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Full Length Research Paper

Plant diversity of Al- Balqa Governorate, Jordan

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Listing and describing plant diversity in terms of the status of flowering vascular plants in Al-Balqa Governorate (North West Amman/Jordan) has been evaluated. Collections of plant specimens have been made during the field trips that have been conducted, in order to study and evaluate the composition and the diversity of the flowering wild plants in Al-Balqa Governorate. A total number of 527 species belonging to 296 genera and 61 families have been recorded. A number of 91 medicinal plants are recorded; some examples are known as medicinal plants like: *Arum palaestinum*, *Achillea santolina*, *Carduus australis*, and others. Poisonous plants such as *Retama raetam*, *Solanum luteum*, *Ferula communis* etc. were also recorded. A number of 30 recorded species are considered as endemic such as *Daucus carota* and *Apium nodiflorum*, and some others are known as edible plant species like: *Salvia hierosolymitana*, *Gundelia tournefortii*, *Eruca sativa* etc. a number of 25 species are endangered such as: *Gundelia tournefortii, Sinapis alba, Sternbergia clusiana* and *Cistus creticus*. Some reported species are rare like: *Lactuca serriola*, *Varthemia iphionoides*, *Echium judaeum*, *Lupinus varius*, *Iris atrophosca* and others. Deciduous Oak (*Quercus ithaburensis*) forest is occurring in the study area mixed with remnants of wild olive (*Olea europaea*), and with shrubs such as *Crataegus azarolus*, and a wild almond tree (*Amygdalus communis),* also with herbaceous bushes such as *Dactylis glomeratus*, *Urginea maritima*, *Colchicum hierosolymitanum, Sarcopoterium spinosum*, *Euphorbia hierosolymitana*, *Salvia indica*, *Alcea setosa*, and *Tulipa stylosa*. However the study area is considered as one of the richest geographical area in Jordan in terms of its plant diversity, but unfortunately the area is negatively affected by different factors that are contributing in the habitat loss and degradation.

Key words: Plant diversity, Flora, Al-Balqa, Jordan.

INTRODUCTION

The main purpose of this study is to survey plant diversity and to identify the flowering plants in Al- Balqa area, and to report the potential of the plant species recorded in terms of its economic, medicinal, poisonous, edible, and ornamental values, as well as the ecological status in terms of endemic, rare, threatened and endangered taxa.

Al- Balqa governorate falls within the Mediterranean phytogeographical region in Jordan and it is considered as subhumid Mediterranean bioclimatic region (Al-Eisawi, 1996). This region is characterized by having the best rainfall and the best vegetation. The area is characterized by its natural *Pinus halepensis* forests especially in Zai

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and Dibeen in Salt area; the deciduous Oak forests of *Quercus ithaburensis* and *Pistacia atlantica* in As- Baihi near Salt area (Al- Eisawi, 1996). Plant biodiversity in Jordan is exposed to several threats leading to sharp decline in most of the Jordanian flora and the extinction of several species. Many species have become at risk, or were classified as threatened or endangered or even extinct on the regional and global levels. This situation has resulted from various natural and man-made activities, as well as from general lack of knowledge and awareness (Oran, 2014; Oran and Abu Zahra, 2014). The rich Jordan diversity of species can be classified into different classes of vegetation, such as herbs, shrubs and trees.

This study is assessing the flowering wild plants of AL-Balqa Governorate diversified and focusing on the diversity of wild plants in an attempt to protect and conserve the plant resources in the study area. AL-Balqa area is a name given to area covering some places in the north, North West of the country (Map 1). Salt, AL-Fuhais, Mahes, and Ghour.

There are some studies that were published which deals with the situation of the wild flowering plants in Jordan Al- Eisawi (1982, 2013) (Oran, 2014; Oran and Al-Eisawi, 2015; Oran, 2015). Other studies related to medicinal plants in Jordan (Oran et al., 1998, Oran, 2014). A previous study conducted by Al- Mohaisen et al. (2005), on plant diversity of Al- Fuhais area. A number of 238 species was recorded. A recent study by Al-Rawashdeh et al. (2013) listed a number of 296 medicinal plants in Wadi shuaib are that explained the effect of climate change on the surrounding vegetation. The edible plants in Jordan were identified by Takruri and Al- Eisawi et al. (1989). The poisonous plants were reported by Abu Irmaileh (1989). An ethnobotanical survey for the northern high mountains in Jordan including the Salt area is published on 2015.

This study has been surveying and identifying mainly the wild flowering plants in Al- Balqa areas, list of studied plants is included in Table 1. The medicinal plants used in folk medicine by locals are shown in Table1; Map of the study area is also presented (Figure 1). Some selected photographs for some plant species are shown in Figure 2A to L.

The numbers of vouchers specimens for those collected and identified for the different areas of Al- Balqa study area are also shown in Table 1. The voucher specimens are deposited at the herbarium of Department of Biological of Sciences/ University of Jordan/ Amman (AMM). The plant specimens are identified and checked out based on using the available flora of Flora palaestina, Volume 1, 2, 3, and 4 (Zohary, 1966; Feinbrun- Dothan, 1986), and also revised online using International Plant Names Index (IPNI) website, plant taxonomist and myself as plant taxonomist. The determination for some plants that are identified as endemic, rare, endangered are evaluated based on the experience of the author of the flora of Jordan, that IUCN standards cannot fit to.

MATERIALS AND METHODS

1. In this botanical survey extensive field trips have been conducted to the study area of Al- Balqa Governorate (Salt, Mahes, Fuhais and Wadi Shuaib).
2. Identification of plant specimens was made by plant taxonomist and by using Flora palaestina Volume 1, 2, 3 and 4 (Zohary, 1966; Feinbrun- Dothan, 1986), and revised online by IPNI website.
3. Photographs have been made for some selected herbs, shrubs and trees or some plant species that are dominating the target area (Figure 2).
4. A list of all recorded plant species is provided. The names of the plant species in the provided list are arranged alphabetically according to their families, genera, and species (Table 1). Medicinal plants are also listed as well as edible, poisonous, endangered endemic and rare are also identified.

RESULTS AND DISCUSSION

A total number of 527 species belongs to 296 genera and 61 families has been recorded, out of which a number of 100 medicinal plants was identified, some examples are *Arum palaestinum*, poisonous plants are listed in Table 1, A number of 30 recorded species are considered as endemic such as *Daucus carota,* and a number of 25 recorded species are endangered*,* all the recorded species are shown in Table 1, and photographs of some plant species are shown in Figure 2. Some plant species are known for their ornamental potential (Table 1).

CONCLUSION AND RECOMMENDATIONS

The results showed a high floral diversity of the study area in terms of the number of plant species recorded. This diversity of plant species is a reflection of the prevailed supportive ecological conditions, with high mountains (900 to 1700 m), adequate rainfall of 400 to 600 mm/year, the best fertile soil type in the country. Plant biodiversity faces the danger of degradation and loss of many plant species as a result of both man-made and natural factors. Changes in biodiversity can directly reduce sources of food, fuel, structural materials and medicinal or genetic resources. These changes are occurring at rapid rate as a consequence of human activities, such as land-use, over- grazing probably climate change, increase of the populations, over exploitation of plant and animal species, and pollution of soil, water and air. Collective efforts are important to preserve and protect the wild species in Al- Balqa study area for its highly diversified plant species that are suffering the danger of degradations and eventual extinction. Jordan is also known for its high richness in Birds such as: ldfinch (*Carduelis carduelis*) common resident, Black bird (*Turdus merula)* very common resident in the geographical study area and Chucker

Table 1. The list of the plant species in the study area (Al- Balqa Governerate).

Family	Scientific name	M	P	End	Ed	O	R	Plant No.
Acanthaceae	*Acanthus syriacus* Boiss.	+						12
Amaranthaceae	*Amaranthus retroflexus* L.							112
	Narcissus tazetta L.	+				+		91
Amaryllidaceae	*Sternbergia clusiana* Ker Gawler	+				+		104
Anacardiaceae	*Pistacia atlantica* Desf.	+			+			68
	P. palaestina Boiss.	+			+			16
Apocynaceae	*Nerium oleander* L.	+	+					92
Araceae	*Arum hygrohpilum* Boiss.	+	+					115
	A. palaestinum Boiss.	+	+					119
	Biarum angus Tatum (Hooker. Fil.) N.E.Br.	+	+					19.95
	Eminium spiculatum (Blume) Kuntze	+						15.58
Aristolochiaceae	*Aristolochia parvifolia* Sm							168
Asclepiadaceae	*Calotropis procera* (Aiton) Aiton fil	+						124
Asteraceae	*Aaronsohnia factorovskyi* Warb. Et Eig					+		151
	Achillea fragrantissima (Forskal) Schultz Bip.	+						166
	A. santolina L.	+						271
	Anthemis cotula L.	+				+		155
	A. cornucopiae Boiss.					+		20
	A. hussknechtii Boiss.et Reuter					+		10
	A. palaestina Reuter					+		6.143
	Calendula arvensis L.	+				+		49
	C. palaestina Boiss.					+		246
	Cardus australis Pomel.	+						105
	C. getulus Pomel.							77
	Carlina hispanica Lam.						+	23
	Carthmus glaucus Bieb.							62
	C. tenuis (Boiss.et Blanche) Bornm							16
	Catananche lutea L.							110
	Centaurea cyanoides Berggren et Wahlenb.							118
	C. iberica Trevex Sprengel							75
	C. lutea L.							111
	C. pallescens Delile							5.29
	C. rigida Banks et Sol.							148
	Chardinia orientalis (L.) O. Kuntze							268
	Chrysanthemum coronarium L.					+		171
	C. segetum L.					+		74
	Cichorium pumilum Jacq.	+				+	+	131
	Cirsium syriacum (L.) Cass.							75
	*Conyza bonariensis (*L.) Cronquist	+						117
	Crepis aspera L.							102
	C. sancta (L.) Bornm.							40.81
	C. seneciodes Delile							148
	Dittrichia viscosa (L.) Greuter	+						57
	Filago contracta (Boiss.) Chrtek & Holub							89
	F. dsertorum Pomel.	+						153
	F. eriocephala Guss.							141
	F. gallica L.							145
	F. pyramidata L.							199
	Geropogon hybrida (L.) Sch. Bip.							94.114
	Gundelia tournefortii L.	+			+			17.39
	Hedypnois rhagadioloides (L.) F. W. Schmidt							10.33

Table 1. Contd.

	Helichrysum sanguineum (L.) Kostel			+		9
	Hyoseis scarba L.			+		16
	Inula crithmoides L.	+				90.138
	I. graveolens L. (Desf.)	+				50
	Lactuca serriola L.	+	+			136.23
	L. viminea (L.) J.et C. Presf.					18.115
	Launaea mucronata (Forskal) Muschler					144
	Leontodon tuberosum L.					42
	Notobasis syriaca (L.) Cass.					122
	Onopordum alexandrinum Boiss.	+		+		140
	Pallenis spinosa (L.) Cass.					13
	Phagnalon rupestre (L.) DC.	+				39
	Picnomon acarna (L.) Cass.					44
	Picris damascena Boiss. & Gaill					30.81
	P. galilaea (Boiss.) Bentham & Hooker fill.					45.51
	Pluchea dioscoridis (L.) DC.					154
	Pulicaria arabica (L.) Cass.					25
	Reichardia tingitana (L.) Roth			+		240
	Rhagadiolus stellatus (L.) Gaertner					35
	Scorzonera papposa DC.			+		11.103
	Senecio vernalis Waldst. & Kit	+		+		104
	Sonchus oleraceous L.	+				53.44
	Thrincia tripolitana Sch. Bip.					10.89
	T. tuberosa (L.) DC.					86
	Tolpis barbatus (L.) Gaertn.			+		113
	T. virgata (Desf.) Bertol.					101
	Tragopogon collinus DC.			+		157
	Urospermum picroides (L.) Scop. Ex F. W. Schmidt			+		35
	Varthemia iphioides Boiss.et Bl.	+			+	83
	Xanthium brasilicum Vell.				+	115
Brassicaeae	*Matthiola aspera* Boiss.			+		140
	M. longipetala (Vent.) DC.			+		78
	Microthlaspi perfoliatum (L.) F. K. Meyer					142
	Nasturtium officinale R. Br.	+				131
	Neslia apiculata Fischer C. A. Meyer & Ave- Lall.					114
	Raphanus sativus L.		+			97.119
	Sinapis alba L.	+	+	+		147
	S. arvensis L.	+				105
	Sisymbrium erysimoides Desf.					6.42.39
	Torularia torulosa (Desf.) O. E. Schulz					142
Campanulaceae	*Campanula strigosa* Banks & Sol.					77
	Legousia falcata (Ten.) Fritsch			+		29
Caprifoliaceae	*Lonicera etrusca* Santi	+		+	+	67
Caryophyllaceae	*Cerastium dichotomum* L.					127
	Dianthus judiacus Boiss.			+		90
	D. strictus Banks et Sol.					82.37
	Gypsophila arabica Barkoudah			+		20
	*Minuartia formosa (*Fenzl) Mattf.					84.116
	M. globulosa (Labill.) Schinz & Thell.			+	+	137
	M. picta (Sibth. & Sm.) Bornm				+	121
	Polycarpon tetraphyllum (L.) L.					38
	Paronychia argentea Lam.	+				98

Table 1. Contd.

	P. desertorum Boiss.					33.103
	P. sinaica Fresen.	+				109
	Pteranthus dichotomus Forskal					99
	Silene aegyptiaca (L.) L. fil.				+	164
	S. conoidea L.			+	+	31.63
	S. crassipes Fenzl					114
	S. damascena Boiss. & Gaill					154
	S. trinervis Banks et Sol.					72
	S. vulgaris (Moench) Gracke	+				488
	Spergularia diandra (Guss.) Helder.et Sart.					159
	Vaccaria pyramidata Medikus	+				126
	Velezia rigida L.					21.50
Chenopodiaceae	*Atriplex halimus* L.	+				102
	Beta vulgaris L.			+		49
	Chenopodium album L.	+				272
	C. murale L.					136
	Salsola vermiculata L.					134
Cistaceae	*Cistus creticus* L.		+		+	47
	C. solvifolia (L.) Webb.	+			+	36
	C. villosus Acut.				+	132
Cistaceae	*Fumana arabica* (L.) Spach				+	170
	F. thymifolia (L.) Webb.					23
	Helianthemum aegyptiacum (L.) Miller				+	46.53
	H. lasiocarpum Desf.					26.31
	H. ledifolium (L.) Miller					6.19
	H. salicifolium (L.) Miller				+	27
	Tuberaria guttata (L.) Fourr.					131
Convolvulaceae	*Convolvulus althaeoides* L.	+				125
	C. arvensis L.	+			+	9.145
	C. betonicifolius Mill					81
	C. dorychnium L.					123
	C. scammonia L.	+				100
	C. siculus L.					134
Crassulaceae	*Sedum caespitosum* (Cav.) DC.	+			+	41
	Umbilicus intermedius Boiss.				+	166
Cucurbitaceae	*Bryonia syriaca* Boiss.	+				169
Cyperaceae	*Cyperus conglomerates* Rottb.					56
	Scripus holoschoenus L.					44
Dipsacaceae	*Cephalaria plimosus* (L.) Coult.					22
	C. syriaca (L.) Coult.					16.75
	C. tenella Paine					6.23
	Pterocephalus brevis Coult.					7.27
	Scabiosa argentea L.					127
	S. eremophila Boiss.					128
	S. palaestina L.					221
	S. prophyroneura Blakelock					47
	S. prolifera L.					140
Euphorbiacea	*Andrachne telephioides* L.					141
	Euphorbia aleppica L.					104
	E. aulacosperma Boiss.					12.139
	E. chamaepeplus Boiss. Gaill.					78
	E. geniculata Ortega					18.88

Table 1. Contd.

	E. helioscopia L.	+		49.59
	E. heterophylla L.			155
	E. hierosolymitana Boiss.			177
	E. macroclada Boiss.			196
	E. peplis L.			109
	E. peplus L.			51
	Mercurialis annua (L.)	+		71
	Ricinus communis L.			89
Fabaceae	*Acacia farnesiana* (L.) Willd.			160
	A. gerrardii Bentham			127
	A. lancifolia Miller			218
	Albizzia lebbeck Benth			116
	Anagyris foetida L.			217
	Astragalus annularis Forskal			3.214
	A. cocephalus Boiss.			83
	A. cretaceous Boiss. & Kotschy			34
	A. cruciatus Link.			65
	A. palaestinus Eig.			166
	A. sanctus Boiss.			216
	Calycotome villosa (Poiret) Link.		+	49.255
	Coronilla critica L.			253
	C. scorpioides (L.) Koch			264
	Hippocrepis unisiliqosa L.			4.150
	Hymenocarpos circinnatus (L.) Savi			86.21
	Lathyrus cicera L.		+	23.46
	L. digitatus (M. B.) Fiori			130
	L. hierosolymitanus Boiss.		+	160
	L. pseudocicera Pamp.			99
	Lens esculenta Moench			215
	Lotus collinus (Boiss.) Heldr.			79.153
	L. corniculatus L.			15.85
	L. creticus L.			108
	L. cytisoides L.			107
	L. tenuis Waldst. & Kit.			121
	Lupinus palaestina L.			47
	L. varius L.			211
	Medicago granadensis Willd.			40.156
	M. lanciniata (L.) Miller	+	+	47
	M. orbicularis (L.) Bartal.			150
	M. polymorpha L.			113
	M. radiata L.			151
	M. rugosa Desv.			248
	M. sativa L.			144
	M. truncatula Gaertn			267
	Onobrychis caput- galli (L.) Lam.			190
	O. crista- galli (L.) Lam.			253
	O. kotschyana Fenzl			166
	O. squarrosa Viv.			157
	Ononis antiquorum L.	+		188
	O. natrix L.	+		139
	Physanthyllis tetraphylla (L.) Boiss.			138
Geraniaceae	*Erodium laciniatum* (Cav.) Willd.			235

Table 1. Contd.

	*E. malacoides (*L.) L' Her.							204
	E. moschatum L. L' Her.							221
	E. touchyanum Delile							122
	Geranium molle L.					+		231
	G. tuberosum (L.)							33.244
Hypecoaceae	*Hypecoum imberbe* Sibth.et Sm.							185
Hypericaceae	*Hypericum olivieri* (Spach) Boiss.							113
	H. serpyllifolium Lam.							181
	H. triquetrifolium Turra							189
Iridaceae	*Crocus hermoneus* L.	+	+		+	+		156
	Gladiolus italicus Miller		+		+	+		202
	Gynandriris sisyrinchium L.		+		+	+		209
	Iris atrofusca Baker			+		+	+	137
	I. barnumae Baker et Foster			+		+		176
	Romulea bulbocodium (L.) Seb. & Mauri			+		+		173
Juncaceae	*Juncus bufonius* L.			+				218
Lamiaceae	*Ajuga chia* Schreber	+		+		+		127
	A. orientalis L.							219
	Ballota saxatilis Sieber ex C. Presl							224
	B. undulata (Fresen) Benth.							225
Liliaceae	*Asparagus acutifolius* L.			+				1.229
	A. aphyllus L.			+				3.230
	*Asphodeline brevicaulis (*Breto) Gay		+			+		235
	*A. brevicaulis (*Breto) Gay					+		173
	Asphodelus aestivus Brot.= microcarpus L.		+			+		182
	A. fistulosus L.	+				+		185
	Bellevalia flexuosa Boiss.				+	+	+	217
	Colchicum hierosolymitanum Feinbr.		+			+		122
	Fritillaria libanotica (Boiss.) Baker					+		216
	Gagea aritime C. Koch.							219
	G. aritime (Pallass) Schult. Fill.							211
	Muscari aritime Guss.					+		212
	M. neglectum Guss.ex Ten							210
	M. Pulchellum Heldr. & Start					+		21.89
	Ornithogallum montanum Cry.					+		55.88
	O. narbonensis L.			+		+		78.86
	O. umbellatum L.					+		89
	Tulipa agenensis DC.					+		87
	Urginea maritima (L.) Baker	+	+			+		117
Linaceae	*Linum mucronatum* Bertol.				+	+		125
	L. pubescens Banks & Sol.					+		119
	L. strictum L.							109
Lythraceae	*Lythrum junceum* Banks et Sol.			+		+	+	209
Malvaceae	*Alcea acaulis (Cav.)* Alef.	+		+		+		218
	A. setosa (Boiss.) Alef.	+				+		177
	Althaea hirsuta L.	+				+		217
	Lavatera cretica L.							214
	L. nicaeensis All.							215
	L. parviflora L.							234
	L. sylvestris L.							164
	Malvella sherardiana (L.) Jaub & Spach							163
Orchidaceae	*Himantoglossum affine* (Boiss.) Schlechter	+		+		+		106

Table 1. Contd.

	Limodorum abortivum (L.) Swar.		+	+	209
	Ophrys fusca Link	+	+	+	223
	O. sphegodes Miller	+	+	+	15.224
	Orchis anatolica Boiss.	+	+	+	144
	O. galilaea (Bornm.et Schulze) Schltr.		+	+	57
	O. saccata Ten.		+	+	136
	O. simia Lam.	+	+	+	4.141
	O. tridentata Scop.		+	+	17.149
	Orobanche aegyptiaca Pers.		+	+	93
Papaveraceae	*Papaver argemone* L.			+	105
	P. hybridum L.			+	115
	P. polytrihcum Boiss.et Ky.		+	+	42
	P. subpiriforme Fedde			+	47.215
	Roemeria hybrida (L.) DC.	+		+	56.94
Plantaginaceae	*Limonium lobatum* (L. fill.) O. Kuntze	+		+	31.56
	Plantago afra L.	+			12.72
	P. ciliata Desf.				20
	P. cretica L.				96.41
	P. cylindrical Forskal				47.31
	P. major L.	+			56.94
	P. psyllium L.				10.56
Plumbaginaceae	*Plumbago europaea* L.	+			35.21
Poceae	*Aegilops ovata* L.				150
	Aegilops biuncialis Vis.				60.210
	Alopecurus utriculatus Banks et Sol.				51.231
	Arrhenatherum kotschyi Boiss.				144.16
	A. palaestinum Boiss.				167
	Avena barbata Pott ex Link.		+		90.217
	A. fatua L.				35.22
	A. sterilis L.				66.105
	Brachypodium distachyon (L.) Beauv.				34.82
	Briza maxima L.				36.229
Poceae	*Bromus lanceolatus* Roth.				209
	B. madritensis L.				188
	B. rubens L.				176
	B. sterilis L.				206
	B. tectorum L.				208
	Catabrosa aquatica (L.) Beauv.				199
	Catapodium rigidum (L.) C. E. Hub.				191
	Crithopsis delileana (Schultes) Ros.				177
	Cyndon dactylon (L.) Pers.				125
	Cynosurus cobratus Lehm.ex Steu.				161
	C. elegans Desf.				179
	Dactylis glomerata L.				233
	Digitaria sanguinalis (L.) Scop.				225
	Echinaria capitata (L.) Desf.				227
	Echinochloa colonum (L.) Link.				37.77
	Hordeum bulbosum L.				72
	H. marinum Hudson				70
	H. spontaneum C. Koch.				66.78
	Lamarckia aurea (L.) Moench				62
	Lolium rigidum Gaud				63

Table 1. Contd.

	Lophochloa berythea (Boiss. & Blan.) Bor						61.65
	Oryzopsis holciformis (M. B.) Hach.						67
	O. miliacea (L.) Asc.et Sch.						74
	Pennisetum setaceum (Forskal) Chiov.						71.83
	Phalaris minor Retz						92
	Poa bulbosa L.						81.90
	Polypogon virids (Gouan) Breistr.						137
	Psilurus incurvus (Gouan) Schinz et Thell.						235
	Setaria verticillata (L.) P. Beauv.						224
	Sorghum halepense (L.) Pers.						133
	S. virgatum (Hackel) Stepf						117
	Stipa capensis Thunb.						67.88
Polygonaceae	*Emex spinosa* (L.) Campd.						227
	Polygonum arenastrum Bor.						220
	P. equisetiforme Sibth et Sm.						234
	P. salicifolium Brows.ex Willd.						134
	Rumex congloeratus Murr.						132
	R. crispus L.						131
	R. cyrius Murb.						130
	R. pulcher L.						129
Primulaceae	*Anagallis arvensis* L.	+	+				13.267
	Asterolinon linum- stellatum (L.) Duby						228
	Cyclamen persicum Miller	+					18.225
Ranunculaceae	*Adonis aestivalis* L.	+				+	19
Solanaceae	*Hyoscyamus aureus* L.	+					67
	H. reticulatus L.	+					115
	Mandragora autumnalis Bertol	+	+				80
	Solanum incanum L.		+	+			22
	S. luteum Mill.	+	+				105
	S. nigrum L.	+					83
	*Withania somnifera (*L.) Dunal	+	+				65
Tamaricaceae	*Tamarix aphylla (*L.) Karst.	+					26.83
Theligonaceae	*Theligonum cynocrambe* L.						558
Thymelaeaceae	*Thymelaea passerina* (L.) Cosson & Gern.						124
Typhaceae	*Typha domingensis* (Pers.) Steudel	+					29.46
Umbelliferae	*Ammi majus L.*	+					170
	Anthriscus lamprocarpa Boiss.						39
	Apium nodiflorum (L.) Lag.				+		169
	Artedia sqamata L.						96.16
	Astoma seselifolium Dc.						40.87
	Bifora testiculata (L.) Schultes						80
	Bupleurum lancifolium Hornem.						91.79
	Chaetosciadium trichosperum (L.) Boiss.						102
	Daucus carota L.	+			+		115
	D. dauriena Lange						73
	Eryngium creticum Lam.	+		+			98
	E. glomeratum Lam.						105
	Exoacantha heterophylla L.						176
	Ferula communis L.		+				101
	Foeniculum vulgare Miller	+					88.1
	Hippomarathrum boissieri Reuter et Hausskn						159
	Lagoecia cuminoides L.	+					102

Table 1. Contd.

	Orlaya daucoides (L.) Greuter			71
	Peucedanum spreitzenhoferi Dingl			119.15
	Pimpinella cretica Poiret			14
	P. olivieri Boiss.			24
	Scandix pectin- veneris L.			112.49
	Torilis arvensis (Hudson) Link			25
	*T. leptophylla (*L.) Reichenb. Fill.			161
	Tordylium aegyptiacum (L.) Lam.			17
	T. trachycarpum (Boiss.) AL-Eisawi,Comb.nov			4.12
	Turgenia latifolia (L.) Hoffm			96.22
Urticaceae	*Parietaria alsinifolia* Delile			81
	P. diffusa Mert.et Koch			42
	P. lusitanica L.			82
	P. officinalis L.			126
	P. punctata Willd.			127
Urticaceae	*Urtica pilulifera* L.	+		101
	U. urens L.	+		9
Valerianaceae	*Valeriana italica* Lam.			27
	Valerianella coronata (L.) DC.		+	173
	V. vescaria (L.) Moench			88
Verbenaceae	*Verbena officinalis* L.			53
Zygophyllaceae	*Fagonia mollis* Delile			24
	Tribulus terrestris L.	+		50

Figure 1. Map of Jordan showing Al- Balqa Governerate (The study area).

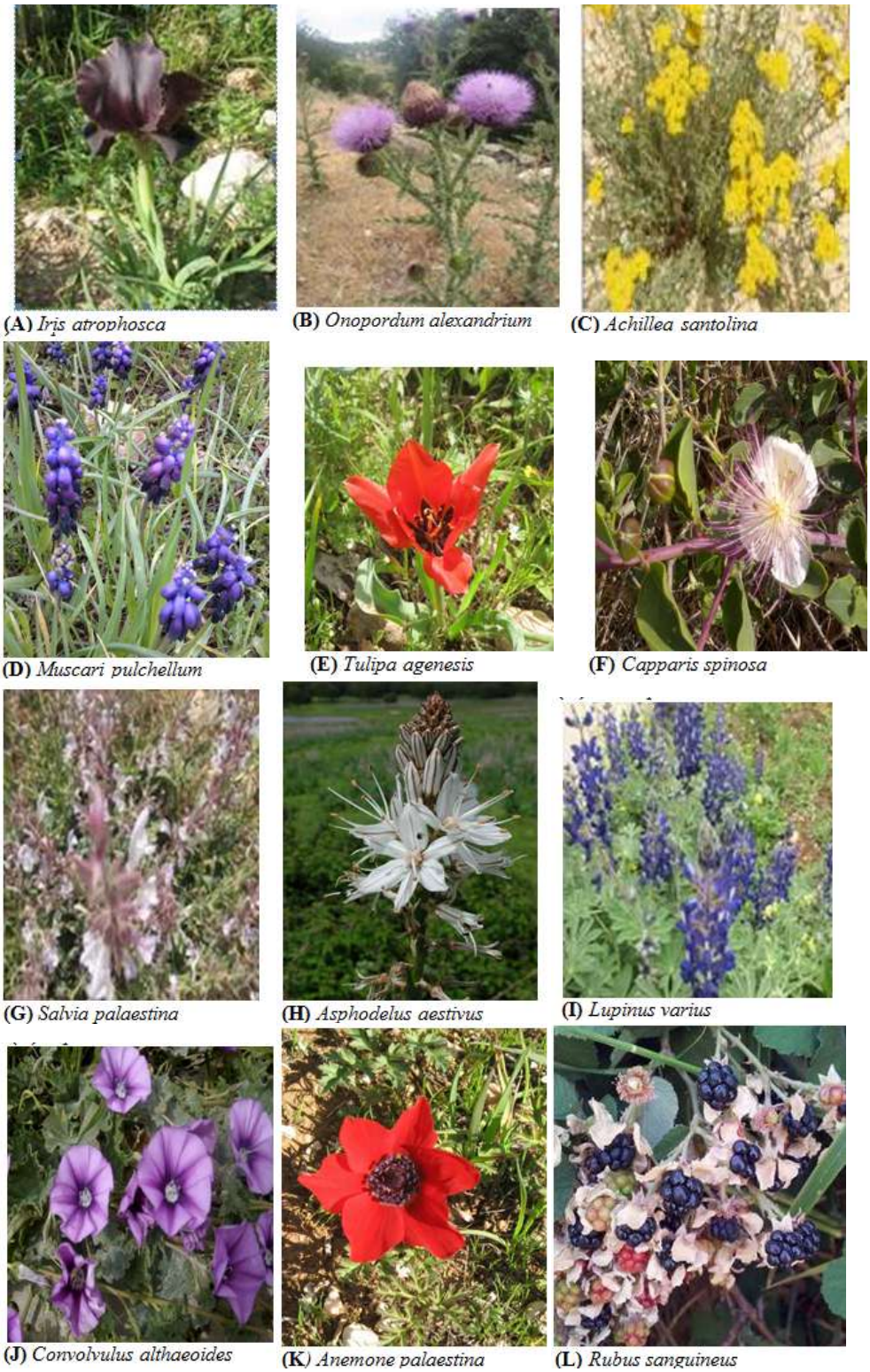

Figure 2. Some selected photographs for some plants.

(*Alectoris chukar)* very common resident; Reptiles such as: *Cyrtopodium kotschi* related to the Oak trees or Pine, *Pseudopus apodus* Common; and mamales such as: Red Fox (*Vulpus vulpus)* very common, common

Badger (*Meles meles)*, Arabian wolf *Canis lupus* common and Striped Hyena (*Hyaena hyaena)* common and others.

Conflict of Interests

The authors have not declared any conflict of interests.

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Local perceptions and importance of endogenous beliefs on sacred groves conservation in South Benin

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Turning forests into sacred groves remains an effective strategy as far as conservation of forests is concerned. Nowadays sacred groves are eroded to a wide range of adversities. In this paper, the authors analyzed (i) perception of population on sacred groves dynamic and (ii) the effect of modern religion expansion on sacred groves conservation. To these end, data were collected using individual interviews on 458 informants sampled in six localities surrounding sacred groves. A Chi-square independence test, analytic comparison of means and principal component analysis were applied for data analysis. Findings showed that the sacred grove areas have decreased by more than half during the last three decades (78.06% of interviewees). Categories of sacred forests that are religious groves were the most threatened (70.30% of interviewees). Twenty plants species belonging to 13 botanic families were identified as symbolic species in the sacred groves, *Milicia excelsa* and *Triplochiton scleroxylon* being the most common species. Sacred groves provide a wide range of services among which cultural service was found to be the most preferred by the local population (76.90% of citation). Religious groves and secret forests were found to be the ones providing the most diversified services. However, religious beliefs did not affect the use of sacred groves. The reinforcement of the conversion of forests into sacred groves by the introduction of the secret societies could be efficient towards conservation. Nevertheless, there is a need to identify biological factors which can indicate possibility of species extinction so as to ensure restoration of sacred groves.

Key words: Local perception, conservation, restoration, sacred groves, symbolic species, Benin.

INTRODUCTION

Sacred groves and natural sites as a whole reflect the general attention of people upon natural resources since centuries ago and this constitutes a particular evidence why spiritual knowledge and values have been known long time ago before the appearance of the modern day methods of conservation (Wild and Mcleod, 2012).

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Sacred groves are widely distributed (Bhagwate and Rutte, 2006) and were detected long time ago (Aubreville, 1937; Chevalier, 1933; Jone, 1963). Such groves stem from forests ecosystem fragmented (Kokou and Sokpon 2006). Statistics show that about 400 to 800 million hectares of forests are under the control of local communities (Barrow and Pathak, 2005) and about 150 to 200 thousands of sacred groves are only found in India (Chatterjee et al., 2004; Gokhale, 2003). In Africa, specifically in Ghana, the number of sacred groves is estimated to be about 1900 (Wild and Mcleod, 2012). In Benin, the number of sacred groves is estimated at 2940 (Sokpon and Agbo, 1999).

They are wooded land, venerated and/or feared. They express cultural identity of a given community and their access and management are regulated by traditional powers. Majority are small in size, generally close to houses (Agbo and Sokpon, 1997) and have a spiritual value specific to communities.

Sacred groves play an important role in natural resources management and conservation of biodiversity (Mama, 1985; Kokou et al., 2005). In countries with few forest coverage like Benin and Togo, sacred groves conservation and the biological diversity they host have been largely documented (Juhé-Beaulaton, 2006; Kokou and Caballé, 2000; Kokou and Kokutse, 2006; Sokpon and Agbo, 1999). For example, sacred groves were found to be the exclusive ecosystems in some regions of south Benin (Juhé-Beaulaton, 2006). Their socio-cultural and ecological functions are very important in some parts of south Benin as they sometimes act as waters points useful for local communities during the time of drought. Nowadays, sacred groves are threatened and tend to disappear due to the escalating human pressure and expansion of modern religions which in turn is threatening the biodiversity they host (Kokou and Sokpon, 2006). From an ecological perspective, sacred forests serve as natural habitats for biological diversity. They protect sources of water for local populations (Agossou, 2012). Harvest of non-timber forest products such as fruits, firewood, medicinal plants, fodder and liana are sometimes allowed (Kokou and Sokpon, 2006).

It is therefore crucial to ensure that sacred groves are managed and conserved sustainably through establishment of urgent policies and strategies. This is why knowledge of symbolic in these ecosystems appears to be of great importance for their biological replenishment. Previous studies showed that socio-cultural values are the real frames of forests and sacred groves conservation and existence (Juhé-Beaulaton et al., 2005). However, these values have been poorly documented and are almost disappearing in Benin (Kokou et al., 2005, Kokou and Sokpon, 2006).

This study was not on the definition of the concept of sacred forests nor discussion on their social, cultural and conservation roles, but details have been reported elsewhere (Agbo and Sokpon,1998; Juhé-Beaulaton and Roussel, 2002); rather the dynamic of different categories of sacred forests as perceived by local communities who are their managers was reported. Thus, based on a sociological approach, this study analyzed perceptions on dynamic and socio-cultural values of sacred forests in relation to beliefs of local communities. The study searched to show the dynamic of sacred forests with emblematic species and the types of services derived from sacred forests based on perceptions of local communities. The study was based on the following hypotheses: (1) maintenance and existence of types of sacred forests depending on the predominance of the traditional cult of *vodoun*, (2) religion has an impact on services derived from sacred forests and (3) forests of divinity are the richest in terms of socio-cultural services. Knowledge on role and services provided by sacred forest could help in their preservation in partnership with local communities (Wild and Mcleod, 2012).

MATERIALS AND METHODS

Study area

This study was carried out in the south-east of the Republic of Benin, a West African country located between 0°40' and 3°45' of longitude east, 06°15 and 12°25' of latitude north. Data were collected in Dassa, Zagnanado, Adjarra, Pobé and Bonou districts, all located in southern part of Benin (Figure 1).

The climate for the study area is of the subequatorial type with two rainy seasons (March to July and September to November) and two alternated dry seasons (August to September and November to March). The annual rainfall ranges from 900 to 1300 mm. Annual mean temperature varies from 26 to 28°C. Ferralitic soils appear to be the principal type of soil in the area. According to Adomou (2005), this area is located in the Guineo-Congolese climatic zone and is dominated by coastal forests, mangrove vegetation, semi-deciduous forests and moisture vegetation. Population size of the study area was estimated at 545 852 habitants (INSAE, 2013) constituting mainly two ethnical groups, namely Fon and Yoruba and their relations (Idatcha, Nago and Holi) are found in the region. Agriculture is the main source of income among the people in these communities.

Data collection

Data were collected from Dassa, Zagnanado, Ifangni, Adjarra, Pobé and Bonou districts. They were selected based on the abundance of sacred groves. The sampling size was determined using the binomial approximation formula of Dagnelie (1998) as described in Equation 1.

$$n = \frac{Pi(1-Pi)\ x\ U^2_{1-\alpha/2}}{d^2} \quad \text{(Equation 1)}$$

Pi represents the proportion of people benefiting from sacred groves services.

Pi was determined using a pre-investigation on 30 informants per district. *Pi* =82.22 %. $U_{1-\alpha/2}$= 1.96 is a statistical value from normal distribution with likelihood of 5% and d is the error associated with all estimated parameters. Value of d was fixed at 3.5%. The sample size based on this approach was estimated to 458 informants. Surveys were conducted from December 2013 to January 2014.

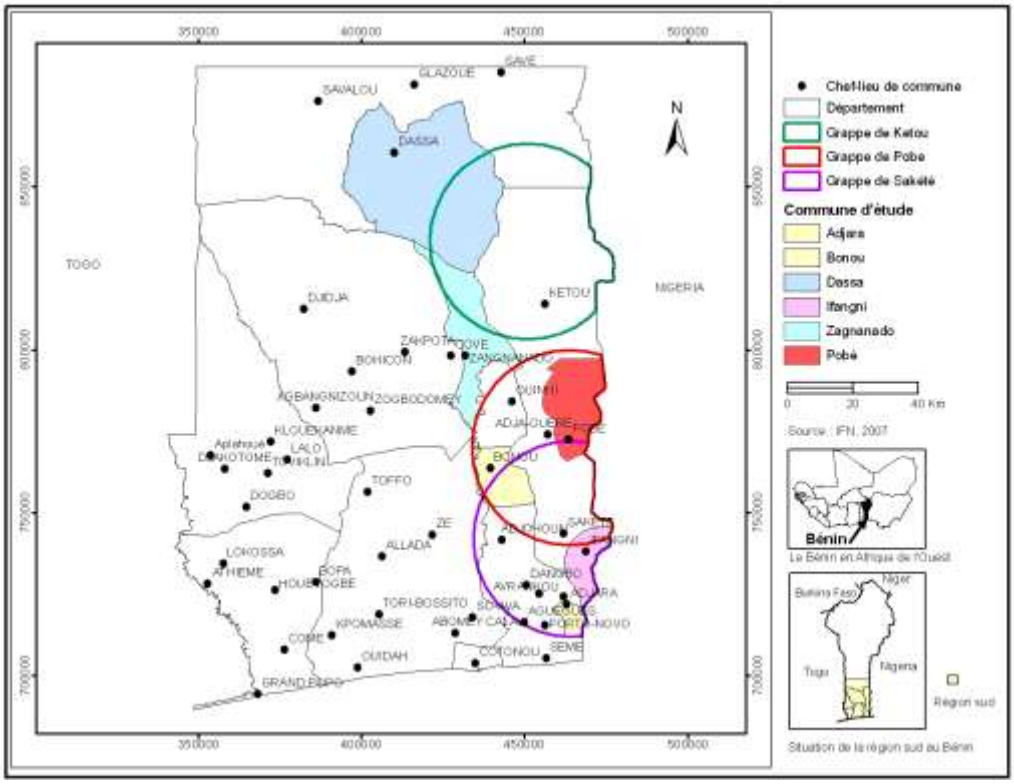

Figure 1. The study zone and sites.

People were firstly interviewed using semi-structured focus groups interviews. These interviews allowed designing a questionnaire for individual semi-structured interviews. Data collected included mainly local perceptions on the spatial and temporal dynamic of sacred groves, emblematic species, the services derived from sacred forests as well as their functions.

Data analysis

The informants were categorized on the basis of their ethnical groups (Idatcha, Goun, Nagot, Mahi, Holi and Ouéménou); religion (Muslim, Christen and Animist), sex (woman and man) and category of age (young: <30 years, adult: 30 to 60 years, old: >60 years) (Assogbadjo et al., 2008). Chi-square test (χ^2) was used to determine the relationship between services derived from sacred forests and socio-cultural categories (ethnic, religion, age and sex). Relative frequency of services provided by sacred groves to local population was calculated. Comparative analysis using relative frequency was used to assess the distribution of services among local populations according to their socio-cultural categories (ethnical groups, religion, age and gender). Because the data were not normally distributed, Kruskal-wallis test was applied in Minitab version 16. The matrix of relatives frequencies of services derived from sacred forests per ethnical groups was established. This matrix was submitted to principal component analysis (PCA) to determine the relationship between services provided by sacred groves and ethnical groups. These analyses were performed using R 2.15.3 (R Core Team 2014, https://www.r-project.org) software. Services' components from the PCA were then correlated to the relative frequencies of populations' beliefs using Pearson correlation test under SAS9.2 software.

Table 1. Relative frequency of sacred groves' existence according to the local populations.

Localities	ASG	ST	DSG	SSSG
Adjarra	100	16.67	11.98	18.59
Bonou	0.00	16.67	20.06	20.28
Dassa	0.00	16.44	22.28	0.00
Ifangni	17.39	16.67	10.58	20.28
Pobe	82.61	16.67	14.76	20.28
Zagnanado	0.00	16.90	20.33	20.56

ASG: Ancestral sacred groves; ST: Sacred trees; DSG: divinity sacred groves; SSSG: secret society sacred groves.

RESULTS

Typology of sacred forests

Three categories of sacred groves were identified in the whole study site namely: religious/divinity sacred groves, ancestral sacred groves and secret societies sacred groves. There are specific distributions of each category of sacred groves (Table 1). It is apparent that ancestral sacred groves were exclusively recognized by population from the three areas, namely Adjarra, Ifangni and Pobè

Table 2. List of threatened, rare and disappeared species of sacred groves in visited localities.

S/N	Species	Family (APGIII, 2009)	Citation frequency (%)
1	*Milicia excelsa*	Moraceae	14.21
2	*Triplochiton scleroxylon*	Sterculiaceae	14.21
3	*Ceiba pentandra*	Malvaceae	13.85
4	*Antiaris toxicaria*	Moraceae	13.85
5	*Celtis zenkeri*	Ulmaceae	9.23
6	*Cola cordifolia*	Malvaceae	3.20
7	*Caesalpinia bonduc*	Fabaceae	3.20
8	*Adansonia digitata*	Malvaceae	3.02
9	*Zanthoxylum zanthoxyloides*	Rutaceae	3.02
10	*Mansonia altissima*	Sterculiaceae	3.02
11	*Khaya senegalensis*	Meliaceae	2.84
12	*Xylopia aethiopica*	Annonaceae	2.49
13	*Dialium guineense*	Fabaceae	2.49
14	*Pterocarpus santalinoides*	Fabaceae	1.95
15	*Albizia ferruginea*	Fabaceae	1.95
16	*Morinda lucida*	Rubiaceae	1.95
17	*Rauvolfia vomitoria*	Apocynaceae	1.78
18	*Oldfieldiaafricana*	Euphorbiaceae	1.24
19	*Bombax costatum*	Malvaceae	1.24
20	*Crudia senegalensis*	Fabaceae	1.24

(Table 1) while sacred groves belonging to secret societies were recognized by all informants except those from Dassa. This could explain the absence of secret societies sacred groves category in this location. As for divinity sacred groves, they were recognized mainly in Dassa and Bonou. Results showed that relative frequency of informants recognizing sacred trees was the same among locations (Table 1).

Local perceptions on the spatial and temporal dynamic of sacred forests

As regards local perception on sacred grove dynamics, results showed that old people (more than 60 years old) understood the dynamic of sacred groves in the whole study location. The proportion of old people appreciating the depletion of sacred grove areas was significantly greater than 50% (proportion= 78.06 ± 6.82 %; t = 4.11; P = 0.005). It was noted that human pressure was the main reason for this depletion. In fact, human activities (56.89% of citation), population's growth (52.87% of citation) or the combination of both factors were the main causes of sacred groves' area regression. However, 9.82% of interviewees supported natural causes of sacred groves regression. Divinities sacred groves were the most threatened (70.3%). 60.3% of cases people believed that modern religions expansion and erosion of ancestral beliefs were the fundamental causes of sacred groves regression. In addition, local populations identified 20 sacred species in the different sacred groves. Table 2 shows the list of such species per order of citation frequency.

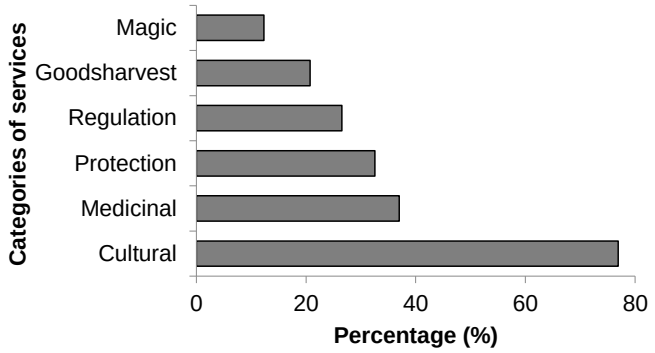

Figure 2. Proportions of people benefiting from sacred groves services.

Diversity of services provides by sacred groves to the local population

Six services were drawn from sacred forests which were: cultural, medicinal, protection, regulation, goods harvest and magic (Figure 2). At least, one service is benefited by

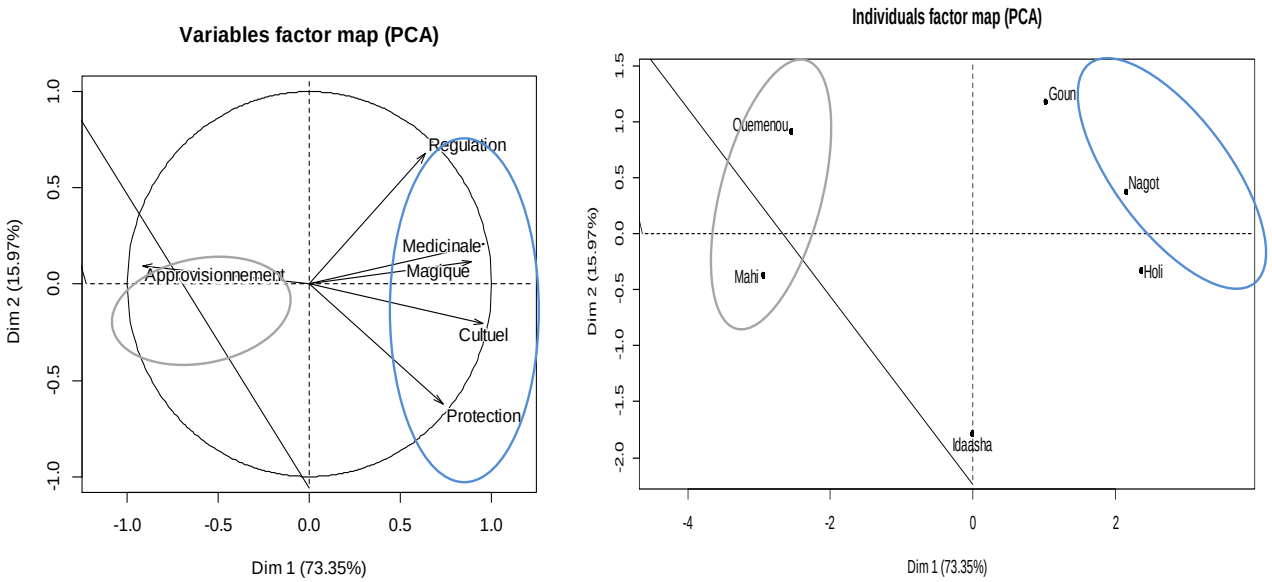

Figure 3. Principal components analysis showing relationship between ethnic groups and services benefited from. a) Correlation circle of services benefited from; b) factorial map of ethnic groups.

all respondents. Cultural services appeared to be the most important (76.90% of citation). Services benefited by local populations were significantly related to their ethnic groups, religions, ages and sex ($P < 0.001$). Relative citation frequency of services was on average smaller than 50% and this indicated the abnormal distribution of different services among local populations. Frequency of citation varies significantly according to the ethnic groups, religion, ages ($P < 0.05$) but not related to the sex ($P > 0.05$).

Results from the principal components analysis revealed that the first two axes, 1 and 2 explained 89.31% of the total variance in benefited services. All the services were positively correlated with the first axis (axis 1) except resources harvesting service (Figure 3a). Projection of the ethnic groups onto the system axis defined by the two axes showed that ethnic groups such as "goun", "nagot" and "holi" benefited more from other services than goods supply (sacred groves harvesting) which was preferred (64.38% of citation) by "mahi" and "ouémènou" ethnic groups (Figure 3b). Cultural services (92.19% of citation) and magic services (74.19% of citation) were the most preferred by "holi". Spiritual services (58.57% of citation) were the most preferred by "idaasha" whereas weather regulation services (56.60% of citation) were preferred by "goun". Medicinal services (75% of citation) were preferred by "nago" (Figure 3b). Correlation analysis showed that religion has no significant impact on services desired by local populations (Table 3).

Table 4 shows functions benefited by local populations according to sacred groves category. Divinities and secret society sacred groves provide a wide range of functions to local populations.

Table 3. Correlation between sacred groves services and religions using principal components.

Religions	Component 1	Component 2
Animist	-0.44 ns	-0.83 ns
Christen	0.12 ns	0.60 ns
Muslim	0.52 ns	0.61 ns

DISCUSSION

Typology of sacred groves and local perception on their dynamic

Most forest communities in the study area were isolated remnants sacred groves which are highly diversified in terms of typology and cultural significance (Kokou and Sokpon, 2006). The current study identified three types of sacred groves including divinities or cemetery, ancestral and secret society sacred groves. Similar result was reported by Kokou and Sokpon (2006) and Agossou (2012). Among these categories of sacred forests, forests of gods or geniuses were cited everywhere but mostly in the regions of Dassa and Bonou. These findings confirm the predominance of the traditional cult *Vodun* in south Benin. In fact, the mental and psychosocial universes of communities in south Benin is highly influenced by the deity *Vodun*. Agossou (2012) showed that *Aja Tadonu* people and *Yoruba* and *Nago* people, even if coming from opposed geographical origins, they all venerated divinities called *Vodun* for the first and *Orisha* for the second. Forests of secret societies were also found

Table 4. Distribution of functions according to sacred groves categories

Categories of sacred groves	Services	Functions
Ancestral/cemetery (Kings cemetery, people that died of accidents, pregnancy, epidemic diseases)	Cultural	Kings and people burial
	Medicinal	Harvest of medicinal plants
	Magic	Kings enthronement ritual
	Protection (spiritual)	Protection against witchcrafts
	Regulation (weather)	Improvement of rainfalls conditions
Divinities' sacred groves (Safeguard divinities and genius; protect taboo trees and living populations).	Religious	Annual ceremonies (Ahanbiba); din for asking prosperity; ritual; dance; initiation; wedding; births celebration; oracle consultation; rain ceremonies; sacrifice; peace and happiness ceremonies; praying for soil fertility; family blessing
	Medicinal	Source of medicinal plants; treatment of malaria, ulcer, sterility, yellow fever, madness, hypertension, chicken pox, bellyache, icterus, measles, hepatitis, pregnancy, leprosy, bewitchment,madness, epidemics, diabetes, etc.
	Magic	Against spiritual diseases; - deliverance ; other magical issues-Exorcism
	Goods harvest	Fuelwood; - timber wood; -food; -fish; - water.
	Protection	Against bad spirits and witchcrafts
	Regulation	Rain ritual, and climate regulation
Secret societies sacred groves (Idols houses such as Orozoun or Oro forest, Kouvitozoun or Kouvito forest, Zangbétozoun or Zangbéto forest and Fâzou or Fâ enthronization forest)	Cultural	Annual ceremonies (Ahanbiba); din for asking prosperity; ritual; dance; initiation; wedding. Births celebration; oracle consultation; rain ceremonies; sacrifice; peace and happiness ceremonies; praying for soil fertility; family benediction.
	Medicinal	All diseases in particular chicken pox, malaria. Bellyache, icterus, measles. Hepatitis, pregnancy, leprosy, bewitchment, madness, epidemics, diabetes, etc.
	Magic	Reproduction; exorcism; bewitchment; magic rings; arresting of witches and rubbers; communication with dead
	Goodsharvest	Plant harvest for mystic bath
	Protection	Disease and evil spirits; against diseases spiritual or mystic; against witchcraft; against fly and attacks; manufacturing of magic potion; against accidents; security
	Climate regulation	Rain ritual and climate regulation

everywhere, except the localities of Dassa. Among *Vodun* of pantheon of South Benin, there were also some divinities of secret societies (*Oro*, *Kouvito* and *Fâ*) which are also influenced by culture and the languages, Yoruba, Nago and namely the divinity Oro mainly found in forests. The high similarity between ancestral and cemetery sacred groves is probably due to the fact that ancestral sacred groves are used as cemetery (Kokou et Sokpon, 2006).

Analysis of local perceptions showed a regression of sacred groves with time and a disappearance or rarefaction of some important and emblematic species of sacred forests. The presence of woody emblematic trees is linked to some utilitarian, ritual and sacramental needs. It is the case for *Milicia excelsa*, *Antiaris toxicaria*, *Cola cordifolia*, *Ceiba pentandra* which shelter divinities and *Triplochiton scleroxylon* which is the preferred sacred tree by the divinity *Oro*. Other tree species such as *Caesalpinia bonduc, Adansonia digitata* and *Zanthoxylum zanthoxyloides* whose leaves are used in all liturgical and purifications ceremonies are of high importance in sacred forests. Similar perceptions were also observed by local populations from other localities in Benin (Inoussa et al., 2013; Ali et al., 2014) and in other African countries especially in Burkina Faso (Kaboré, 2010; Savadogo et al., 2011), Congo (Luketa, 2000), Cote d'Ivoire (Tahous, 2002), Cameroon (Oyono, 2004), Tanzania (Ylhäisi, 2004) and Togo (Kokou et al., 1999).

Anthropogenic pressure, human population growth or the combined effect of both factors were the principal causes of sacred groves degradation in the study area.

Juhe-Beaulaton (2010) reported that sacred groves lost more than the half of their surface area from 1998 to 2007 due to high intensity of human pressures and population growth. Moreover, traditional religions extinction coupled with the modern religions expansion were also

found to be among the main causes of sacred groves degradation (Bhagwat and Rutte, 2006; Juhe-Beaulaton, 2008). Ancestral/cemetery forests and forests of god or of geniuses were the most exposed because of the expansion of modern religions, the erosion of ancestral beliefs and weakening of the power of traditional chiefs and priests of *Vodun*. Bhagwat and Rutte (2006) and Juhe-Beaulaton (2007) reported similar results. These authors reported that the increasing conversion of local people to monotheist religions and particularly to western beliefs constitute the main reason for the degradation of sacred forests. Results also showed that forests of secret societies are currently the most protected and conserved, probably because of the rules of restriction on resources exploitation imposed to local communities. In fact, the principle of conservation is based on the fear inspired by the divinities of the secret societies. The latter organizes seasonal maintenance of the forests (management of the entrance and roads, pruning, weeding, etc.).

Diversity of uses of sacred groves and importance of endogenous beliefs on their conservation

Sacred forests offered six services to local communities, cultural service being the most cited (76.90%) followed by medicinal service (37%), protection (32.54%), regulation (26.5%) and provisioning (20.76%). Nevertheless, the preferences of the services vary with ethnical groups. The sacred forests are assigned a number of prohibitions related to their uses which protect them (Juhé-Beaulaton, 2010). The variability of the sacred character of sacred forests is highly linked to the diversity of their functions, the multiplicity of their divinities and to the legend that determines their origins (Kokou and Sokpon, 2006; Garcia et al., 2006). People religion did not affect the services they sought from sacred forests. The “sacred” status of a forest then seems to be more anchored in *Vodun* beliefs and determines the maintenance and the conservation of these forests. Similar observations were made by Wadley and Colfer (2004) and Bhagwat and Rutte (2006) who reported that the “sacred” status of sites and forests in India and Indonesia is linked to animist belief and societies of hunters.

This study suggests that sacred groves can provide other advantages to local populations apart from their spiritual status. Like all forest ecosystems, sacred groves provide a range of goods and services to the local populations. Sacred groves in the study area were found to provide six services and the highest diversity of services was observed for divinities and secret societies’ groves. Services provided by sacred groves of divinities could explain their abundance throughout studied localities. According to Kokou and Sokpon (2006), 60% of sacred groves are divinity ecosystems. The salience of the cultural function confirms the traditional nomenclature of these types of forests. Indeed, this nomenclature system is highly based on the cult *Vodun* (Agossou, 2012; Juhé-Beaulaton, 2007). The therapeutic function is also ensured by all the categories of sacred forests but more intensely by forests of divinities and secret societies that supply medicinal plants and offer magico-therapeutic stays. Similar study in India showed that services of protection and medicinal plants provisioning are the most offered by sacred forests. In spite of these known services, several factors that have contributed to their isolation progressively concur to their encroachment and even degradation (Boraiah et al., 2003).

Conclusion

This study has facilitated a better understanding of the categories of sacred forests in south Benin. Forest of gods or geniuses also named forests of divinities are the most common but the least conserved. The size of the majority of the sacred forests has declined and emblematic species, very important to the existence of the sacred forests, are also prone to disappearance. The causes are mostly of human origin. However, the forests of secret societies were the most conserved because of access restrictions and prohibitions on the harvest of forest resources. The study also revealed six majors services provided by sacred forests, the two most important being cultural service and medicinal service. These services are influenced by ethnical groups, sex and age of interviewees. In spite of the acknowledged services, several factors however favor encroachment and degradation of sacred forests. Introduction of restrictions on access and use of the forests and divinities of secret societies in the forests of gods and geniuses and ancestral forests could reinforce their conservation and persistence with time.

Conflict of interest

The authors declare that they have no conflict of interest.

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