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Floristic Diversity Analysis of Ait Baâmrane Region–Sidi Ifni Province, in South-Central Morocco and The Ecological Factors That Control and Influence Its Geographic Distribution

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Abstract

Aim of study: Aim was to characterize and analyses the vascular flora along coastal transect to continental of the Ait Baamrane region.

Area of study: The territory of Ait Baâmrane is located in the South-central Morocco. Its location, in the nearness of the Atlantic Ocean, the Canary Islands, and the pre-Sahara, makes it a well-defined geographical entity where a large natural area is distinguished.

Material and methods: The flora was characterized by the specific richness, the endemism and the conservation status. Further, plant diversity was evaluated by Shannon diversity, Evenness, disturbance and Jaccard similarity indices, as well as the plant functional groups were identified in three geographic zones; the littoral zone (A), the plateau's zone (B), and the continental zone (C).

Main results: The studied area highlighted an important floristic richness with 281 vascular species and subspecies. Therophytes are the most represented (43.42%). The endemic flora represented 21.35% of all inventoried species. Concerning the rate of threatened species, 7% of the inventoried flora were considered as threatened, and 11% are near threatened. The diversity parameters vary according to the continentality.

Highlights: The studied region is quite diverse by its flora and endemic species. This diversity is linked to the global location of the region and particular ecological conditions.

Keywords: South-Center of Morocco, Ait Baâmrane Region, Vascular Flora, Plant Diversity, Macaronesian Flora.

Güney-Orta Fas'taki Ait Baâmrane Bölgesi–Sidi Ifni Eyaletinin Floristik Çeşitlilik Analizi ve Coğrafi Dağılımını Kontrol Eden ve Etkileyen Ekolojik Faktörler

Öz

Çalışmanın amacı: Bu çalışmada Ait Baamrane bölgesinin vasküler florasını kıyıdan kıtaya doğru karakterize etmek ve analiz etmek amaçlanmıştır.

Çalışma alanı: Ait Baâmrane bölgesi Güney-orta Fas'ta yer almaktadır. Atlantik Okyanusu, Kanarya Adaları ve Sahra-öncesi'nin yakınında bulunan konumu, onu geniş bir doğal alanın ayırt edildiği, iyi tanımlanmış bir coğrafi varlık haline getirir.

Materyal ve yöntem: Flora, kendine özgü zenginlik, endemizm ve koruma durumu ile karakterize edildi. Ayrıca bitki çeşitliliği Shannon çeşitliliği, Evenness, Disturbance ve Jaccard benzerlik indeksleri ile değerlendirilmiş ve ayrıca bitki fonksiyonel grubu üç coğrafi bölgede tanımlanmıştır; kıyı bölgesi (A), plato bölgesi (B) ve kıta bölgesi (C).

Temel sonuçlar: İncelenen alan 281 damarlı tür ve alt tür ile önemli bir floristik zenginliği ön plana çıkarmıştır. Terofitler en çok temsil edilenlerdir (%43.42). Endemik flora, envanteri yapılan tüm türlerin %21.35'ini temsil etmiştir. Tehdit altındaki türlerin oranı ile ilgili olarak, envanteri yapılan floranın %7'si tehdit altında, %11'i ise Tehdit altına girebilir kategorisindedir. Çeşitlilik parametreleri kıtasallık durumuna göre değişir.

Araştırma vurguları: İncelenen bölge florası ve endemik türleri açısından oldukça çeşitlidir. Bu çeşitlilik, bölgenin küresel konumu ve geçmişte ve şimdiki belirli ekolojik koşulları ile bağlantılıdır.

Anahtar Kelimeler: Fas'ın Güney Merkezi, Ait Baâmrane Bölgesi, Vasküler Flora, Bitki Çeşitliliği, Macaronesian Flora.

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Introduction

The Mediterranean region is recognized as a global phyto-biodiversity "hotspot" area because of the numerous physical and ecological originalities, which give its eco-diversity a global patrimonial value (Radford et al., 2011). Morocco is one of the richest countries in the Mediterranean basin in terms of phyto-biodiversity (Rankou et al., 2015). This specific richness and the high rate of endemism are essentially determined by the ecological conditions, which are the most varied of the countries of the western Mediterranean region. This variety depends on its location bordered by two seas, the Atlantic and the Mediterranean, and the desert, as well as its altitude varying between 0 and 4167 m (Toubkal summit) and the existence of important local factors such as the cold streams of the Canary Islands (Quézel, 1983; Médail & Myers, 2004). These natural potentialities allow the settlement of 3913 vascular species, 872 additional subspecies and 426 vascular type subspecies, distributed among 981 genera and 155 families (Fennane & Ibn Tattou, 2012). The Moroccan flora is characterized by a high percentage of endemic species (22%), comprising 879 endemic species, in comparison with neighboring countries such as Spain and Algeria with 19.1 % and 10.1, respectively (Rankou et al., 2013). At the level of additional subspecies, out of the 872 presents, 280 (32%) are exclusively Moroccan (Fennane & Ibn Tattou, 2012).

The Western Anti-Atlas, because of its latitude, is located at the hinge of the Mediterranean region to the north and the Sahara to the south, the result is a very original area, both on the bioclimatic and biogeographic sens (Msanda et al., 2002). Thus, Géhu & Biondi (1998) and Tayi (2011) declared that the southwestern coast of Morocco presents a considerable interest given its particular phytocoentic biogeography, and to its location between the Atlantic Ocean and the pre-Sahara area.

The climatic conditions in this area are very similar to those in the tropics due to the high humidity, mostly during the summer period, and the vicinity to the Sahara (Marzol et al, 2010). These climatic characteristics link this region of Morocco to the Macaronesian ecoregion affected by the Canary sea streams, including the Canary Islands and the islands of Madeira and Capo Verde, and Azores. As a result of the presence of a large number of specific species, the flora has a strong originality, e.g. *Bassia tomentosa* (Lowe) Maire & Weiller, *Cakile maritima* Scop. subsp. *maritima*, *Euphorbia balsamifera* Aiton, *Euphorbia paralias* L., *Salsola frankenioides* (Caball.) Botsch., *Suaeda ifniensis* Caball. ex Maire and *Traganum moquinii* Webb ex Moq, some of which are endemic to the Macaronesian region (Peltier, 1982; Médail & Quézel, 1997; 1999; Géhu & Biondi, 1998; Alifriqui, 2004).

The current study consists of a quantitative and qualitative analysis of the vascular flora of the Ait Baâmrane region using certain key parameters: species richness, Shannon diversity, evenness, disturbance and Jaccard similarity indices, life-forms, the rate of the endemism and the conservation status. The results of the current work would contribute to understanding of the flora and vegetation of the studied site and the ecological factors that control and influence their geographic distribution. Therefore, this research will be useful for both conservation and rehabilitation attempts.

Material and Methods

Study Area

The territory of Ait Baâmrane (29°09' N, 10°12' W) is located in the north-west of the Guelmim-Oued Noun region; it covers 1310 km². It is limited to the north by the urban commune of Sidi Ifni, to the south by the province of Guelmim, to the east by the rural communes of Imi N'fast and Amellou, and to the west by the Naala plateau (Figure 1). Its location, in the nearness of the Atlantic Ocean, the Canary Islands, and the pre-Sahara, makes it a well-defined geographical entity where a large natural area is distinguished, corresponding to the western chain of the Anti-Atlas mountains composed of the granite massif of Sidi Ifni (Tayi, 2011).

The three sampling zones in the study are listed below (Figures 1 and 2):

Zone A: The coastal zone (dunes and seaside cliffs) is characterized by a flat relief, in relation to a geomorphological dynamic linked to the proximity of the Atlantic Ocean.

The substrate in this area is sandy. The vegetation is a steppe dominated by a few representatives of the Amaranthaceae family (*Atriplex* genus) and Euphorbiacae (such as *Euphorbia balsamifera* Aiton), very adapted to salty coastal soils.

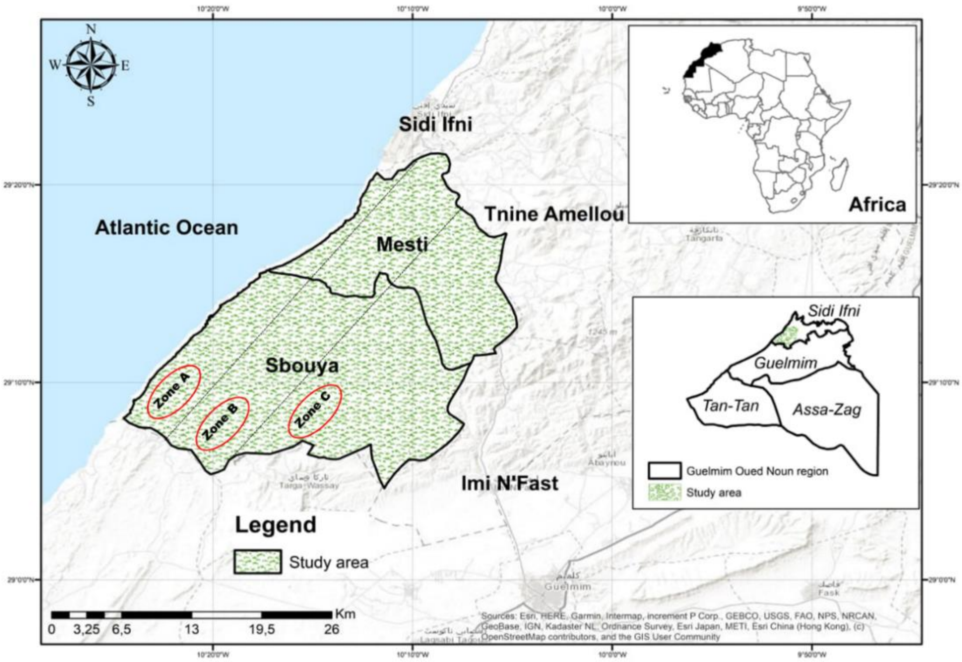

Figure 1. Geographic location of the studied area (Ait Baâmrane) and sampled units (A, B and C). [Zone A: dunes and seaside cliffs, Zone B: coastal plains, hills and plateau, Zone C: mountains inside Argan forest]. Map constructed with ArcGIS.

Figure 2. Pictures of the sampled areas. [Zone A: dunes and seaside cliffs, Zone B: hills and plateau, Zone C: mountains inside Argan forest.]

The rest are mostly annual species. The altitude is between 0 and 100m.

Zone B: the plateaus and hills constitute the second unit. It has a levelled surface and a low to medium slope. The oceanic influences allow an abundance of humidity on the coastal zone where fogs are very frequent. The substrate of this area is predominantly clayey. The climax vegetation has been greatly altered by intense plantations of prickly pear (*Opuntia ficus-indica* (L.) Mill.), which is an introduced species. In contrast, we are currently witnessing a plant dynamic and a return of natural vegetation, specially, numerous regenerations of the argan tree and other woody plants. The dominant physiognomy of the current stands is a woody steppe with Argan trees and a bushy stratum with *Lycium* and *Euphorbia* spp. The altitude is between 100 and 400m.

Zone C: the continental mountainous area, constitutes the third zone. The land is rugged, with great relief protecting the area from Saharan influences. The substrate of this area is predominantly clayey. The vegetation is made up of a shrubland forest with climax argan trees, mainly in company of euphorbia (*Euphorbia officinarum* subsp. *echinus* (Hook. f. & Coss.) Vindt and *Euphorbia regis-jubae* (J. Gay) and various bushes. The altitude is between 400 and 900m.

In view of its pedological characteristics, the Aït Baâmrane area is dominated by poorly evolved soils, followed by calcimagnesic soils. The fersialitic and iso-humic soils are less represented in the zone. However, this distribution of soil classes should be regarded as a rough estimate in the absence of more detailed soil studies. (Tayi, 2011).

The climate in general is Mediterranean, with a strong Saharan and Atlantic effects, with dry hot summers and wet cool winters. The region receives an average of 203 mm of rain per year. Average annual temperature is about 18.1 °C with a minimum of 14.4 °C in January and a maximum of 22.8 °C in August (Figure 3) (URL-1). According to the Bagnouls and Gaussen (1953) diagram, the drought period extends over the entire year (Figure 3).

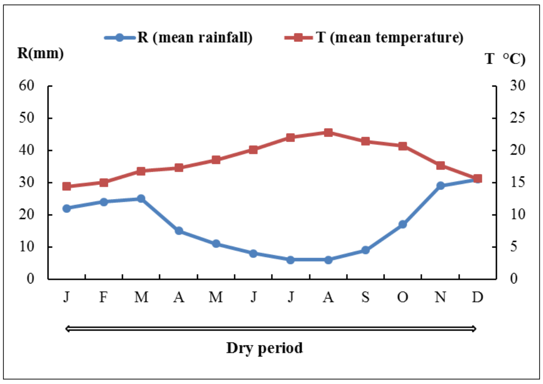

Figure 3. Diagram of Gaussen and Bagnouls applied for Sidi Ifni region.

In addition, the continentality index (M-m) were M, mean maximum temperature of the warmest month (°C); and m, mean minimum temperature of the coldest month (°C) (Debrach, 1953) is equal to 15.8°C, so the thermal climate is Coastal (15 > M-m < 25°C) (Table 1).

Table 1. Climatic characteristics of Sidi Ifni region.

	January	February	March	April	May	June	July	August	September	October	November	December
Relative humidity (%)	65	65	63	70	73	76	71	72	77	72	68	65
Average annual temperature (°C)	14.4	15	16.8	17.3	18.5	20.1	22	22.8	21.4	20.7	17.7	15.6
Average temperature of the coldest month (m) (°C)	10.7	11.5	13.2	14.3	15.7	17.3	18.9	19.8	18.7	17.6	14.4	12
Average temperature of the warmest month (M) (°C)	18.4	18.9	20.8	20.7	21.8	23.4	25.7	26.5	24.8	24.3	21.4	19.6
Continentality index (M-m): 15.8 (°C)												

The region is characterized by significant summer cloudiness accompanied by relative coolness and very high relative humidity which frequently exceeds 60% throughout the year, with a minimum of 63% in March and a maximum of 77% in September (Table 1) (URL-1).

This makes it very similar to the Macaronesian zone, which includes the Atlantic islands (Canary, Madeira, Azores, Capo Verde Islands, etc.) and part of the Moroccan coast, between Essaouira in the north and Tarfaya in the south (Peltier, 1982; Médail & Quézel, 1999; Alifriqui, 2004).

Flora Sampling and Plants Identification

Field studies allowed the selection of sampling points and collecting the flora. They were carried out over a period of three successive years (2016, 2017 and 2018), during the blooming and fruiting period of vegetation. Plant samples were collected following the geographic zoning mentioned above (Figures 1 and 2). The collection method differs according to the life-forms of the collected plant species. The samples are labeled and placed in the press to identify them in the herbarium 'MARK' of Cadi Ayyad University where they were conserved

(Thiers, 2020). A total of 90 floristic surveys were carried out in the sampling zones (Figure 2); The releve was taken when the structure and physiognomy of vegetation or its habitat changed, over an area equivalent to the minimum area in the sense of Guinochet (1973), ranging from 100 to 400 m² depending on the structure of the vegetation and its environment.

The identification of collected plants was done following Fennane et al. (1999;2007;2014), and Dobignard (2002, 2009). In addition, the 'MARK' herbarium collection was used as a base to compare and verify the accuracy of the identity of the collected specimen. The nomenclature of taxa follows the Fennane et al. (1999;2007;2014), and the African Plant Database (URL-2), an international source, is used as the taxonomic backbone. Names of the families of Angiosperms follow APG III (Chase & Reveal, 2009; Haston et al., 2009).

The determination of the status of endemic taxa was made on the basis of the Fennane & Tattou (1998). This catalogue adopts five categories of endemism: E: Endemic to Morocco; I: Endemic to Morocco and the Iberian Peninsula; A: Endemic to Morocco and Algeria; M: Endemic to Morocco and the Mauritania; C: Endemic of Morocco and the Canary Islands. Combinations are naturally possible; IA: Endemic to Morocco, the Iberian Peninsula and Algeria; IC: Endemic to Morocco, the Iberian Peninsula and the Canary Islands; IM: Endemic to Morocco, the Iberian Peninsula and the Mauritania; IAC: Endemic to Morocco, the Iberian Peninsula and Algeria and the Canary Islands.

The assessment of the red list of the studied flora was made from Fennane (2016, 2017a, 2017b, 2017c, 2018a, 2018b, 2018c, 2018d, 2018e, 2018f) and the IUCN Redlist categories (IUCN, 2012).

Data Analysis

Species richness (S) corresponds to the number of species present in a given sample (Magurran, 2004).

Shannon diversity index (*H')* is commonly used to measure species diversity (Eq. 1). H' = 0, when the sample contains only one species; $H' \approx 0$, when a dominant species exists; H' increases as the number of species increases. For a given number of species, H' is maximum (H'max) when all species' abundances are exactly even in the sample. This index always varies from 0 to Log_2 S (Faurie et al., 2003).

$$H' = -\sum_{i=1}^{S}\left[\left(\frac{ni}{N}\right) \times Log_2\left(\frac{ni}{N}\right)\right] \quad (1)$$

Where: ni/N is the relative abundance, ni is the number of individuals of species, N is the total number of individuals of all species, and S is the total number of species (species richness).

The evenness index (E) is the most widely used index to compare the structure of different stands (Eq. 2). It is the ratio of Shannon index (*H*') and the maximum diversity value that is assessed for S species with equal population distribution. Evenness varies between 0 and 1 (Faurie et al., 2003).

$$E = H' / S \quad (2)$$

When individuals are equally distributed between species (even population densities), E value tends to 1, and it is minimal (tends towards 0) when a single species dominates the entire stand and there are several rare species.

Jaccard similarity index (CJ) was used to compare vegetation species richness between the two climate regions.

The following formula was used to calculate it (Eq. 3):

$$CJ \text{ (survey x and y)} = c / (a + b - c) \quad (3)$$

Where a and b: the total number of species present in survey x and y, respectively; c: the number of species found in both surveys x and y (Magurran, 2004).

Life-forms: Plant life-forms are related to the phenological state of the species encountered. The Raunkiaer's classification (revised by Ellenberg & Mueller-Dombois, 1967) is based on the position of the vegetative buds in relation to the soil surface during the unfavorable season. The main life-forms are phanerophytes (trees), nanophanerophytes (small trees), chamaephytes (shrubs), hemicryptophytes (perennial herbaceous plants), geophytes (perennial herbaceous plants with bulbs or rhizomes) and therophytes (annual plants).

Disturbance index: According to Barbero et al. (1990), therophytization is an ultimate stage of vegetation degradation. The importance of this index is proportional to the dominance of therophytes (Bradai et al., 2015). The disturbance index (Id), established by Loisel and Gamila (1993), was calculated in order to measure the level of therophytization of each rangeland within a climatic region (Eq. 4):

Id [%] = (Number of therophytes + Number of chamaephytes)/Species richness. (4)

Results

Diversity Parameters

According to the floristic analysis of the study area, the specific richness is estimated at 281 vascular species and subspecies, grouped into 187 genera belonging to 48 botanical families (Table 2). The zone C had 47 families, followed by the Zone B with 46 families, while zone A has only 43 families (Table 2). The four most widely represented families constitute 40.57% of the total flora; Asteraceae with 51 species represents 18.15% of the inventoried flora and 36 genera (19.25%); followed by the Fabaceae with 26 species and 14 genera, the Poaceae with 19 species and 18 genera, and the Lamiaceae is in the fourth rank with 18 species and 11 genera, containing respectively 9.25%, 6.76% and 6.41% of all species and 7.49%, 9.63% and 5.88% of genera (Table 2). This was also seen through the Zone A, Zone B and Zone C, where Asteraceae had the highest frequency with 9.61%, 12.46% and 14.95% of total species and 12.30%, 13.90% and 17.11% of genera, respectively (Figure 4).

Table 2. Checklist of inventoried flora in Ait Baâmrane region

Voucher numbers	Taxa (accepted names according to APD)	Families (APG III)	Zones	Life forms	Endemism	Conservation status
10801	*Acacia gummifera* Willd.	Fabaceae	A, B and C	Ph	E	LC
10889	*Acanthorrhinum ramosissimum* (Coss. & Durieu) Rothm.	Plantaginaceae	A, B and C	Ch (NPh)		LC
10664	*Achyrophorus laevigatus* (L.) Talavera & M. Talavera	Asteraceae	A	H		LC
10661	*Achyrophorus valdesii* J M. Jiménez, M. Ángeles & al.	Asteraceae	C	T		LC
10882	*Adonis microcarpa* DC.	Ranunculaceae	C	T		LC
10738	*Aeonium arboreum* (L.) webb & Berthel.	Crassulaceae	A	H	E	NA
10611	*Aizoanthemopsis hispanica* (L.) Klak	Aizoaceae	A, B and C	T		LC
10610	*Aizoon canariense* L.	Aizoaceae	A, B and C	T		LC
10772	*Ajuga iva* (L.) Schreb.	Lamiaceae	B and C	H(T)		LC
10613	*Amaranthus albus* L.	Amaranthaceae	B and C	T		
10914	*Anarrhinum fruticosum* Desf.	Plantaginaceae	A, B and C	Ch	A	LC
10911	*Andryala mogadorensis* subsp. *jahandiezii* (Maire) M.Z. Ferreira, Álv. Fern. & M.Seq.	Asteraceae	A	T	A	
10852	*Anisantha madritensis* (L.) Nevski	Poaceae	A, B and C	T		LC
10617	*Apteranthes europaea* (Guss.) Murb.	Apocynaceae	A and B	Ch		NT
10888	*Argania spinosa* (L.) Skeels	Sapotaceae	B and C	Ph	A	NT
10616	*Arisarum vulgare* O.Targ.Tozz.	Araceae	A, B and C	G		LC
10908	*Aristida adscensionis* L.	Poaceae	C	T		LC
10637	*Artemisia herba-alba* Asso	Asteraceae	A, B and C	Ch		DD
10638	*Artemisia reptans* Buch	Asteraceae	A and B	Ch	C	NT
10716	*Arthrocaulon macrostachyum* (Moric.) Piirainen & G. Kadereit	Amaranthaceae	A	NPh		LC
10621	*Asparagus acutifolius* L.	Asparagaceae	A, B and C	NPh		LC
10624	*Asparagus albus* L.	Asparagaceae	A, B and C	NPh		LC
10626	*Asparagus horridus* L.	Asparagaceae	B	NPh		LC
10625	*Asparagus pastorianus* Webb & Berthel.	Asparagaceae	A and B	NPh	C	NT
10632	*Asphodelus macrocarpus* Parl.	Xanthorrhoeaceae	A, B and C	G		LC
10634	*Asphodelus ramosus* L.	Xanthorrhoeaceae	B and C	G		LC
10633	*Asphodelus tenuifolius* Cav	Xanthorrhoeaceae	A, B and C	T		LC
10639	*Asteriscus graveolens* (Forssk.) Less.	Asteraceae	A, B and C	Ch		LC
10641	*Asteriscus schultzii* (Bolle) Pit. & Proust	Asteraceae	A	Ch	C	NT
10803	*Astragalus hamosus* L.	Fabaceae	A, B and C	Ph		LC
10804	*Astragalus pelecinus* (L.) Barneby	Fabaceae	A, B and C	T		LC

Table 2. (Continued)

Voucher numbers	Taxa (accepted names according to APD)	Families (APG III)	Zones	Life forms	Endemism	Conservation status
10800	*Astragalus solandri* Lowe	Fabaceae	B and C	T		NT
10904	*Astydamia latifolia* (L. f.) Kuntze	Apiaceae	A	H	C	NT
10642	*Atractylis cancellata* L.	Asteraceae	C	T		LC
10709	*Atriplex colerei* Maire	Amaranthaceae	A	Ch	E	EN
10718	*Atriplex dimorphostegia* Kar. & Kir.	Amaranthaceae	C	T		LC
10721	*Atriplex glauca* subsp. *ifniensis* (Caball.) Rivas Mart. et al.	Amaranthaceae	A and B	Ch		
10719	*Atriplex halimus* L.	Amaranthaceae	B	NPh		LC
10723	*Atriplex semibaccata* R. Br.	Amaranthaceae	C	NPh		LC
10853	*Avena sativa* L. subsp. *sativa*	Poaceae	A, B and C	T		LC
10774	*Ballota hirsuta* Benth.	Lamiaceae	B and C	Ch		LC
10722	*Bassia muricata* (L.) Asch.	Amaranthaceae	A and B	T		
10724	*Bassia tomentosa* (Lowe) Maire & Weiller	Amaranthaceae	A	Ch	C	LC
10742	*Biscutella didyma* L.	Brassicaceae	B and C	T		LC
10854	*Brachypodium atlanticum* Dobignard	Poaceae	B	H		VU
10905	*Bupleurum dumosum* Coss. & Balansa	Apiaceae	A, B and C	Ch	E	DD
10903	*Cakile maritima* Scop. subsp. *maritima*	Brassicaceae	A	T		LC
10643	*Calendula arvensis* (Vaill.) L.	Asteraceae	B and C	T		LC
10645	*Calendula maroccana* (Ball) B. D. Jacks.	Asteraceae	C	H	E	LC
10646	*Calendula suffruticosa* Vahl	Asteraceae	A, B and C	Ch	E	DD
10728	*Caroxylon vermiculatum (*L.) Akhani & Roalson	Amaranthaceae	A and B	Ch		LC
10743	*Carrichtera annua* (L.) DC.	Brassicaceae	A, B and C	T		LC
10648	*Carthamus pinnatus* Desf.	Asteraceae	C	H		LC
10650	*Catananche arenaria* Coss. & Durieu	Asteraceae	B and C	T		LC
10891	*Catapodium rigidum* (L.) C.E. Hubb.	Poaceae	B and C	T		LC
10879	*Caylusea hexagyna* (Forssk.) M. L. Green	Resedaceae	B and C	H		LC
10855	*Cenchrus americanus* subsp. *monodii* (Maire) Sosef	Poaceae	C	T		NA
10651	*Centaurea aspera* subsp. *gentilii* (Braun-Blanq. & Maire) Dobignard	Asteraceae	B and C	H		VU
10652	*Centaurea maroccana* Ball	Asteraceae	B and C	T		LC
10707	*Cerastium dichotomum* L.	Caryophyllaceae	C	T		LC
10805	*Chamaecytisus mollis* (Cav.) Greuter & Burdet	Fabaceae	C	NPh	E	NT
10878	*Chamaerops humilis* L.	Arecaceae	C	NPh (Ch)		LC
10720	*Chenopodium album* L.	Amaranthaceae	A, B and C	T		LC
10877	*Cistanche phelypaea* (L.) Cout.	Orobanchaceae	A	G		LC
10732	*Cistus salviifolius* L.	Cistaceae	C	Ch		LC
10872	*Citrullus colocynthis* (L.) Schrad.	Cucurbitaceae	A and B	G		LC
10653	*Cladanthus arabicus* (L.) Cass.	Asteraceae	A, B and C	T		LC
10731	*Convolvulus althaeoides* L.	Convolvulaceae	A, B and C	H		LC
10736	*Convolvulus arvensis* L.	Convolvulaceae	A, B and C	G		LC
10737	*Convolvulus trabutianus* Scheweinf. & Muschl.	Convolvulaceae	A, B and C	Ch		NT
10806	*Coronilla scorpioides* (L.) W.D.J. Koch	Fabaceae	A, B and C	T		LC
10799	*Coronilla viminalis* Salisb.	Fabaceae	B and C	NPh	E	LC
10866	*Crepis vesicaria* L.	Asteraceae	B and C	T		LC
10851	*Cutandia dichotoma* (Forssk.) Trab.	Poaceae	B and C	T		NA
10856	*Cynodon dactylon* (L.) Pers.	Poaceae	A, B and C	H		LC
10697	*Cynoglossum cheirifolium* subsp. *heterocarpum* (Kunze) Maire	Boraginaceae	C	H		LC
10850	*Cyperus capitatus* Vand.	Cyperaceae	A, B and C	G		LC
10857	*Dactylis glomerata* L.	Poaceae	A, B and C	T(H)		LC
10858	*Dasypyrum villosum*(L.) P. Candargy	Poaceae	A	T		DD
10906	*Daucus carota* L.	Apiaceae	A, B and C	T(H)		LC
10848	*Dipcadi serotinum* (L.) Medik.	Asparagaceae	B and C	NPh		LC
10746	*Diplotaxis catholica* (L.) DC.	Brassicaceae	B and C	T		LC
10745	*Diplotaxis erucoides* (L.) DC. subsp. *erucoides*	Brassicaceae	A, B and C	T		DD
10747	*Diplotaxis harra* subsp. *crassifolia* (Raf.) Maire	Brassicaceae	A, B and C	H		LC
10750	*Diplotaxis virgata* (Cav.) DC.	Brassicaceae	A and B	H	A	LC
10627	*Drimia maritima* (L.) Stearn	Asparagaceae	A, B and C	G		LC
10628	*Drimia undata* Stearn	Asparagaceae	A, B and C	G		DD
10725	*Dysphania ambrosioides* (L.) Mosyakin & Clemants	Amaranthaceae	A, B and C	T		LC
10655	*Echinops spinosissimus* Turra	Asteraceae	A, B and C	H		LC
10698	*Echium arenarium* Guss.	Boraginaceae	A and C	T		RE
10700	*Echium humile* Desf.	Boraginaceae	B and C	H		LC

Table 2. ***(****Continued)*

Voucher numbers	Taxa (accepted names according to APD)	Families (APG III)	Zones	Life forms	Endemism	Conservation status
10701	*Echium petiolatum* Barratte & Coincy	Boraginaceae	B and C	T	E	LC
10702	*Echium plantagineum* L.	Boraginaceae	A and B	T		LC
10871	*Emex spinosa* (L.) Campd.	Polygonaceae	A, B and C	T		LC
10749	*Ephedra altissima* Desf.	Ephedraceae	A, B and C	Ph		LC
10755	*Ephedra fragilis* Desf.	Ephedraceae	A, B and C	NPh		LC
10756	*Ephedra major* Host	Ephedraceae	A, B and C	NPh		
10763	*Erodium atlanticum* Coss.	Geraniaceae	C	Ch	I	DD
10764	*Erodium ciconium* (L.) L'Hér.	Geraniaceae	C	T		LC
10769	*Erodium hesperium* (Maire) H. Lindb.	Geraniaceae	B and C	T	E	EN
10770	*Erodium laciniatum* (Cav.) Willd.	Geraniaceae	C	T		LC
10907	*Eryngium ilicifolium* Lam.	Apiaceae	A, B, and C	T		LC
10909	*Eryngium tricuspidatum* L.	Apiaceae	C	H		LC
10757	*Euphorbia balsamifera* Aiton	Euphorbiaceae	A	NPh		NT
10758	*Euphorbia guyoniana* Boiss. & Reut.	Euphorbiaceae	B	H		DD
10748	*Euphorbia officinarum* subsp. *echinus* (Hook. f. & Coss.) Vindt	Euphorbiaceae	A, B and C	NPh	M	NT
10744	*Euphorbia paralias* L.	Euphorbiaceae	A	Ch		NT
10759	*Euphorbia regis-jubae* J. Gay	Euphorbiaceae	A, B and C	NPh	C	NT
10912	*Fagonia cretica* L.	Zygophyllaceae	A, B and C	Ch		LC
10913	*Fagonia harpago* Emb. & Maire	Zygophyllaceae	A and B	Ch	E	NT
10915	*Fagonia indica* Burm. f.	Zygophyllaceae	B and C	T		DD
10847	*Ficus carica* L.	Moraceae	A, B and C	Ph		NA
10657	*Filago pygmaea* L.	Asteraceae	B and C	T		LC
10656	*Filago pyramidata* L.	Asteraceae	C	T		LC
10910	*Foeniculum vulgare* Mill.	Apiaceae	B and C	Ch		LC
10760	*Frankenia corymbosa* Desf.	Frankeniaceae	A, B and C	Ch		LC
10761	*Frankenia laevis* subsp. *velutina* (DC.) Maire	Frankeniaceae	A	Ch	E	LC
10762	*Frankenia pulverulenta* L.	Frankeniaceae	A and B	T		LC
10833	*Fumaria rupestris* Boiss. & Reut. subsp. *rupestris*	Papaveraceae	A, B and C	T	IA	LC
10807	*Genista tamarrutii* Caball.	Fabaceae	B and C	NPh	E	LC
10809	*Genista tricuspidata* Desf.	Fabaceae	B and C	NPh		LC
10766	*Gladiolus italicus* Mill.	Iridaceae	A, B and C	G		LC
10658	*Glebionis coronaria* (L.) Spach	Asteraceae	A, B and C	T		LC
10659	*Glebionis segetum* (L.) Fourr.	Asteraceae	A, B and C	T		LC
10765	*Globularia alypum* L.	Plantaginaceae	B and C	Ch		
10838	*Guenthera amplexicaulis* subsp. *souliei* (Batt.) Gómez-Campo	Brassicaceae	B and C	T		LC
10726	*Hammada scoparia* (Pomel) Iljin	Amaranthaceae	B and C	Ch		
10887	*Haplophyllum broussonetianum* Coss.	Rutaceae	A, B and C	Ch	E	VU
10835	*Hedypnois arenaria* (Schousb.) DC.	Asteraceae	A	T	IC	LC
10735	*Helianthemum confertum* Dunal	Cistaceae	A and B	Ch		
10733	*Helianthemum lippii* (L.) Dum. Cours.	Cistaceae	A and C	Ch		
10734	*Helianthemum pergamaceum* Pomel subsp. *pergamaceum*	Cistaceae	A, B and C	Ch	A	LC
10706	*Heliotropium bacciferum* Forssk.	Boraginaceae	A	Ch		
10705	*Heliotropium ramosissimum* (Lehm.) DC.	Boraginaceae	A, B and C	Ch		LC
10811	*Hippocrepis atlantica* Ball	Fabaceae	B and C	Ch		NT
10812	*Hippocrepis biflora* Spreng.	Fabaceae	A, B and C	T		LC
10810	*Hippocrepis multisiliquosa* L.	Fabaceae	A, B and C	T		LC
10860	*Hordeum murinum* L.	Poaceae	A, B and C	T		LC
10896	*Hyoscyamus albus*L.	Solanaceae	C	T		LC
10662	*Hypochaeris angustifolia* (Litard. & Maire) Maire	Asteraceae	A, B and C	H	E	LC
10834	*Ifloga spicata* (Forssk.) Sch. Bip.	Asteraceae	B and C	T		
10822	*Ismelia carinata* (Schousb.) Sch. Bip.	Asteraceae	A	T	E	VU
10890	*Kickxia aegyptiaca* (L.) Nábělek	Plantaginaceae	B and C	T		LC
10665	*Kleinia anteuphorbium* (L.) Haw.	Asteraceae	A, B and C	NPh	E	NT
10861	*Lamarckia aurea* (L.) Moench	Poaceae	A, B and C	T		LC
10813	*Lathyrus clymenum* L.	Fabaceae	A, B and C	T		LC
10816	*Launaea arborescens* (Batt.) Murb.	Asteraceae	A, B and C	NPh		LC
10808	*Launaea mucronata* subsp. *cassiniana* Kilian	Asteraceae	B and C	T		LC
10797	*Launaea nudicaulis* (L.) Hook. f.	Asteraceae	B	T		LC
10776	*Lavandula coronopifolia* Poir.	Lamiaceae	C	Ch		DD
10775	*Lavandula dentata* L.	Lamiaceae	B and C	Ch (NPh)		LC
10777	*Lavandula multifida* L.	Lamiaceae	B and C	Ch		LC
10788	*Leontodon saxatilis* Lam.	Asteraceae	C	T		LC

Table 2. (Continued)

Voucher numbers	Taxa (accepted names according to APD)	Families (APG III)	Zones	Life forms	Endemism	Conservation status
10844	*Limonium fallax* (Wangerin) Maire	Plumbaginaceae	A, B and C	H	E	NT
10846	*Limonium lobatum* (L.f.) Chaz.	Plumbaginaceae	A, B and C	T		LC
10845	*Limonium mucronatum* (L. fil.) Chaz.	Plumbaginaceae	A, B and C	H	E	
10849	*Limonium sinuatum* (L.) Mill.	Plumbaginaceae	A, B and C	T		LC
10892	*Linaria amethystea* (Vent.) Hoffmanns. & Link	Plantaginaceae	A, B and C	T	I	LC
10894	*Linaria bipartita* (Vent.) Willd.	Plantaginaceae	A, B and C	T	E	LC
10796	*Lithospermum arvense* L.	Boraginaceae	B	T		LC
10751	*Lobularia libyca* (Viv.) Meisn.	Brassicaceae	A, B and C	T		LC
10864	*Lolium perenne* L.	Poaceae	A, B and C	H		LC
10865	*Lolium temulentum* L.	Poaceae	A, B and C	T		LC
10754	*Lomelosia stellata* (L.) Raf.	Caprifoliaceae	A, B and C	T		LC
10814	*Lotus arenarius* Brot.	Fabaceae	A, B and C	T	IC	LC
10815	*Lotus assakensis* Coss. ex Brand	Fabaceae	A	Ch	E	VU
10818	*Lotus villicarpus* Andr.	Fabaceae	B and C	H	E	NT
10897	*Lycium europaeum* L.	Solanaceae	A and B	NPh		NA
10898	*Lycium intricatum* Boiss.	Solanaceae	A, B, C	NPh(Ch)	E	LC
10876	*Lysimachia arvensis* (L.) U. Manns & Anderb.	Primulaceae	A, B and C	T		LC
10880	*Lysimachia tyrrhenia* U. Manns & Anderb.	Primulaceae	B and C	H		NT
10787	*Mairetis microsperma*(Boiss.) I. M. Johnst.	Boraginaceae	B and C	T	C	NT
10829	*Malva parviflora*L.	Malvaceae	A, B and C	T		LC
10780	*Marrubium vulgare* L.	Lamiaceae	B and C	Ch		LC
10752	*Matthiola longipetala* (Vent.) DC.	Brassicaceae	A and B	T		LC
10753	*Matthiola parviflora* (Schousb.) R. Br.	Brassicaceae	A	T		LC,
10819	*Medicago laciniata* (L.) Mill.	Fabaceae	A, B and C	T		LC
10817	*Medicago littoralis*Loisel.	Fabaceae	A	T		LC
10867	*Melica humilis* Boiss.	Poaceae	A, B and C	H		LC
10820	*Melilotus albus* Medik	Fabaceae	A	T		NA
10821	*Melilotus officinalis* (L.) Pall.	Fabaceae	A, B and C	T		NA
10612	*Mesembryanthemum crystallinum* L.	Aizoaceae	A and B	T		LC
10790	*Micromeria arganietorum* (Emb.) R. Morales	Lamiaceae	C	Ch	E	EN
10768	*Moraea sisyrinchium* (L.) Ker Gawl.	Iridaceae	C	G		LC
10629	*Muscari comosum* (L.) Mill.	Asparagaceae	B and C	G		LC
10781	*Nepeta barbara* Maire	Lamiaceae	C	H	E	VU
10786	*Nitraria retusa* (Forssk.) Asch.	Nitrariaceae	A and B	NPh		
10785	*Nolletia chrysocomoides* (Desf.) Cass.	Asteraceae	B and C	Ch		LC
10784	*Nonea calycina* (Roem. & Schult.) Selvi, Bigazzi et al.	Boraginaceae	A, B and C	T		
10779	*Notoceras bicorne* (Aiton) Amo	Brassicaceae	A, B and C	T		LC
10778	*Olea europaea* L. subsp. *europaea*	Oleaceae	B and C	Ph		LC
10631	*Oncostema peruviana* (L.) Speta	Asparagaceae	A, B and C	G		LC
10824	*Ononis biflora* Desf.	Fabaceae	A, B and C	T		LC
10823	*Ononis tournefortii*Coss.	Fabaceae	A and B	T	IM	NT
10773	*Onopordum dissectum* Murb.	Asteraceae	A, B and C	T	E	LC
10767	*Opuntia ficus-indica* (L.) Mill.	Cactaceae	A, B and C	NPh		NA
10618	*Orbea decaisneana* subsp. *hesperidum* (Maire) Jonkers	Apocynaceae	B	Ch	E	NT
10630	*Ornithogalum narbonense* L.	Asparagaceae	B and C	G		LC
10831	*Orobanche alba* Willd.	Orobanchaceae	A	G		DD
10826	*Orobanche minor* Sm.	Orobanchaceae	A	T		LC
10635	*Otoglyphis pubescens* (Desf.) Pomel	Asteraceae	A, B, and C	T		LC
10667	*Pallenis spinosa* (L.) Cass.	Asteraceae	B and C	H		LC
10836	*Papaver rhoeas* L.	Papaveraceae	A, B and C	T		LC
10637	*Papaver somniferum* L.	Papaveraceae	B and C	T		NA
10744	*Parietaria mauritanica* Durieu	Urticaceae	C	T		LC
10708	*Paronychia argentea* Lam.	Caryophyllaceae	C	H		LC
10859	*Patzkea coerulescens* (Desf.) H. Scholz	Poaceae	A, B and C	H		LC
10916	*Peganum harmala* L.	Nitrariaceae	A, B and C	Ch		LC
10619	*Periploca angustifolia* Labill.	Apocynaceae	B and C	NPh		LC
10668	*Perralderia coronopifolia* Coss.	Asteraceae	A	Ch		LC
10669	*Phagnalon purpurascens* Sch. Bip.	Asteraceae	A, B and C	Ch		LC
10670	*Phagnalon saxatile* (L.) Cass.	Asteraceae	B and C	Ch		LC
10868	*Piptatherum miliaceum* (L.) Coss.	Poaceae	A, B and C	H		LC
10839	*Plantago afra* L.	Plantaginaceae	A, B and C	T		LC
10842	*Plantago albicans*L.	Plantaginaceae	B	H		LC
10840	*Plantago amplexicaulis* Cav.	Plantaginaceae	A, B and C	T		LC
10841	*Plantago coronopus* L.	Plantaginaceae	A	H		LC
10711	*Polycarpaea nivea* (Aiton) Webb	Caryophyllaceae	A	Ch	C	VU

Table 2. (Continued)

Voucher numbers	Taxa (accepted names according to APD)	Families (APG III)	Zones	Life forms	Endemism	Conservation status
10869	*Polypogon maritimus* Willd.	Poaceae	A, B and C	T		LC
10782	*Prasium majus* L.	Lamiaceae	C	NPh		LC
10678	*Pseudopodospermum undulatum* (Vahl) Zaika, Sukhor. & Kilian	Asteraceae	A, B and .C	H		LC
10671	*Pulicaria undulata* (L.) C.A. Mey.	Asteraceae	C	Ch		NT
10881	*Ranunculus spicatus* subsp. *blepharicarpos* (Boiss.) Grau	Ranunculaceae	A, B and C	H		LC
10672	*Reichardia tingitana* (L.) Roth	Asteraceae	A, B and C	T		LC
10883	*Reseda elata* Müll. Arg.	Resedaceae	A	Ch	E	VU
10884	*Reseda lutea* L.	Resedaceae	C	T		LC
10875	*Rumex bucephalophorus* L. subsp. *bucephalophorus*	Polygonaceae	A, B and C	T		LC
10873	*Rumex scutatus* subsp. *induratus* (Boiss. & Reut.) Nyman.	Polygonaceae	B and C	Ch		DD
10874	*Rumex vesicarius* L.	Polygonaceae	A, B and C	T		LC
10741	*Ruta montana* (L.) L.	Rutaceae	A, B and C	Ch		
10843	*Saharanthus ifniensis* (Caball.) M.B.Crespo & Lledó	Plumbaginaceae	A	NPh		NT
10727	*Salsola frankenioides* (Caball.) Botsch.	Amaranthaceae	A	Ch	E	NA
10717	*Salsola oppositifolia* Desf.	Amaranthaceae	A, B and C	NPh		LC
10783	*Salvia aegyptiaca* L.	Lamiaceae	B and C	Ch		LC
10789	*Salvia verbenaca* L.	Lamiaceae	B and C	H		LC
10886	*Sanguisorba minor* Scop.	Rosaceae	A, B and C	G		LC
10704	*Sclerosciadium nodiflorum* (Schousb.) Ball	Apiaceae	A	T	E	NT
10676	*Scolymus hispanicus* L.	Asteraceae	C	H		LC
10825	*Scorpiurus muricatus* L.	Fabaceae	A, B and C	T		LC
10893	*Scrophularia arguta* Sol.	Scrophulariaceae	A, B and C	T		LC
10895	*Scrophularia canina* L.	Scrophulariaceae	B and C	Ch		LC
10703	*Searsia albida* (Schousb.) Moffett	Anacardiaceae	A	NPh	C	NT
10614	*Searsia pentaphylla* (Jacq.) F.A. Barkley	Anacardiaceae	C	NPh		LC
10615	*Searsia tripartita* (Ucria) Moffett	Anacardiaceae	B and C	NPh		LC
10739	*Sedum sediforme* (Jacq.) Pau	Crassulaceae	A, B and C	Ch		LC
10681	*Senecio glaucus* L.	Asteraceae	A, B and C	T		LC
10682	*Senecio hesperidum* Jahand., Maire & Weiller	Asteraceae	B and C	T	E	CR
10710	*Silene glabrescens* Coss.	Caryophyllaceae	B and C	T	E	VU
10712	*Silene virescens* Coss.	Caryophyllaceae	C	T	E	LC
10899	*Solanum nigrum*L.	Solanaceae	A, B and C	T		LC
10900	*Solanum villosum* Mill.	Solanaceae	A	T		LC
10684	*Sonchus maritimus* L.	Asteraceae	A	H		LC
10685	*Sonchus tenerrimus* L.	Asteraceae	B and C	T		LC
10713	*Spergula fimbriata* (Boiss. & Reut.) Murb.	Caryophyllaceae	A and C	H		LC
10699	*Stachys arenaria* subsp. *mollis* (Willd. ex Benth.) F. Gómiz	Lamiaceae	B and C	Ch	E	LC
10714	*Stellaria media* (L.) Vill.	Caryophyllaceae	C	T		LC
10870	*Stipa capensis* Thunb.	Poaceae	A, B and C	T		LC
10832	*Striga gesnerioides*(Willd.) Vatke	Orobanchaceae	A, B and C	G		NT
10729	*Suaeda ifniensis* Caball. ex Maire	Amaranthaceae	A	Ch	M	EN
10730	*Suaeda vera* Forssk. ex J.F.Gmel.	Amaranthaceae	A and B	NPh		LC
10917	*Tetraena gaetula* (Emb. & Maire) Beier & Thulin	Zygophyllaceae	A	Ch		LC
10791	*Teucrium antiatlanticum* (Maire) sauvage & Vindt	Lamiaceae	B and C	Ch	E	EN
10794	*Teucrium aureo-candidum* Andr.	Lamiaceae	A, B and C	Ch		DD
10793	*Teucrium chamaedrys* L.	Lamiaceae	C	Ch		LC
10795	*Teucrium demnatense* Coss. ex Batt.	Lamiaceae	B and C	Ch	E	LC
10798	*Teucrium fruticans* L.	Lamiaceae	B and C	NPh (Ch)		LC
10696	*Traganum moquinii* Webb ex Moq.	Amaranthaceae	A	NPh		
10687	*Tragopogon porrifolius* L.	Asteraceae	B and C	T		LC
10827	*Tripodion tetraphyllum* (L.) Fourr.	Fabaceae	A, B and C	T		LC
10740	*Umbilicus horizontalis* (Guss.) DC.	Crassulaceae	B, C	G		NA
10715	*Velezia rigida* L.	Caryophyllaceae	C	T		LC
10828	*Vicia sativa* L.	Fabaceae	A, B and C	T		LC
10830	*Vicia villosa* subsp. *pseudocracca* (Bertol.) Rouy	Fabaceae	C	T		
10771	*Vitex agnus-castus* L.	Lamiaceae	B and C	NPh		LC
10688	*Volutaria crupinoides* (Desf.) Maire	Asteraceae	A, B and C	T		LC
10689	*Volutaria lippii* (L.) Cass. ex Maire	Asteraceae	B and C	T	E	LC

Table 2. (Continued)

Voucher numbers	Taxa (accepted names according to APD)	Families (APG III)	Zones	Life forms	Endemism	Conservation status
10692	*Volutaria muricata* (L.) Maire	Asteraceae	A and C	T		LC
10693	*Warionia saharae* Benth. & Coss.	Asteraceae	A, B and C	NPh		NT
10901	*Withania adpressa* Coss. ex Batt.	Solanaceae	B	NPh		NT
10902	*Withania frutescens* (L.) Pauquy	Solanaceae	A, B and C	NPh	IAC	LC
10695	*Ziziphus lotus* (L.) Lam.	Rhamnaceae	A, B and C	NPh		LC

[APD: African Plants Database. APG III: Angiosperm Phylogeny Group III. Zone A: dunes and seaside cliffs, Zone B: coastal plains, hills and plateau in the hinterland, planted with prickly pear, Zone C: mountains inside Argan forest trees. Life forms: Ph = Phanerophyte, NPh = Nanophanerophyte, Ch = Chamaephyte, H = Hemicryptophyte, G = Geophyte, T = Therophyte. Endemism: E: Endemic to Morocco; C: Endemic to Morocco and the Canary Islands; I: Endemic to Morocco and the Iberian Peninsula; A: Endemic to Morocco and Algeria; M: Endemic to Morocco and Mauritania; IA: Endemic to Morocco, the Iberian Peninsula and Algeria; IC: Endemic to Morocco, the Iberian Peninsula and the Canary Islands; IM: Endemic to Morocco, the Iberian Peninsula and the Mauritania; IAC: Endemic to Morocco, the Iberian Peninsula and Algeria and the Canary Islands. Conservation status: NA: Not applicable, DD: Insufficient data, LC: Least Concern, NT: Near Threatened, VU: Vulnerable, EN: Endangered, CR: Critically Endangered, RE: Regionally Extinct.]

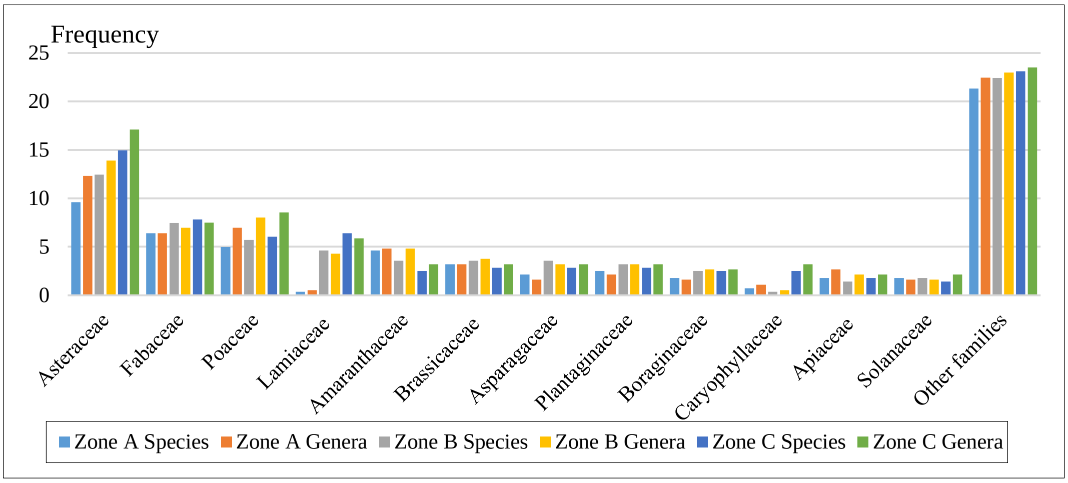

Figure 4. Families ordered according to frequency of species and genera they comprise in the Ait Baâmrane region

Other families are those with a number of species equal or less than 5, Zone A: dunes and seaside cliffs, Zone B: hills and plateau, Zone C: mountains inside Argan forest.

The total species richness evolves according to the continentality: zone C is the richest in species (218); zone B is the second richest with 204 species, while zone A has only 172 species.

Table 3 shows the variations of Shannon diversity index (*H'*) and Evenness index (E) in areas A, B and C.

Table 3. Variation of Shannon and Evenness indices in the Ait Baâmrane region.

	Zone A	Zone B	Zone C
Shannon diversity index	5.89	6.09	6.11
Evenness index	0.92	0.93	0.91

Zone A: dunes and seaside cliffs, Zone B: hills and plateau, Zone C: mountains inside Argan forest.

The results relating to the variation of the floristic similarity index (Jaccard index) are reported in Table 4.

Table 4. Variation of the Jaccard similarity index in the Ait Baâmrane region.

	Zone A	Zone B	Zone C
Zone A	1		
Zone B	0.54	1	
Zone C	0.43	0.72	1

Zone A: dunes and seaside cliffs, Zone B: hills and plateau, Zone C: mountains inside Argan forest.

Life-Forms

The therophytes are the most represented (43.42%), followed by chamaephytes and nanophanerophytes with 21% and 13.52%, respectively (Table 5, Figure 5). Frequency of presence of different life forms compared using Raunkiaer's normal spectrum indicated that the study site showed high proportions of therophytes, followed by chamaephytes, while phanerophytes and hemicryptophytes were less than Raunkiaer's normal spectrum (Table 5).

Table 5. Life-forms and biological spectra of the vascular flora of the Ait Baâmrane region.

Life-forms	Effective	Biological spectra (%)	Raunkiaer normal spectrum
Phanerophytes	5	1.78	46
Nanophanerophyte	**38**	**13.52**	
Chamaephytes	**59**	**21**	9
Hemicryptophytes	**38**	**13.52**	26
Geophyte	19	6.76	6
Therophytes	**122**	**43.42**	13
Total	281	100	100

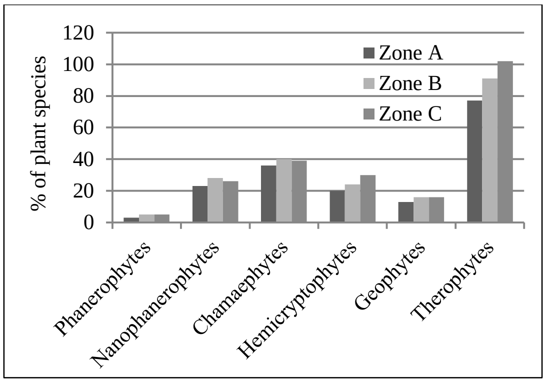

Figure 5. Distribution of life-forms in the Ait Baâmrane region.
Zone A: dunes and seaside cliffs, Zone B: hills and plateau, Zone C: mountains inside Argan forest.

Disturbance Index

The disturbance index values of the region of Ait Baamrane are higher than 50% in the three zones (Table 6).

Table 6. Variation of Disturbance index in the Ait Baâmrane region.

	Zone A (n=172)	Zone B (n=204)	Zone C (n=218)	Total (n=281)
Disturbance index	66%	64%	65%	64%

Zone A: dunes and seaside cliffs, Zone B: hills and plateau, Zone C: mountains inside Argan forest.

Endemic Flora

In detail, the flora offers a high rate of endemism which is 21.35% (60 species) of all species differentiated in two classes of endemic species: the strict endemic of Morocco with 37 species and endemic *sensu lato*; Morocco and the Canary Islands with 9 species, Morocco and Algeria with 5 species, Morocco and the Iberian Peninsula with 2 species, Morocco and Mauritania with 2 species, Morocco, Iberian Peninsula and Algeria with 1 species, Morocco, Iberian Peninsula, Algeria and the Canary Islands with 1 species and Morocco, Iberian Peninsula and Mauritania with 1 species.

The littoral zone is the richest in endemic species. The rate of endemism is estimated at 22.67%, followed by the plateau which has an overall endemism rate of 18.14%, and then the continental zone where the endemism rate is 17.05%. In other words, the endemism decreases from the coast to the interior (Table 7).

Table 7. Endemism in the studied area.

	Zone A	Zone B	Zone C
E	**19**	**23**	**26**
C	8	4	2
I	1	1	2
A	4	4	3
M	2	1	1
IA	1	1	1
IC	2	1	1
IM	1	1	0
IAC	1	1	1
Total	39	37	37

E: Endemic to Morocco; C: Endemic to Morocco and the Canary Islands; I: Endemic to Morocco and the Iberian Peninsula; A: Endemic to Morocco and Algeria; M: Endemic to Morocco and Mauritania; IA: Endemic to Morocco, the Iberian Peninsula and Algeria; IC: Endemic to Morocco, the Iberian Peninsula and the Canary Islands; IM: Endemic to Morocco, the Iberian Peninsula and the Mauritania; IAC: Endemic to Morocco, the Iberian Peninsula and Algeria and the Canary Islands. Zone A: dunes and seaside cliffs, Zone B: hills and plateau, Zone C: mountains inside Argan forest.

Conservation Status of the Flora

Approximately 6% of the vascular flora species in the Ait Baâmrane region are considered as Threatened (categories VU, EN, CR and RE). There are 29 species considered as Near Threatened (NT) (Table 8).

Table 8. Conservation status of the species of vascular flora assessed in the Ait Baâmrane region.

Conservation status	LC	NT	VU	EN	CR	RE
Effective	196	29	9	5	1	1
Frequency	70%	11.3%	3.2%	2%	0.36%	0.36%

NA: Not applicable, DD: Insufficient data, LC: Least Concern, NT: Near Threatened, VU: Vulnerable, EN: Endangered, CR: Critically Endangered, RE: Regionally Extinct.

The degree of the flora considered as Threatened on the littoral zone is estimated at 5.23%, on the plateau it is 3.43% and on the continental zone it is 4.12%. The number of species considered as Near Threatened is 19 in the coastal zone, 20 in the plateau and 15 in the continental zone.

About 6.5% of the vascular flora species considered as Threatened are strictly endemic to Morocco. Among these species, we cite: *Senecio hesperidum* Jahand., Maire & Weiller, which is strictly endemic to Morocco (E) and critically endangered (CR), and *Atriplex colerei* Maire, *Erodium hesperium* (Maire) H. Lindb., *Micromeria arganietorum* (Emb.) R. Morales and *Teucrium antiatlanticum* (Maire) Sauvage & Vindt are strictly endemic to Morocco (E) and endangered (EN).

According to our results, 13 plant species belonging to the DD IUCN category, which represent 4.62 % the inventoried flora, this relatively high rate highlight the recommended species of future assessment studies.

Discussion

The studied region is fairly rich and diverse by its flora and vegetation. The whole vascular flora found in this region is 281 species and sub-species grouped into 187 genera and 48 families. This specific richness represents 5.39% in relation to Morocco (Fennane & Ibn Tattou, 2012) and 22.66% in relation to Oued Souss basin (Peltier, 1982). The genera present in the area of Ait Baâmrane account for 19.06% of those of Morocco and 33.63% of those of the Oued Souss basin. Thus, the families inventoried in the Ait Baâmrane region represent 30.97% of the families present in Morocco and 50.53% of those present in the Oued Souss basin (Table 9).

Table 9. Comparative analysis of the vascular flora of the Ait Baâmrane region in relation to Morocco according to Fennane & Ibn Tattou (2012) and the Oued Souss basin according to Peltier (1982)

	Families	Genera	Vascular species and subspecies
Species richness in Morocco	155	981	5211
Species richness in the Oued Souss basin	95	556	1240
Species richness in the Ait Baâmrane region	48	187	281
Frequencies in relation to the flora of Morocco	30.97%	19.06%	5.39%
Frequencies in relation to the flora of the Oued Souss basin	50.53%	33.63%	22.66%

The Asteraceae family is the most dominant in the region of Ait Baâmrane and the richest in species (51 species) and genera (36 genera), which is in agreement with its first rank in the Moroccan flora with more than 550 species and subspecies (Fennane & Ibn Tattou, 2012) and in the Oued Souss basin with 181 species (Peltier, 1982).

Moreover, the analysis of the vegetation shows that the specific richness of Ait Baâmrane varies according to the continentality. Indeed, the continental zone is the richest in species (218), followed by the plateau (204 species) and finally the littoral zone with 172 species. This was also confirmed by the Shannon and evenness indices. Shannon index was low in both zone A (H' = 5.89) and zone B (H' = 6.09), and increased slightly in zone C (H' = 6.11). Evenness values drop slightly in zone C (E = 0.91) compared to zones A and B which recorded values of 0.92 and 0.93, respectively. That is, zone C and zone B are the most diversified compared to zone A, and the distribution of the number of individuals by species was found to be very similar between the three zones. The Jaccard index revealed a low similarity value (0.43) between zone A and zone C. In contrast, the values of the floristic similarity index remain high between zone A and B (0.54) and zone B and C (0.72), where the indices are higher than (0.5), which means that half of the floristic procession is common to zones A and B and to zones B and C. This variation might be influenced by the edapho-climatic factor of the local environment. This difference could only be explained by the topography of zone C (continental) located in the mountains, which allowed the plots to absorb runoff water and fogs making the soil more moist and enriching with nutrients. Thus, the mountains provide a very favorable climate, while the area with the lowest biodiversity is zone A (littoral); the cause is certainly climatic, edaphic but also anthropogenic. In zone A, the effect of factors related to sea proximity is manifested most notably by extremely high atmospheric humidity, sea breezes transporting sand and salt spray to depths of a few hundred meters from the littoral zone. The vegetation is then adapted to these physical parameters, especially salinity and sand, by the appearance of succulent plants. Some species are then exclusive to this littoral zone, such as, *Astydamia latifolia* (L. f.) Kuntze, *Atriplex colerei* Maire, *Bassia tomentosa* (Lowe) Maire & Weiller, *Cakile maritima* Scop. subsp. *maritima*, *Euphorbia balsamifera* Aiton, *Euphorbia paralias* L., *Hedypnois arenaria* (Schousb.) DC., *Ismelia carinata* (Schousb.) Sch. Bip., *Polycarpaea nivea* (Aiton) Webb, *Salsola frankenioides* (Caball.) Botsch., *Suaeda ifniensis* Caball. ex Maire, *Traganum moquinii* Webb ex Moq. Similar results reported by Su & Zhao (2003) showed that climate conditions have an impact on the recovery of a degraded habitat. Indeed, the littoral zone (zone A) knew a great agricultural activity (mainly cereal farming), currently abandoned, because of the drought, and the migratory phenomena of the population which prefers other activities than agriculture. We are seeing a convergence of ecological and social factors here, which explains these findings. Thus, Cao et al. (2007) declared that in dryland rangelands, water is the most important limiting factor for vegetation growth, and the growth of annuals that accompany permanent vegetation is dependent on rainfall (Abd El-Ghani & Amer, 2003). However, Yang et al. (2006) reported that water is not always the limiting factor for plant growth in arid and semi-arid areas because there are many species that show high colonization, while soil water is low. It is also well known that other factors are involved in these variations such as soil texture. According to Zhao et al. (2006), instability of the sandy substrate prevents plant propagules from settling. In fact, soils in the plateau's and the continental zones are predominantly clayey, while those in the coastal zone are sandy, which probably explains the difference in diversity parameters.

Furthermore, Raunkiaer (1934) stated that the essential patterns of climates are characterized by the fact that one or few life-forms are, relatively or absolutely, dominant. This can be expressed numerically as the phytoclimate can be characterized by statistical survey of the life-forms (Raunkiaer, 1934). The community's life form composition is an aspect of its constituent species' adaptations to climatic conditions (Jamir & Pandey, 2003).

This study revealed that the distribution of plant life-forms is characterized by the following scheme:

Therophytes>Chamaephytes>Hemicryptophytes>Nanophanerophytes>Geophytes>Phanerophytes.

It is clear that therophytes (43.42%) and chamaephytes (21%) predominated overall. When compared with Raunkiaer's normal spectrum, therophytes in Ait Baamrane region are three times higher than that of the normal spectrum (Table 5). High percentage of therophytes in any specific region indicated that this region have arid climate and disturbed habitats (Smith, 1980). These life-forms characterize plant adaptation strategy in drylands (Hashemi, 2001). Indeed, the hyper-arid climate and unstable soil structure encourage the growth of short-lived plants (therophytes, mainly annuals) (Neffar et al., 2013). The high level of therophytes registered is in agreement with the study by Olivier et al. (1995) that argues that the level of this plant life-forms in the Mediterranean region is about 50%. Our results indicated high similarities of life-forms composition between the zones subject to study. The predominance of therophytes is a common indicator of hot, dry climates with human and animal disturbances (Bridal et al., 2015). On the other hand, the heterogeneity of local topography, edaphic factors, and microclimatic conditions could lead to variation in the distributional pattern of plants (Abdel-Khalik et al., 2013). Barbero et al. (1990) presented therophytes as a form of resistance to drought and high temperatures in arid environments. On the other hand, chamaephytes indicate a temperate phytoclimate (Meher-Homji, 1964).

Therefore, the observed dominance of therophytes followed by chamaephytes over other life forms in Ait Baamrane region appears to be a response to the arid climate with insufficient rainfall and few microhabitats available to support high percentage of perennials. It also reflects anthropogenic and livestock impacts on the region (Al Shaye et al., 2020).

Moreover, phanerophytes are less than that of normal spectrum by about three times (Table 5). Since phanerophytes pertain to warm humid regions such as tropical zones (Raunkiaer, 1934) arid conditions prevailing in Ait Baamrane region were unfavorable for such life form. As well as according to Bradai et al., (2015); as for the phanerophytes, the arid and semiarid climates are not favorable for their occurrence, hence their small percentage in our case. High percentage of therophytes and low percentage of phanerophytes are, collectively, indicative arid climate and disturbed habitats (Al Shaye et al., 2020).

The degree of therophytization can be used as a proxy for desertification stage and intensity (Jauffret & Lavorel, 2003). In our case, this index reached 66% in zone A, 64% in zone B and 65% in zone C. Jauffret & Lavorel (2003) declared that ephemeral plants are more drought resistant than hemicryptophytes and geophytes because they spend the summer as seeds, whereas the others remain as vegetative organs. In addition, the Ait Baâmrane region has an endemism rate of 21.35% (60 species) of all species, of which 37 are endemic in the strict sense and 23 endemic species in the broad sense. This endemic flora presents a rate of 3.85% compared to the endemic flora of Morocco (1559 species and subspecies) (Fennane & Ibn Tattou, 2012), and 42.25% compared to that of the Oued Souss basin (142 species and subspecies) (Peltier, 1982).

Although the rate of endemism in the strict sense is quite high, it nevertheless differs from one site to another, and it is proportional to the species richness. Furthermore, (Ouhammou, 2003; 2005), has clearly shown the strong correlation between altitude and the rate of endemism.

Conclusions

The floristic analysis of the Ait Baâmrane region revealed that this study site represents an important center of "hot spot" phytobiodiversity (Médail & Quézel, 1997; Médail, 2001). This center is linked to the particular ecological conditions, which have favored the development of a rich and diversified flora, often endemic to the area. However, this floristic biodiversity is currently under threat as the degree of flora threatened in the three zones is 6% and 11% of the near-threatened species. This vulnerability is even more striking, especially as 6.5% of the threatened taxa (categories CR, EN, VU and NT) are strictly endemic to Morocco. This threatened flora and its importance reflect the serious state of degradation of the ecosystem. Therefore, this study will be a useful tool in conservation and rehabilitation activities. The management methods and types of use of these environments will strongly influence their protection and preservation (Austrheim et al., 1999).

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Author Contributions

Conceptualization: F. Z. Y., A. O., M. A.; Investigation: F. Z. Y., A. O., M. A; Material and Methodology: F. Z. Y., A. B. L., A. O., M. A.; Supervision: A. O., M. A.; Visualization: A. O., M. A.; Writing-Original Draft: F. Z. Y.; Writing-review & Editing: F. Z. Y., A. O., M. A., H. Z.; Other: All authors have read and agreed to the published version of manuscript.

Conflict of Interest

The authors have no conflicts of interest to declare.

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