Algerian Journal of Research and Technology
ISSN : 2543-3954
A.J.R.T Volume 1 (N°2) (2016) 9 - 17

Study of the Floristic Diversity in Bissa Forest, Chlef, Algeria

F. Senouci[a]*, A. Ababou[b], M. chouieb[c], N. Amrous[b], N.H. Boukeffoussa Ghoul[b]

[a]*Department of Biology, Faculty of Natural and Life Sciences, University of Mostaganem-Abd El Hamid Ibn Badis, Algeria.*
[b]*Department of Biology, Faculty of Natural and Life Sciences, University of Chlef-Hassiba Ben Bouali, , Algeria.*
[c]*Department of Agronomy, Faculty of Natural and Life Sciences University of Mostaganem-Abd El Hamid Ibn Badis, Algeria.*

**Corresponding author. senoucifatima55@yahoo.fr*

Abstract. The exceptional biological richness of Mediterranean ecosystems was highlighted by many researchers. As part of the Mediterranean basin, northern Algeria is characterized by a high plant biodiversity, estimated to almost 3139 species.
In this context, this study focused on the floristic diversity in the Bissa forest, a cork oak forest in the Northwest of Algeria.
Throughout the seven cantons of Bissa forest, 122 plant species belonging to 43 families were identified and listed in a local floristic database. The most dominant families in terms of species percentage were the Asteraceae and Fabaceae.
The highest biodiversity was shown respectively by the cantons of Ain Lemcen, Oued Rihane and Tizerouine, while the lowest biodiversity was observed in the cantons of Yahia Bouzekri and Sidi M'hamed Aberkane.
Through the phytosociological analysis, three major vegetation units with different numbers of diagnostic species with fidelity thresholds ranging from 0.17 to 1 were distinguished.
Furthermore, many differential species with a wide ecological spectrum were observed.
Finally five species have been identified as generalists present in all cantons and adapting to all conditions of this forest.

Keywords. Biodiversity, Phytosociology, Diversity indices, Phi coefficient, Similarity, Bissa forest.

INTRODUCTION

In ecology, ecosystems are often described by their floristic composition, which form under suitable environmental conditions the vegetal associations (McIntosh, 1985).
In this context, the vegetal association is a plant community characterized by definite floristic and sociological features (Braun-Blanquet, 1932) and growing under a uniform habitat conditions (Flahault and Schroter, 1910), each plant community is recognized by a certain number of diagnostic species as defined by Westhoff and Van der Maarel (1978).

According to Curtis (1959), the term diagnostic species is an important concept in vegetation classification; it is a plant of high fidelity to a particular community, whose presence serves as a criterion of recognition of that community.

The relative constancy or abundance of these diagnostic species distinguishes one association from another (Whittaker, 1962). By their presence, abundance or potency, these species are considered to indicate certain site conditions (Gabriel and Talbot 1984).

Patterns of vegetal association are assessed using floristic readings including a list of plants registered in a relatively uniform habitat (Mueller-Dombois and Ellenberg, 1974); the floristic composition characterizing any habitat can be expressed by species richness (Fulbright, 2004), percent cover (Gimenez and Diaz, 2001) and fidelity measurements (Bruelheide, 2000; Chytrý et *al*., 2002).

North part of Algeria is characterized by a high plant diversity, estimated to almost 3139 species, among which 700 endemic species (Quezel and Santa, 1962; 1963), under a constant anthropic and climatic pressure (Molinier, 1971).

Unfortunately, apart from the great work of Quezel and Santa (1962; 1963), this floristic richness remains poorly known and requires more consideration.

The clear and precise knowledge and description of this natural richness is the key element that allows the preservation of this national wealth.

In order to contribute to the description and the preservation of the Algerian flora, the aim of this study is the creation of local floristic database with the complete inventory of the flora, the identification of the floristic pattern in Bissa, one of the healthiest cork oak forests in Northwest Algeria.

MATERIAL AND METHODS

Study area

Covering approximately 23 km^2, the Bissa Forest is an ecological sanctuary located in a mountainous region 10 km from the Mediterranean and 45 km northeast of Chlef Wilaya, daira of Zeboudja, this forest belongs to the district of Zeboudja and Beni Haoua and is part of Oued Fodda province, extending between 36°25'30"- 36°28'41" of North latitude and 1°25'34"- 1°30'00" of East longitude (Fig. 1).

The area is characterized by a very rugged relief, steep slopes and an average height of 700 meters the highest point stands over 1100 m. it is a typical Mediterranean area in terms of climate, distinguished by hot, dry summers and relatively rainy winters, with an annual dry period of 5 months and 74% of the annual precipitations are recorded during winter and autumn.

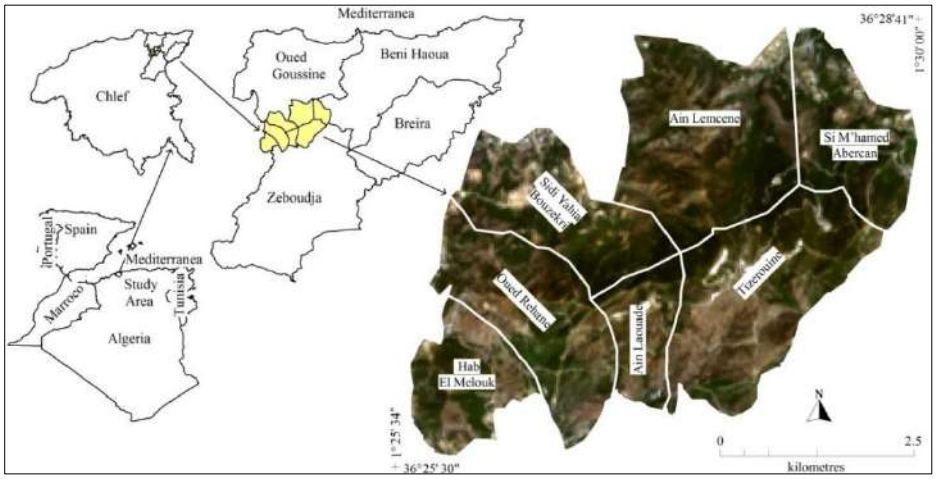

Fig 1. Location of Bissa forest.

Vegetation sampling

The floristic surveys were carried out over the spring between 2014 and 2016 all around the 7 cantons of Bissa forest (Hab Melouk, Ain Lemcen, Ain Laaouad, Oued Rihane, Tizerouine, Yahia Bouzekri and Sidi M'hamed Aberkane) and over a minimum area of 10×10m, using the presence/absence method. Species identification was done based on Quezel and Santa (1962; 1963).

Study of Biodiversity

Shannon Index (H)

To characterize the species diversity at the cantons level the Shannon (Shannon and Weaver, 1948) Index (H) was used. It's calculated as follows:

$H = -\sum_{i=1}^{s} p_i \ln p_i$ (1)

Where: p_i is the proportion (n/N) of individuals of one particular species found (n) divided by the total number of individuals found (N), ln is the natural log, Σ is the sum of the calculations, s is the number of species.

Phytosociology

- Sokal and Sneath similarity index and UPGMA algorithm

In order to classify the floristic surveys we combined the Sokal and Sneath binary index (Sokal and Sneath, 1963) to create a similarity matrix and the unweighted pair-group method with arithmetic mean (UPGMA) as agglomerative method based on the similarity matrix. The Sokal and Sneath index ranges between 0 and 1 and is defined as follows:

$S = a/(a + 2(b + c))$ (2)

Where: a is the number of species common to the two quadrats, b is the number of species unique to the first quadrat, c is the number of species unique to the second quadrat.

- The Φ coefficient of association

To extract the main vegetation's units from the floristic surveys classification, the ϕ-coefficient of association is a statistical measure of association ranging between 0 and 100%, that can be used as a measure of fidelity; it's calculated as follows (Bruelheide, 2000; Ababou et *al.*, 2009; 2010; 2015):

$$\Phi = \frac{N.n_p - n.N_p}{\sqrt{n.N_p.(N-n).(N-N_p)}} \quad (3)$$

Where: N is the total number of floristic surveys, Np is the number of floristic surveys in a particular group of sites obtained through Sokal and Sneath-UPGMA classification; n is the number of occurrences of the species in the all sites; np is the number of occurrences of the species in a particular group of sites.

RESULTS AND DISCUSSION

Biodiversity analysis

122 species distributed over 43 families were recorded throughout the 7 cantons of Bissa forest. Among the 43 families, the 8 most commonly represented were the Asteraceae, Fabaceae, Poaceae, Caryophyllaceae, Lamiaceae, Rosaceae, Geraniaceae and Rubiaceae. Indeed 54% of the total numbers of species belong to these families, while just the Asteraceae and Fabaceae alone accounted for 25% of the total number of the 122 species (Fig. 2).

According to Shannon diversity index, the highest biodiversities were registered successively in the cantons Ain Lemcen, Oued Rihane and Tizerouine, while the lowest biodiversities were observed respectively in Yehia Bouzekri and Si M'hamed Aberkane cantons (Fig. 3).

The highest Eveness (EH) values of almost 1 confirmed that all inventoried species were equally distributed throughout the 7 cantons with no dominant species (Fig. 3).

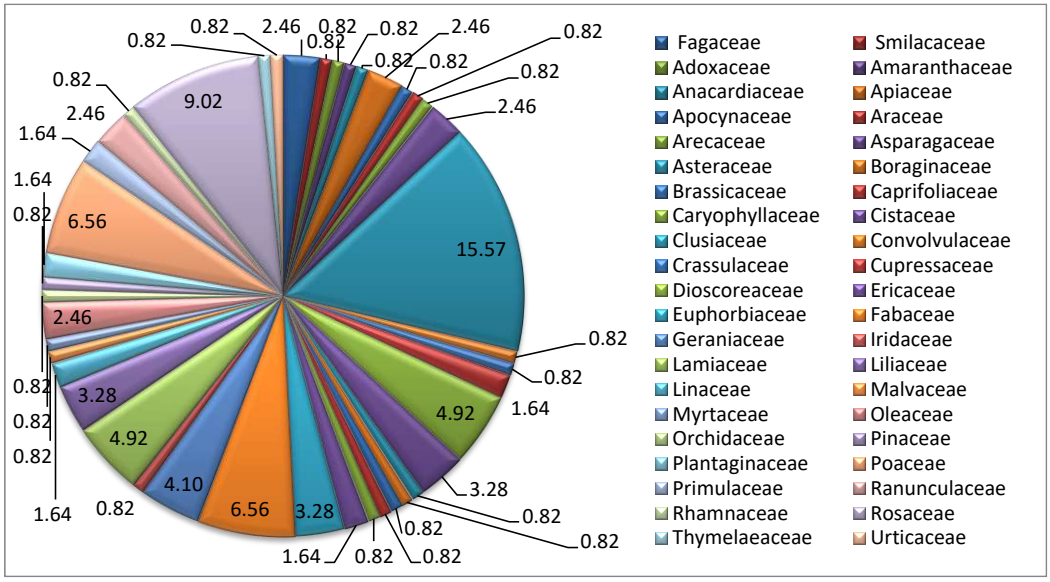

Fig 2. Percentage of families recorded in Bissa forest.

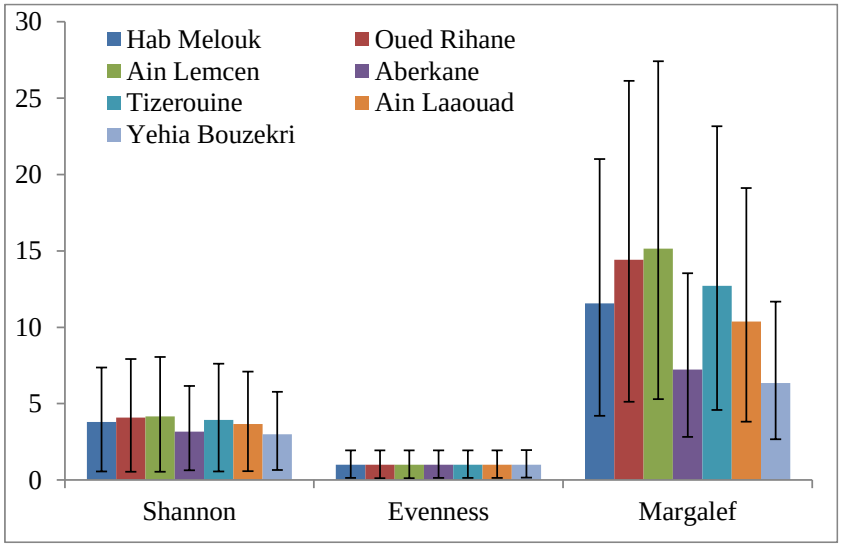

Fig 3. Biodiversity indices in the different cantons of Bissa.

In terms of specific richness (Margalef Index), the cantons of Ain Lemcen and Oued Rihane showed the highest specific richness, while the lowest specific richness was recorded in the cantons of Ain Laaouad, Si M'hamed Aberkane, and Yehia Bouzekri (Fig. 3).

T-test revealed that the differences between the floristic diversities of the 7 cantons vary between non-significant to highly significant.

The highest differences ($P < 0.001$, and $P < 0.01$) were observed between Yehia Bouzekri canton and all the remaining cantons and also between Si M'hamed Aberkane and Hab Melouk, Oued Rihane, Ain Lemcen, Tizerouine and Ain Laaouad cantons.

Whereas, the remaining combinations were not significantly different ($P > 0.05$) such as those observed between Tizerouine canton and Hab Melouk, Oued Rihane, Ain Lemcen and Ain Laaouad cantons (Table 1).

Table. 1. Shannon index and comparison between the biodiversity in the seven cantons of Bissa using the t-test.

	Test-t						
	H.Melouk	O.Rihane	A.Lemcen	M.Aberkane	Tizerouine	A.Laaouad	Y.Bouzekri
Shannon(H)	3.81	4.09	4.16	3.18	3.93	3.66	3.00
H.Melouk		2.08	2.59	3.58	0.87	0.94	4.36
O.Rihane	*		0.51	5.46	1.22	3.00	6.15
A.Lemcen	*	NS		5.90	1.73	3.49	6.56
M.Aberkane	***	***	***		4.38	2.69	0.87
Tizerouine	NS	NS	NS	***		1.80	5.13
A.Laaouad	NS	*	***	**	NS		3.51
Y.Bouzekri	***	***	***	NS	***	**	

*NS ($p > 0.05$), * ($p < 0.05$), ** ($p < 0.01$) and *** ($p < 0.001$).*

Phytosociological analysis

The analysis of Bissa forest flora showed a high variability throughout the prospected area, some cantons were very rich and highly diversified such as Ain Lemecen and Oued Rihane, whereas other cantons such as Yehia Bouzkri and M'hammed Aberkane were poor with a limited diversity, to explore the constancy of this flora and the vegetation units that is influenced by specific ecological parameters for each canton, the application of the Sokal and Sneath similarity index combined to the UPGMA algorithm resulted in 3 groups of homogeneous cantons in term of flora (Fig. 4).

In order to extract the main vegetation units related to the three groups of cantons, the ϕ-coefficient was applied.

Following the application of the φ coefficient of fidelity throughout the 3 group of cantons, 3 vegetation units were extracted, each containing a certain number of diagnostic species strictly related to a different set of cantons.

Through this coefficient, it was also possible to distinguish the existence of several differential species shared between two vegetation units. Finally, among the 122 species recorded in Bissa forest, 5 species were found to be generalist, distributed all over the study area, characterized by a wide ecological spectrum.

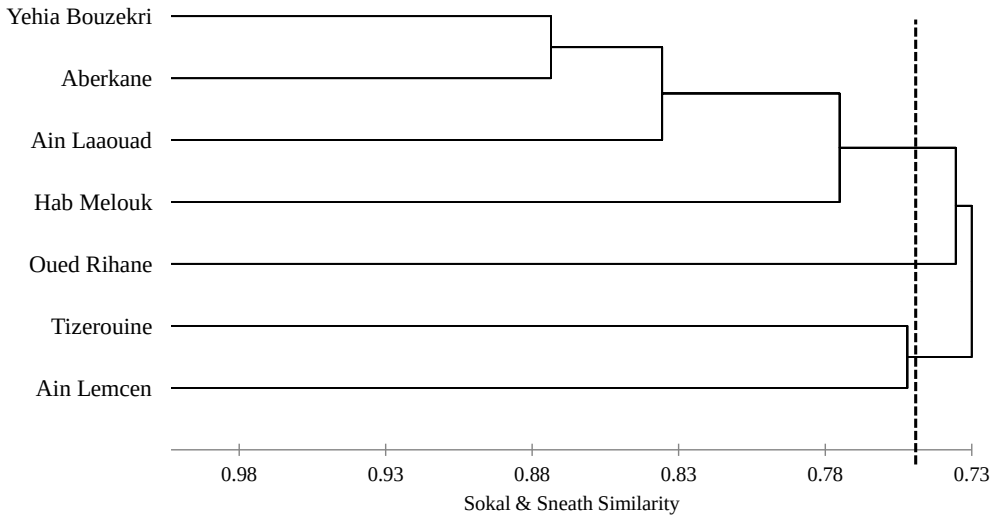

Fig 4. Dendrogram showing the classification of 7 cantons in Bissa forest based on the Sokal and Sneath Index and UPGMA.

Diagnostic species

The three vegetation units extracted through the φ coefficient of fidelity were as follows:

- Vegetation unit A: Hypericum perforatum L

This vegetation unit was found to be specific to Ain Laaouad, Yehia Bouzekri, Hab Melouk and M'hammed Aberkane cantons. This unit is composed of 25 diagnostic species with relatively low degrees of fidelity ranging from 0.17 to 0.55, the highest fidelity values in this unit were shown by *Hypericum perforatum* (0.55) and *Cistus ladaniferus* (0.47), the list of diagnostic species in this vegetation unit were as follows:

Hypericum perforatum (ϕ = 0.55)
Cistus ladanifeus (ϕ = 0.47)
Silene conica (ϕ = 0.42)
Anagallis monelli (ϕ = 0.35)
Asparagus stipularis (ϕ = 0.35)
Avena bromoides (ϕ = 0.35)
Bromus madritensis (ϕ = 0.35)
Centaurea pullata (ϕ = 0.35)
Chenopodium murale (ϕ = 0.35)
Cistus salviifolius (ϕ = 0.35)
Convolvulus althaeoides (ϕ = 0.35)
Daphne gnidium (ϕ = 0.35)
Filago minima (ϕ = 0.35)
Filago exigua (ϕ = 0.35)
Galactites sp (ϕ = 0.35)
Linum tenue (ϕ = 0.35)
Muscari comosum (ϕ = 0.35)
Picris cupuligera (ϕ = 0.35)
Pinus halepensis (ϕ = 0.35)
Plantago amplexicaulis (ϕ = 0.35)
Sanguisorba officinalis (ϕ = 0.35)
Satureja calamintha (ϕ = 0.35)
Silene pseudovestita (ϕ = 0.35)
Trifolium angustifolium (ϕ = 0.35)
Biscutella didyma (ϕ = 0.17)

The relative weakness of the coefficient φ for most species of this unit indicates that these species also show some non-significant fidelity to other vegetation units.

- Vegetation Unit B: Crataegus monogyna Jacq

This vegetation unit was specific to the cantons of Ain Lemcen and Tizerouine. It is the richest of the three vegetation units with 38 diagnostic species, most of them showing a high degree of fidelity ranging from 0.30 to 1.00, the highest fidelity value (φ = 1.00) within this unit was shown by *Crataegus monogyna*, *Cruciata glabra*, *Mentha Pulegium* and *Arenaria sepyllifolia* meaning that these 4 species were strictly limited to the cantons of Ain Lemcen and Tizerouine, this unit included the following species:

Crataegus monogyna (ϕ = 1.00)
Cruciata glabra (ϕ = 1.00)
Mentha pulegium (ϕ = 1.00)
Arenaria sepyllifolia (ϕ = 1.00)
Bellis annua (ϕ = 0.73)
Genista tricuspidata (ϕ = 0.73)
Leucanthemum vulgare (ϕ = 0.73)
Rosa canina (ϕ = 0.73)
Sherardia arvensis (ϕ = 0.73)
Tamus communis (ϕ = 0.73)
Bellis sylvestris (ϕ = 0.65)
Erodium moschatum (ϕ = 0.65)
Leucanthemum paludosum (ϕ = 0.65)
Quercus canariensis (ϕ = 0.65)
Rhamnus alaternus (ϕ = 0.65)
Senecio vulgaris (ϕ = 0.65)
Spergularia marginata (ϕ = 0.65)
Urtica pilulifera (ϕ = 0.65)
Viburnum tinus (ϕ = 0.65)
Urginea maritima (ϕ = 0.40)
Asparagus acutifolius (ϕ = 0.30)
Briza maxima (ϕ = 0.30)
Crataegus laevigata (ϕ = 0.30)
Pardoglossum cheirifolium (ϕ = 0.30)

Euphorbia segetalis (ϕ = 0.65)
Euphorbia cyparissias (ϕ = 0.65)
Galactites duriaei (ϕ = 0.65)
Galium mollugo (ϕ = 0.65)
Lavatera arborea (ϕ = 0.65)
Lavandula dentata (ϕ = 0.65)
Bellis major (ϕ = 0.65)
Hordeum murinum (ϕ = 0.30)
Iris planifolia (ϕ = 0.30)
Nerium oleander (ϕ = 0.30)
Reichardia tingitana (ϕ = 0.30)
Rubus fruticosus (ϕ = 0.30)
Valerianella discoidea (ϕ = 0.30)
Mercurialis ambigua (ϕ = 0.30)

The high fidelity values (φ > 0.5) showed by the majority of the species indicated that the diagnostic species of this unit were rarely observed outside the cantons of Ain Lemcen and Tizerouine.

- Vegetation unit C : Myrtus communis L

This vegetation unit was composed of 30 diagnostic species, it showed also the largest number of most faithful diagnostic species, indeed among the 30 diagnostic species, 13 species showed a maximal φ coefficient (φ = 1.00) indicating that these species were strictly limited to this vegetation unit and therefore strictly related to the canton of Oued Rihane, whereas the low φ values (0.26 and 0.47) of the remaining species indicated that these species were non significantly shared by other vegetation units. The list of diagnostic species of this unit with their fidelity values was as follows:

Myrtus communis (ϕ = 1.00)
Anemone palmata (ϕ = 1.00)
Anthemis maritima (ϕ = 1.00)
Chamaerops humilis (ϕ = 1.00)
Euphorbia peplus (ϕ = 1.00)
Herniaria hirsuta (ϕ = 1.00)
Lamium amplexicaule (ϕ = 1.00)
Linum strictum (ϕ = 1.00)
Medicago rigidula (ϕ = 1.00)
Ornithogalum algeriense (ϕ = 1.00)
Ruscus aculeatus (ϕ = 1.00)
Sedum acre (ϕ = 1.00)
Stellaria media (ϕ = 1.00)
Trifolium campestre (ϕ = 0.65)
Anacyclus radiatus (ϕ = 0.47)
Astragalus lusitanicus (ϕ = 0.47)
Phillyrea angustifolia (ϕ = 0.47)
Arisarum vulgare (ϕ = 0.47)
Lonicera implexa (ϕ = 0.47)
Lotus edulis (ϕ = 0.47)
Phagnalon saxatile (ϕ = 0.47)
Poa bulbosa (ϕ = 0.47)
Rubia tinctorum (ϕ = 0.47)
Rubus ulmifolius (ϕ = 0.47)
Calicotome intermedia (ϕ = 0.35)
Daucus carota (ϕ = 0.35)
Lavandula stoechas (ϕ = 0.35)
Pistacia lentiscus (ϕ = 0.35)
Asphodelus microcarpus (ϕ = 0.26)
Olea europaea (ϕ = 0.26)

Differential and generalist Species

Among the remaining species, 24 species were identified as differentials (shared by two vegetation units) and 5 generalist species (distributed all around Bissa forest) (Table 2).

Finally, among very few studies carried out in Chlef region, our study is similar to that carried out in the Beni-Haoua forest (Ababou et *al*., 2015), which improved understanding species distributions and occurrence in a southern Mediterranean forest.

Table. 2. Synoptic table of differential and generalist species in Bissa forest.

Vegetation Unit	Unit A	Unit B	Unit C
Differential Species	φ Coefficient		
Cistus salviifolius	**0.42**	-	**0.35**
Clematis cirrhosa	-	**0.30**	**0.65**
Eryngium tricuspidatum	-	**0.30**	**0.65**
Eryngium campestre	-	**0.30**	**0.65**
Galactites tomentosa	-	**0.30**	**0.65**
Ophrys tenthredinifera	-	**0.30**	**0.65**
Rubia peregrina	-	**0.30**	**0.65**
Crepis vesicaria	-	**0.73**	**0.47**
Geranium purpureum	-	**0.73**	**0.47**
Geranium rotundifolium	-	**0.73**	**0.47**
Hypochaeris laevigata	-	**0.55**	**0.35**
Juniperus oxycedrus	-	**0.55**	**0.35**
Plantago lagopus	-	**0.55**	**0.35**
Ranunculus paludosus	-	**0.55**	**0.35**
Smilax aspera	-	**0.55**	**0.35**
Ampelodesmos mauritanicus	-	**0.40**	**0.26**
Anagallis arvensis	-	**0.40**	**0.26**
Bromus rubens	-	**0.40**	**0.26**
Erodium moschatum	-	**0.40**	**0.26**
Geranium malviflorum	-	**0.40**	**0.26**
Phillyrea latifolia	-	**0.40**	**0.26**
Cytisus villosus	-	**0.26**	**0.17**
Nepeta multibracteata	-	**0.26**	**0.17**
Schismus barbatus	-	**0.26**	**0.17**
Generalist species			
Arbutus unedo	-	-	-
Cistus monspeliensis	-	-	-
Erica arborea	-	-	-
Quercus ilex	-	-	-
Quercus suber	-	-	-

CONCLUSION

Through the seven cantons of Bissa, 122 species belonging to 43 families were listed in our floristic database. The Asteraceae and Fabaceae were the most important families in terms of species percentage.

The highest biodiversity was shown by Ain Lemcen, Oued Rihane and Tizerouine cantons, while the lowest biodiversities were observed in the cantons Yahia Bouzekri and Sidi M'hamed Aberkane.

The phytosociological analysis distinguished 3 major vegetation units with different numbers of diagnostic species according to the φ coefficient ranging from 0.17 to 1. Furthermore, many differential species with a lager ecological spectrum were observed. Finally five species have been identified as generalists present in all cantons and adapting to all conditions of Bissa forest.

REFERENCES

Ababou A., Chouieb M., Khader M., Mederbal K., Saïdi D., Bentayeb Z., 2009. B. Soc. Bot. Mex. 85, 59-69.

Ababou A., Chouieb M., Khader M., Mederbal K., Saïdi D., 2010. Turk. J. Bot. 34, 1-10. Ababou A., Chouieb M., Bouthiba A., Said, D., Mederbal, K., 2015. Ecologia mediterranea. 41 (2).

Braun-Blanquet J., 1932. Ed. McGraw-Hill, 476.

Bruelheide H., 2000. Journal of Vegetation Science. 11, 167-178.

Chytry M., Tichy L., Holt J, Botta-Dukat Z., 2002. Journal of Vegetation Science. 13,79-90.

Curtis J.T., 1959. University of Wisconsin Press, Madison, Wisconsin.

Fernandez-Gimenez M, Allen-Diaz B., 2001. Plant Ecology. 157,101-118.

Flahault C., Schroter C., 1910. Proceedings of the 3rd International Botanical Congress, Brussels. 1,131-164.

Fulbright T.E., 2004. Journal of Arid Environments. 58, 119-133.

Gabriel H.W., Talbot S.S., 1984. Bureau of Land Management, Washington, D.C.

McIntosh R. P., 1985. Cambridge, Cambridge University Press, 400.

Molinier R., Vignes P., 1971. Ed. Delachaux and Niestle. Paris, France.

Mueller-Dombois D., Ellenberg H., 1974. New York: John Wiley.

Quezel P., Santa S., 1962. . ed. CNRS, Paris.1.

Quezel P., Santa S., 1963. . ed. CNRS, Paris. 2.

Shannon C. E., 1948. The Bell System Technical Journal. 27, 379–423, 623–656.

Sokal R.R., Sneath P.H.A., 1963. Freeman, San Francisco, 359 .

Westhoff V., van der Maarel E., 1973. In: Whittaker, R.H. (ed.) Handbook of vegetation science, part 5, Classification and ordination of communities, pp. 617-726. Junk, The Hague. Whittaker R.H., 1962. The Botanical Review. 28,1-239.