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Seed Bank Dynamics in Altitudinal Gradient on an Inselberg in a Nigerian Secondary Forest

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Abstract: We studied the germinable soil seed bank along an altitudinal gradient on an Inselberg in a secondary rain forest in Nigeria. We selected three sampling plots at three altitudinal levels (290, 370 and 450 m). We assessed the composition of the established vegetation. We took twenty soil samples (0-15 cm depth) at each plot in dry and rainy seasons and the seed banks composition was determined by greenhouse germination over a 6-months period. The similarity between the composition of the seed bank flora and that of the established vegetation was low throughtout the gradient. Seed bank density and diversity is environment-dependent for most species. At low altitudes, richness is greater and annual species dominate while at higher altitudes richness diminishes and perennial dominates.

Key words: Environmental gradient, soil seed bank, forest, inselberg, Nigeria

INTRODUCTION

Environmental factors such as altitude and topography have been recognized as key factors in the structure, function and floristic composition of vegetation in the tropics. Altitude-related changes have been detected in the floristic composition and species richness of vegetation. Seed bank density and species richness have been reported to change along temporal (succession) and spatial (altitude, latitude) gradients (Thompson, 1978; Warr *et al*., 1993). For example Thompson (1978, 1985) showed that seed bank density decreases with altitude. This is because at high altitude, there is a predominance of slow-growing and long-lived species and environmental conditions (short growing season) are less favourable to seed production (Archibold, 1984; Thompson, 1992). These ideas were reinforced by the results of Ortega *et al*. (1997) who found that richness and density of seed bank decreased with altitude in Spanish mountain grasslands. At low altitudes, richness is greater and annual species dominate, while at higher altitudes, richness diminishes and perennial dominates (Montalvo *et al*., 1991a, b). On a local scale, topography cause a water-stress gradient and influences the size of seed banks (Ortega *et al*., 1997). If the dominant species at high altitude do not form a persistent seed bank, the similarity between the composition of established vegetation and seed bank should decrease with altitude (Peco *et al*., 1998).

However, an altitude hypothesis has been proposed (Funes *et al*., 2003). In cold climate (e.g., high mountains or high altitudes) several factors would contribute to the maintenance of many seeds in the soil (Archibold, 1984; Cavieres and Arroyo, 2001). The diversity of both seed predators and fungi tends to be low in high-mountain habitats (Mc Graw and Vavreck, 1989) and low temperatures are associated with low embryonic metabolic rates and show consumption of seed reserves, favouring seed longevity (Murdoch and Ellis, 2000) and thus the formation of persistent seed bank remain in the soil for long periods (Thompson *et al*., 1997). This is high carry-over of soil seeds from year to year should increase the total seed bank density toward higher altitudes. If this assumption is correct, seed bank density should increase with altitude. Thompson and Grime (1979)

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suggested that seed bank strategy is independent from the environment. However, Ortega *et al*. (1997) and Funes *et al*. (2001) reported different populations of the same species, in relation to changing micro-environmental conditions at the local scale. Furthermore, a temporal pattern in the number of germinable seeds in the soil has been detected with a minimum in spring (Young *et al*., 1981). Predator mainly takes place in the summer coinciding with the period of maximum insect activity, most germination occurs in the autumn after the first effective rains (Espigares and Peco, 1993).

The aim of this study is to examine the variation in richness and density of soil seed banks and the relationship between the composition of the established vegetation and seed banks at different altitudes on an inselberg in Ile-Ife area of Southwestern Nigeria.

MATERIALS AND METHODS

Study Area

The study was carried out on an inselberg in a secondary rain forest in the Biological Gardens of the Obafemi Awolowo University, Ile-Ife (latitude 7°30' to 7°35' N, longtitude 4° 0' to 4°35' E) southwestern Nigeria. The elevation ranges from 286 to 461 m a.s.l. (Hall, 1969). The forest is a natural regrowth under conservation within and outside the Gardens with minimal human disturbance. The age of the forest cannot be accurately determined since the time of last major disturbance is not known but it is estimated to be about 59 years old (Muoghalu and Okesan, 2005).

The Ife area lies in dry deciduous forest zone (Onochie, 1979). White (1983) described the vegetation as Guineo-Congolian dried forest type. There are two seasons in the area, the rainy season (March to November) and the dry season (November to March). The annual rainfall averaged 1413 mm per year in a 5 year survey (Duncan, 1974) and showed two peaks, one in July and the other in September. The mean annual temperature ranges from 22.5 to 31.4°C.

The area is underlain by rocks of the Basement complex, which are the Precambrain age (De Swardt, 1953). The forest covers the base and lower slope and grassland and woodland cover the upper slope and peak of the inselberg underlain by granite gnesiss. Soil has been classified as Lixisols (FAO/UNESCO, 1974) and Ultisols (USDA, 1975). Soils are usually acidic and contain <10% clay which is kaolinite and hence are characterized by low cation exchange capacity (Ayodele, 1986).

Data Collection

Three sample plots designated A, B and C, each 25×25 m, were established at 80 m intervals along an altitudinal gradient from the base 290 m a.s.l. to the peak 461 m a.s.l. of the inselberg. Within each plot all shrubs, trees and herbaceous species were identified to species level and enumerated. Species nomenclature follows those of Hutchinson and Dalziel (1954-1972). In each of the three plots, twenty replicate soil samples were randomly collected to a depth of 15 cm using a soil auger of diameter 8.5 cm, taking into account that most viable seeds are located within the first few cm (Funes *et al*., 2001). The soil samples were collected in March 2004 for the dry season and October 2004 for the rainy season in order to capture both the transient seed bank of the present year and persistent fraction of the seed bank. The samples were put in polythene bags, labeled and were then transferred to the laboratory where they were spread on tables to dry. The soil samples were transferred after drying into porous plates and placed in the screen house in April 2004 (dry season collection) and November 2004 (rainy season collection) where they were watered daily and monitored for seedling emergence. There were ten plates for each plot for each for each season making a total of sixty plates per for the two seasons. Plates were kept in the screen house for 6 months and whenever possible seedlings were identified at an early stage and removed from the plates. When flowers and or fruits were required for correct identification, seedlings were transplanted into separate plots and grown on natural unfertilized soil within the same screen house. Most of the seedlings were identified to species level. Once in a while, the soil in each plate was turned over and mixed so as to aid seed germination. The germination method is considered the most appropriate for studying the composition of species in the soil seed bank, particularly in natural systems with high floristics richness (Gross, 1990).

The total number of individuals and species in each plate for each plot for both dry and rainy seasons collection was determined. The percentage contribution of each species to the seed bank were also determined seasonally. Sorenson index of similarity was also used to compare the similarity in species composition among the plots in each sampling gradient. To assess the contribution of the seed bank to the various forest plant community, the occurring species in seed bank and the established vegetation were compared.

RESULTS

Standing Vegetation Composition

There were 126 plant species encountered in 117 genera and 49 families while 5 plant species were unidentified in the vegetation at all the three altitudes (plots). The plant species in these three study plots consist of a total of 86 woody species (68.5%), 5 grass species (3.9%), 11 forbs (8.7%) and 24 climber species (18.8%) (Table 1). The common woody species in the standing vegetation at all the three altitudes are: *Albizia zygia*, *Alchornea latifolia*, *Baphia nitida*, *Dialium guineensis*, *Holarrhena floribundia*, *Lecaniodiscus cupanoides*, *Monodora tenufolia*, *Newbouldia laevis* and *Rothmania longiflora* while no grass, forb and climber species was common in the vegetation at the three altitudes (plots).

Table 1: Plant species composition of the study plots along altitudinal gradient on an inselberg in Ile-Ife area of Southwestern Nigeria

		Plots		
Trees and shrubs species	Family	A	B	C
Afzelia africana	Caesalpinoideae	-	+	-
Albizia adianthifolia	Mimosoideae	+	+	-
Albizia zygia	Mimosoideae	+	+	+
Alchornea latifolia	Euphorbiaceae	+	+	+
Allophylus africanus	Sapindaceae	+	-	-
Alstonia boonei	Apocynaceae	+	+	-
Antiaris africana	Moracaeae	+	+	-
Baphia nitida	Papilionoideae	+	+	+
Bambusa vulgalris	Poaceae	+	-	-
Blighia sapida	Sapindaceae	+	+	-
Blighia unijugata	Sapindaceae	+	+	-
Bombax buonopozense	Bombacaceae	+	+	-
Brachystegia nigerica	Caesalpiniodaceae	-	-	+
Bridelia atrovidris	Euphorbiaceae	+	-	-
Bridelia micraantha	Euphorbiaceae	+	+	-
Canarium schweinfurthii	Anarcardiaceae	-	+	-
Canthium vulgare	Rubiaceae	-	+	-
Carpolobia lutea	Polygalaceae	+	+	-
Celtis philippensis	Ulmaceae	+	+	-
Celtis zenkeri	Ulmaceae	+	+	-
Chassalia kolly	Rubiaceae	+	+	-
Chrysophyllum albidum	Sapotaceae	+	+	-
Coffea ebracteolata	Rubiaceae	+	-	-
Cola milleni	Sterculiaceae	+	+	-
Cola nitida	Sterculiaceae	-	+	-
Cuviera acutifolia	Rubiaceae	-	+	-
Cuviera nigrescens	Rubiaceae	-	+	-
Daniella ogea	Caesalpinoideae	+	+	-
Deinbollia pinnata	Sapindaceae	+	+	-

Table 1: Continued

		Plots		
Trees and shrubs species	Family	A	B	C
Dialium guineense	Caesalpinoideae	+	+	+
Diachapetalum guineense	Dichapetalaceae	+	-	-
Dictyandra arborenscens	Rubiaceae	+	-	-
Didymosalpinx abbeokutea	Rubiaceae	-	+	-
Diospyros monbuttensis	Ebenaceae	+	+	-
Discoglypremna calonura	Euphorbiaceae	-	+	-
Draceana arborea	Agavaceae	+	+	-
Elaeis guineensis	Palmae	-	+	-
Ficus exasperata	Moraceae	+	-	-
Ficus mucuso	Moraceae	+	+	-
Funtumia elastica	Apocynaceae	+	+	-
Glyphaea brevis	Tiliaceae	+	+	-
Holarrhena floribunda	Apocynaceae	+	+	+
Holoptela grandis	Ulmaceae	-	+	-
Homalium letestui	Sapindaceae	+	-	-
Lannea welwitschii	Anacardaceae	-	-	+
Lecanioidiscus cupanoides	Sapindaceae	+	+	+
Malancantha alnifolius	Sapotaceae	+	-	+
Manihot glaziovii	Euphorbiaceae	-	+	-
Mallotus oppositifolius	Euphorbiaceae	+	-	-
Margaritaria discoidea	Euphorbiaceae	-	+	-
Microdesmis puberula	Pandaceae	+	+	-
Milicia excelsa	Moraceae	-	+	-
Milletia thonnigii	Papilioniodeae	+	-	-
Maesopsis eminii	Rhamnaceae	-	+	-
Monodora tenufolia	Annonceae	+	+	+
Morinda lucida	Rubiaceae	+	-	-
Myrianthus arboreus	Moraceae	+	+	-
Napoleona vogelii	Lecythidaceae	+	+	-
Newbouldia laevis	Bignoniceae	+	+	+
Ouratea flava	Ochinaceae	-	+	-
Oxyanthus speciosus	Rubiaceae	+	-	-
Pevatta corymbosa	Rubiaceae	-	+	-
Pierreodendron africanum	Simaroubaceae	-	+	-
Piptadenistrum africanum	Mimosoideae	+	-	-
Pleioceras barteri	Apocynaceae	+	-	-
Phychotria sp.	Rubiaceae	+	-	-
Pterocarpus mildbraedii	Papilionoideae	+	-	-
Pycnanthus angolensis	Myristiceae	+	+	-
Rauvolfia vomitoria	Apocynaceae	+	+	-
Ricinodendron heudelotii	Euphorbiaceae	-	+	-
Rothmania longiflora	Rubiaceae	+	+	+
Rytignia nigerica	Rubiaceae	-	+	-
Spheocentrum jollyanum	Menispermeceae	+	+	-
Spondias mombin	Anacardiaceae	+	-	-
Steculia tragacantha	Sterculiaceae	+	-	+
Tabernaemontana pachysihon	Apocynaceae	-	+	-
Terminalia ivorensis	Combretaceae	-	+	-
Tetrapleura tetraptera	Mimosoidaeae	+	-	-
Tectrochidium didymostemon	Euphorbiaceae	-	+	-
Theobroma cacao	Sterculiaceae	-	+	-
Trichilia heudelotti	Meliaceae	+	+	-
Trichilia prieureana	Meliaceae	+	+	-
Trema orientalis	Ulmaceae	+	+	-
Trilepisium madagascariense	Moraceae	+	-	-
Voacanga africana	Apocynaceae	+	+	-
Zanthoxylum rubescens	Rutaceae	-	+	-
No. of woody species		60	63	13

Table 1: Continued

		Plots		
Trees and shrubs species	Family	A	B	C
Grasses				
Andropogon tectorum	Poaceae	-	+	+
Monocymbium ceressiforme	Poaceae	-	-	+
Panicum maximum	Poaceae	-	-	+
Pennisetum polystachium	Poaceae	-	-	+
Rottboelia exaltata	Poaceae	-	+	-
No. of grass species		-	2	4
Forbs				
Aloe sp.	Liliaceae	-	-	+
Aspilia africana	Compositae	-	-	+
Boerhavia diffusa	Nyctaginaceae	-	-	+
Chromoleana iterate	Compositae	-	-	+
Costs after	Zingiberaceae	-	+	-
Cyanostis sp.	Commelinaceae	-	-	+
Dissotis sp	Melastomaceae	-	-	+
Hypoetes verticillaris	Labiteae	-	-	+
Indigofera spicata	Papilionoideae	-	-	+
Tephrosia bracteolata	Papilionoideae	-	-	+
Sida acuta	Malvaceae	-	-	+
No of forb spp.		-	1	10
Climbers				
Acacia ataxacantha	Mimosoideae	+	+	-
Agelae sp.	Connaraceae	+	+	-
Alifia barteri	Apocynaceae	+	-	-
Aristolochia godigerana	Aristolochiaceae	-	+	-
Cnestis ferruginea	Connaraceae	+	+	-
Culcasia saxatitilis	Araceae	-	+	-
Calopogonium mucunoides	Papilionoideae	-	+	-
Combretum smeathmannii	Combretaceae	-	+	-
Dalbergia welwitschii	Papilionoideae	-	+	-
Dalbergia luctea	Papilionoideae	-	-	+
Dioscorea alata	Discoreaceae	-	+	-
Entada pursaetha	Mimosoideae	+	+	-
Hippocratea velutina	Celasteraceae	+	-	-
Icacinia trichantha	Icacinaceae	-	+	+
Ipomea eriocarpa	Convolvulaceae	-	+	+
Leptoderrsis micrantha	Papilionoideae	+	+	-
Mucuna pruiens	Papilionoideae	+	+	-
Motadra guineensis	Apocynaceae	-	+	-
Neostachyanthus occidentalis	Icacinaceae	-	+	-
Phyllantus mullerianus	Euphorbiaceae	-	+	-
Ritchiea longipedicellata	Carpparidaceae	+	+	-
Rutidea olentricha	Rubiaceae	-	+	-
Smilax anceps	Smilacaceae	-	+	-
Spiropetalum sp.	Connaraceae	-	+	-
No. of climber species		09	21	03
Total No. of plant species		69	87	30

+ = Species present, - = Species absent

Species Richness and Density of Soil Seed Bank

In total 71 species belonging to 27 families germinated from the soil samples. The dominant plant families were Poacea (7 species), Euphorbiacea (6 species), Asteracea and Moracea (5 species each). The number of species found per sample was higher in the dry season soil collection than rainy season soil collection. The species richness of the seed bank changed significantly with altitude both in dry and rainy season ($p<0.05$). In the dry season soil collection the lower altitudes showed significantly more species than the other higher altitudes (Table 2). In the rainy season soil it follows the same trend but less gradual (Table 3)

Table 2: Density of species (seedlings (cm^{-2}) and seeds (m^{-2})) that emerged from the dry season soil collection in the three study plots along an altitudinal gradient on an inselberg

		Plots								
		A (290 m a.s.l.)			B (370 m a.s.l.)			C (450 m a.s.l)		
Species	Family	1	2	3	1	2	3	1	2	3
Alchornea cordifolia	Euphorbiaceae				04	70	1.44	02	35	1.15
Andropogon gayanus	Poaceae				12	210	4.33	16	280	9.17
Andropogon tectorum	Poaceae				14	245	5.06	24	420	13.76
Aspilia africana	Asteraceae							25	438	14.35
Brachaiara deflexa	Poaceae				03	53	1.09	08	140	4.59
Calapagonium mucunoides	Papilionaceae				01	18	0.37			
Cassia absus	lLeguminosal				01	18	0.37			
Carica papaya	Caricaceae	02	35	0.65						
Chromolaena iterate	Asteraceae	46	805	14.96	18	315	6.50	55	963	31.54
Clerodendron splendens	Verbanaceae	23	403	7.49	07	123	2.54			
Coccorus aestinans		06	105	1.95						
Commelina benghalensis	Commeliaceae				02	35	0.72			
Commelina diffusa	Commeliaceae				01	18	0.37	01	18	0.59
Dioscorea bulbifera	Dioscoreae				05	88	1.82	01	18	0.59
Elytratia marginata	Poaceae				01	18	0.37			
Eragrotis tenella	Poaceae				03	53	1.09	01	18	0.59
Eulophia guineensis	Orchidaceae				01	18	0.37			
Euphorbia hirta	Euphorbiaceae	01	18	0.34						
Ficus exasperata	Moraceae	01	18	0.34	09	158	3.26			
Ficus mucuso	Moraceae				01	18	0.37			
Gloriosa superva	Liliaceae							01	18	0.59
Gongronema latifolia		01	18	0.34	01	18	0.37			
Kalachoe crenata	Crassulaceae				02	35	0.72			
Lactinca taraxacifolia	Asteraceae				05	88	1.82			
Laportea aestuans	Urticaceae	33	576	10.70	09	158	3.26			
Laportea ovalifolia	Urticaceae	01	18	0.34						
Lidernia numularifolia	Scophulariaceae	01	18	0.34						
Ludwigia decurrens	Onagraceae	05	88	1.64	08	140	2.89	01	18	0.59
Malvastrum caromandelianum	Malvaceae	09	158	2.94	03	53	1.09			
Manihot glaziovii	Euphorbiaceae	01	18	0.34	01	18	0.37			
Mariscus alternifolius	Cyperaceae	01	18	0.34	05	88	1.82	04	70	2.29
Mariscus longibracteatus		01	18	0.34						
Marsilea sp.		01	18	0.34						
Mitracarpus scaber	Rubiaceae				02	35	0.72			
Momordica charantia	Cucurbitaceae	01	18	0.34						
Morinda lucida	Rubiaceae				02	35	0.72			
Morus mesazygia	Moraceae	26	455	8.46	15	263	5.43			
Myrianthus arboreus	Moraceae	02	35	0.65	05	88	1.82	01	18	0.59
Oldenlandia corymbosa	Rubiaceae	01	18	0.34	04	70	1.44	01	18	0.59
Oxalis corniculata		64	1120	20.81	05	88	1.82			
Palisota hersuta	Commelinaceae							02	35	1.15
Pepperomia pellucida	Piperaceae	04	70	1.30	20	350	7.22	02	35	1.15
Phyllantus amarus	Euphorbiasceae	05	88	1.64	07	123	2.54			
Pyyllantus mullerianus	Euphorbiaceae				10	175	3.61			
Physalis angulata	Solanaceae	05	88	1.64	01	18	0.37	02	35	1.15
Pouzolia guineensis	Urticaceae	01	18	0.34	11	193	3.98	07	123	4.03
Rottboellia cochinchinensis	Poaceae							01	18	0.59
Scoparia dulcis	Scrophulariaceae	01	18	0.34	05	88	1.82	05	88	2.88
Sida rhombifolia	Malvaceae				01	18	0.37			
Smilax anceps	Smilacaceae				02	35				
Solanum torvum	Solanaceae	14	245	4.55	12	210	4.33	02	35	1.15
Solanum verbasifolia	Solanaceae	01	18	0.34				02	35	1.15
Solenostrum monostachyus	Laminaceae				01	18	0.37			
Spigelia anthelmia	Loganiaceae	12	210	3.90	10	175	3.61	03	53	1.74
Spilanthes filicaulis		02	35	0.65						
Talinum trangulare	Portulacaceae	09	158	2.94	07	123	2.54	01	18	0.59
Tephrosia pedicellata	Leguminosae							01	18	0.59

1 = Seedling (cm^{-2}), 2 = Seedling (m^{-2}), 3 = SB (%)

Table 2: Continued

		Plots								
		A (290 m a.s.l.)			B (370 m a.s.l.)			C (450 m a.s.l)		
Species	Family	1	2	3	1	2	3	1	2	3
Tithonia rotundifolia	Asteraceae				01	18	0.37			
Trema orientalis	Ulmaceae	26	455	8.46	35	613	12.65	01	18	0.59
Tridax procumbens	Asteraceae				01	18	0.37			
Triplochiton scleroxylon	Moraceae							02	35	1.15
Wassadula anplissima	Malvaceae							02	35	1.15
Zehrenia capphsia					02	35	0.72			
Total		307	5381	100%	276	4845	100.0%	172	3053	100%

1= Seedling (cm^{-2}), 2 = Seedling (m^{-2}), 3 = SB (%)

Table 3: Density of species (seedlings (cm^{-2}) and seeds (m^{-2})) that emerged from the rainy season soil collection in the three study plots along an altitudinal gradient on an inselberg

		Plots								
		A (290 m a.s.l.)			B (370 m a.s.l.)			C (450 m a.s.l)		
Species	Family	1	2	3	1	2	3	1	2	3
Acalypha ciliata	Euphorbiaceae	04	70	2.50	08	140	6.49			
Andropogon gayanus	Poaceae				03	53	2.46	06	105	7.48
Andropogon tectorum	Poaceae							01	18	1.28
Axonopus compressus	Poaceae	01	18	0.64						
Brachaiara deflexa	Poaceae	01	18	0.64	39	683	31.68	18	315	22.45
Chromolaena iterate	Asteraceae	05	88	3.14	10	175	8.12	23	403	28.72
Euphorbia hirta	Euphorbiaceae	01	18	0.64				03	53	3.78
Ipomea triloba	Convolvulaceae				01	18	0.84			
Momordica charantia	Cucurbitaceae	01	18	0.64						
Oxalis corniculata		01	18	0.64						
Parquetina nigrescens		01	18	0.64	01	18	0.84			
Pepperomia pellucida	Piperceae	03	53	1.89	01	18	0.84	01	18	1.28
Phyllantus amarus	Euphorbiaceae				02	35	1.62			
Physalis angulata	Portulacaceae							02	35	2.50
Portulaca quadrifolia	Portulaceae	105	1838	65.53	02	35	162			
Pouzolia guineensis	Urticaceae				01	18	0.84			
Sloanum terinthum	Solanaceae	02	35	1.25						
Solenostrum monostachyus	Laminaceae	01	18	0.64	04	70	3.25	02	35	2.50
Spigelia anthelmia	Loganiaceae				02	35	1.62	01	18	1.28
Talium triangulare	Portulacaceae	34	595	21.21	47	823	38.17	23	403	28.72
Xanthosoma esculentus	Araceae				02	35	1.62			
Total		160	2805	100%	123	2156	100%	80	1403	100%

1= Seedling (cm^{-2}), 2 = Seedling (m^{-2}), 3 = SB (%)

Soil seed bank density decreased with altitude both in the dry and rainy season soil collections (Table 2 and 3), although, this difference was significant ($p<0.05$) only in the dry season soil collection. Furthermore, seed density was significantly greater in the dry season than in rainy season ($p<0.05$). As altitude increased, the number of seed m^{-2} of the dry season seed banks dropped from 5381 to 3053 (Table 2) and in the rainy season, this number fell from 2805 to 1403 (Table 3).

Established Vegetation and Soil Seed Bank

At all altitudes, both on the dry and rainy seasons, the Sorensen similarities between the established vegetation and the soil seed bank were low. One hundred and six species present in the vegetation were absent from the seed banks at all the three altitudes. Moreover, 61 species occurring in the seed bank were absent in the established vegetation. Only 10 species were found both in established vegetation and in the seed bank and these include 6 trees/shrubs, 2 forbs, 1 grass and 1 climber.

DISCUSSION

The decrease in seed density in the dry and rainy seasons germinable seed banks as altitude increases seems to be related to the change of species communities determined by climatic variation. The low temperatures at the high end of the gradient cause a shortening of the reproductive period (Ortega *et al*., 1993). These species probably reduce their seed production at the expense of increasing their vegetative growth as a form of alternative reproduction in unfavourable situations. The negligible contribution of perennial species to seed banks has already been described by Major and Pyolt (1966) and Thompson (1985) have also observed smaller seed banks as altitude increases in British pastures. The fall in species richness (21) of the seed banks when the pasture altitude rises is also probably linked to the fall in richness found in the vegetation (Mantalvo *et al*., 1991b). The floristic composition of the standing vegetation in this study site falls from 69 to 30 as the altitude rises (461 m.a.s.l). The change in microclimate and fertility associated with topography gradient (Pope and Lioyd, 1975) in which the low zones have a more favourable environment for the development of vegetation may also be responsible for the decline in species and density of seed bank as altitude rises. Furthermore, the accumulation of water in the low slope zones, which can be regarded as positive factor in the low positions on the altitudinal gradient can contribute to higher species diversity and density seed bank because it can cause the accumulation of the seeds (Ortega *et al*., 1997). The patterns found by Ortega *et al*. (1997) and Thompson (1978, 1985) whereby seed bank density falls as altitude increases were repeated in the study but does not agree with the finding of Funes *et al*. (2003) whereby seed bank richness increased with altitude. We found a low degree of similarity between the composition of established vegetation and that of soil seed banks along the gradient. Present data confirm the results obtained in several part of the world, where a very low degree of association has been found between the composition of seed banks and that of the standing vegetation (Major and Pyott, 1966; Abrams 1988, D' Angela *et al*., 1988; Bakker, 1989, Warr *et al*., 1993; Oke *et al*., 2006).

The relation between seed bank density, diversity and altitude has been proven and seasonal variation of seed numbers is environment-dependent for most species. At low altitudes, richness is greater and annual species dominate while at higher altitudes richness diminishes and perennial dominates

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