnos(a)			Akagerine (103b)	
		Alkaloids: Corynanthe	Antirhine (16c)	
			Antirhine methobromide (16c)	
		Alkaloids: Indoloquinolizine	Angustine (76c)	
Densiflorae(c)	*S. densiflora* Baill.	na	na	Pain relief (42)
	S. innocua Delile	na	na	Snakebites, toothaches, Stomach ache, Gonorrhoea, Pulmonary tuberculosis, Penis disorders (Phimosis), Anthrax, Haemorrhagy of pregnancy, Fever, Uterine fibroma (14), Stomach ache, Toothache, Hernia, Cough, Malaria, Gonorrhoea, Syphilis, Bilhalzias, Snakebite (*Per. obs.* 2004)
	S. lucens Baker	na	na	Na
	S. madagascariensis Poir.	na	na	Snakebites, Constipation, Fever, Kidney problems, Bilharzias, Malaria, Meningitis, Wounds (14)
	S. nigritana Bak.	Alkaloids: Bisindole	Nigritanine (64b, 68c)	Na
			10-Hydroxynigritanine (64b, 68c)	
			18-Dehydronigritanine (64b, 68c)	
			18-Dehydro, 10-hydroxynigritanine (64c, 68c)	
		Alkaloids: Strychnos	Akagerine (64a)	
			Kribine (64a)	

	S. pungens Soler.	Alkaloids: Strychnos	*O*-Acetylretuline (91abc)	Ophthalmia, Snakebites, Sore eyes, Wounds, Stomach ache, Bronchitis (14), Snakebite, Convulsion, Heart pains (*Per. obs.* 2004)
			Diaboline(91abc)	
			11-methoxydiaboline (91abc)	
			11-methoxyneo-oxydiaboline (91abc)	
			12-hydroxy,11-methoxydiaboline (91abc)	
			Henningsamine (91abc)	
			11-methoxyhenningsamine (91abc)	
			12-hydroxy, 11-methoxyhenningsamine (91abc)	
		Alkaloids: Corynanthe	Sitsirikine (91abc)	
			16 (R)-isositsirikine (91abc)	
			16 (S)-isositsirikine (91abc)	
	S. staudtii Gilg.	Alkaloids: Strychnos	12-hydroxy, 11-methoxyhenningsamine (90abc)	na
			11-methoxyhenningsamine (90abc)	
			12-hydroxy, 11-methoxy-diaboline (90abc)	
			11-Methoxydiaboline (90abc)	
	S. zenkeri Gilg. ex Baker	na	na	na
	S. samba Duvign	Alkaloids: Indoloquinolizine	Angustine (76c)	na
			Angustidine (76c)	
Brevitubae (c)			Angustoline (76c)	
	S. barteri Solered	Alkaloids: Strychnos	Akagerine (64ab)	na

		Alkaloids: Bisindole	Nigritanine (64e)	
Dolichanthae (c)			10-Hydroxynigritane (64c)	
			18-Dehydro, 10-hydroxynigritane (64c)	
			18-Dehydronigritane (64bc)	
		Alkaloids: Oxidole	Oxidole I & II (64c)	
	S. gossweileri Excell	Alkaloids: Ajmalicine-like	Alstonine (26a, 27a)	na
		Alkaloids: unclassified	Diploceline (26a, 27a, 28a)	
			Isodolichantoside (29a)	
			16-epi-Diploceline (29a)	
	S. odorata A. Chew	Alkaloids: Indoloquinolizine	Angustine (76c)	Fever (42)
			Angustidine (76c)	
			Angustoline (76c)	
	S. xantha Leeu.	Alkaloids: Indoloquinolizine	Angustine (76c)	na
			Angustidine (76c)	
			Angustoline (76c)	
	S. chrysophylla Gilg.	Alkaloids: Strychnos	Longicauditine (56b)	na
	S. dinklagei Gilg.	Alkaloids: unclassified	Ellipticine (59b)	na
Lanigerae (c)			17-Oxo-ellipticine (59b, 60b)	
			Ellipticine *N*-oxide (61b)	
			18-Hydroxy-ellipticine (61b)	

		10-Hydroxy-ellipticine (61b)	
		3, 14-Dihydro-ellipticine (61b)	
		3, 14, 4, 21-Tetrahydro-ellipticine (61b)	
		17-Oxo-ellipticine *N*-oxide (61b)	
S. memecyloides S. Moore	Alkaloids: Bisindole	Usambarensine (30a)	na
S. ngouniensis Pellegr	Alkaloids: Strychnos	Ngouniensine (55h)	na
		Longicaudatine (56a)	
S. panganiensis Gilg.	Alkaloids: Bisindole	Matopensine (65a)	na
		16-(*S*)-*E*-isositsirikine (65a)	
	Alkaloids: Strychnos	12-hydroxy-11-methoxydiaboline (65a)	
		N_a-Desacetylretuline (65a)	
		Desacetylisoretuline (65a)	
		Panganensines R, S, X and Y (65a)	
	Alkaloids: Akuammiline	12-Hydroxy-11-methoxy-nor-*C*-fluorocurarine (65a)	
		12-Hydroxy-11-methoxy-*N*-acetylmon-*C*-fluorocurarimine (65a)	
S. scheffleri Gilg.	Alkaloids: Indoloquinolizine	Angustine (76c)	na
		Angustidine (76c)	
		Angustoline (76c)	
	Alkaloids: Strychnos	N_a-Acetylstrychnosplendine (24b)	
		N_a-Acetyl-*O*-methylstrychnosplendine (24b)	

			Strychnobrasiline (24b)	
			Strychnofendlerine (24b)	
			Desacetylisoretuline (24b)	
			Bisnordihydrotoxiferine (24b)	
		Alkaloids: unclassified	Mavacurine (24b)	
	S. soubrensis Hutch. et Dalz.	Alkaloids: Strychnos	Isosplendine (70b)	na
			Strychnofendlerine (70b)	
			Strychnobrasiline (70b)	
			14-*β*-Hydroxy-strychnobrasiline (70b)	
	S. splendens Gilg.	Alkaloids: Strychnos	Strychnosplendine (45c, 48bf)	na
			Splendoline (46c, 48bf)	
			Isosplendine (47c, 48bf)	
			Isostrychnosplendine (47c, 48bf)	
			N_a-Acetyl-*O*-methylstrychnosplendine (47c, 48bf)	
	S. dale De Wild.	Alkaloids: Strychnos	Akagerine (80b)	na
			17-*O*-methylakagerine (80b)	
Rouhamon (c)			Kribine (80b)	
			21-*O*-Methylkribine (80b)	
			Decussine (80b)	
			3,14-Dihydrodecussine (80b)	

S. decussata (Pappe) ex Gilg.	Alkaloids: unclassified	Gluco-alkaloid (74c)	na
	Alkaloids: Strychnos	Akagerine (82b)	
		17-*O*-methylakagerine (82b)	
		10-Hydroxy, 17-*O*-methylakagerine (82b)	
		10-Hydroxy, 21-*O*-methylkribine (82b)	
		10-Hydroxy, *epi*-21-*O*-methylkribine (82b)	
		10-Hydroxyakagerine (72b)	
		Akagerine lactone (72b)	
		Decussine (82b)	
		3, 14-Dihydro-decussine (82b)	
		10-Hydroxy-3, 14-dihydro-decussine (82b)	
		Rouhamine (82b)	
		Bisnordihydrotoxiferine (82b)	
	Alkaloids: Yohimbinoid	Macusine B (73b)	
		O-Methylmacusine (73b)	
		Macusine A or C (73b)	
	Alkaloids: Indoloquinolizine	Malindine (73b)	
S. elaeocarpa Gilg. ex Leeu.	Alkaloids: Strychnos	Akagerine (79b)	na
		17-*O*-Methylakagerine (79b)	
		Kribine (79b)	

		21-*O*-Methylkribine (79b)	
		Epi-21-*O*-Methylkribine (79b)	
		Decussine (81b)	
		3, 14-Dihydrodecussine (82b)	
		Bisnordihydrotoxiferine (82b)	
	Alkaloids: unclassified	Strychnocarpine (79b)	
S. floribunda Gilg.	Alkaloids: Indoloquinolizine	Angustine (76c)	na
	Alkaloids: Strychnos	Akagerine (105b, 106b)	
		Decussine (105b, 106b)	
		Desacetylisoretuline (105b, 106b)	
		Bisnordihydrotoxiferine (105b, 106b)	
		Isorosibiline (106b)	
		Rouhamine (106b)	
S. potatorum L.	Alkaloids: Indoloquinolizine	Angustine (76c)	Mental illness (14), Stomach ache, Toothache, Hernia, Cough, Malaria, Gonorrhoea, Syphilis, Bilhalzia, Snakebite (*Per. obs.* 2004)
		Angustidine (76c)	
	Alkaloids: Strychnos	Diaboline (58a, 87abc)	
		Acetyldiaboline (58a, 87abc)	
		Dihydrolongicaudatine (58a)	
	Alkaloids: unclassified	Harmane (58a)	
S. usambarensis Gilg	Alkaloids: Bisindole	Usambarensine (2a, 30a, 32a)	Pain relief, General body weakness (42)

	N_b-Methylusambarensine (2a)
	5', 6'-Dihydrousambarensine (2a)
	Usambarine 9c, 49c, 51c)
	O-Methyl-dihydrousambarine (9c)
	C-Calebassine (8a, 34a)
	Usambarine (9c)
	18,19-Dihydrousambaridine (9c)
	Usambaridine Vi. (9c)
	18, 19-Dihydro-usambaridine (9c)
	Strychnobaridine (9c)
	Strychnopentamine (9c, 35c)
	Strychnofoline (9c)
	Isostrychnofoline (9c, 32c, 33c)
	Strychnophylline (9c, 32c, 33c)
Alkaloids: unclassified	Harmine (4a, 30a)
	5,6-Dihydroflavopereirine (3a)
	Melinonine F (23a)
Alkaloids: Indoloquinolizine	Angustine (75c)
Alkaloids: Strychnos	Dihydrotoxiferine (8a, 34a)
	C-Curarine (8a, 34a)

		Afrocurarine (8a, 34a)	
		Akagerine (7a)	
	Alkaloids: Yohimbinoid	Macusine B (5a)	
		O-Methylmacusine (5a)	
	Alkaloids: Akuammiline	Fluorocurarine (23a)	
S. variabilis De Wild.	Alkaloids: Strychnos	Desacetylretuline (95a)	na
		Bisnordihydrotoxiferine (95a)	
		Strychnobiline (95a)	
		12'-Hydroxyisostrychnobiline (95a)	
		Desacetylisoretuline (6a, 94a)	
		Retuline (94ac)	
		Isoretuline (93a, 95c)	
		O-Acetylisoretuline (94a, 95a)	
		Retulinal (96a)	
		Isoretulinal (96a)	
		12-Hydroxyretulinal (96a)	
		12-Hydroxyisoretulinal (96a)	
		Rosibiline (97a)	
		16-Hydroxyisoretulinal (97a)	
		Isorosibiline (99a)	

			Desacetyl,*N*-formyl-retuline (99a)	
			11-methoxy-*O*-acetylisoretuline (93e)	
			11-methoxyisoretuline(93e)	
		Alkaloids: Akuammiline	Strychnopivotine (97a)	
			Fluorocurine (98a)	
		Alkaloids: unclassified	Mavacurine (98a)	
Loganiaceae clade	***SPIGELIA***			
	Spigelia anthelmia Linn. (b)	Alkaloids: unclassified	Spiganthine (111c)	Headache, throbbing pains, neuralgia, stabbing violent pain, congestion, Intestinal worms (117)
			20-deoxyspiganthine (111c)	
			8 α-hydroxyspiganthine (111c)	
			20-norspiganthine-5-carboxylic acid (111c)	
			Ryanodine (111c)	
			10-epi-ryanodine (111c)	
			8,9-dehydro-10-epi-ryanodine (111c)	
			20-hydroxyryanodine (111c)	
	GARDNERIA			
	Gardneria multiflora Makino (b)	Alkaloids: Bisindole	Gardfloramine (85h)	na
		Alkaloids: Oxindole	Gardmultine (85h)	na
			Gardneramine N4-oxide	
			Demethoxygardfloramine (85h)	
			Demethylgardneramine (113h)	

		Demethoxygardneramine (113h)	
		Garderamine oxindole (114h)	
		16-Hydroxygardneramine (114h)	
G. nutans Sieb. and Zucc (b)	Alkaloids: Oxindole	Gardneramine (113h)	na
		Gardneramine N4-oxide (113h)	
		Demethylgardneramine (113h)	
		Demethoxygardneramine (113h)	
		Gardnerine (89c)	
		Gardquinoline (89c)	
		Gardnutine (89c)	
		18- hydroxygardnerine (89c)	
		18 – hydroxygardnutine (89c)	

a = Root barks, b = Stem bark, c = Leaves, d = Stem, e = Seeds, f = fruits, g = flowers, h = unspecified part, i = other parts; na = Information not available; Numbers in parentheses followed by letters represent reference code numbers; (a) closely related to section Spinosae; (b) closely related to genus *Strychnos,* (c) less related to section Spinosae.

Appendix VIIc Bioactivity of indole alkaloids reported from genus *Strychnos* and other related genera of the 'Loganiaceae clade'

Compound(s) category	Compound name(s)	Reported bioactivity	Species	References
Indole alkaloids: Strychnos	Strychnohexamine	antiplasmodial	*Strychnos icaja****	Phillip *et al.*, 2002
	Akagerine	anticancer	*S.spinosa, S. nigritana***, S. barteri*, S. camptoneura***, S. dale*, S. decussata*, S. alaeocarpa*, S. floribunda*, S. usambarensis**	Pettit *et al.*, 1994
	Strychnosungucine A, B	antiplasmodial	*Strychnos icaja****	Frederich *et al.*, 2001
	Isoretuline	antiplasmodial, anti-inflammatory, analgesic	*S. henningsii***, Strychnos variabilis**	Tits *et al.*, 1991
	Vomicine	antiplasmodial	*Strychnos icaja****	Frederich *et al.*, 2000
		anticonvulsant		Sandberg and Kristianson, 1970
	Diaboline	hypotensive	*S spinosa, S. afzelii***, S. henningsii***, S.pungens***, S. potatorum**	Kapoor *et al.*, 1988
	Caracurine V	neuromuscular blocking agent	*S. afzelii***, S. angolensis***, S. dolichothyrsa***, S. urceolata****	Verrporte and Svanden, 1978, Harborne *et al.* 1999
	12-Hydroxystrychnine	anticonvulsant	*Strychnos icaja****	Sandberg and Kristianson, 1970
	Strychnine	anticonvulsant/ central nervous system and respiratory stimulant	*S. henningsii***, S. icaja****	Sandberg and Kristianson, 1970, Harborne *et al.* 1999
	3- Hydroxystrychnine (Pseudostrychnine)	anticonvulsant	*S. icaja****	Sandberg and Kristianson, 1970
		anticonvulsant	*S. icaja****	Sandberg and Kristianson, 1970

	colubrine)			
	10,11-Methoxystrychnine (Brucine)	anticonvulsant/ central nervous system stimulant	*S. icaja****	Sandberg and Kristianson, 1970, Harborne *et al.* 1999
	Strychnine-N oxide (Genostrychnine)	anticonvulsant	*S. icaja****	Sandberg and Kristianson, 1970
	Strychnobrasiline	antimalarial	*S. diplotricha***, S. mytoides***, S. scheffleri*, S. soubrensis**	Rasoanaivo *et al.*, 1994
	Malagashanine	antimalarial	*S. diplotricha***, S. mytoides****	Rasoanaivo *et al.*, 1994
	Icajine	anticonvulsant	*S. icaja****	Sandberg and Kristianson, 1970
	Bisnodihydrotoxiferine	antidiarrhoeal, anticonvulsant	*S. afzelii***, S. dolichothyrsa***, S .icaja***, S. urceolata***, S. decussata*, S. elaeocarpa*, S. floribunda*, S. variabilis**	Thomas *et al.*, 1992
	Longicaudatine	spasmolytic	*S. afzelii***, S. dolichothyrsa***, S. longicaudata***, S. urceolata**, S. chrysophylla*, S. ngouniensis**	Demedeiros *et al.*, 1991
Indole alkaloids: Bisindole	Strychnopentine	antiamoebic, antiplasmodial	*S. usambarensis**	Wright *et al.*, 1991
	Styrchnopentamine	antitumour, antiamoebic, antiplasmodial, anticancer	*S. usambarensis**	Tits *et al.*, 1984, Wright *et al.*, 1991, Pettit *et al.*, 1994
	3,4-dihydrousambarensine	antiamoebic, antiplasmodial, anticancer	*S. tchibangensis***, S. usambarensis**	Wright *et al.*, 1991, Pettit *et al.*, 1994
	Usambarensine	Antiamoebic, Anticancer, Antimuscarinic	*S.tchibangensis***, S. memecyloides*, S. usambarensis**	Wright *et al.*, 1991, Pettit *et al.*, 1994, Harborne *et al.* 1999
		Antiamoebic, Anticancer	*S. usambarensis**	Wright *et al.*, 1991, Pettit *et al.*,

				1994
	18,19-dihydrousambarine	Antiamoebic, Anticancer	*S. usambarensis**	Wright *et al.*, 1991, Pettit *et al.*, 1994
	Isostrychnopentamine	Anticarcinogenic	*S. usambarensis**	Frederich *et al.*, 2003
	10'-Hydroxyusambarensine	Antimalarial	*S. usambarensis**	Frederich *et al.*, 1999b
Alkaloids: unclassified	Ellipticine	Anticancer	*S. dinklagei**	Acton *et al.*, 1994
	Diploceline	Antiparasitic	*S. gossweileri**	Gasquet *et al.*, 1992
	Ryanodine Spiganthine	Cardiotonic	*Spigelia anthelmia***	Jenden and Fairhurst, 1969, Penefsky, 1974, Vierling, 1988, Achenbach *et al.*, 1995, Sutko *et al.*, 1997

*** = closely related to *S. spinosa*; ** = relatively close to *S. Spinosa;* * = less related to *S. spinosa*

Appendix VIIIa Other bioactive compounds isolated from the leaves of *Pterocarpus tinctorius* and their spectra characteristics

Peak no.	Compounds name(s)	Retention time (min)	Main peaks (m/z)	Molecular weight	Molecular formula	Compound category/classification
1	4-Anilinophenol	0.9	184	185	$C_{12}H_{11}NO$	Simple aromatic natural products
	2-Aminodiphenylamine			184	$C_{12}H_{12}N_2$	Simple acyclic amine alkaloids
	Epitesterone			288	$C_{19}H_{28}O_2$	Steroids
	2'-Hydroxy-5'-methoxybenzophenone			228	$C_{14}H_{12}O_3$	Stilbenoids: resveratrol
	1,2-Dihydroxyanthraquinone			240	$C_{14}H_8O_4$	Polycyclic aromatic natural products
	Hydrazobenzene			184	$C_{12}H_{12}N_2$	Simple acyclic amine alkaloids
	Phenazopyridine			213	$C_{11}H_{11}N_5$	Miscellaneous acyclic amine alkaloid
	2,4-Dintrophenol			184	$C_6H_4N_2O_5$	Aliphatic natural products
	1.8-Dihydroxyanthraquinone			240	$C_{14}H_8O_4$	Polycyclic aromatic natural products
	8-Carbomethoxyoctanoic acid			202	$C_{10}H_{18}O_4$	Polycyclic aromatic natural products
	2,6-Dinitrophenol2,6-Dinitrophenol			184	$C_6H_4N_2O_5$	Aliphatic natural products
2, 3	7-Amino-3-phenylcoumarin	1.9, 2.2	238	237	$C_{15}H_{11}NO_2$	Flavonoids: coumarins
	5-Hydroxy-7-methoxyflavone			268	$C_{16}H_{12}O_4$	Flavonoids: Isoflavonoids
4	Hydroxylupanine	3.0	247	264	$C_{15}H_{24}N_2O_2$	Alkaloids lupine
	Cholesteryl benzoate			490	$C_{34}H_{50}O_2$	Steroids
10	Vitamin D3 (Cholestcarciferol)	15.1	351	384	$C_{27}H_{44}O$	Steroids

11	4,4'-di(Dimethylamino)benzophenone	15.5	251	268	$C_{17}H_{20}N_2O$	Simple aromatic natural products
	Vitamin D3 (Cholestcarciferol)			384	$C_{27}H_{44}O$	Steroids
	Warfarin			308	$C_{19}H_{16}O_4$	Flavonoids: coumarins
	Dienestrol			266	$C_{18}H_{18}O_2$	Steroids
13	Colchine, (+)-	15.9	311	399	$C_{22}H_{25}NO_6$	Alkaloids: colchicines-type
	Vitamin D3 (Cholestcarciferol)			384	$C_{27}H_{44}O$	Steroids
	Aldosterone			360	$C_{21}H_{28}O_5$	Steroids
14	Elymoclavine	16.1	254	254	$C_{16}H_{18}N_2O$	Indole alkaloids
	N-Acetylcolchinol methyl ether			371	$C_{21}H_{25}NO_5$	Alkaloids: colchicines-type
20	Retinol (Vitamin A1)	19.1	286	286	$C_{20}H_{30}O$	Steroids
21	4,7-Diphenyl-1,10-phenanthroline	19.4	277	332	$C_{24}H_{16}N_2$	Simple acyclic amine alkaloids
24	6,7-Diethoxy-1-(3,4-diethoxybenzyl)isoquinoline	21.0	352	395	$C_{24}H_{29}NO_4$	Polycyclic aromatic natural products
	Vitamin D3 (Cholestcarciferol)			384	$C_{27}H_{44}O$	Steroids
25	Colchicine	21.2	356	399	$C_{22}H_{25}NO_6$	Alkaloids: colchicines-type
27	Ergosterol (Provitamin D)	22.5	377	396	$C_{28}H_{44}O$	Steroids

Appendix VIIIb Other bioactive compounds isolated from the stem bark of *Pterocarpus tinctorius* and their spectra characteristics

Peak no.	Compounds name(s)	Retention time (minutes)	Main peaks (m/z)	Molecular weight	Molecular formula	Compound category/classification
1	Testosterone	0.8	203	288	C19H28O2	Steroids
	Gibberellic acid			346	$C_{19}H_{22}O_6$	Terpenoids
	Physostigmine aminoxide			291	$C_{15}H_{21}N_3O_3$	Indole alkaloids
	α-Naphthylphenylamine			219	$C_{16}H_{13}N$	Simple acyclic amine alkaloids
	6,7-Dimethoxy-1-(3,4,5-triethoxyphenyl)isoquinoline		397	397	$C_{23}H_{27}NO_5$	Isoquinoline alkaloids
	Syrosingopine			666	$C_{35}H_{42}N_2O_{11}$	Indole alkaloids
2	Methoserpidine	0.9	365	608	$C_{33}H_{40}N_2O_9$	Indole alkaloids
4, 5	Xylomethazoline	1.6, 1.7	243	244	$C_{16}H_{24}N_2$	Simple acyclic amine alkaloids
	7-Methoxy-8-isopentenylcoumarin			244	$C_{15}H_{16}O_3$	Flavonoids: coumarins
	Dihydrocyperaquinone			244	$C_{14}H_{12}O_4$	Stilbenoids
	3,3'-dimethoxy-benzidine			244	$C_{14}H_{16}N_2O_2$	Polycyclic aromatic natural products
	4,7,8-trimethoxy- furo[2,3-b]quinoline			259	$C_{14}H_{13}NO_4$	Quinoline alkaloids
6	1,2-Benzenedicarboxylic acid, dioctyl ester	2.0	279	350	$C_{24}H_{38}O_4$	Polyketides
13	Physostigmine	21.9	217	216	$C_{15}H_{21}N_3O_2$	Indole alkaloids
	1-Naphthalenamine, N-phenyl-			219	$C_{16}H_{13}N$	Simple acyclic amine alkaloids
	5-Ethyl-5-p-tolylbarbituric acid			246	$C_{13}H_{14}N_2O_3$	Indole alkaloids (JNP 2005, 68: 1416)

Phenyl isocyanide, 4,4'-methylenebis-		218	$C_{15}H_{10}N_2$	Simple acyclic amine alkaloids
4-(Dimethylamino)benzophenone	224	225	$C_{15}H_{15}NO$	Simple acyclic amine alkaloids
1-Aminoanthraquinone		223	$C_{14}H_9NO_2$	Polycyclic aromatic natural products
Drometrizole		225	$C_{13}H_{11}N_3O$	Simple acyclic amine alkaloids
Benzophenone, 4,4'-bis(dimethylamino)-	268	268	$C_{17}H_{20}N_2O$	Simple aromatic natural products
1,4-diamino-2-methoxy-antraquinone		268	$C_{15}H_{12}N_2O_3$	Polycyclic aromatic natural products
3,4-Dihydro-1,2,5,6-dibenzcarbazole		269	$C_{20}H_{15}N$	Simple acyclic amines alkaloids
Retinol (Vitamin A1)		286	$C_{20}H_{30}O$	Steroids
N,N'-Bisdimethylamino;benzophenone		268	$C_{17}H_{20}N_2O$	Simple aromatic natural products
Naphthacene		288	$C_{18}H_{12}$	Polycyclic aromatic natural products
Adenine, N-benzyl-		225	$C_{12}H_{11}N_5$	Simple acyclic amine alkaloids
Vincamine		354	$C_{21}H_{26}N_2O_3$	Indole alkaloids
Anthraquinone, 1,4,5,8-tetramino-		268	$C_{14}H_{12}N_4O_2$	Polycyclic aromatic natural products
Diethylstilbestrol propionate		380	$C_{24}H_{28}O_4$	Stilbenoids
Phenolphthalein		318	$C_{20}H_{14}O_4$	Polycyclic aromatic natural products
4-Anilinoazobenzene		273	$C_{18}H_{15}N_3$	Miscellaneous acyclic amine alkaloids
Colchicine	298	399	$C_{22}H_{25}NO_6$	Alkaloids: Colchicine-type
Isoquinoline, 6,7-diethoxy-1-(3,4-diethoxybenzyl)-	321	395	$C_{24}H_{29}NO_4$	Isoquinoline alkaloids

Appendix VIIIc Other bioactive compounds isolated from the root bark of *Pterocarpus tinctorius* and their spectra characteristics

Peak no.	Compounds name(s)	Retention time (minutes)	Main peaks (m/z)	Molecular weight	Molecular formula	Compound category/classification
1	2,6-Dichlorophenylenediamine	0.8	146	176	$C_6H_6Cl_2N_2$	Simple acyclic amine alkaloids
	8-Hydroxyquinoline			145	C_9H_7NO	Indole alkaloids
	2-Quinoxalinone			146	$C_8H_6N_2O$	Simple aromatic natural products
	P-(Dimethylamino)cinnamaldehyde			175	$C_{11}H_{13}NO$	Simple aromatic natural products
	Citropten (SH)			206	$C_{11}H_{10}O_4$	Flavonoids: Coumarins
	Estriol			288	$C_{18}H_{24}O_3$	Steroids
	2-Hydroxy-p-naphthoquinone			174	$C_{10}H_6O_3$	Flavonoids: Coumarins
	Estrone			270	$C_{18}H_{22}O_2$	Steroids
	Quinoxaline-6-carboxylic acid			174	$C_9H_6N_2O_2$	Simple aromatic natural products
	N,N'-diphenylbenzidine			336	$C_{24}H_{20}N_2$	Simple acyclic amine alkaloids
	1,2-Dinitrobenzene			196	$C_6H_4N_2O_4$	Simple aromatic natural products
	1,3-Dinitrobenzene			168	$C_6H_4N_2O_4$	Simple aromatic natural products
	4-Cyano-1-naphthylamine			168	$C_{11}H_8N_2$	Simple acyclic amine alkaloids
	3,4-Dihydroxyphenylacetic acid			168	$C_8H_8O_4$	Simple aromatic natural products
	Diphenylamine			169	$C_{12}H_{11}N$	Simple acyclic amine alkaloids
	4-, Aminobenzophenone			197	$C_{13}H_{11}NO$	Simple aromatic natural products
	2-aminodiphenylamine			184	$C_{12}H_{12}N_2$	Simple acyclic amine alkaloids

	4-Phenoxyaniline			185	$C_{12}H_{11}NO$	Simple aromatic natural products
	4-Phenylazodiphenylamine			273	$C_{18}H_{15}N_3$	Miscellaneous acyclic amine alkaloid
	2,3,4-Trimethoxybenzaldehyde			196	$C_{10}H_{12}O_4$	Simple aromatic natural products
	1,5-Dichloronaphthalene			196	$C_{10}H_6Cl_2$	Polycyclic aromatic natural products
	2,3,4-Trichlorophenol			196	C3H6Cl3O	Simple aromatic natural products
	2',4',6'-Trimethoxyacetophenone			210	$C_{11}H_{14}O_4$	Simple aromatic natural products
	N-Phenyl-4-aminoazobenzene			273	$C_{18}H_{15}N_3$	Miscellaneous acyclic amine alkaloid
	3,3'-Dimethylbenzidine			212	$C_{14}H_{16}N_2$	Simple acyclic amine alkaloids
	Acridone			195	$C_{13}H_9NO$	Simple aromatic natural products
	Hexachlorophenol			404	$C_{13}H_6Cl_6O_2$	Simple aromatic natural products
	Physostigmine			275	$C_{15}H_{21}N_3O_3$	Indole alkaloids
	7-Acetoxy-4-methylcoumarin			218	$C_{12}H_{10}O_4$	Flavonoids: coumarins
	1-Naphthalenamine, N-phenyl-			219	$C_{16}H_{13}N$	Simple acyclic amine alkaloids
	Colchine		313	399	$C_{22}H_{25}NO_6$	Alkaloids; Colchicine-type
	Methoserpidine		365		$C_{33}H_{40}N_2O_9$	Indole alkaloids
	7-Dehydrocholesterol acetate		366	426	$C_{29}H_{46}O_2$	Steroids
	Isoquinoline, 1-(3,4-diethoxybenzyl)-6,7-diethoxy-			395	$C_{24}H_{29}NO_4$	Isoquinoline alkaloids
2, 4	1,5-Dihydroxyanthraquinone	1.3	239	240	$C_{14}H_8O_4$	Polycyclic aromatic natural products
	Comestrol			268	$C_{18}H_{20}O_2$	Steroids
	Anthraquinone			208	$C_{14}H_8O_2$	Polycyclic aromatic natural products

	1,4-Diamino-2,3-dihydroanthraquinone			240	$C_{14}H_{12}N_2O_2$	Polycyclic aromatic natural products
	7-amino-3-phenylcoumarin			237	$C_{15}H_{11}NO_2$	Flavonoids: coumarins
	5-Hydroxy-7-methoxyflavone (Formononetin)			268	$C_{16}H_{12}O_4$	Flavonoids: Isoflavonoids
	1-amino-2-methylanthraquinone			237	$C_{15}H_{11}NO_2$	Polycyclic aromatic natural products
	Stibestrol dipropionate			380	$C_{24}H_{28}O_4$	Stilbenoids
	4-Dimethylamino-3'-methylazobenzene			239	$C_{15}H_{17}N_3$	Miscellaneous acyclic amine alkaloid
3, 4	Phystostigmine	15.5, 18.1	217	275	$C_{15}H_{21}N_3O_2$	Indole alkaloids
	1,2-Benzocarbazole			217	$C_{16}H_{11}N$	Simple acyclic amine alkaloids
	N-Phenyl-1-napthylamine			219	$C_{16}H_{13}N$	Simple acyclic amine alkaloids
5	Ergosterol (Provitamin D)	20.00	363	396	$C_{28}H_{44}O$	Steroids
	Cholesterone		385	384	$C_{27}H_{44}O$	Steroids
6	Cholesterone	20.60	327	384	$C_{27}H_{44}O$	Steroids
	2,4,6-Tribromoaniline			327	$C_6H_4Br_3N$	Simple acyclic amine alkaloids
7	α-D-Glucopyranoside, α-D-glucopyranosyl	20.80	301	342	$C_{12}H_{22}O_{11}$	Carbohydrates
	6,7-Diethoxy-1-(3,4-diethoxybenzyl)isoquinoline			395	$C_{24}H_{29}NO_4$	Isoquinoline alkaloids
	Cholecalciferol			384	$C_{27}H_{44}O$	Steroids
	Betulin			442	$C_{30}H_{50}O_2$	Triterpenoids
8	Colchine(+)	22.4	399	399	$C_{22}H_{25}NO_6$	Alkaloids: colchine-type
	β-Carotene			536	$C_{40}H_{56}$	Steroids
	4-Benzeneazodiphenylamine			273	$C_{18}H_{15}N_3$	Miscellaneous acyclic amine alkaloids

10, 11	Colchine	23.1, 26.4	298	399	$C_{22}H_{25}NO_6$	Alkaloids: colchine-type
	Nonadecanoic acid			298	$C_{19}H_{38}O_2$	Lipids
	N-Acetylcolchinol methyl ether			371	$C_{21}H_{25}NO_5$	Alkaloids: colchicines-type
	Cholesta-5,7-dien-3-ol, acetate, (3 £)-			426	$C_{29}H_{46}O_2$	Steroids

Appendix IXa Other bioactive compounds isolated and identified from the stem bark of *Strychnos spinosa* and their spectra characteristics

Peak no.	Compound name(s)	Retention time (min)	Main peaks (*m/z*)	Molecular weight	Molecular formula	Compound category
1 - 2	5-Chloro-2-nitrobenzoic acid	0.8 – 0.9	203	202	$C_7H_4ClNO_4$	Simple aromatic natural products
	Reserpine		365	608	$C_{33}H_{40}N_2O_9$	Indole alkaloids
	Brucine			394	$C_{23}H_{26}N_2O_4$	indole alkaloids
	Rescinnamine			634	$C_{35}H_{42}N_2O_9$	Indole alkaloids
4 - 5	Otrivine	1.6 – 1.7	243	244	$C_{16}H_{24}N_2$	Simple acyclic amine alkaloids
	Cortisone			360	$C_{21}H_{28}N_5$	Steroids
	Dihydrocodeinone			299	$C_{18}H_{21}NO_3$	Isoquinoline alkaloids
	Riboflavin			376	$C_{17}H_{20}N_4O_6$	Miscellaneous nitrogen compounds
	Diphenylbenzidine			336	$C_{24}H_{20}N_2$	Simple acyclic amine alkaloids
	Diphenoxylic acid		424	424	$C_{28}H_{28}N_2O_2$	Aromatic carboxylic acid
	Verticinone		429	429	$C_{27}H_{43}NO_3$	Isosteroidal alkaloids
8	3-Amino-N-ethylcarbazole	8.9	211	210	$C_{14}H_{14}N_2$	Simple acyclic amine alkaloids
16 - 17	Brucine	13.0 - 13.1	393	394	$C_{23}H_{26}N_2O_4$	indole alkaloids
20	Vincamine	15.3	353	354	$C_{21}H_{26}N_2O_3$	indole alkaloids
21	Strychnine	17.5	335	334	$C_{21}H_{22}N_2O_2$	indole alkaloids
22 - 23	1,2-Benzo-carbazole	21.8 – 22.4	217	217	$C_{16}H_{11}N$	Simple acyclic amine alkaloids

	5-Ethyl-5-p-tolylbarbituric acid			246	$C_{13}H_{14}N_2O_3$	Simple aromatic natural products
	N-Phenyl-1-naphthylamine			219	$C_{16}H_{13}N$	Simple acyclic amine alkaloids
	Phenyl isocyanide, 4,4'-methylenebis-			218	$C_{15}H_{10}N_2$	Simple acyclic amine alkaloids
	Codeine (Dihydrocodeinone)		299	299	$C_{18}H_{21}NO_3$	Isoquinoline alkaloids
24	Prednisone	22.6	301	358	$C_{21}H_{26}O_5$	Simple aromatic natural products
	Bufotalin		323	444	$C_{26}H_{36}O_6$	Simple aromatic natural products
	Gamabufotalin			402	$C_{24}H_{34}O_5$	Simple aromatic natural products
	Reserpine		413	608	$C_{33}H_{40}N_2O_9$	indole alkaloids
	Rescinnamine			634	$C_{35}H_{42}N_2O_9$	indole alkaloids

Appendix IXb Other bioactive compounds isolated and identified from the root bark of *Strychnos spinosa* and their spectra characteristics

Peak no.	Compound name(s)	Retention time (minutes)	Main peaks (*m/z*)	Molecular weight	Molecular formula	Compound category
2	Ergosterol (Provitamin D)	3.4	309	396	$C_{28}H_{44}O$	Steroids
3 - 4	Benzamide, N,N-diethyl-4-methyl (Phendimetrazine)	17.9	190	191	$C_{12}H_{17}NO$	Simple acyclic amine alkaloids
	2,6-Dichlorobenzoic acid			190	$C_7H_4Cl_2O_2$	Aromatic carboxylic acid
	11H-Benzo/a/carbazole			217	$C_{16}H_{11}N$	Simple acyclic amine alkaloids
	4'-Pentylactophenone			190	$C_{18}H_{19}O$	Polycyclic aromatic natural products
	Tetrachloro-o-benzoquinone			244	$C_6Cl_4O_2$	Polycyclic aromatic natural products
	8-Hydroxyjulolidine			189	$C_{12}H_{15}NO$	Simple acyclic amine alkaloids
	5-cyano-5h-dibenzo(b,f)azepine			218	$C_{15}H_{10}N_2$	Simple acyclic amine alkaloids
	Diethyltoluamide			191	$C_{12}H_{17}NO$	Simple acyclic amine alkaloids
	2, 3-Dimethylanthraquinone		236	236	$C_{16}H_{12}O_2$	Polycyclic aromatic natural products
	Barbonine			395	$C_{24}H_{29}NO_4$	Isoquinoline alkaloids
	1-Amino-2-methylanthraquinone			237	$C_{15}H_{11}NO_2$	Polycyclic aromatic natural products