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Plant species richness in the Cape Verde Islands—eco-geographical determinants

Maria Cristina Duarte · Francisco Rego ·
Maria Manuel Romeiras · Ilídio Moreira

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Abstract Plant species richness in the Cape Verde archipelago is examined relative to island eco-geographical factors. Species-area and species-area-habitat relationships are analysed using the classical species-area model and the recently proposed species-choros model. The number of floristic zones (used to estimate the choros parameter) provides an adequate estimate of the potential habitat diversity, and the species-choros model achieved a better fit with both total flora and endemic species. In addition to area and habitat diversity, longitude also emerges as an important determinant of species diversity, whereas latitude, minimum distance to the nearest island, and total rural population do not display any correlation. As in other insular ecosystems, the species richness (about 140 per 100 km^2) is lower than in nearby mainland regions; the proximity to the desert areas of the Sahel can also be seen as related with this low value. The floristic heterogeneity in Cape Verde is high, as is usual in island ecosystems. In a comparative analysis of the species richness on the different islands (using α-values), Brava stands out as having the highest total flora species densities, while for endemic flora Brava and São Nicolau jointly occupy the leading position. The high diversity for both total and endemic species on Santo Antão, São Vicente, São Nicolau, Fogo and Brava reinforces their importance in conservation terms - in the case of most of them, something that is already recognized in the established network of protected areas.

Keywords Biodiversity · Conservation · Macaronesia · Species-area relationship · Species-area-habitat relationship · West Africa

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M. C. Duarte (✉) · M. M. Romeiras
Jardim Botânico Tropical, Instituto de Investigação Científica Tropical, Trav. Conde da Ribeira 9,
1300-142 Lisbon, Portugal
e-mail: mcduarte@mail.telepac.pt

F. Rego
Centro de Ecologia Aplicada Prof. Baeta Neves, Instituto Superior de Agronomia, Tapada da Ajuda,
1349-017 Lisbon, Portugal

I. Moreira
Departamento de Fitoecologia e de Protecção das Plantas, Instituto Superior de Agronomia,
Tapada da Ajuda, 1349-017 Lisbon, Portugal

Introduction

In order to achieve a better understanding of global patterns of biodiversity a great deal of work has gone into the study of spatial patterns of floristic richness, with particular emphasis on island ecosystems (e.g., Moody 2000; Lomolino and Weiser 2001; Panitsa and Tzanoudakis 2001; Morrison 2002). This interest is currently at renewed heights given that a profound understanding of island systems can improve our knowledge of biological processes in ecologically isolated regions, such as fragmented landscapes or patchy ecosystems (e.g., Watson 2002).

Because floristic data are available for many geographical areas and it is possible to extrapolate them more widely, inventory-based approaches are one of the most commonly used methods (Mutke et al. 2001).

The increase in floristic richness with area is largely accepted (e.g., Connor and McCoy 1979; Kohn and Walsh 1994; Fernández-Palacios and Andersson 2000), and several species-area models have been proposed for the standardisation of species richness, including those of Arrhenius (1921), Gleason (1922) and Evans et al. (1955). Arrhenius's model is one of the most extensively used, especially in comparative studies. It postulates that the species (S)–area (A) relationship is a power function ($S = cA^z$).

The reasons for the increase in floristic richness with the increase in area have long been the object of debate (e.g., Connor and McCoy 1979). The straightforward interpretation of species-area relationships has been questioned by authors like Williamson (1989), who considered them to be an expression of environmental heterogeneity. The particular importance of habitat diversity in explaining species richness has been reinforced for different taxonomical groups of both flora and fauna (e.g., Newmark 1986; Kohn and Walsh 1994; Ricklefs and Lovette 1999; Fox and Fox 2000).

According to Triantis et al. (2003) two major mutually complementary species addition mechanisms have been identified: the "area *per se* hypothesis" (included in the "Equilibrium theory", MacArthur and Wilson 1967), which points to the higher probabilities of species survival and dispersion in larger habitats; and the "habitat heterogeneity hypothesis", which considers habitat area to be a surrogate variable of habitat heterogeneity (Williams 1964).

In order to unify these two dominant explanatory mechanisms Triantis et al. (2003) proposed the choros model ($S = cK^z$), where choros (K) is related with the number of habitats and the total area of the region. The application of this model relies on the availability of data about habitat diversity for the taxonomic group in analysis.

In addition to area and habitat diversity other additional factors might contribute to an understanding of species richness patterns. According to Fernández-Palacios and Andersson (2000) geographic position (mainly latitude), altitude (related with habitat diversity), isolation (distance to the mainland), and geological age are the major geographical determinants of floristic richness in island ecosystems. However, these authors say that the level of analysis is decisive, since the factors explaining inter-archipelago variations are not necessarily the same as those that account for species variation at the intra-archipelago level. The taxonomical group under analysis is also important, since the eco-geographical factors affect distinct types of species dispersal differently (Beyhl 1990; Fernández-Palacios and Andersson 2000; Koh et al. 2002); area and altitude are particularly important for the groups with long-distance dispersal ability (as is the case with flora in general), while in groups with low-distance dispersal ability (e.g., certain groups of fauna) geological age, and isolation are determinant (Fernández-Palacios and Andersson 2000).

For Macaronesia—a geographic denomination used to designate the North-East Atlantic Azores, Canaries, Madeira, Salvages and Cape Verde archipelagos—Beyhl (1990) concluded that for most of the taxonomical groups the specific richness in these archipelagos was positively correlated with area and with altitude, and negatively correlated with distance to the mainland; only the pteridophytes did not display dependence on the latter. Sergel and Baez (1990) reported that the species number for several groups of plants, birds, and insects depended on habitat diversity, distance to the mainland, and the island's area; for some islands they also concluded that the biota diversity depended on the area, suggesting that the species number's dependence on area could be an epiphenomenon. Within the Canary Islands, Fernández-Palacios and Andersson (2000) stressed the role of area, and habitat diversity in the floristic richness of vascular plants.

Ongoing research has enhanced the complexity that underlies floristic diversity patterns; evolutionary processes, spatial interactions and the geographic, ecological, and historic specificity of each region create specific diversity patterns which, although controlled by some well known drivers, are also influenced by a number of incompletely known factors.

One of the parameters that are most commonly used to compare species diversity in standard areas from different geographical regions is the c-value from Arrhenius's equation (e.g., Malyshev 1991; Rosenzweig 1995; Barthlott and Porembski 1996). However, Hobohm (2000, 2003) considers that this poses some methodological constraints, because of the non-linearity of the species-area curve. As an alternative he has proposed the use of the α-index obtained from the Arrhenius equation. This index can be used as an indicator for species diversity in different area sizes and has proved successful in ranking biodiversity hotspot areas (Hobohm 2003; Werner and Buszko 2005).

The aims of the present study are: (1) to establish the species richness patterns of total and endemic Cape Verdean flora using Arrhenius's species-area model (1921) and Triantis et al.'s species-choros model (2003); (2) to identify ecological and geographical determinants involved in floristic richness; and (3) to make some quantitative floristic comparisons with other North-Eastern Atlantic archipelagos and with the African mainland. Also, (4) the analysis of species diversity at the intra-archipelago level (using the α-index) and the distribution of some endemic species are evaluated in order to assess their implications for biodiversity conservation.

Materials and methods

Study area

The Cape Verde archipelago is situated in the Eastern Atlantic, c. 600 km from the African mainland (Senegal) and 1,400 km from the Canary archipelago. It comprises ten islands: Santo Antão, São Vicente, Santa Luzia, São Nicolau, Sal, Boavista, Maio, Santiago, Fogo, and Brava (Fig. 1), all of which are volcanic in origin. Mean temperatures range from c. 23–27°C at sea level to c. 18–20°C at altitude. Annual precipitation ranges from c. 80–300 mm (lowlands) to more than 1,600 mm (highlands).

Vascular flora

The flora of the Cape Verde Islands was mainly compiled from Hansen and Sunding (1993), Rustan and Brochmann (1993), Brochmann et al. (1997), Lobin et al. (1998), Duarte et al. (1999, 2002), and Gomes et al. (1995, 1999), and from the published fascicles

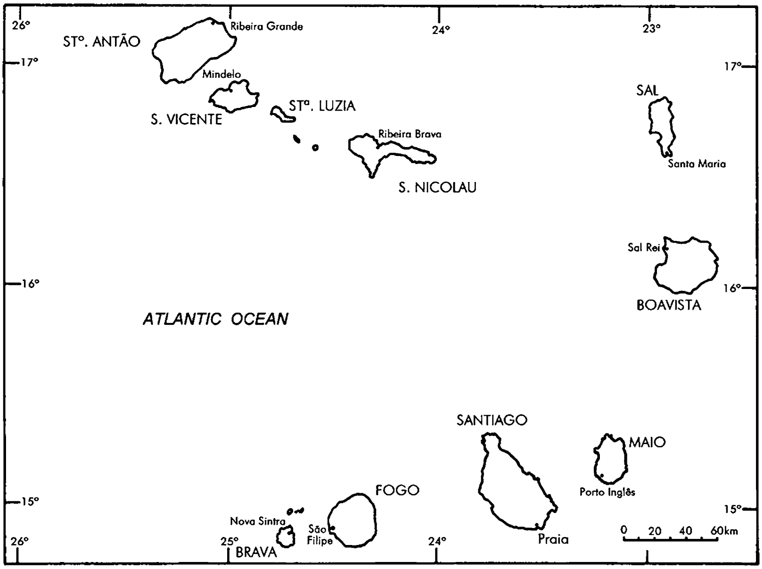

Fig. 1 Cape Verde archipelago

of the *Flora de Cabo Verde* (Paiva et al. 1995–1996; Martins et al. 2002). As in most similar studies, total flora included both spontaneous and naturalized taxa. In Cape Verde the assessment of exotic flora is an especially important problem since, as Lobin and Zizka (1990) note, 30% of the taxa are of doubtful origin.

Ecological and geographical factors

The following geophysical parameters were considered for each geographic unit (Table 1): average latitude and longitude, area, and maximal altitude; in order to determine isolation the minimum distance to the nearest island was estimated for each island. The approximate distance to the African mainland was indirectly determined using longitudes.

Given the climatic constraints imposed by drought, the importance of agricultural activities (the main activity in the archipelago) as measured by the number of rural inhabitants (Instituto Nacional de Estatística de Cabo Verde, census 2000) was used as an indicator of each island's suitability for plant life.

As other authors have suggested (e.g., Fernández-Palacios and Andersson 2000), the number of "floristic altitudinal zones" was assessed and used as an indicator of the habitat diversity on each island. In accordance with previous studies carried out on Santiago Island (Duarte et al. 2005), an average figure of 350 m was considered as the limit between a lowland vegetation zone dominated by xerophilous flora and an upper altitudinal vegetation zone with mesophilous flora; six of the islands were considered to have two floristic altitudinal zones.

Numerical analysis

The analysis of species richness in the Cape Verde Islands was performed using both the classical Arrhenius (1921) species-area model ($S = cA^z$) and the recently proposed

Table 1 Geophysical, ecological and floristic features of Cape Verde Islands

	Latitude midpoint (approx.) (°N)	Longitude midpoint (approx.) (°W)	Area (km^2)	Maximum altitude (m)	Minimum distance to nearest island (km)	Total rural population	Number of floristic zones[a]	Choros′[b]	Total taxa	Endemic taxa	Exclusive endemics
Santo Antão	17.1	25.2	779	1979	13	32820	2	1558	477	47	11
São Vicente	16.8	25.0	227	725	9	4174	2	454	296	35	1
Santa Luzia	16.8	24.8	35	395	9	0	1*	35	81	10	0
São Nicolau	16.6	24.3	343	1304	30	8152	2	686	338	46	8
Sal	16.7	22.9	216	406	39	1507	1*	216	147	15	1
Boavista	16.1	22.8	620	387	39	2182	1*	620	212	14	0
Maio	15.2	23.2	269	436	25	4076	1*	269	220	11	0
Santiago	15.1	23.6	991	1392	25	112854	2	1982	477	38	3
Fogo	14.9	24.4	476	2829	18	29137	2	952	373	38	7
Brava	14.8	24.7	64	976	18	4940	2	128	239	25	0

[a] Islands with a very small or negligible area above the 350 m were considered to have one floristic region

[b] Choros′ (K') = Area * Number of floristic zones

(Triantis et al. 2003) choros model ($S = cK^z$). For the comparison of the two models the R^2 value was used as a measure of goodness-of-fit.

The choros-parameter as defined by Triantis et al. (2003) $K = H*A$ was adjusted, because the number of habitats (H) in each island is unknown. K′ was computed by multiplying the total area (A) of each island by the respective number of floristic zones (H'), as defined as above ($K' = H'*A$).

The α-index was used to compare inter-island species richness. This index was computed from the choros model equation: $\alpha = \log S - (z * \log K' + \log c)$; positive values refer to areas with above average species diversity, and negative values refer to those with below average species diversity (Hobohm 2000, 2003). Pearson correlation coefficients (r) were used to assess correlations between species diversity (α-index) and the eco-geographic parameters. As some data records were not distributed normally, they were log-transformed prior to correlation analysis.

Cape Verde's floristic richness was compared with that of the African mainland using the c-value. The area size of the elementary flora was 100 km^2. This value is commonly used for minor floras (e.g., Malyshev 1991). The floristic heterogeneity of the archipelago was compared with that of other geographical regions using the z-value.

Both indicators (c-value and z-value) were computed using the species-choros equation, inasmuch as they maintain the same biological significance as in the Arrhenius equation (Triantis et al. 2003).

Results

At present the inventory of Cape Verde flora comprises 736 spontaneous or naturalized taxa from 90 families. Values range from a maximum on Santiago and Santo Antão (477 taxa) to a minimum (81 taxa) on Santa Luzia (Table 1). The best represented families are the *Fabaceae* and the *Asteraceae* (with 71 and 67 taxa, respectively) in the dicotyledons, and the *Poaceae* (with 121 taxa) in the monocotyledones. According to Brochmann et al. (1997) the endemic flora totals 82 taxa, including one endemic genera—*Tornabenea* (*Apiaceae*). Santa Luzia and Maio have few endemic taxa (10 and 11, respectively), whereas Santo Antão and São Nicolau present the maximum values (47 and 46, respectively); together with Fogo the latter islands also have the largest number of exclusive endemic species (Table 1).

The Arrhenius model gives us the following equation for the Cape Verde Islands: $S = 26.11*A^{0.406}$ ($R^2 = 0.6202$). The adapted choros model offers a considerable improvement: $S = 21.12*K'^{0.413}$ ($R^2 = 0.8442$). The z-value for the archipelago is very similar in both equations (0.406 and 0.413, respectively).

For endemic flora the species-area equation is $S = 4.49*K'^{0.30}$ ($R^2 = 0.274$), whereas the species-choros equation is $S = 2.66*K'^{0.36}$ ($R^2 = 0.5367$); a substantially better fit is also achieved using the latter model.

The average number of plant species for a standard area of 100 km^2 is about 140.

Turning to the total floristic diversity in the Cape Verde islands, as expressed by the α-index, Brava presents a well above average value (0.19), whereas Boavista displays the lowest value (−0.143). Three islands can be considered to possess low diversity (negative α-values): Santa Luzia, Sal and Boavista (Table 2, Fig. 2a). Where endemic flora is concerned, we should note the high values for São Nicolau and Brava, with an α-index of 0.216 and 0.214, respectively, and those well below the mean for Boavista and Maio (−0.284 and −0.259, respectively) (Table 2, Fig. 2b).

Table 2 Values of the α-index (total and endemic flora) in Cape Verde islands (ordination by decreasing value)

Total flora	α-index	Endemic flora	α-index
Brava	0.190	São Nicolau	0.216
São Vicente	0.057	Brava	0.214
Santo Antão	0.045	São Vicente	0.162
São Nicolau	0.041	Santo Antão	0.098
Fogo	0.026	Fogo	0.082
Maio	0.022	Santa Luzia	0.019
Santiago	0.002	Santiago	−0.032
Santa Luzia	−0.049	Sal	−0.090
Sal	−0.115	Maio	−0.259
Boavista	−0.143	Boavista	−0.284

The α-value plot (Fig. 3) reveals a group of islands—Brava, São Vicente, São Nicolau, Santo Antão, and Fogo—with high (positive) α-values both for total and endemic species, whereas Sal and Boavista display low (negative) α-values for both species groups.

Pearson's correlation coefficients between eco-geographical factors and the α-index (total and endemic flora) (Table 3) show significant correlations with longitude, and consequently with distance from the African mainland.

The eco-geographical factors were subjected to correlation analysis in order to detect covariation within the dataset (Table 4). Due to the layout of the archipelago the distance between two neighbouring islands tends to be smaller for the western islands than for the eastern ones. As expected, total rural population is positively correlated with altitude, given that climatic restrictions impose serious restrictions on such activities in arid and semiarid lowlands. Higher-altitude islands are thus the most suited for plant life.

Discussion

The species-choros model (Triantis et al. 2003) proved more accurate than the species-area one (Arrhenius 1921) when it came to expressing total plant species variation in the Cape Verde Islands. Floristic richness is thus better explained by the choros parameter (K') than by area alone, thereby further demonstrating the simultaneous effects of area and habitat diversity on species numbers. Although the real number of habitats could not be used to estimate the K parameter (as proposed by Triantis et al. 2003), the number of floristic zones turned out to be adequate, inasmuch as the model obtained revealed a good fit and explained 84% of the variance in species richness. For endemic flora the species-choros model also proved a better fit than the species-area model, but in this case the percentage of explained variance was lower (54%). This can be related with the fact that speciation processes are linked to a number of other factors, such as the geological age of islands, the presence of gene pools, and the geographic or ecological isolation of populations.

As stated by several authors (e.g., Newmark 1986; Kohn and Walsh 1994; Triantis et al. 2003), the number of habitats should be decided in accordance with the taxonomic group under analysis; in Cape Verde the number of floristic zones is a good reflection of the pattern of plant species richness and can be considered informative in relation to the islands' bioclimatic zonation, and used as a rough estimate of potential habitat diversity. This parameter provides some important ecological information, given that the conditions for plant life in the archipelago are considerably improved at altitudes above 300–400 m (on windward and leeward slopes, respectively), because vertical precipitation is further

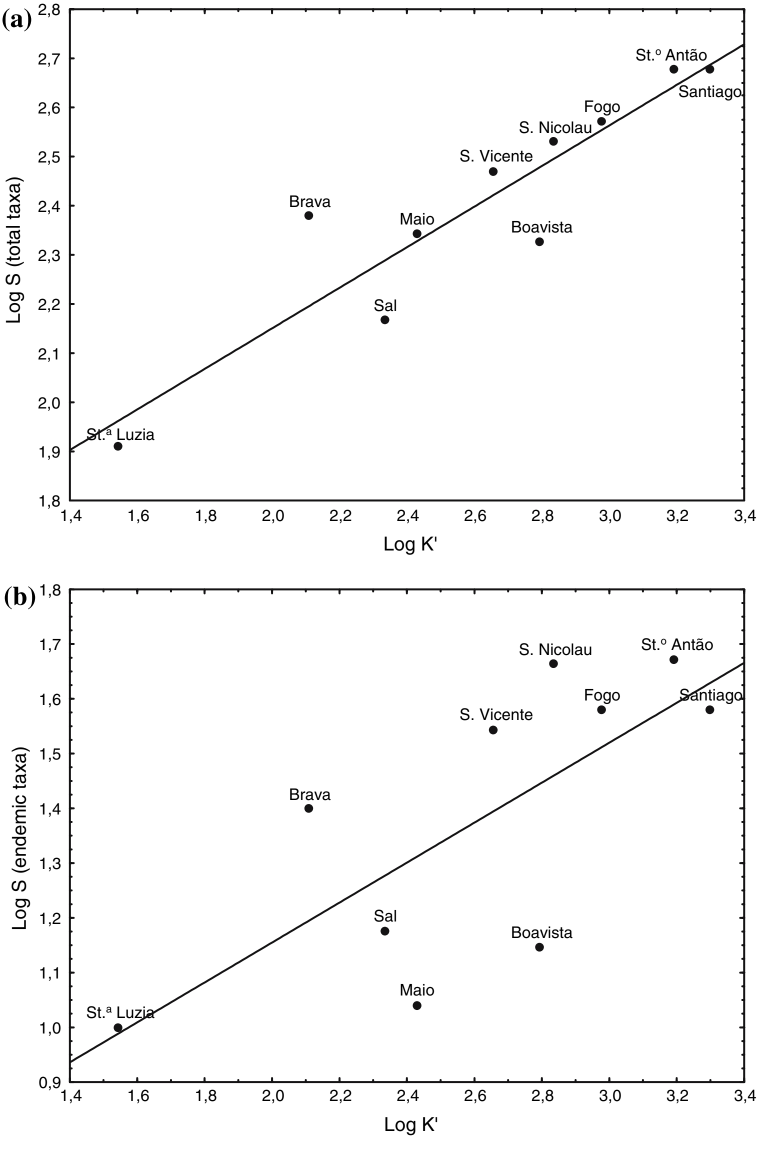

Fig. 2 The species-choros′ (area*number floristic zones) relationships of Cape Verde for (**a**) total taxa and (**b**) endemic taxa. The islands with positive α-values (over the regression) have species diversity above the average (and vice-versa)

increased by horizontal precipitation linked to mist formation, especially on N and NE slopes (Duarte et al. 2005); a more pronounced climatic gradient in both altitude and slope aspect is thus displayed.

The species-area-habitat relationship does a good job of explaining most of Cape Verde's floristic richness. The unexplained component (corresponding to the positive and negative α-values) seems to be related with longitude (Table 3). The importance of this

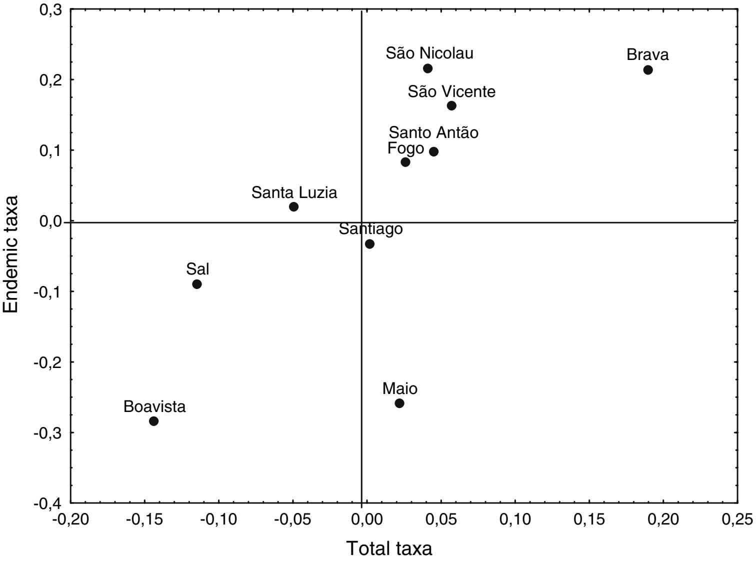

Fig. 3 Plot of α-value of total and endemic taxa

Table 3 Pearson's correlation coefficients of α-index with eco-geographical factors (log values) (*P*—significance levels: n.s.—not significant; * $P < 0.05$; ** $P < 0.01$; *** $P < 0.001$)

	α-index (total flora)		α-index (endemics)	
	R	*P*	*r*	*P*
Latitude (km)	−0.377	n.s.	−0.120	n.s.
Longitude (km)	0.673	*	0.834	**
Minimum distance from nearest island (km)	−0.420	n.s.	−0.506	n.s.
Altitude (m)	0.525	n.s.	0.599	n.s.
Total rural population	0.315	n.s.	0.114	n.s.

factor cannot be associated with the increase in distance to the African mainland, since insular species richness is expected to decrease when distance to the mainland increases (Malyshev 1991). Although it is only possible to note a tendency (Table 4), western islands (the more distant from the African mainland) are frequently the highest. This is related with the islands' age and the geological processes that produced them. According to available data (Torres 1998; Plesner et al. 2002) the age of the Cape Verde islands varies: 25.6 ± 1.1 Myr—Sal, 21.1 ± 6.3 Myr—Maio, 10.3 ± 0.6 Myr—Santiago, 5.9 ± 0.1 Myr—Brava, and 7.57 ± 0.56 Myr—Santo Antão. The western islands are the most recent in the archipelago and exhibit a strong orography, owing to the fact that the effects of erosion processes are not as marked as in the eastern islands (the oldest). They have a particularly high habitat diversity (both climatic and topographic) and a high species richness, which offers a good contrast with the reduced habitat diversity of their arid and semi-arid low eastern counterparts.

Unrelated with floristic diversity (total and endemic flora) is latitude, probably because the possibly related differences in climatic characteristics between the islands are not significant. In his analysis of the relationships between the Macaronesian archipelagos

Table 4 Pearson's correlation coefficients between eco-geographical factors (log values) (*P*—significance levels: n.s.—not significant; * $P < 0.05$; ** $P < 0.01$; *** $P < 0.001$)

	Latitude	Longitude	Minimum distance from nearest island	Altitude
Longitude	0.211 n.s.			
Minimum distance from nearest island	−0.264 n.s.	−0.855**		
Altitude	−0.270 n.s.	0.530 n.s.	−0.172 n.s.	
Total rural population	−0.387 n.s.	−0.077 n.s.	0.361 n.s.	0.656*

Hobohm (2000) found a different result, inasmuch as α-index to total flora emerged as related with latitude, whereas this correlation was non-existent with endemic flora, thus reinforcing the importance of the spatial level of analysis and of the target species group under study. The geographical and ecological relationships of the islands in the archipelago cannot be fully represented by quantitative parameters like altitude, longitude, latitude or proximity to neighbouring islands, and as Hobohm (2000) says, the size and distribution of the individual islands within an archipelago are essential to the evolutionary and speciation processes.

The minimum distance from the nearest island—a factor that could be related with a better dispersal of species—seems unimportant where within-archipelago islands are concerned. Nor do total rural population and the underlying agricultural suitability have significant effects on species diversity. However, on Santiago Island it could be suggested that the particularly large number of rural inhabitants is responsible for a lower than expected species diversity, especially of endemics, since it is the only island with two floristic zones that presents a negative α-value.

In Cape Verde the decrease in total species diversity is generally accompanied by a decrease in the diversity of endemic species (the correlation between both α-index is significant: $r = 0.715$; $P = 0.020$). This pattern is common in other archipelagos and can result from a mutual relationship between habitat diversity and species diversity (Hobohm 2000).

The islands with a large number of exclusive endemic species—Santo Antão (11), São Nicolau (8), and Fogo (7)—generally include high altitudes and large areas, thus suggesting that they are particularly suitable for speciation processes. In fact, to the effects of an increase in floristic zones—and thus in habitat diversity—we must add those of the increase in area, which, as Lomolino and Weiser (2001) point out, improves the carrying capacity and extinction/immigration dynamics, and provides internal geographical isolation for in situ speciation. The gene flow is reduced in mountainous zones and plant populations are consequently more isolated. This is supported by the occurrence in these islands of several genera represented by different endemic taxa in geographically separated habitats [e.g., *Diplotaxis antoniensis* Rustan, *D. gorgadensis* Rustan subsp. *brochmannii* Rustan and *D. gorgadensis* Rustan subsp. *gorgadensis* on Santo Antão, *Diplotaxis gracilis* (Webb) O.E. Schulz and *D. sundingii* Rustan on São Nicolau, and *Tornabenea humilis* Lobin & K.H. Schmidt and *T. tenuissima* (A. Chev.) A. Hans. & Sunding on Fogo]. What is more, recent molecular studies on the endemic populations of *Echium stenosiphon* on Santo Antão (Romeiras et al. 2007) revealed a high genetic diversity and reduced levels of gene flow between the geographical isolated populations, and point to ongoing speciation processes.

On the other hand, endemic species with a wider distribution range are those which belong to the arid and semi-arid environments that are common in lowlands [e.g., *Aristida cardosoi* Cout., *Kickxia elegans* (G. Forst.) D.A. Sutton subsp. *elegans* (on 10 islands), *Forsskaolea procridifolia* Webb (on 9), *Paronychia illecebroides* Webb, *Sarcostemma daltonii* Decne. (on 8), *Asparagus squarrosus* J.A. Schmidt and *Nauplius daltonii* (Webb) Wikl. subsp. *vogelli* (Webb) Wikl. (on 7)]. A species' ability to expand its range is enhanced in the case of xerophytes, because there are arid and semi-arid ecosystems in all the islands and this allows a more successful gene flow.

The low number of taxa present in Cape Verde (140 per 100 km^2) is related with the proximity of areas with low floristic richness—the case of the desert and sub-desert regions of the Sahara (156 species according to Malyshev 1991) and the Sahel, and also with the fact that it is an insular system a long way from the mainland, and this restricts colonisation events. According to Malyshev (1991), islands which lie more than 100/200 km from the mainland experience a pronounced floristic impoverishment, mainly due to ecological isolation.

The floristic heterogeneity (z-value)—a phytogeographically important parameter, given that it reveals the increase in species richness with area—for Cape Verde presents a value of 0.41. This parameter, which varies with the geographic unit and with the taxonomic group under analysis (MacArthur and Wilson 1967, Malyshev 1991), is within the range of values which Rosenzweig (1995) indicated for islands or isolated habitat patches (0.2–0.5), and which Hobohm (2000) put forward (0.3–0.6 for archipelagos around the world in general, and 0.4 for Macaronesia). This value is much higher than that computed for the hot dry area of the Sahara, Sudan and Senegal in Africa (0.075), or even than the value given for the tropical African zone, where it reaches 0.2. This reinforces Malyshev's (1991) findings that floristic heterogeneity values are generally higher in isolated floras or in insular systems than in nearby mainland regions. The lower value which Fernández-Palacios and Andersson (2000) calculated for plant species in the Canaries—0.27—may be related with the latter archipelago's proximity to the African mainland.

In Cape Verde special attention has been paid to plant species conservation in the higher altitude areas of Santo Antão, São Vicente, São Nicolau, Santiago and Fogo (Silva et al. 1999). The large number of species and endemisms in these islands is confirmed by the high α-values (excluding Santiago), and their ecological value as biodiversity hotspots is indubitable, especially considering that they are seriously threatened by agricultural activities. Beyond these areas, we should point to a number of lowland zones, where arid and semi-arid habitats occur. The sand dunes and the very restricted areas of salt marsh, where psammophytic and halophytic plant species occur respectively, are fragile ecosystems and are currently threatened by the increase in leisure and tourism-related activities, as evidenced by recent field work (2005) by the first author. It is also reported that on some islands a number of xerophyte endemic species have become extinct [e.g., *Brachiaria lata* subsp. *caboverdeana* on São Nicolau, *Diplotaxis glauca* on Boavista, *Lotus brunneri* on São Vicente, *Pulicaria diffusa* on Maio and Fogo, and *Sporobolus minutus* subsp. *confertus* on Sal (Brochmann et al. 1997)]. Although quantitative floristic indices provide information that is relevant to conservation issues, data about the location of rare species or rare vegetation types are also necessary for sustainable conservation planning (Bonn and Gaston 2005).

Though in the Cape Verde archipelago there is a strong correlation between the areas with a high diversity of both total species and endemics, as Werner and Buszko (2005) note, priority conservation schemes should be worked out separately for total and endemic species because many species-poor ecosystems (like those of arid and semi-arid areas) are refuges for remarkable plant species.

If the α-value is used to rank biodiversity hotspots, Brava (for total and endemic flora) and São Nicolau (for endemic species) stand out from the other Cape Verde islands. Little attention has been paid to Brava—one of the smallest members of the archipelago (64 km^2), albeit with an appreciable altitude (979 m)—in particular, and this suggests the need for a more careful evaluation of the conservation issues. This is reinforced by the fact that this island displays the highest percentage of extinct or threatened endemic species in the archipelago (64%, according to Leyens and Lobin 1996).

Although there is a certain tendency to conserve single large islands rather than several small ones, if the probabilities of species persistence are to be maximised, conservation planning must bear in mind the specificity of the areas under evaluation and, as mentioned by Koh et al. (2002), the way in which target taxonomical groups respond to biogeographical variables. A desirable goal in the establishment of protected areas is to maximise environmental diversity—a factor which, as Faith and Walker (1996) say, should guarantee the representation of a diversity of species.

In Cape Verde archipelago about 31.3% of the native vascular flora and 53.6% of endemic species are extinct or threatened (Leyens and Lobin 1996). Most endemic species populations are small in size, are geographically isolated and are influenced by human impacts on their natural habitats. The conservation and management of natural plant resources in this archipelago is a huge challenge, and several criteria must be set in order to ensure not only the safeguarding of existing diversity, but also that of the long-term evolution of this insular flora.

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