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Ecological Amplitudes of Ecuadorian Palms

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Ecuador is situated on the west coast of South America, straddling the equator. The mainland part of the country covers 279000 km^2 (excluding territories in reclamation), and is divided by the Andes Mountains, which traverse the country from north to south, into three natural regions: the coastal plain to the west, towards the Pacific Ocean; the mountains in the central part of the country with several snow-capped peaks more than 5000 m high; and the Amazonian lowlands to the east. In the western part of the country a strong precipitation gradient exists, with rainfall ranging from approximately 6000 mm in the north to less than 500 mm in the south. In the Andes, a range of climatic zones are found, depending on elevation and humidity. In this part of the country climate varies greatly from valley to valley, depending on its orientation and local rain shadow effects. The overall result of the varied climatic and topographical conditions is the occurrence of a wide range of ecological life zones, as defined by temperature and humidity (Cañadas 1983). The palm flora of Ecuador is correspondingly rich. One-hundred-twenty-four native species in 29 genera have been recorded in the country, corresponding to 43% of the genera and 24% of the species recognized for the Americas by Henderson et al. (1995).

In a recent publication, Skov and Borchsenius (in press) used the rich palm flora of Ecuador to test a GIS (Geographical Information System) model for predicting plant species distributions based on herbarium vouchers and climatic maps of temperature and precipitation. In this paper we provide a list of the palm taxa presently recorded in Ecuador, together with information on their ecological amplitude generated during that study.

Materials and Methods

Distributions of Ecuadorian palm species were derived from a data base containing information about more than 1900 herbarium specimens determined to species, subspecies, or variety. Naming is in accordance with Henderson et al. (1995), with the following exceptions. In the case of *Geonoma macrostachys*, a narrower concept of taxa was applied as this better suits the pattern of morphological variation found in Ecuador: plants with very narrow bluish-green leaves and male flowers with slender, briefly jointed filaments (conspicuously jointed in *G. macrostachys*), were treated as a separate species, *G. tamandua*, following Wessels-Boer (1968) and Skov (1989); mountain plants with affinity to *G. macrostachys*, but different in their male flower and leaf morphology, were referred to *G. paradoxa*, following Skov (1989); and an unnamed variety of *G. macrostachys* with flowers similar to those of var. *macrostachys*, but with somewhat divided leaves and veins conspicuously raised on the adaxial leaf surface (veins are never raised in the other varieties of *G. macrostachys* in Ecuador), was treated as a separate taxon (var. 1). *Bactris schultesii* was segregated from *B. simplicifrons* and recognized as a separate species due to its simple, wedge-shaped leaf blade and branched inflorescence (in *B. simplicifrons* the blade has 1–10 sigmoid pinnae, and the inflorescence is unbranched). *Bactris setiflora* was segregated from *B. macroacantha* on the basis of its straight, spinulose, more or less regularly inserted pinnae and pale spines on the leaf sheaths (pinnae are sigmoid, glabrous, and strongly grouped in *B. macroacantha*, and the leaf sheath spines are black: A. Henderson, personal communication). Finally, a group of *terra firme* understory palms with affinity to *Bactris corossilla* but different in their much smaller size, distinctly sigmoid pinnae, and proportionally large fruits were treated as a distinct, unnamed species (*Bactris* sp. 1). Segregation of varieties of *Bactris concinna* and *Euterpe*

Table 1. Recorded ecological amplitudes of native Ecuadorian palms.

Species	Number of Records	Altitude Above Sea Level (m)		Mean Annual Precipitation (mm)		Mean Annual Temperature (°C)		Humidity Index		Tolerance of a Dry Season
	N	min	max	min	max	min	max	min	max	
Aiphanes chiribogensis	8	80	2031	2031	5865	16.2	27.6	0.23	0.31	−
Aiphanes eggersii	7	74	441	600	1494	23.2	26.0	0.76	2.14	+
Aiphanes erinacea	17	600	2200	1448	6000	15.7	24.3	0.19	0.54	+
Aiphanes gelatinosa	1	1100	1100	2344	2344	22.9	22.9	0.53	0.53	−
Aiphanes grandis	4	1028	2400	1300	1512	14.2	21.0	0.50	0.75	+
Aiphanes hirsuta subsp. *fosteriorum*	4	800	1600	3090	6000	20.1	24.4	0.19	0.33	−
Aiphanes macroloba	4	568	877	3332	6000	24.0	25.5	0.19	0.38	−
Aiphanes tricuspidata	6	40	600	843	5996	23.0	27.3	0.18	1.19	+
Aiphanes ulei	31	200	1850	3000	6000	17.4	25.9	0.18	.48	−
Aiphanes verrucosa	2	2422	2595	2053	2081	15.0	15.2	0.58	0.58	−
Aiphanes weberbaueri	4	1000	1850	3000	4787	17.7	23.2	0.20	0.42	−
Ammandra dasyneura	4	257	299	3088	3229	25.4	25.6	0.44	0.45	−
Aphandra natalia	6	200	806	2000	5000	23.2	25.9	0.24	0.63	−
Asterogyne martiana	8	100	863	3467	6000	24.0	27.5	0.18	0.37	−
Astrocaryum chambira	10	200	307	3000	4009	25.4	25.9	0.35	0.48	−
Astrocaryum jauari	7	200	299	3000	3229	25.4	25.9	0.44	0.46	−
Astrocaryum standleyanum	4	3	300	1820	3266	24.4	27.3	0.34	0.66	−
Astrocaryum urostachys	20	200	690	3000	4838	24.6	25.9	0.26	0.48	−
Attalea butyracea	14	200	400	3000	4522	25.1	25.9	0.29	0.48	−
Attalea colenda	10	3	368	930	3318	23.3	27.3	0.37	1.32	+
Attalea insignis	6	200	200	3000	3000	25.9	25.9	0.46	0.47	−
Attalea maripa	9	215	400	3000	3180	24.7	25.9	0.44	0.48	−
Bactris acanthocarpa var. *acanthocarpa*	3	200	290	3000	3201	25.5	25.9	0.44	0.46	−
Bactris coloniata	2	100	207	1486	3000	25.9	26.0	0.48	0.77	+
Bactris coloradonis	2	35	495	2190	3351	23.7	27.3	0.32	0.38	+
Bactris concinna	10	200	566	3000	5000	24.6	25.9	0.25	0.48	−
Bactris corossilla	20	200	880	3000	4838	22.0	25.9	0.21	0.48	−
Bactris hirta var. *mollis*	1	300	300	3000	3000	25.4	25.4	0.47	0.47	−
Bactris hondurensis	3	535	801	6000	6000	24.3	25.7	0.19	0.22	−
Bactris macana	6	100	985	930	3750	22.8	25.6	0.25	1.32	+
Bactris maraja var. *maraja*	20	27	810	2991	4536	22.4	27.3	0.25	0.48	−
Bactris riparia	6	200	290	3000	3201	25.5	25.9	0.44	0.46	−
Bactris schultesii	17	200	600	3000	4536	24.7	25.9	0.28	0.48	−
Bactris setiflora	7	600	1000	4000	4397	21.1	23.6	0.22	0.27	−
Bactris setulosa	14	35	1666	2344	6000	18.3	27.3	0.20	0.53	−
Bactris simplicifrons	10	200	1100	2344	3636	22.9	25.9	0.39	0.53	−
Bactris sp. 1	10	200	300	3000	3636	25.4	25.9	0.39	0.48	−
Ceroxylon alpinum subsp. *ecuadorense*	5	1563	1788	1300	2917	16.0	19.6	0.25	0.50	+
Ceroxylon amazonicum	5	1000	1149	2000	3000	22.1	23.4	0.42	0.58	−
Ceroxylon echinulatum	4	1800	1965	1300	4516	15.7	19.2	0.23	0.65	+
Ceroxylon parvifrons	10	1819	3597	1160	2072	9.0	17.4	0.50	1.01	+
Ceroxylon parvum	1	1333	1333	1106	1106	20.7	20.7	0.95	0.95	+
Ceroxylon ventricosum	2	2008	2205	1000	1679	14.4	17.8	0.41	0.75	+
Ceroxylon vogelianum	6	1989	2595	1809	4334	12.8	17.0	0.23	0.59	−
Chamaedorea deneversiana	8	750	1600	2315	6000	20.1	24.6	0.19	0.52	−
Chamaedorea linearis	78	3	2223	783	6000	15.6	27.2	0.19	2.08	+
Chamaedorea pauciflora	41	200	1000	2000	4838	21.6	25.9	0.24	0.60	−
Chamaedorea pinnatifrons	128	200	2329	999	6000	16.0	25.9	0.18	1.21	+
Chelyocarpus ulei	3	200	600	3000	3000	23.5	25.9	0.43	0.47	−
Desmoncus cirrhiferus	11	3	824	2548	6000	22.9	27.2	0.18	0.49	+
Desmoncus giganteus	11	200	441	3000	4838	24.7	25.9	0.26	0.48	−
Desmoncus mitis var. *mitis*	7	200	280	3000	3166	25.5	25.9	0.45	0.48	−
Desmoncus orthacanthos	3	227	290	3000	3201	25.5	25.9	0.44	0.48	−
Desmoncus polyacanthos var. *prunifer*	6	215	1000	3000	4625	21.0	25.9	0.20	0.48	−
Dictyocaryum lamarckianum	5	1149	1600	2694	6000	18.4	20.9	0.18	0.35	−
Elaeis oleifera	2	400	400	3000	3000	24.7	24.7	0.44	0.44	−
Euterpe caatinga var. *roraimae*	3	1000	1029	4455	4481	20.8	21.1	0.20	0.21	−
Euterpe oleracea	7	0	40	1479	3960	27.0	27.4	0.33	0.86	−
Euterpe precatoria	12	40	441	3000	5967	25.1	27.3	0.22	0.48	−

Table 1. Continued.

Species	Number of Records	Altitude Above Sea Level (m)		Mean Annual Precipitation (mm)		Mean Annual Temperature (°C)		Humidity Index		Tolerance of a Dry Season
Geonoma arundinacea	9	200	1850	3000	4763	17.7	25.9	0.26	0.47	−
Geonoma brongniartii	18	200	300	3000	3586	25.4	25.9	0.40	0.48	−
Geonoma camana	13	200	300	3000	4155	25.5	25.9	0.34	0.46	−
Geonoma congesta	8	44	535	4517	6000	25.7	27.6	0.20	0.29	−
Geonoma cuneata var. *cuneata*	59	16	1426	985	6000	20.5	27.3	0.18	0.89	+
Geonoma cuneata var. *gracilis*	8	80	801	2190	6000	23.4	27.6	0.18	0.33	+
Geonoma cuneata var. *procumbens*	30	36	1201	2583	6000	21.2	27.6	0.19	0.40	+
Geonoma cuneata var. *sodiroi*	11	247	900	2885	6000	21.2	24.6	0.19	0.35	+
Geonoma densa	11	2183	3085	1159	3412	11.4	16.4	0.27	0.90	−
Geonoma deversa	26	20	1200	3000	6000	20.9	27.3	0.22	0.46	−
Geonoma gastoniana	3	1807	1819	3030	3033	17.8	17.9	0.34	0.34	−
Geonoma interrupta	18	3	1200	2000	4438	20.2	27.2	0.22	0.64	−
Geonoma irena	10	40	300	2813	3318	24.4	27.3	0.34	0.38	+
Geonoma laxiflora	7	200	200	3000	3000	25.9	25.9	0.46	0.46	−
Geonoma leptospadix	20	256	1821	985	6000	18.4	26.9	0.19	0.89	+
Geonoma linearis	2	200	295	5380	5426	26.2	26.7	0.20	0.20	−
Geonoma longepedunculata	17	200	1000	3000	3241	23.1	25.9	0.40	0.47	−
Geonoma macrostachys var. *acaulis*	20	200	604	3000	4536	23.5	25.9	0.29	0.47	−
Geonoma macrostachys var. *macrostachys*	78	200	1119	3000	5884	21.0	25.9	0.21	0.48	−
Geonoma macrostachys var. 1	34	200	1106	3000	5000	21.2	25.9	0.19	0.47	−
Geonoma maxima var. *maxima*	24	200	400	3000	3636	24.7	25.9	0.39	0.48	−
Geonoma orbignyana	29	1396	2899	1300	6000	12.7	20.1	0.19	0.70	+
Geonoma paradoxa	18	935	1917	2364	6000	17.4	22.2	0.18	0.48	−
Geonoma poeppigiana	4	200	300	3000	3000	25.4	25.9	0.46	0.47	−
Geonoma polyandra	10	200	604	3000	3594	23.5	25.9	0.35	0.48	−
Geonoma stricta var. *piscicauda*	70	200	1582	2344	5000	18.5	26.0	0.20	0.53	−
Geonoma stricta var. *stricta*	32	200	1000	3000	4838	23.4	25.9	0.26	0.48	−
Geonoma stricta var. *trailii*	14	200	1000	3000	4155	23.4	25.9	0.34	0.47	−
Geonoma tamandua	16	200	431	3000	4826	24.7	25.9	0.27	0.47	−
Geonoma tenuissima	4	400	566	3032	3084	23.4	24.0	0.33	0.33	+
Geonoma triglochin	12	200	1000	3000	3201	23.1	25.9	0.41	0.47	−
Geonoma undata	45	528	2289	996	6000	15.9	24.6	0.19	1.22	+
Geonoma weberbaueri	9	2000	2791	1692	2845	11.2	16.4	0.24	0.60	−
Hyospathe elegans	74	200	1800	2000	6000	17.1	25.9	0.18	0.53	+
Hyospathe macrorachis	6	1819	2245	3030	3419	16.0	17.8	0.28	0.34	−
Iriartea deltoidea	30	40	1029	2000	5426	20.8	27.3	0.20	0.64	+
Manicaria saccifera	1	16	16	2784	2784	27.2	27.2	0.43	0.43	−
Mauritia flexuosa	9	200	800	2116	4339	23.7	25.9	0.28	0.59	−
Mauritiella armata	5	227	290	3000	3503	25.5	25.9	0.41	0.48	−
Oenocarpus bataua var. *bataua*	23	3	1100	2344	4536	21.1	27.3	0.24	0.53	−
Oenocarpus mapora	14	100	800	2000	5426	23.6	26.7	0.20	0.62	−
Parajubaea cocoides	2	100	2307	740	2755	16.4	25.1	0.39	2.06	+
Pholidostachys dactyloides	23	40	1316	1016	6000	21.5	27.3	0.19	0.86	+
Pholidostachys synanthera	7	604	1819	2000	6000	17.8	24.1	0.19	0.61	−
Phytelephas aequatorialis	14	3	1200	776	5426	20.5	27.3	0.20	1.69	+
Phytelephas tenuicaulis	16	200	664	3000	4536	23.2	25.9	0.25	0.48	−
Prestoea acuminata	32	600	2527	1093	6000	14.8	25.3	0.18	0.73	+
Prestoea carderi	4	1819	2245	3030	3419	16.0	17.8	0.28	0.34	−
Prestoea decurrens	14	99	1206	1000	6000	20.9	27.2	0.19	1.20	+
Prestoea ensiformis	20	40	1877	1572	6000	16.9	27.3	0.16	0.78	+
Prestoea schultzeana	49	200	1571	3000	6000	18.5	25.9	0.19	0.48	−
Socratea exorrhiza	24	40	1000	2000	5967	21.2	27.3	0.19	0.64	−
Socratea rostrata	13	400	1582	2116	6000	18.5	24.5	0.19	0.59	+
Syagrus sancona	5	3	710	1300	4542	23.2	27.2	0.27	0.77	+
Syagrus smithii	2	200	604	3000	3594	23.5	26.0	0.35	0.47	−
Synechanthus warscewiczianus	22	3	600	985	6000	23.0	27.3	0.20	0.89	+
Welfia regia	4	204	422	2875	3736	24.0	24.7	0.25	0.36	−
Wettinia aequalis	11	180	630	2813	6000	22.8	25.9	0.22	0.38	+
Wettinia aequatorialis	3	1582	1854	2456	3081	17.4	18.5	0.32	0.42	−

Table 1. Continued.

Species	Number of Records	Altitude Above Sea Level (m)		Mean Annual Precipitation (mm)		Mean Annual Temperature (°C)		Humidity Index		Tolerance of a Dry Season
Wettinia anomala	4	1033	1704	2923	6000	18.8	21.7	0.19	0.29	−
Wettinia drudei	1	400	400	3000	3000	24.7	24.7	0.44	0.44	−
Wettinia fascicularis	3	1799	2000	4158	6000	17.0	17.9	0.18	0.25	−
Wettinia kalbreyeri	7	600	2000	1300	3045	16.6	23.1	0.27	0.57	+
Wettinia longipetala	2	1000	1000	3000	3000	23.4	23.4	0.42	0.42	−
Wettinia maynensis	21	215	1800	2074	5000	18.5	25.9	0.21	0.70	−
Wettinia minima	1	1601	1601	3957	3957	17.9	17.9	0.26	0.26	−
Wettinia oxycarpa	6	600	1197	2344	6000	20.2	25.7	0.19	0.53	−
Wettinia quinaria	12	100	1100	2344	6000	22.9	27.3	0.19	0.53	−
Wettinia radiata	1	824	824	4600	4600	24.2	24.2	0.27	0.27	−
Wettinia verruculosa	2	1494	1600	1546	1572	20.2	20.8	0.78	0.78	−

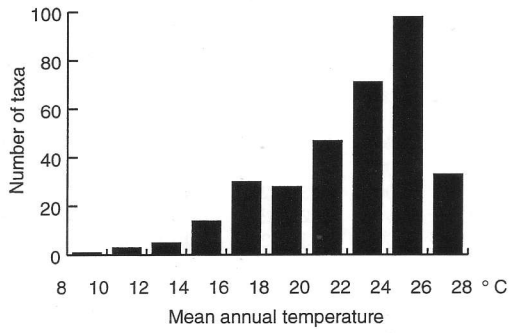
precatoria was not made, as we were at the time uncertain of their delimitation in Ecuador.

Bactris gasipaes, Cocos nucifera, and *Elaeis guineensis,* together with a number of introduced garden ornamental palms, were omitted from the study although present in Ecuador. We did this for two reasons. First, the focus of the study was on naturally occurring palms. Second, herbarium vouchers of the mentioned species are very scarce or absent, and clearly do not give a representative reflection of the conditions under which these palms are grown.

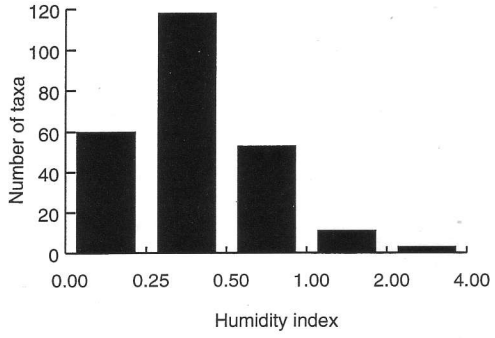
Each herbarium collection was georeferenced using available maps. Information about elevation above sea level, annual average temperature, humidity, precipitation, and presence or absence of a dry period (i.e., one or more months in which potential evapotranspiration exceeds precipitation) for the collection site was extracted from a GIS model, described in detail in a separate paper (Skov and Borchsenius, in press). The humidity index presented is calculated as the ratio between potential evapotranspiration and precipitation, summarized over the whole year. Values below one thus indicate a net yearly precipitation surplus (wet conditions), while values above one indicate a deficit (dry conditions).

Results and Discussion

A list of the 129 native palm taxa known from Ecuador and their recorded ranges of ecological conditions in the wild is given in Table 1. Most palms prefer, not surprisingly, a warm and moist climate (Figs. 1,2). Of the 129 Ecuadorian palm taxa, 98 (76%) demand a mean annual temperature of at least 18°C, and 58 (45%) demand more than 23°C. The highest number of species (98) is found in the temperature range between 24° and 26°C, while only 1–5 species occur in each of the intervals 8°–10°, 10°–12°, and 12°–14°. Similarly, only 11 taxa (9%) are found in areas with a net annual precipitation deficit (humidity index > 1), while 76 species (77%) are restricted to areas



1. The number of palm taxa found in areas of Ecuador with different mean annual temperatures.



2. The number of palm taxa found in areas of Ecuador with different humidity index.

where the yearly precipitation is at least twice as high as the potential evapotranspiration (humidity index ≤ 0.5). Finally, the occurrence of a dry season has a marked influence on the species diversity. Only 39 taxa (30%) are able to tolerate a dry season of any length. The hardiest palm species in the Ecuadorian flora is *Ceroxylon parvifrons*, able to grow at 3500 m elevation with a mean annual temperature of only approximately 9°C, and *Aiphanes eggersii*, found in warm areas with only 600–1 500 mm precipitation and a dry season of 6–8 months.

The presented list of ecological amplitudes of Ecuadorian palms growing in the wild may serve as a rough guideline for ecologists and palm growers, who wish to have an idea of the climatic conditions under which these palm taxa occur in nature. It should, however, be remembered that the list is based on existing herbarium vouchers and estimates of the environmental conditions calculated from available meteorological and topographical information. Many species are not so well collected that their full ecological amplitude is appreciated, and other species may have a wide ecological tolerance under certain conditions, but a much narrower optimum for growth. Finally, the basic information about climate is still scarce for some remote parts of Ecuador, and the extrapolations necessary to construct the climatic model for the entire territory of the country automatically add a certain amount of uncertainty to the results. This is particularly true for low-elevation cloud forest found on mountain ridges in western Ecuador, e.g., in the coastal mountain range and in the Andean foothills, where precipitation and temperature data may be relatively poor predictors of the humidity conditions experienced by the plants. Apparent tolerance of dry conditions indicated for the species *Aiphanes tricuspidata*, *Chamedorea pinnatifrons*, *Geonoma undata*, and *Prestoea decurrens*, which in our judgement demand moist conditions, can probably be explained by their occurrence in that type of habitat.

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