

PHYTOGEOGRAPHIC SURVEY OF CUBA

I. THE PHYTOGEOGRAPHIC CHARACTERISTICS AND EVOLUTION OF THE FLORA OF CUBA

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Some of the main characteristics of the flora of Cuba are exposed and discussed, as the dominance of endemics, disjunction, vicariancy, inversion, microphyllia, micranthia, relict character and vulnerability. The origin, evolution and presumable migrations of the flora are also discussed, based on the results of the geological up-to-date investigations on the plate tectonics. In the process of the flora evolution three main phases are distinguished, the early plate phase, the middle-tertiary land-bridge phase and the late archipelago phase. As the last important period of the flora immigrations the middle tertiary land-bridge phase is discussed with its different floras, as the broad-leaved Honduras-flora, and the sclerophyllous Madro-Tethyan flora. In the late archipelago phase the broad-leaved Guyana-flora, the semideciduous Yucatan-flora and the extratropical North-American flora influenced the evolution of the flora and vegetation of Cuba. At last the evolution centres of the ecologically and/or phytosociologically adapted species groups and their migratory routes are designed and explained.

The phytogeographic characteristics of Cuba

Some outstanding phytogeographic features of Cuba

The floristic analysis and the study of chorological types suggest that the most important and most typical characteristics of the flora of Cuba are as follows: 1. Dominance of endemics, 2. Disjunction, 3. Vicariancy, 4. Inversion, 5. Microphyllia, 6. Micranthia, 7. Relics, and 8. Vulnerability.

The dominance of endemics

As shown earlier (BORHIDI 1982), the endemics comprise a total of 51.4% of the native flora. This is outstandingly the largest percentage in the Antilles. MARIE-VICTORIN (1942 1944, 1956) attributed this to the high Mg and Fe concentrations of "limonite areas". According to ALAIN's (1958 p. 16) hypothesis, the reasons are the early isolation of the flora during the upper Miocene, the diverse edaphic soil conditions of the country and the arid climate of certain areas.

The ecology of endemic speciation

In examining the ecological background of the speciation of endemics MUÑIZ (1970) found that eight habitat types have substantial influence on flora development. These habitats occur in 25 areas in Cuba. The habitat types with the number of areas in brackets are:

- A. Ferritic soils and tropical brown soils derived from serpentine (6)
- B. Ferralitic soils derived from serpentine (5)
- C. Oligotrophic quartz-allitic yellow soils (2)
- D. White sandy habitats (2)
- E. Young, arid, coastal limestone areas (4)
- F. Young, montane, karstic limestone areas (2)
- G. Old, montane limestone karst, "haystack mountains" (1)
- H. High montane areas

The geographic distribution of these habitats is shown in the Atlas Nacional of Cuba p. 60. No doubt that the number of factors facilitating the speciation of endemics is large. The influence and importance of these factors differed with time and space. Factors potentially influencing speciation are listed below:

- A. Insularity and isolation
 - a. Geographic factors
 - external (insularity)
 - internal (isolation)
 - b. Ecological factors
 - ba. Orographic factors
 - alternation of lowlands and mountains
 - great relief-energy
 - bb. Geological and edaphic factors
 - serpentine and other ultrabasic rocks
 - frequent occurrence of limestone karsts
 - frequent occurrence of acid, slaty bedrocks
 - frequent occurrence of acid, white sands
 - bc. Sociological factors
 - community mosaics
 - communities as barriers of migration
 - interactions between plants and animals
- B. Climatic changes
 - c. Alternation of wet and dry periods
 - d. Alternation of cool wet and warm dry periods
- C. Genetic factors
 - e. Mutagenic speciation
 - f. Hybridogenic speciation, introgression
 - g. Genetic drift

Horizontal distribution of endemics

The study of the horizontal and vertical distribution of endemics yields valuable information on the ecological effects influencing speciation and geographic range. Figure 1 shows the number of endemic species per area. The intertidal mangroves and mangrove swamps are the poorest in endemics. The lowlands of central Cuba and the southern part of Isla de Pinos are moderately poor, having 25–50 endemic species. Moderately rich areas (50–75) are the younger coastal limestone habitats (Guanahacabibes peninsula, the southern coast of Las Villas and the northwestern coast of Oriente), the slaty outcrops and white sands in Isla de Pinos, the hilly regions of Central Cuba and the medium altitude zone of Sierra Maestra. The rich areas, containing 76–100 regional endemics, are the slaty outcrops of Pinar del Rio, the ancient serpentines of Cajalbana, the younger serpentine zones of Habana,

Matanzas and Motembo, the rainforest region of Sierra Escambray, the southern coast at Sierra Maestra and the northern karstic zone (Guisa-Baire) in Oriente, and the limestones of the Sagua-Baracoa massif. Most areas very rich in endemics (100–150) are on serpentine, three are younger (Santa Clara, Camagüey, Holguín) and three others are ancient latosol areas (Nipe, Cristal, Moa-Baracoa). In respect of endemic richness only the ancient karsts with conical formations in the Sierra de los Organos, the montane zone of Sierra Maestra and the xerotherm semi-deserts of southern Baracoa are commensurable to the above localities. Outstandingly rich areas are found only in the montane zone of ancient serpentine mountains, such as the Nipe Mts., the surroundings of Pico del Cristal and the highlands of Moa (El Toldo, Iberia, etc.), where more speciation-inducing factors (age, serpentine, isolation, montane character) are combined.

Vertical distribution of endemics

After reading the foregoing one would expect that the number of endemics increases as altitude increases, due to the montane effects. However, as our studies in Pico Turquino showed, the vertical distribution of endemics is a more complex matter. Figure 2 demonstrates that the number of endemics increase up to the lower limit of the cloud zone and then rapidly decreases. Its reason is that the vertical distribution of regional endemics of lowlands and mountains of medium height differs from that of the local montane endemics. The number of species from the first group increases up to 1000 m, hardly changes up to 1500 m and then falls on a sudden. The number of montane endemics, however, abruptly increases between 1000 and 1500 m and does not change any more. The disappearance of lowland regional endemics from the high altitude zone causes the decrease of endemic species (Fig. 2/A). Contrary to the absolute figures, the relative proportion of endemics rapidly increases with altitude. That is, the few endemics occurring become predominant at higher elevations (Fig. 2/B).

Relationship between aridity and the number of endemics

STEBBINS (1953) pointed out that ecological drought stimulates speciation. The ecological and chorological study of many Cuban endemics provides evidence for this phenomenon. The largest number and highest density of endemics may be observed in the arid zones (semi-desert, coast) and in the physiologically dry habitats (serpentines, limestone karsts, white sands). Also, the majority of endemics have xeromorphic leaves. Table 1, and Fig. 3 show the

Table 1

The leaf-size distribution of 1115 tree and shrub species occurring in 40 native forest communities of Cuba

Leaf-size category	Non endemics		Endemics		Total	
	No.	%	No.	%	No.	%
Macrophyll	6	100	0	0	6	100
Mesophyll	58	65	30	35	88	100
Notophyll	96	43	125	57	221	100
Microphyll	163	33	337	67	500	100
Nanophyll	45	22	155	80	200	100
Leptophyll	14	20	56	80	70	100
Aphyll	5	18	25	82	30	100

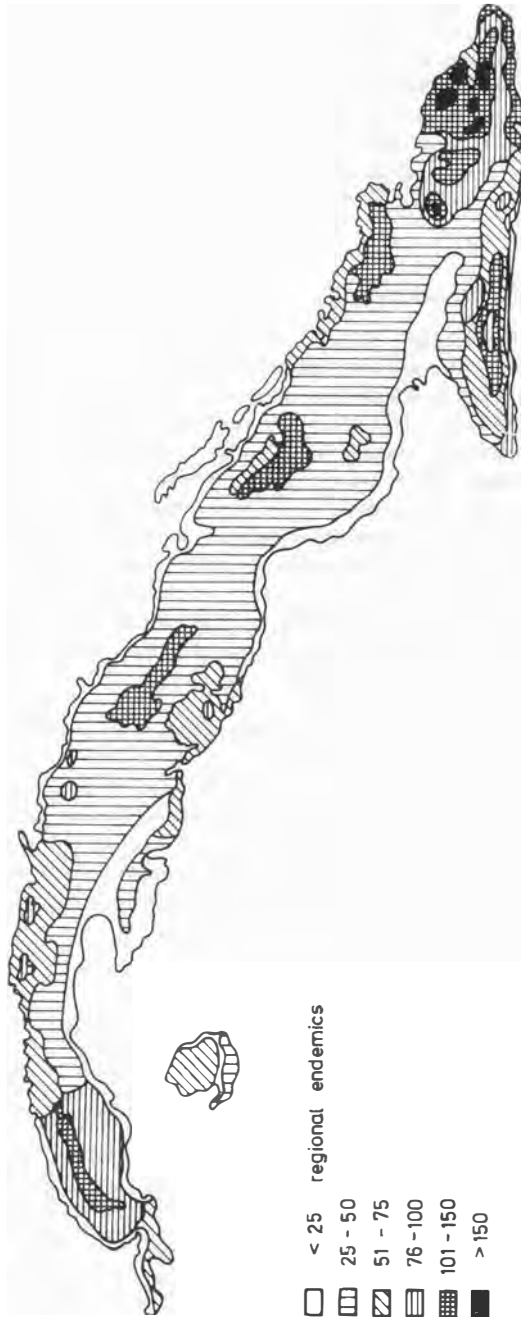


Fig. 1. Number of the regional endemic species per area

leaf-size distribution of 1115 tree and shrub species occurring in forty native forest communities of Cuba. Among macrophylls and mesophylls the widely distributed species dominate, but in the microphyll, nanophyll, leptophyll and aphyll categories the endemics outnumber the others and their proportion increases as leaf-size decreases.

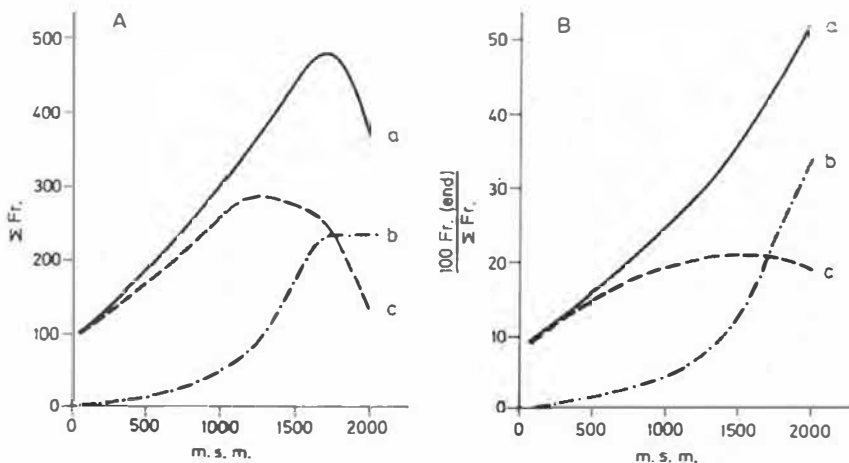


Fig. 2. Vertical distribution pattern of endemic species in Cuba (A), and their relative frequency in the zonal vegetation types (B) along a vertical gradient. — a: total of endemics, b: local montane endemics, c: regional lowland endemics

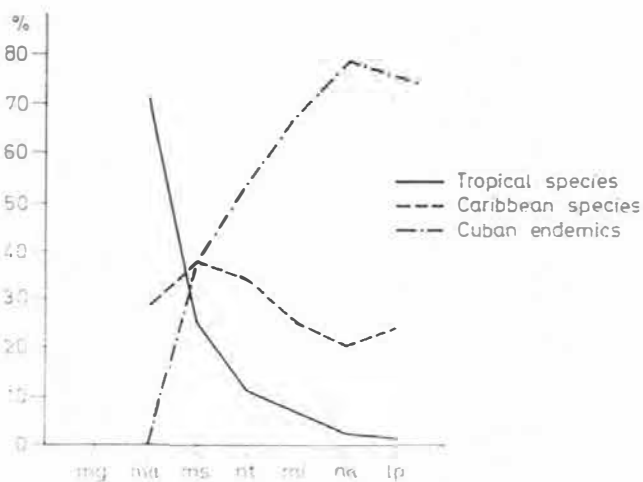


Fig. 3. The leaf-size class pattern of Cuban trees and shrubs — mg: megaphylls, ma: macrophylls, ms: mesophylls, nt: notophylls, mi: microphylls, na: nanophylls, lp: leptophylls and aphylls

Disjunction

Another chorological characteristic of the flora is disjunction, the separation of the geographic range of a given taxon into several isolated areas. Many different types of disjunction, such as bipolarity, bi-, tri-, and multi-sectorial distribution may be observed in Cuba.

Bipolarity

The most striking type of disjunction is the bipolarity of the geographical range of certain genera (SAMEK 1973) that occur only in western Cuba and Isla de Pinos, and also in the mountainous regions of Oriente. This is the case with *Purdiaea* (Fig. 4), *Heptanthus* (Fig. 5), *Spathelia* (Fig. 6), *Pinus*, *Podocarpus* and many other genera. The reason is that the eastern and western parts of Cuba has been isolated for a long period of time from the beginning of the Tertiary. In most cases, the number of species in the disjunct genera is higher in Oriente than in western Cuba. The larger area and more diversified landscape of Oriente cannot explain this observation, since the Sierra Maestra emerged only at the end of the Tertiary, and western Cuba has more diverse geological conditions than Oriente. A more acceptable interpretation is that Oriente and the continent had been connected through Hispaniola for a relatively longer period of time, facilitating a steadier "gene supply" for this province.



Fig. 4. The geographical distribution of the genus *Purdiaea* in Cuba (after THOMAS 1960, SAMEK 1973 and BORHIDI 1973)

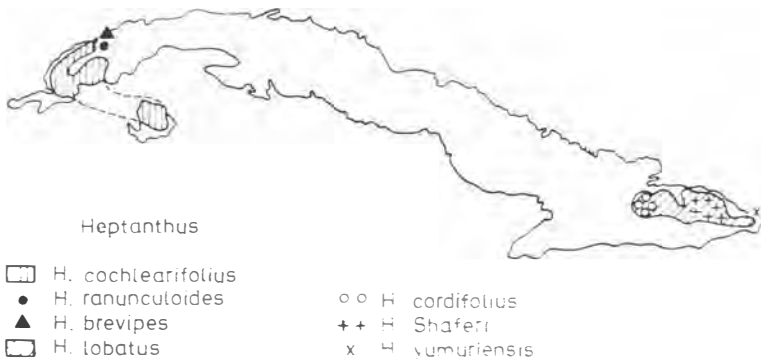


Fig. 5. The geographical distribution of the genus *Heptanthus* Griseb. (after BORHIDI 1972)

Geologists (ARNDT 1917-1922; SCHUCHERT 1935) pointed out that the separation of western and eastern Cuba preceded that of Oriente and Hispaniola, although botanists, following URBAN (1923 p. 52), disagreed. The present analysis of the flora, however, provides a botanical evidence for the geological results. It is noted that G. SILVA (1979) arrived at the same conclusion in his studies on the Chiroptera fauna of Cuba.

At species level only a few examples of bipolar distribution exist. These species are found mainly on serpentines, e.g., *Amyris lineata*, *Vernonia angustissima*, *Croton bispinosus*, and *Helicteres trapezifolia*, but also in limestone karsts, such as *Byttneria microphylla* and *Nyrognellia cubensis*.

Bisectorial geographic distributions

Another type of disjunction is represented by some rainforest species (*Magnolia cubensis*, *Hedyosmum grisebachii*, *Ocotea ekmanii*, see Fig. 7) occurring both in the mountains of Oriente and the Guamuhaya massif. Up to the early Tertiary, these regions were connected as still indicated by the presence of the relict block-mountains of Sierra de Najasa. This con-

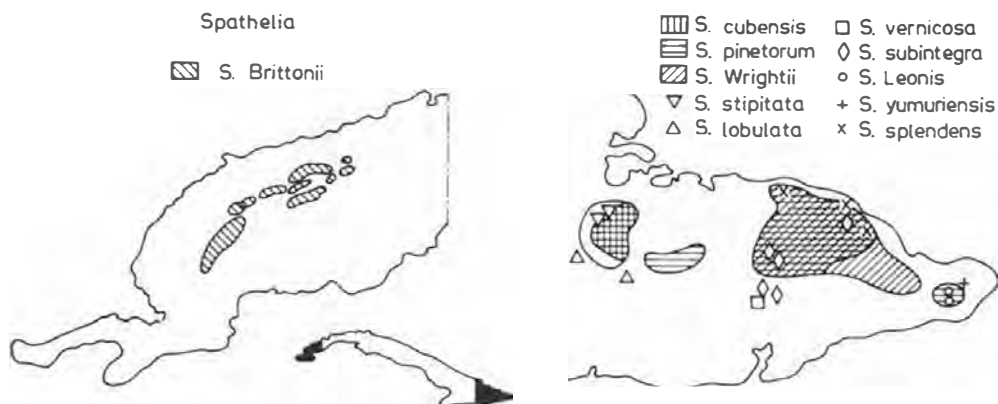


Fig. 6. The geographical distribution of the genus *Spathelia* in Cuba (after MARIE-VICTORIN 1944, SAMEK 1973, complemented by BORHIDI)

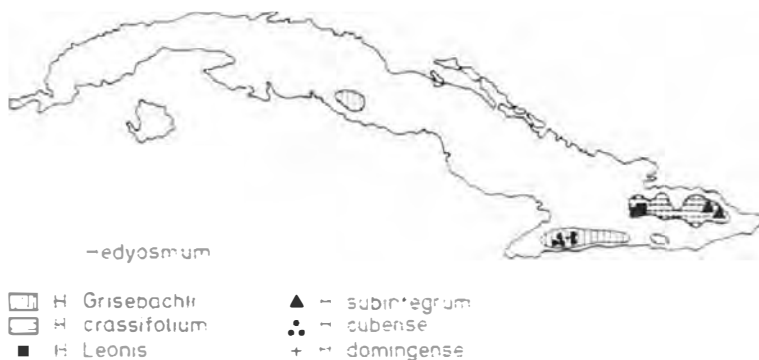


Fig. 7. Geographical distribution of the *Hedyosmum* species in Cuba (after MARIE-VICTORIN 1942, modified)

nection, however, must have come to an end in short time, since most common elements belong to ancient dicotyledonous families (Magnoliaceae, Lauraceae, Chloranthaceae, etc.). Other two types of the bisectorial distribution have developed between the mountainous region of western Cuba and the Guamuhaia massif:

1. the plants of karstic forests and other limestone areas (*Sapium leucogynum* and *Miconia cubensis*), and
2. species on serpentines in Pinar del Rio and the Escambray mountains (*Coccothrinax crinita* and *Linodendron venosum*).

Trisectorial distributions

The occurrence of several taxa in three isolated spots (western Cuba, Guamuhaia massif, Oriente) indicates that these areas had been separated for a long period of time in the Tertiary as a result of shallow-sea transgression of the island. The genera of *Lyonia* and *Vaccinium*; some montane forest species, such as *Tetrazygiopsis laxiflora* and *Sapium pallens*; and some acidophilous species, e.g., *Hypericum stypheloides* exhibit such a trisectorial distribution. As a consequence of longer geographic and ecological isolation of the *Hypericum stypheloides* populations, this species falls into three subspecies (LIPPOLD 1971). Some taxa considered earlier to have bi- or tri-sectorial distribution, proved to be taxonomically heterogeneous, such as *Amyris lineata*, *Croton brittonianus*, *Ditta myricoides*, *Lyonia elliptica*, and *Vaccinium cubense*.

Multisectorial areas

Several serpentine species (Figs 8–9) have relatively large geographic range falling into many isolated spots. In these cases the reason of disjunction is the scattered occurrence of acceptable habitats, rather than the prehistoric geographic effects. Examples are *Phyllanthus orbicularis*, *Neobraccia valenzuelana*, *Rondeletia camarioca*, and *Jacaranda cowellii*. This type of geographical range is characteristic of the common species of the numerous isolated serpentine areas, as well as the plants of the isolated coastal limestones (*Castela calcicola*, *Machaonia havanensis*, *Dendrocereus nudiflorus*, and *Neobraccia angustifolia*).

Vicariancy

The third characteristic feature of the flora of Cuba is the abundance of vicarious taxa. All types of vicariancy are widespread. This fact indicates prehistoric isolations and allows the surveyor to make inference concerning the influence of ecological factors on evolution and the development of certain related taxa.

Geographic vicariancy

Many examples exist in Cuba. Figure 10 shows the range of two endemic vicarious genera of lianes, *Lescaillea* and *Harnackia*. Both occur in pinewoods and evergreen shrublands on latosols derived from serpentine. This serves as an evidence suggesting a relationship not only between the recent vegetation of the Cajalbana and Nipe Mountains, but also in the past flora development of these regions. Further examples are *Anemia coriacea* (Fig. 11) and *Moacroton* (Fig. 12), among many others. The ranges of *Thrinax* and *Hemithrinax* also exemplify geographic vicariancy (Fig. 13). *Thrinax radiata* is a species of rocky and sandy beaches.

whereas *Th. morrisii* and *Th. drudei* occur in the karsts of western Cuba replacing each other. In central and eastern Cuba this genus is substituted by *Hemithrinax* (*H. ekmaniana* and *H. compacta*). The ecological vicariads of them, namely *H. rivularis* and *H. savannarum*, occur on the serpentines of Moa. The latter two are ecological vicariads of each other, being forest and scrub species, respectively.

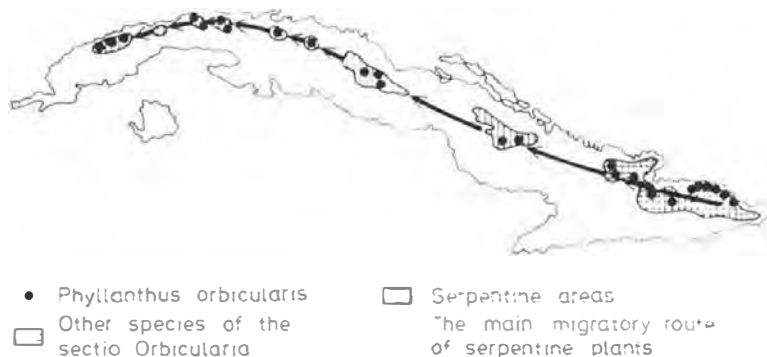


Fig. 8. Geographical distribution of the serpentine areas and the *Orbicularia* section of the genus *Phyllanthus* in Cuba (after WEBSTER 1958)



Fig. 9. The geographical distribution of the genus *Neobraccia* Britt. in Cuba (after BONIDI 1973 and LIPPOLD 1979)



Fig. 10. The geographical distribution of the genera *Lescaillea* Wr. in Sauv. and *Harnackia* Urb. (after BONIDI 1973)



Fig. 11. Geographical distribution of *Anemia coriacea* Griseb. s.l. (after BORHIDI 1973 and DUEK 1975)

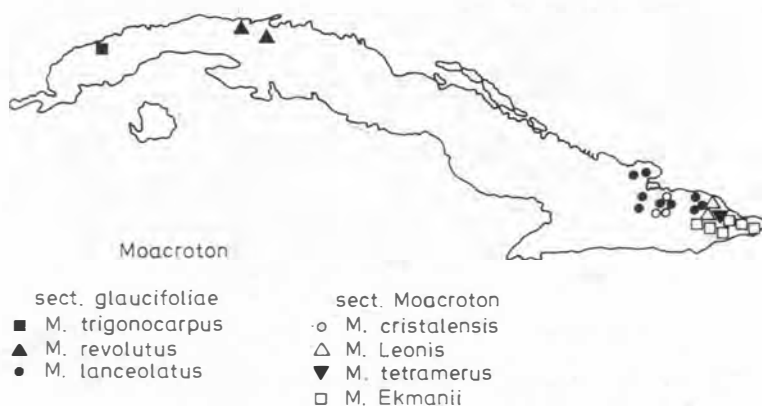


Fig. 12. Geographical distribution of the genus *Moacroton* Croiz. (after BORHIDI 1973)

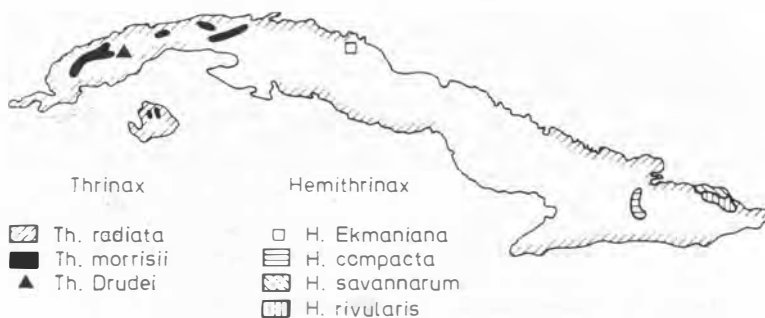


Fig. 13. Geographical distribution of the genera *Thrinax* and *Hemithrinax* in Cuba (after BORHIDI 1973 and READ 1976)

Combinations of geographic and ecological vicariancy

The genus *Platygyne* (Fig. 14) exhibits both types of vicariancy discussed so far. *P. hexandra*, an ubiquitous species found all over the country, is replaced by *P. parviflora* on serpentines in Camagüey and Holguín, by *P. dentata* in the montane zone of Sierra Maestra, and by other four species in the serpentine mountains of northeastern Oriente. Furthermore, the latter four species are also vicarious in their geographic distribution within the province.

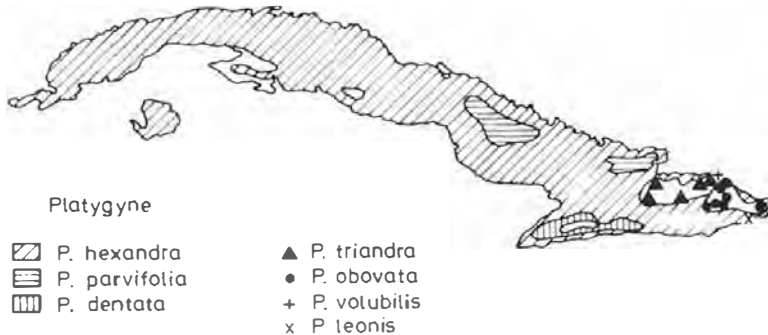


Fig. 14. Geographical distribution of the genus *Platygyne* Muell. Arg. (after BORHIDI 1972)

This observation supports the view that speciation is more intensive on serpentines than on other bedrocks (BORHIDI 1972a). An interesting exception is the genus *Neobraccia* (Fig. 9) with two species on serpentine, *N. ekmanii* endemic to Moa and the Pan-Cuban *N. valenzuelana*. Although the latter occurs on all serpentine outcrops in Cuba, the morphological variability of populations living under different climatic conditions remains within specific limits. Conversely, the ancestral form of the limestone species has been broken into four vicarious species along the coasts consisting of old and recent limestones. These species constitute morphologically well-separated small populations with considerably isolated geographic distributions.

Ecological vicariancy at the infraspecific level

The ecological factors affecting speciation may be best investigated and demonstrated through examples of infraspecific vicariancy. This term means that a young species of great migratory and penetrative power colonizes new habitats which in turn modify the populations. *Maytenus buxifolia* (Fig. 15), an Antillean species, is a good example. It falls into five vicarious subspecies in Cuba: the widely spread ancestor, two subspecies on serpentines (ssp. *cajalbanica* in western Cuba and ssp. *serpentina* in the east), another adapted to montane belt (ssp. *monticola*), and an extremely drought-tolerant subspecies in the semi-desert belt (ssp. *cochlearifolia*). An endemic microphyllous drought-tolerant shrub, *Reynosia mucronata* (Fig. 16) exhibits similar vicariancy. The ancestor occurs in the shrublands of central Cuba with preference in favour of neither limestone nor serpentine. However, the populations on the latosols of Nipe Mts. (ssp. *nipensis*) and the stands occurring in the semi-desert zone of southern Baracoa (ssp. *azulensis*) have been geographically isolated subspecies (cf. BORHIDI and MUÑOZ 1971).

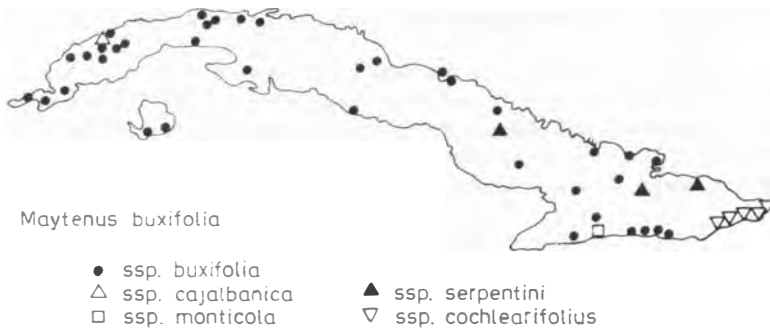


Fig. 15. The geographical distribution of the subspecies of *Maytenus buxifolia* (A. Rich.) Griseb. in Cuba (after BORHIDI 1973)



Fig. 16. The geographical distribution of the subspecies of *Reynosia mucronata* Griseb. in Cuba (after BORHIDI 1973)

Geographic vicariancy at the infraspecific level

The infraspecific geographic vicariancy indicates climatic changes in the recent geological past and casts light upon the role of potential cenological barriers. Examples are found in the serpentine mountains of northeastern Oriente. The climate of this region might have been that of tropical rainforests in the Holocene. Since then, a gradually drying climatic gradient has developed. As a result of this change some species, e.g., *Casasia nigrescens* (Fig. 17), *Amyris stromatophylla* (BORHIDI and MUÑIZ 1973), *Manilkasa mayasensis* and *Anemia coriacea* (Fig. 11) fall into vicarious subspecies with large leaves and tall habit in Moa and with small leaves and body size in the Cristal and Nipe Mountains.

Phytosociological isolation and vicariancy

Development of geographically vicarious subspecies may often be facilitated by the existence of species-saturated communities or vegetation types in different habitats separating the drifted populations, e.g., those of mountains alternating with more or less wide valleys. Here, only the distribution of the taxa of *Calycogonium rosmarinifolium* s. l. (Fig. 18) is shown, although the vicarious subspecies of *Phyllanthus erythrinus* (WEBSTER 1959) could have also been selected as a good example.

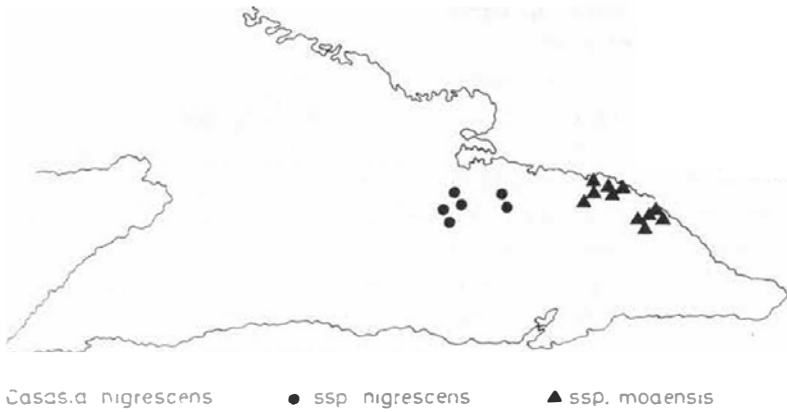


Fig. 17. The geographical distribution of the subspecies of *Casasia nigrescens* (Griseb.) Wr. ex Urb. in Cuba (after BORRINI 1973)

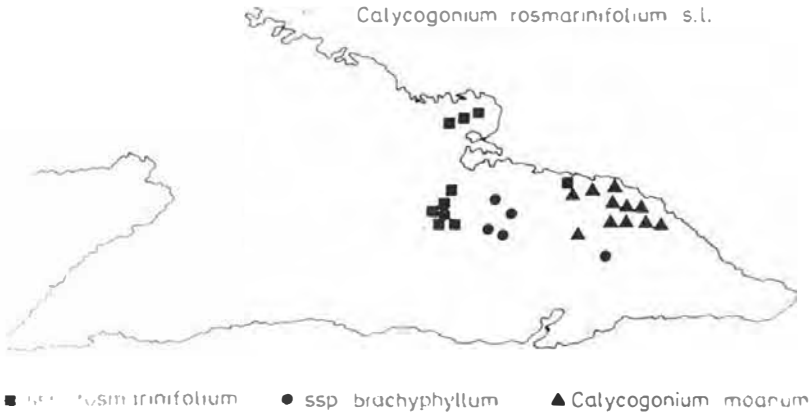


Fig. 18. The geographical distribution of the taxa of *Calycogonium rosmarinifolium* Griseb. s.l. (after BORRINI 1973)

Inversion of floristic elements

Another typical feature of the flora, observed mainly in western Cuba, is inversion (SÁMEK 1973). Certain genera of mountains or temperate regions, which otherwise occur positively in high mountains at similar latitude, are found in Cuba at low elevation. Examples are *Pinus*, *Podocarpus*, *Kalmiella*, *Vaccinium*, *Lyonia*, *Befaria cubensis*, and *Quercus sagraeana*, etc. Inversion is probably caused by two factors:

1. One of the cool periods during the Quaternary when these species or their ancestors reached Cuba and became established in the lowlands and hills, and

2. The abundance of serpentines and other rocks and soils (e.g., slate and quartz sand) of poor nutrient supply, which might have facilitated the adaptation of cool-resistant species to the increasing mean temperature (such inversions may develop under the same conditions even today).

The vegetation inversion occurring on soils derived from serpentine is discussed in BORHIDI (1973, 1976) and BORHIDI and MUÑIZ (1980). Of course, this is accompanied with the inversion of floristic elements constituting the corresponding vegetation type. In addition to the above mentioned taxa, this phenomenon is exemplified by the species of *Myrica*, *Ilex*, *Lobelia*, *Laplacea*, and *Baccharis* occurring on serpentines or white sands.

Microphyllia

This is an important feature characteristic not only of the flora of Cuba but also of the flora of the West Indies. As pointed out in earlier, aridity must have had an important role in influencing speciation. Table I shows that of the 1115 species examined, 800 (72%) proved to be microphyll, nanophyll, leptophyll and aphyll, most of those (563 species) being endemics. There are numerous genera represented in Cuba and the Antilles by highly specialized microphyll, sclerophyll or spiny sections or species, but the corresponding taxa in the continent are broad leaved. Examples are *Plinia*, *Myrcia*, *Calypttranthes*, *Eugenia*, *Rondeletia*, *Machaonia*, *Psychotria*, *Phyllanthus*, *Croton*, *Acalypha*, *Jacaranda*, *Tabebuia*, *Byrsonima*, *Malpighia*, etc. Typical West Indian genera are *Catesbaea*, *Scolosanthus*, *Ottoschmidia*, *Acidocroton*, *Picrodendron*, *Krugiodendron*, and *Sarcomphalus*. Their abundance and substantial cover in the vegetation allow for the conclusion that during the main period of the flora development in the West Indies there was a direct relationship to the continental flora composed of drought-tolerant elements. Then, the flora must have further evolved in a warm, arid subtropical climate, probably in the second half of the Miocene.

Micranthia

A striking feature of the flora of the Antilles, and particularly of Cuba, is its richness in small-flowered plants, whereas the floras of Palaeotropical and Neotropical regions in the continents abound in showy, big-flowered species.

Among many thousands of plant species illustrated in Botanical Magazine and Garden-flora, Antillean species only occasionally occur. (None of the 3000 endemics in the exceptionally rich flora of Cuba has big enough flowers to deserve the honour of being the 'national flower', so *Hedychium coronarium*, an Asiatic species, was given this title.)

The small flowers are pollinated by endemic, highly specialized microscopic sized insects that are usually not capable of long distance flying. To avoid strong winds blowing from the sea, these insects stay in the shelter of plants. Thus, gene flow between remote plant populations is occasional, if not impossible. This barrier must have contributed significantly to the isolation of populations subjected to genetic drift, and resulted in the formation of numerous vicarious endemics. The fact that most vicariads differ very little from one another indicates the influence of genetic drift. Therefore, some taxonomists consider these vicariads as simple varieties. However, this view is unacceptable since the morphology of these microspecies is stable, the segregation is complete and no intermediate forms and genetic relationships exist. *Micranthia* may be a partial explanation of the discrepancy that genera represented by only one or two widespread species in the continent may fall into a dozen of endemic species with geographic range restricted to a single mountainous region in the Antilles.

Relict character

The flora of tropical moist vegetation types, such as lowland and sub-montane rainforests and seasonal evergreen forests in the Antilles is relatively young and contains few endemics. It is likely that these types had become widespread only at the end of the Pliocene and during the pluvial periods synchronous with the Pleistocene glacials. During the Pleistocene the flora rich in Tertiary xerophilous and sclerophyll elements retreated. This process still goes on. In my opinion the recent climate is far too moist for the sclerophyll vegetation types and the constituting species. The increase in the number of permanently established deciduous and semi-deciduous species coming from other community types supports this view. This degradation process is significantly accelerated by human impact. The formerly widespread dry evergreen formations (thickets, woodlands, forests and pinewoods) composed of Tertiary sclerophylls are now restricted to relict habitats, serpentines and the slopes and cliffs of conical karsts. The geographic range of endemic sclerophylls, which account for 40% of the flora, covers less than 20% of the area of the island. The relict character of the flora is clearly demonstrated by the presence of primitive, taxonomically isolated groups (*Microcycas*, *Dracaena*, *Cneorum*, *Spathelia* sect. *Brittonii* and sect. *Splendentes*, and *Harpalyce* sect. *Cubenses*, etc.), the abundance of disjunct geographical distribution types, and the large number of local endemics represented by small populations.

Vulnerability

In general, island floras are vulnerable for several reasons:

1. The populations colonizing new biotopes are selected from a reduced gene pool,

2. There has been no possibility of changing this gene pool for millions of years,

3. As a consequence of isolation, the ecological tolerance and genetic flexibility of populations decreased, so that,

4. The competitiveness of species generally diminished or even disappeared in all but one respects,

5. Therefore, they cannot react satisfactorily upon new ecological impacts, cannot take the advantage of succession, and cannot resist to or force back new competitors.

Thus, island floras are usually composed of ecologically rigid populations not qualified to adapt to major environmental changes. The social recuperability is reduced, the populations and communities are vulnerable to external effects. The vulnerability of the flora of Cuba is more pronounced because

a) The island flora itself is constituted by set of ancient, isolated floras,

b) Most endemics have been adapted to the extreme ecological conditions of oligotrophic or bare areas. Thus, the level of metabolism became low in these organisms, and their competitiveness diminished.

c) The sociability of many endemics is low. There are some rare taxa represented by few populations, and few individuals therein. Consequently, the flora of Cuba is one of the most endangered island floras of the world. The list of endangered species of Cuba contains about a thousand items which amount to 16.5% of the entire set of flowering species in the island. Approximately 30% of the endemics are endangered.

The origin and migration of the flora of Cuba

Palaeobotanical and geological evidences

● Our knowledge on the origin and migration of the flora of Cuba is insufficient. As few as three noteworthy findings have been reported, one probably from the Eocene and another from the Pleistocene of Sierra de Chorrillo, and the third from the Miocene of Yumuri Valley in Matanzas (see GRAHAM 1973). The total number of taxa coming from these three periods is still below fifty. Moreover, no palynological data are available from the Quaternary of Cuba. Then, the only possibility to give a rough picture on past changes in the flora is offered by the simultaneous analysis of the recent flora, geographical distribution types and of the tectonic events revealed by structural geology.



Fig. 19. The geographical position of the Greater Antilles in the late Miocene according to WEGENER's continental drift theory in the interpretation of CORRAL (1939)

CORRAL's version of WEGENER's theory

The geological past of the Antilles has been described by CORRAL (1939, 1940) in accordance with WEGENER's theory (Fig. 19). It is conceivable that portions of the Greater Antilles used to be connected to one another and to South America, as CORRAL claims. However, these lands must have started to become separated from the continent not later than the Upper Triassic. Due to chronological unreliabilities and consequential inconsistencies in CORRAL's theory, it was soon rejected (ALAIN 1958) and SCHUCHERT's (1935) concepts were accepted.

SCHUCHERT's concepts on the Tertiary in the Antilles

According to SCHUCHERT, the Greater Antilles had been connected to Central America via a land strip of Honduras from the Triassic to the Late Pliocene, apart from short intervals in the Upper Cretaceous and the Upper Oligocene. Eastern Cuba was connected to the continent via the Cayman Ridge and indirectly via the Nicaragua Ridge, Jamaica and Hispaniola. In addition, there was also a connection to the Bahamas and Florida during the Upper Cretaceous and the Eocene. In the Upper Oligocene Cuba became separated from Hispaniola and Yucatan, and its connection to the continent ceased to exist any longer. Although in the Middle Miocene Cuba and Hispaniola had been united again for a short time, no link was formed between the Antilles and Honduras. In the Upper Miocene Cuba finally became completely separated from all the other islands of the Antilles and the continent. According to SCHUCHERT, the Honduras-Jamaica-Hispaniola land strip was finally broken only at the beginning of the Pleistocene. In my views, however, this break up must have been completed in the Miocene, as suggested by the very primitive mammal fauna of the Greater Antilles.

The influence of SCHUCHERT's concepts on phytogeographical interpretations

The recent position of the West Indies, which are wedged in between two continents and are surrounded by narrows and closed bays, makes the impression as if the West Indies were a sort of appendage of the continent that became separated not long before. Some botanists consider the flora of the West Indies as a descendant of the continental flora in which the widespread and highly variable continental species are represented by endemic subspecies