Structure of Vegetation in the Canary Islands

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ESTRUCTURA DE LA VEGETACION EN LAS ISLAS CANARIAS:

R E S U M E N

1. Este estudio intenta describir dos asociaciones arbustivas, una en la parte occidental de Tenerife, dominado por la tabaiba roja, *Euphorbia atropurpurea,* con césped de hierbas anuales, la otra en Fuerteventura, su aspecto dominado por verode, *Kleinia neriifolia,* y espina blanca, *Asparagus albus.*

2. La estructura de la vegetación ha sido descrito según el sistema fisionómico de Dansereau. Las dos comunidades vegetales son parecidas salvo en la abundancia de espinas en la asociación de *Kleinia - Asparagus,* y las gramíneas más extendidas en la asociación de *Euphorbia atropurpurea.*

3. Cada especie tiene un "valor de importancia" calculado de su frecuencia relativa y su dominancia relativa. El total de los valores de importancia de todas especies en cada asociación llega a 100.

4. Para el análisis de las formas biológicas se utiliza un sistema derivado de obras de Raunkiaer (1934), Du Rietz (1931), y Schmid (1956). Tipo biológico, ramificación, sistema de raices, caída de las hojas, tipo de inflorescencia, y diseminulos están incluidos en este sistema.

5. Diferencias entre las dos comunidades vegetales existen en: la importancia menor de hierbas anuales de la asociación de *Kleinia* y *Asparagus,* plantas más ramificadas con hojas más caducas de la misma, las inflorescencias más pequeñas y más escondidas, y los diseminulos de la misma asociación adaptados al transporte por el viento y por los pájaros. Muchos de los diseminulos del tabaibal de *Euphorbia atropurpurea* podrían ser adaptados al transporte por cabras.

† 1931 - 1968

6. El análisis de la distribución geográfica de las especies revela el carácter africano de la asociación de *Kleinia* y *Asparagus*. La comunidad de *Euphorbia atropurpurea* se interpreta como un césped de origen mediterráneo, colonizado por una especie endémica tinerfeña de *Euphorbia*.

7. Como factores del ambiente, responsables para las diferencias estructurales de las dos asociaciones, se citan los siguientes: altura más elevada (1000 m) del sitio de *Euphorbia atropurpurea*, con un clima más frío y lluvioso; suelo mucho más pedregoso y seco del sitio de *Kleinia* y *Asparagus; influencia* de cabras, indudable en Tenerife; también se cita la proximidad a la costa africana de la isla de Fuerteventura (100 km).

INTRODUCTION

The plants of the Canary Islands have been described and classified for almost a century and a half, beginning with the account by Leopold von Buch (1825), followed by the massive monograph of Webb and Berthelot (1836-1850), the explorations of Bolle (1863, 1891), Christ (1888), Pitard and Proust (1908), Burchard (1929), and recent discoveries made by Sventenius (1948 - 1949, 1950 - 1954, 1960). The most recent compilation of the flora (Lems, 1960a) contains 1531 species of vascular plants. It is important to make a distinction between the concept of *flora* and that of *vegetation*. A flora is a list of species, arranged according to genus and family, in which each species counts equally, whether it be the "Drago" (*Draccena draco* L.) with massive crown and trunk, or "Pata de Camello" (*Aizoon canariense* L.) with a few short stems and leaves flat on the desert floor. Vegetation is different from flora in two respects: First; the species contribute different numbers of individuals, so that some are more conspicuous (dominant) than others, and by their greater biomass contribute more to the production of organic matter; this consideration is important to those who use vegetation as a source of lumber, fuel, or fodder for domestic animals. This usage will, in turn, modify the vegetation, either favorably or unfavorably. A second aspect of vegetation, by which it is different from the concept of flora, is that the components of vegetation have a growth-form which gives rise to a distinctive physiognomy, a structure which is composed of elements *(synusiae)*, containing those plants whose growth form is similar. Thus, a Canary laurel forest may consist of a *synusia* of evergreen broadleaved trees *(Laurus canariensis, Ocotea foetens, Heberdenia excelsa, Notelaea excelsa)*, an element of shrubs *(Viburnum rugosum, Ilex canariensis,* and young individuals of the tree species which for a time play the role of shrubs), a *synusia* of ferns *(Woodwardia radicans, Dryopteris oligodonta, Athyrium umbrosum)*, another of perennial flowering herbs *(Ranunculus cortusaefolius, Senecio cruentus)*, and finally a ground layer composed of moss and lichen.

The analysis of vegetation in the Canary Islands has only just begun. The 19th century and the first half of the 20th produced only accounts of the zonation of vegetation, and general descriptions of its various aspects. Von Humboldt (1814), and Schimper (1907) were among the illustrious botanists who contributed to the development of a concept of zonation and structure of vegetation in the Canary Islands. It remained for Ceballos and Ortuño (1951) to provide a comprehensive classification and maps showing the distribution of the vegetation zones; their work constitutes a summary of the first phase of Canarian vegetation analysis.

While the vegetation of Europe has been described in greater detail than that of any other continent, mainly by the quantitative methods developed by Braun-Blanquet (1932) and his associates, it is surprising that such methods have only recently been employed in the Canaries, where the description of plant associations had its first impetus from work by Rivas Goday and Esteve Chueca (1964), Oberdorfer (1965), and the present writer (Lems, 1958). Much more patient and systematic accumulation of data is needed before a syllabus of Canarian plant associations can be published, comparable to the one for the Netherlands (Westhoff, et al., 1946), and before we can expect detailed vegetation maps like those made of French vegetation (Emberger and Braun-Blanquet, 1955).

It is the purpose of the present article to introduce a consideration of the second major criterion of vegetation: its structural composition in terms of plant growth forms. Since the classification of plant associations is as yet incomplete, I shall restrict these remarks to the analysis of several actual stands of vegetation which were studied using a method of analysis that is based on structural criteria. The selection of a suitable method will constitute the first problem. Its application to Canarian vegetation will be the second phase of this study. Its relevance to the central problem of Canarian botany: the origin of the vegetation, will be considered last.

M E T H O D S

The study of vegetation structure, as a dimension distinct from its floristic composition, depends upon the selection of a set of criteria dealing with the form of the component plants, their physiognomy, and their behaviour in terms of leaf fall, branch and inflorescence production, root systems, and methods of dispersal. Such a list of criteria, when applied to an actual stand of vegetation, will define its physiognomy, its response to seasonal cycles, its utilization of the substrate, and its capacity for self-maintenance and dispersal. No single system has as yet been proposed that will measure all of these criteria, but adequate classifications are now available for individual aspects.

PHYSIOGNOMY. Dansereau (1958) has worked out a set of categories for the definition of vegetation structure in which each basic life-form is represented by a symbol. Table 1 lists the criteria in each category. The main emphasis in this system is on foliage, its height above the ground, its permanence, texture, and array of shapes and sizes. In addition to the criteria listed, Dansereau provides a pictorial representation for each one, and also recognizes in his diagrams the presence of buttresses, stilt roots, spines, and different shapes of tree crowns. The system has been found useful for the comparison of vegetation formations on a worldwide scale. It emphasizes the evolution of structural similarities in areas of similar climate and substrate.

GROWTH FORM. Parallel with the physiognomic classification, there has developed a series of classifications based upon the shoot system, and the rate and mode of branching of the plants. The initial impetus came from Warming (1908). Du Rietz (1931) contributed a classification of stem types based upon their orientation, relation to the soil, thickness and consistency. Unfortunately, his growth form classification remained incomplete. Recently, the classification of plant growth forms based upon shoot types has been advanced by Schmid (1956) who proposed a set of categories and criteria, together with pictorial symbols. This approach has been found especially useful in the comparison of forest types (Schmid, 1957), and in tracing the evolutionary modification of the shoot system in certain genera of plants (Lems, 1960b). I have found it desirable to modify the classification proposed by Schmid, and present my revision in Table 2.

The growth form scheme is not designed to depict physiognomy of vegetation, but rather the array of morphological types present in a given plant community. Coverage, used by Dansereau as sole criterion for the importance of each structural component, is here regarded as but one of several phytosociological criteria which contribute to the importance of a plant. Curtis and McIntosh (1951) use tree diameter, frequency of species, and abundance in a sample series from a stand of forest to arrive at an "importance value". A similar procedure can be used on non-forest vegetation, using coverage, frequency, and abundance. For proposes of the present study, only the former two data were available. The importance value of each of the species in the community was calculated from relative coverage and relative frequency, and expressed as a percentage of the sum of relative coverages and relative frequencies of all species found in the community. Where coverage of the species was negligible, only its frequency was counted towards the importance value.

ROOT SYSTEMS. The importance of root systems to the biology of plant communities is obvious. Most of the knowledge of root systems of plants derives from work done in grassland (Weaver, 1958) and savanna (van Donselaar - ten Bokkel Huinink, 1966) on a relatively homogeneous substrate which allows for the unhampered development of roots. In regions where most of the substrate consists of recent and partially weathered lava with small soil pockets, studies of root systems are physically impossible, except for transplant and seedling experiments. For a more complete classification of root growth forms the reader is referred to van Donselaar - ten Bokkel Huinink (1966).

DISPERSAL. Although dispersal is not ordinarily regarded as part of the structural analysis of vegetation, it has adaptive, evolutionary aspects; it contributes not only to the internal dynamics and maintenance of the community, but also to its geographic distribution. Dispersal is an integral part of the biology of plant communities. The most familiar classification of dispersal methods is that of Molinier and Muller (1938), based upon the agent of transport. In order to improve the logic and ease of application of the dispersal classification, Dansereau and Lems (1957) have replaced the "zoochore, anemochore" approach with a classification based on adaptive morphology shown in Table 3. The symbols which they provided can be used in pictorial diagrams of vegetation.

STRUCTURE OF TWO COMMUNITIES

Two plant communities will now be analysed as to structure (Fig. 1-2). The phytosociology of these two communities was described by the author (Lems, 1958) but additional data have now become available. The following list will indicate the ecological and geographic differences between the two communities:

	Euphorbietum atropurpureae	*Kleinio - Asparagetum albae*
Island:	Tenerife	Fuerteventura
Locality:	Between Santiago and Masca	Volcán de La Oliva
Elevation:	900 1100 m	250 - 350 m
Mean annual rainfall:	575 mm	214 mm
Mean annual temperature:	13.8° C	18.1° C
Substrate:	Loam with boulders over old-Tertiary basalts	coarse lava "mal-pais" with small soil pockets rock of Quaternary age
Number of sample areas:	5	4
Dominants:	*Euphorbia atropurpurea* annual grasses	*Asparagus albus* *Kleinia neriifolia*

Table 4 shows the floristic composition of the *Euphorbietum atropurpureae*, near Santiago, Tenerife. Coverage values are given according to the combined estimate scale of Braun-Blanquet (1932). From the coverage and the frequency in 5 sample plots, an "importance value" has been calculated, as discussed in the previous section. In the columns following the importance value, the physiognomic criteria of Table 1 have been applied to the species, as well as the growth form criteria listed in Table 2, and the dispersal class of Table 3. These results will be discussed below. Table 5 shows the same set of data for the Kleinio - Asparagetum albae of La Oliva, Fuerteventura.

It is now possible to compare the structural features of the two communities, not only of the individual species, but also taking into account their relative importance as building blocks of the vegetation. Fig. 3 is based upon the physiognomic classification by Dansereau (1958), using the pictorial symbols proposed by that author. The spacing and number of symbols in these diagrams are based solely on coverage. Those physiognomic types which amount to less than 4% of area covered are not represented. But different species of the same physiognomy are combined, so that from a physiognomic point of view there is no difference between *Euphorbia atropurpurea* and *E. regis-jubae*, and their coverages can be added together and the same symbol is used.

The basic similarity of both vegetation types is immediately evident: they can both be classified as open scrub. However, some of the subtler differences are of interest: the greater coverage of graminoid herbs *(Vulpia, Avena, Briza)* in the *Euphorbia atropurpurea* community perhaps correlated with more continuous soil; the greater prevalence of spines in the *Kleinia - Asparagus* community, suggesting pressure from browsing by goats, and selection of resistant plants *(Lycium afrum, Asparagus albus, Launaea spinosa, Opuntia ficus-indica)*. On the other hand, it should be noted that *Euphorbia* species, have a defense against goats in their bitter, burning latex; in fact, the entire landscape of the Canary Islands near sea level is dominated by goat-resistant vegetation.

An analysis of the more complex growth form formulas yields further interesting differences between the two communities. The first consideration is that of life form. Table 6 shows how a spectrum of life forms can be constructed for each of the communities, in two different ways. First, the number of species can be counted in each category. The species in both communities are predominantly annual (therophytes), with a slightly higher number in the *Kleinia - Asparagus* community. But if the importance of the species is taken into account, by adding the importance values of species having the same life form symbol, the picture corresponds more closely to the relationships existing in the field: therophytes account for less than one fourth of the vegetation in the *Kleinia - Asparagus* community, and for almost one half in the *Euphorbia atropurpurea* community. Exactly the opposite is truc for the shrubs (nanophanerophytes). Branching habit in the two communities is also strikingly different. Using the importance value totals, we find the following percentages:

Kleinia - Asparagus

very dense - 33%, dense - 27%, sparse - 32%, unbranched - 8%

Euphorbia atropurpurea

very dense - 7%, dense - 30%, sparse - 35%, unbranched - 28%.

Apparently there is selection in favor of very densely branched plants in the dry lava fields of the *Kleinio-Asparagetum* in Fuerteventura.

The fall of leaves in both communities is rather comparable, and the differences may not be significant.

Kleinia - Asparagus

aphyllous - 13%, deciduous - 46%, semideciduous - 23%, relay evergreen - 17%, persistent evergreen - 1%.

Euphorbia atropurpurea

aphyllous - 4%, deciduous - 47%, semideciduous - 16%, relay evergreen - 23%, persistent evergreen - 10%.

There appears to be a slight shift toward evergreen leaves in the latter community.

Another interesting difference shows up in a comparison of inflorescence sizes and exposure. Even without summarising the percentages, it is more than evident that the *Euphorbia atropurpurea* community has a preponderance of medium sized inflorescences (11-100 flowers) with several large and very large species (*Aeonium urbicum, Echium aculeatum, Rumex lunaria)*, and no plants with individual flowers; in the *Kleinia - Asparagus* community, small inflorescences prevail (2 - 10 flowers) with none in the large (over 100 flowers) category, and many with individual flowers. The degree of exposure of the inflorescence is also strikingly different: long stalks have an importance value of 53% in the *Euphorbia atropurpurea* community, 13% in the *Kleinia - Asparagus* community. Flowers concealed among the foliage total 7% in the *Euphorbia atropurpurea* plots, 39% in the *Kleinia - Asparagus* community. An explanation of these differences would involve the availability of pollinating insects, their possible tendency to stay near the ground in Fuerteventura, and less reliance on visual factors, in finding the flowers. Further implications have to do with dispersal.

The disseminules produced by the two communities are summarised in Table 7. The species lists of the two stands differ mainly in the complete absence of disseminules with fleshy outer covering, presumably dispersed by birds, in the *Euphorbia atropurpurea* community. If the importance values are taken into account, other differences can be added: desmochores are a large group in the *Euphorbia atropurpurea* community, due mainly to the prevalence of grasses such as *Bromus rubens, Vulpia myuros,* etc., whose pointed, awned lemmas are easily entangled in the fur of animals, suggesting that goats play a role in dispersal, at least on a local scale. Pogonochores, i.e. seeds and fruits with parachutes, are somewhat more important in the *Kleinia - Asparagus* community *(Kleinia, Caralluma,* and *Launaea* are in this group). In general, the latter community is better adapted to long-range dispersal (Wind, birds) and can be predicted to have a wider range over the islands. Indeed Oberdorfer (1965) reports similar vegetation from Tenerife. Fig. 4 is a pictorial representation of the most important growth forms, in decreasing order of stature; the symbols used are a modification of those of Schmid (1956) and Lems (1958).

PHYTOGEOGRAPHIC IMPLICATIONS

The species found in the two communities can be classified according to their degree of endemism in the flora of the Canary Islands. Some of them *(Opuntia ficus-indica, Nicotiana glauca)* are foreigners which have settled in the warmer regions of the Canaries. In Tables 4 - 5 these species are marked I (introduced). Others are plants of Mediterranean origin with a wide geographic range, including all of the Canary Islands, marked W (wide-spread) in Tables 4 - 5. Thirdly, there are plants which have their main area of distribution in the islands, but are also found on the African mainland (A in Tables 4 - 5); such Afro-Canarian species are: *Euphorbia regis-jubae, Helianthemum canariense, Caralluma burchardii, Beta patellaris, Launaea spinosa, Linaria sagittata,* and other species (cf. Rivas Goday and Esteve Chueca, 1964). Fourthly, there is a contingent of Macaronesian species, i.e. plants found on other Atlantic Island groups as well as the Canaries (M in Tables 4 - 5). Examples are" *Micromeria varia,* and *Lavandula pinnata.* It is noteworthy that *Euphorbia* and *Kleinia* communities contain very few of these species, in contrast with the Canarian laurel forest which is composed mainly of Macaronesian species. Finally, there are two classes of endemic species: the Canarian endemics, and the insular endemics (C and E, respectively in Tables 4 - 5). Examples of the former class are: *Kleinia neriifolia,* and *Rubia fruticosa,* found on all of the islands, *Echium aculeatum,* found on three of the western islands, and *Lotus lancerottensis,* found on the two eastern islands. Such species are useful in the recognition of plant associations that extend over several of the islands. Among the insular endemics, which give the associations on each island a different character, are: *Euphorbia atropurpurea* of Tenerife and *Ruthea herbanica* and *Echium fuerteventurae* of Fuerteventura. Table 8 summarises the geographic status of the two communities, according to species as well as importance values.

The two communities have several features in common. In both, wide-ranging Mediterranean species are the most numerous, and have the highest importance value. The next most important category in both communities is the Canarian element.

In the *Euphorbia atropurpurea* community, insular endemics are small in number, but constitute 10% of the importance value, due to the principal dominant. The Afro-Canarian element has a relatively low importance value (7.3%).

In the *Kleinia - Asparagus* community on the other hand, local endemics are of little importance, and the Afro-Canarian group is more prominent. These differences suggest that the *Kleinia - Asparagus* community is a member of the African scrub formation discussed by Rivas - Goday and Esteve Chueca (1964) under the general name *Kleinio - Euphorbion. Kleinia neriifolia* has relatives in Morocco *(K. anteuphorbium)* and in East and South Africa. *Asparagus albus* of the Canary Islands belongs to a separate variety, var. *pastorianus* which also occurs in Morocco. *Ruthea herbanica* is a member of a South African genus.

The *Euphorbia atropurpurea* community is more heterogeneous, and lacks the African affinity. It is perhaps best regarded as a Mediterranean annual grassland which has been invaded by an insular endemic species af *Euphorbia*. The absence of the characteristic African element is correlated with the high elevation. The altitudinal belt from 1000 to 2000 m in the Canary Islands usually bears a distinctly Mediterranean stamp (Schmid, 1954).

S U M M A R Y

1. Two shrub communities are described, one on western Tenerife, dominated by *Euphorbia atropurpurea* and annual grasses, the other on northern Fuerteventura, dominated by *Kleinia neriifolia* and *Asparagus albus*.
2. The structure of the vegetation is described in terms of Dansereau's physiognomic system. The two communities are physiognomically similar, except for a prevalence of thorns and spines in the *Kleinia - Asparagus* community, and greater coverage of annual grasses in the *Euphorbia atropurpurea* community.
3. For the purpose of growth form analysis, each species is given an importance value, based upon relative frequency and relative coverage; the sum of all importance values in each community is 100.

4. Growth forms are analysed by means of a system derived from Raunkiaer (1934), Du Rietz (1931) and Schmid (1956). It is concerned with life form, branching pattern, root type, leaf fall, inflorescence type, and dispersal type.
5. The *Kleinia - Asparagus* community differs from the *Euphorbia atropurpurea* community in that the former has: fewer annuals, more densely branched components, slightly more deciduous plants, smaller, more concealed inflorescences, fewer disseminules adapted to dispersal by mammals, and more adapted to bird and wind dispersal.
6. Analysis of the geographic distribution of the component species shows a more strongly African character in the *Kleinia - Asparagus* community, while the *Euphorbia atropurpurea* community is interpreted as an annual grassland of Mediterranean affinity, invaded by an insular endemic *Euphorbia.*
7. Environmental factors responsible for the differences include: the higher elevation, lower temperature, higher rainfall in the *Euphorbia atropurpurea* community. Influence of goats is also a probable factor, especially in the *Euphorbia* community. Closer proximity of Fuerteventura to the African mainland affects the floristic composition of the vegetation, but this is regarded as an historic, rather than an ecological factor.

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TABLE 1. DANSEREAU'S SIX CATEGORIES OF CRITERIA TO BE APPLIED TO A STRUCTURAL DESCRIPTION OF VEGETATION TYPES (DANSEREAU, 1958).

1. *Life form*
   - W erect woody plants
   - L climbing or decumbent woody plants
   - E epiphytes and crusts
   - H herbs
   - M bryoids
2. *Stratification*
   - 1 more than 25 metres
   - 2 10 - 25 metres
   - 3 8 - 10 metres
   - 4 2 - 8 metres
   - 5 0.5 - 2 metres
   - 6 0.1 - 0.5 metres
   - 7 0.0 - 0.1 metres
3. *Coverage*
   - b barren or very sparse
   - p in patches, tufts, clumps
   - i interrupted, discontinuous
   - c continuous
4. *Function*
   - d deciduous
   - s semideciduous
   - e evergreen
   - j evergreen succulent or evergreen - leafless
5. *Leaf shape and size*
   - o leafless
   - n needle, spine, scale, or subulate
   - g graminoid
   - a medium or small
   - h broad
   - v compound
   - q thalloid
6. *Leaf texture*
   - o leafless
   - f filmy
   - z membranous
   - x sclerophyll
   - k succulent or fungoid
7. *Spines*
   - * present

TABLE 2. GROWTH FORM CRITERIA, REVISED FROM SCHMID (1956), RAUNKIAER (1934) AND OTHERS.

Life form

- M1 megaphanerophytes (trees over 30 m)
- M2 mesophanerophytes (trees 8 - 30 m)
- M3 microphanerophytes (trees 2 - 8 m)
- N nanophanerophytes (shrubs 0.5 - 2 m)
- C1 woody chamaephytes (subshrubs to 0.5 m)
- C2 semi-woody chamaephytes (half-shrubs with woody lower stem)
- C3 herbaceous, creeping chamaephytes (permanent stem on the ground)
- C4 caespitose chamaephytes (cushion plants)
- H1 rosette hemicryptophytes (buds at soil level from basal rosette)
- H2 caespitose hemicryptophytes (sod-forming with buds at soil level)
- G1 rhizomatous geophytes (underground horizontal stem)
- G2 corm geophytes (underground upright stem)
- G3 bulbose geophytes (with underground bulb)
- G4 tuberose geophytes (with underground tubers)
- G5 root-budding geophytes
- Hy hydrophytes (perennials adapted to survival under water)
- T therophytes (annuals and other short-lived plants without permanent axis)

Lignification of the main axis (symbol follows life form in parentheses)

- a axylic (separate vascular bundles, secondary growth producing only parenchyma)
- o oligoxylic (xylem weakly developed or largely parenchymatous)
- h hemixylic (xylem well developed but with soft, thin-walled elements)
- x holoxylic (xylem well developed, forming firm continuous cylinder of wood)

p perxylic (xylem unusually hard, thick walled elements, often impregnated with hardening materials)

m meroxylic (only the lower portion of the stem lignified, becoming axylic or oligoxylic in the upper half

Permanence of the main axis (symbol follows life form in parentheses)

1/2 ephemeral (life cycle completed in few months)

1 annual (life cycle completed in one growing season)

1. 1/2 winter annual (life cycle completed in one full year)

2 biennial (life cycle completed in two growing seasons)

3 pluriennial (plant developing over several years, but not perennial)

4 perennial (plant surviving for indefinite number of years)

B - Branching pattern (symbols following letter B, in parentheses)

Position of branches

F originating from aerial portion of main axis

L originating from basal portion of main axis

E originating from both aerial and basal part main axis

J originating from main axis below soil level

I main axis simple, without branches below the inflorescence

Orientation of branches

a arching, drooping or pendulous

e erect

h horizontal

s sinuous, climbing or winding

x divergent in several directons, ascending, or diffuse

Density of branches

v moderately dense to sparse (1-3 new branches per previous branch)

w dense (4-6 new branches per original branch)

z very dense (more than 6 new branches per previous branch)

Mode of branching

d determinate (each branch terminating in flower, inflorescence, or dead tip; branching from axillary meristems)

i indeterminate (branches elongating from year to year; flowers or inflorescences produced laterally)

m mixed (some branches indeterminate, others determinate)

R - Root system (symbol follows R in parentheses)

P1 thick primary root (taproot)

P2 diffuse primary root system

P3 primary root system of horizontal orientation

Pb with buttress roots

F1 fibrous root system with root-tubers

F2 diffuse fibrous root system

F3 fibrous root system of horizontal orientation

A1 adventitious root system from aerial stem (incl. prop roots, stilts)

A3 adventitious root system from underground stems

A3 adventious root system from underground stems

L - Leaves (symbol follows L in parentheses)

a aphyllous or with ephemeral leaves (photosynthetic function largely or entirely fulfilled by green stems)

d deciduous (shoots losing all leaves during part of the year)

e evergreen with persistent leaves (leaves remain for well over one year)

r relay - evergreen (leaves persisting just long enough to overlap with next year's foliage, but only one set of mature leaves is present at any time) s semideciduous (shoots losing a substantial proportion of leaves during the unfavorable season)

F - Inflorescence (symbols follow F in parentheses)

Size

1 flowers singly attached to the vegetative axis
2 flowers in small, usually simple inflorescences, 2 - 10 flowers
3 flowers in medium-sized, often compound inflorescences with 11 - 100 flowers
4 flowers in large inflorescences with 100 - 1000 flowers
5 flowers in very large inflorescences, over 1000 flowers
- underlining indicates pseudoflowers (morphologically compact inflorescences, e.g. cyathum, capitulum, spikelet)

Exposure

c concealed (reproductive axis shorter than the permanent axis, flowers concealed among the foliage)
d apparent (reproductive axis short, but long enough to expose the flowers on the periphery of the vegetative body of the plant)
e exposed (reproductive axis far exceeding the vegetative body of the plant, exposing the flowers well above it)
p pendulous (reproductive axis elongating downward, hence the fruits of flowers exposed below the crown)
r ramiflorous (attached to the leafless lower branches)
t trunciflorous (attached to the main trunk)
b basiflorous (attached to the base of the main trunk)

D - Disseminule (symbols to follow D in parentheses; for criteria, see Table 3)

TABLE 3. DISSEMINULE TYPES, AFTER DANSEREAU & LEMS (1957), SLIGHTLY MODIFIED.

Autochores (dispersal by parent plant)

1. Sclerochores (disseminules without apparent morphological or physiological adaptation for dispersal, neither very heavy nor very light)
2. Barochores (disseminules very heavy, dispersed by gravity)
3. Auxochores (disseminules deposited on the ground by arching or elongating stalks of the parent plant)
4. Ballochores (disseminules shot away from the parent plant by the release of valves or other mechanism)

Allochores (dispersal by agency in the environment)

Anemochores

5. Sporochores (disseminules small and light enough to be carried by air currents)
6. Pogonochores (disseminules provided with capillary hairs or bristles, allowing it to float in the air for some time)
7. Pterochores (disseminules provided with wing-like appendages, breaking the fall)
8. Cyclochores (branched framework containg seeds, capable of rolling on ground; tumbleweeds)

Zoochores

9. Desmochores and ixochores (disseminules provided with bristles, hooks or barbs, or mucilaginous, allowing them to stick to various animals)
10. Sarcochores (disseminules with fleshy or juicy covering and resistant inner part, allowing them to be carried in animal intestine)
11. Chromatochores (disseminules not fleshy or juicy, but attractive to animals, especially birds, because of conspicuous or contrasting colors, especially red).

TABLE 4. *Euphorbietum atropurpureae*, floristic composition, importance of the species, physiognomy, and growth forms. All data from W. Tenerife, between Santiago and Masca, 950 - 1050 m.

Species		Coverage in plot no. 1	2	3	4	5	Imp. Value	Physiognomy formula (Table 1)						
Euphorbia atropurpurea (Brouss.) W. & B.	E	1	-	2	2	3	9.8	W5isaz	N (h4)	B(Fxvm)	R(p)	L(s)	F(3d)	D(1)
Vulpia myuros (L.) Gmel.	W	-	1	-	3	2	7.4	H6idgz	T (a1)	B(1e-d)	R(f)	L(d)	F(3e)	D(9)
Micromeria varia Benth.	M	1	+	1	2	+	6.7	W7penx	C1(x4)	B(Exzd)	R(p)	L(e)	F(2d)	D(1)
Avena barbata L.	W	1	1	+	2	+	6.7	H6idgz	T (a1)	B(Levd)	R(f)	L(d)	F(3e)	D(9)
Phagnalon purpurascens Sch.Bip.	A	1	1	1	+	-	5.2	W7peaz	C1(x4)	B(Exwd)	R(p)	L(r)	F(1e)	D(6)
Retama monosperma (L.) Boiss.	W	1	-	+	+	1	4.3	W5pjoo	N (x4)	B(Eewd)	R(p)	L(a)	F(2c)	D(1)
Echium aculeatum Poir.	C	1	1	+	+	-	4.3	W6peax*	C1(x4)	B(Exwm)	R(p)	L(r)	F(4d)	D(9)
Briza maxima L.	W	-	1	-	-	2	4.0	H6pdgz	T (a1)	B(1e-d)	R(f)	L(d)	F(2e)	D(7)
Inula viscosa Ait.	W	-	1	+	1	-	3.7	W6peaz	C2(m4)	B(Exwd)	R(a2)	L(r)	F(3e)	D(6)
Bromus rubens L.	W	1	1	+	-	-	3.7	H7pdgz	T (a1)	B(1e-d)	R(f)	L(d)	F(2d)	D(9)
Cistus monspeliensis L.	W	-	-	-	-	3	3.4	W5peaz	N (x4)	B(Exwm)	R(p)	L(e)	F(2d)	D(1)
Evax pygmaea (L.) Pers.	W	1	1	-	-	-	3.1	H7pdaz	T (a1)	B(1e-d)	R(p1)	L(d)	F(2d)	D(1)
Euphorbia regis-jubae W. & B.	A	-	-	1	+	+	2.7	W5psaz	N (h4)	B(Fxwm)	R(p)	L(s)	F(3d)	D(1)
Tunica prolifera (L.) Scop.	W	+	+	1	-	-	2.7	H7bdgz	T (a1)	B(1e-d)	R(p)	L(d)	F(2e)	D(1)
Wahlenbergia lobelioides DC.	W	+	1	+	-	-	2.7	H6bdaz	T (a1)	B(Eevd)	R(p)	L(d)	F(3e)	D(1)
Hyparrhenia hirta (L.) Stapf	W	-	-	2	-	-	2.5	H6psgz	H2(a4)	B(Lewd)	R(f)	L(s)	F(3e)	D(6)
Silene gallica L.	W	+	1	-	-	-	2.1	H7bdaz	T (a1)	B(1e-d)	R(p)	L(d)	F(2e)	D(1)
Tolpis barbata Gaertn.	W	+	-	1	-	-	2.1	H7bdaz	T (a1)	B(Lxvd)	R(p)	L(d)	F(2e)	D(6)
Papaver sp.	W	+	1	-	-	-	2.1	H6bdvz	T (a1)	B(fxvd)	R(p)	L(d)	F(2e)	D(1)
Cynosurus elegans Desf.	W	-	+	-	-	1	2.1	H6bdgz	T (a1)	B(1e-d)	R(f)	L(d)	F(1e)	D(9)

Medicago minima L.	W	-	1	+	-	-	2.1	H7bdvz	T (a1)	B(Exvd)	R(p)	L(d)	F(2c)	D(9)
Monanthes pallens (Webb) Christ	C	-	-	1	-	-	1.5	H7beak	C4(04)	B(le-1)	R(p1)	L(r)	F(2d)	D(1)
Galactites tomentosa Moench	W	-	-	1	-	-	1.5	H6bdaz	T (o1)	B(Fxvd)	R(p)	L(d)	F(2e)	D(5)
Calerdula arvensis L.	W	-	-	1	-	-	1.5	H7bdaz	T (a1)	B(Lxvd)	R(p)	L(d)	F(2d)	D(7)
Pallenis spinosa (L.) Cass.	W	-	-	1	-	-	1.5	H6bdaz	T (o1½)	B(Fxvd)	R(p)	L(d)	F(2e)	D(1)
Rumex lunaria L.	C	-	-	+	-	-	0.6	W5beak	N (h4)	B(exwm)	R(p)	L(r)	F(4d)	D(7)
Cytisus proliferus L.f.	C	+	-	-	-	-	0.6	W5bevz	M3(x4)	B(Fxwi)	R(p)	L(r)	F(2c)	D(1)
Lavandula pinnata L.f.	M	-	-	+	-	-	0.6	W6bevz	C1(x4)	B(exvd)	R(p)	L(r)	F(3e)	D(1)
Aeonium urbicum (Chr.Sm.) W. & B.	C	-	-	+	-	-	0.6	W5beak	N (h3)	B(le-d)	R(a1)	L(r)	F(4e)	D(1)
A. sedifolium Webb	C	-	-	+	-	-	0.6	W6bsak	C1(h4)	B(Exwm)	R(a1)	L(s)	F(2e)	D(1)
A. canariense W. & B.	E	-	-	+	-	-	0.6	H6behk	C4(04)	B(Lhvd)	R(a2)	L(r)	F(4e)	D(1)
Greenovia aurea (Chr. Sm.) W. & B.	C	-	-	+	-	-	0.6	H6beak	C2(04)	B(Lhvd)	R(a2)	L(r)	F(3e)	D(1)
Lobularia intermedia W. & B.	C	+	-	-	-	-	0.6	W6beaz	C1(x4)	B(Exwd)	R(p)	L(r)	F(3e)	D(7)
Sonchus congestus Willd.	C	-	-	+	-	-	0.6	H5bshz	C4(04)	B(Lxvd)	R(p)	L(s)	F(3e)	D(6)
Polycarpaea teneriffae Lam.	C	+	-	-	-	-	0.6	H7beaz	C2(m4)	B(Exwd)	R(p)	L(r)	F(3d)	D(1)
Silene vulgaris (Moench) Gcke	W	-	+	-	-	-	0.6	H6beaz	C3(04)	B(Exwd)	R(p)	L(r)	F(3e)	D(1)
Lamarckia aurea Moench	W	-	-	+	-	-	0.6	H7bdgz	T (a1)	B(Levd)	R(f)	L(d)	F(3e)	D(9)
Oryzopsis miliacea (L.) Batt.	W	-	-	+	-	-	0.6	H6begz	H2(a4)	B(Lewd)	R(f)	L(r)	F(3e)	D(1)
Psoralea bituminosa L.	W	-	-	+	-	-	0.6	W6bevz	C1(x4)	B(Exwd)	R(p)	L(r)	F(2e)	D(1)
Umbilicus horizontalis (Guss.) DC.	W	-	-	+	-	-	0.6	H7bdak	G2(a4)	B(Jevd)	R(a3)	L(d)	F(3e)	D(1)
Urginea maritima (L.) Baker	W	+	-	-	-	-	0.6	H6bdgz	G3(a4)	B(Jevd)	R(a3)	L(d)	F(4e)	D(7)
Erodium chium (L.) Willd.	W	-	-	+	-	-	0.6	H7bdaz	T (a1)	B(Lxvd)	R(p)	L(d)	F(2d)	D(4)
Cheilanthes pulchella Bory	C	-	-	+	-	-	0.6	H7bevz	H1(a4)	B(lh-i)	R(f2)	L(r)	F(--)	D(5)
Notholaena vellea (Ait.) Desv.	W	-	-	+	-	-	0.6	H6bevz	H1(a4)	B(lh-i)	R(f2)	L(r)	F(--)	D(5)

TABLE 5. Kleinie - Asparagetum albae, floristic composition, importance of the species, physiognomy, and growth-forms. All data from La Oliva, Fuerteventura, Plot 1: March 1966, Plots 2, 3, 4: August 1956.

Species:	Endemism	Coverage in plot no. 1	2	3	4	% Imp. Value	Physiognomy formula (Table 1)	Life form	Main Axis	Branch develop-ment	Root system	Leaves	Inflor-escence	Dispersal type
Asparagus albus L.	W	2	2	2	1	14.1	W5isnz*	N	(x^4)	B(Eazi)	R(f)	L(s)	F(2c)	D(10)
Kleinia neriifolia Haw.	C	1	2	2	2	14.1	W5idak	N	(h^4)	B(Fxvm)	R(p)	L(d)	F(3d)	D(6)
Euphorbia regis-jubae W. & B.	A	+	1	1	2	9.2	W5psaz	N	(h^4)	B(Fxwm)	R(p)	L(s)	F(3d)	D(1)
Caralluma burchardii N.E.Br.	A	1	1	+	1	7.6	H7pjoo	G1	(o^4)	B(Jev)	R(a3)	L(a)	F(2c)	D(6)
Rubia fruticosa Ait.	C	1	+	1	+	6.0	W5peaz	N	(x^4)	B(Exwi)	R(p)	L(r)	F(2c)	D(10)
Lycium afrum L.	W	1	1	-	+	5.3	W6pdak*	C1	(x^4)	B(Exzn)	R(p)	L(d)	F(1c)	D(10)
Lotus lancerottensis Webb	C	1	+	+	+	4.4	H7pevz	C2	(m^4)	B(Ehzd)	R(p)	L(r)	F(2d)	D(4)
Launaea spinosa (Forsk.) Sch. Bip.	A	1	-	-	+	3.0	W6bjco*	C1	(x^4)	B(Exzd)	R(p)	L(a)	F(1c)	D(6)
Linaria sagittata Hook.f.	A	+	+	+	+	2.8	W7beaz	C2	(m^4)	B(Exzd)	R(p)	L(r)	F(1d)	D(1)
Opuntia ficus-indica (L.) Mill.	I	1	-	-	-	2.3	W5bjco*	N	(o^4)	B(Exvd)	R(a)	L(a)	F(1d)	D(10)
Ruthea herbanica Bolle	E	1	-	-	-	2.3	H6bdvz	H1	(o^4)	B(Levd)	R(pl)	L(d)	F(3e)	D(1)
Mercurialis annua L.	W	1	-	-	-	2.3	H6bdez	T	(a1)	B(Fxwd)	R(p)	L(d)	F(2d)	D(1)
Echium fuerteventurae Lems & Hlz.	E	1	-	-	-	2.3	H6bdez	T	(a1)	B(le-d)	R(pl)	L(d)	F(3e)	D(7)
Nicotiana glauca Grah.	I	+	-	-	+	1.4	W4beaz	M3	(x^4)	B(Fawd)	R(p)	L(r)	F(2e)	D(1)
Geranium rotundifolium L.	W	+	-	-	+	1.4	H7bdvz	T	(a1)	B(Lxwd)	R(p)	L(d)	F(2d)	D(4)
Arenaria leptoclados (Rchb.) Guss.	W	-	+	-	+	1.4	H7bdaz	T	(a1)	B(Exwd)	R(p)	L(d)	F(2d)	D(1)
Phillyrea angustifolia L.	W	-	-	+	-	0.7	W6beax	C1	(x^4)	B(Exwi)	R(p)	L(e)	F(1c)	D(10)
Micromeria varia Benth.	M	-	+	-	-	0.7	W7benx	C1	(x^4)	B(Exzd)	R(p)	L(r)	F(2d)	D(1)
Helianthemum canariense Pers.	A	-	-	-	+	0.7	W7beaz	C2	(m^4)	B(Ehzd)	R(p)	L(r)	F(2d)	D(1)
Spergularia fimbriata Boiss.	W	+	-	-	-	0.7	H7benz	C2	(m^4)	B(Exzd)	R(p)	L(r)	F(2d)	D(7)

Atriplex glauca L.	W	+	-	-	-	0.7	V6beaz	C1(m4)	B(Exzd)	R(p)	L(e)	F(3d)	D(1)
Umbilicus horizontalis (Guss.) DC.	W	-	-	+	-	0.7	H6bdak	G2(a4)	B(Jevd)	R(a3)	L(d)	F(3e)	D(1)
Avena barbata Brot.	W	+	-	-	-	0.7	H6bdgz	T (a1)	B(Levd)	R(f)	L(d)	F(3e)	D(9)
Bromus macrostachys Desf.	W	+	-	-	-	0.7	H6bdgz	T (a1)	B(le-d)	R(f)	L(d)	F(2e)	D(9)
Bromus rigidus Roth.	W	+	-	-	-	0.7	H6bdgz	T (a1)	B(Levd)	R(f)	L(d)	F(2e)	D(9)
Lamarckia aurea Moench	W	+	-	-	-	0.7	H7bdgz	T (a1)	B(Levd)	R(f)	L(d)	F(3e)	D(9)
Stipa tortilis Desf.	W	+	-	-	-	0.7	H6bdgz	T (a1)	B(Lewd)	R(f)	L(d)	F(3d)	D(9)
Asphodelus fistulosus L.	W	-	-	-	+	0.7	H6bdgz	T (a1½)	B(Levd)	R(f1)	L(d)	F(3e)	D(1)
Sonchus oleraceus L.	W	+	-	-	-	0.7	H6bdvz	T (a1)	B(le-d)	R(p1)	L(d)	F(2e)	D(6)
Picridium vulgare Desf.	W	+	-	-	-	0.7	H7bdaz	T (o1)	B(le-d)	R(p1)	L(d)	F(2e)	D(6)
Linum strictum L.	W	+	-	-	-	0.7	H7bdnz	T (a½)	B(le-d)	R(p)	L(d)	F(2d)	D(1)
Antirrhinum orontium L.	W	+	-	-	-	0.7	H7bdaz	T (a½)	B(le-d)	R(p)	L(d)	F(2d)	D(1)
Scrophularia arguta Soland.	W	+	-	-	-	0.7	H6bdaz	T (a1½)	B(le-d)	R(p)	L(d)	F(2e)	D(1)
Silene gallica L.	W	+	-	-	-	0.7	H7bdaz	T (a1)	B(le-d)	R(p)	L(d)	F(2e)	D(1)
Ononis pendula Desf.	W	+	-	-	-	0.7	H6bdvz	T (a1)	B(Exwd)	R(p)	L(d)	F(2d)	D(1)
Lobularia lybica W. & B.	W	+	-	-	-	0.7	H7bdaz	T (a1)	B(Ehwd)	R(p)	L(d)	F(2d)	D(7)
Fagonia cretica L.	W	+	-	-	-	0.7	H7bdvz*	T (m1½)	B(Ehwd)	R(p1)	L(d)	F(1c)	D(1)
Atractylis cancellata L.	W	+	-	-	-	0.7	H7bdaz	T (a1)	B(Lxvd)	R(p1)	L(d)	F(1d)	D(6)
Beta patellaris Moq.	W	+	-	-	-	0.7	H7bdak	T (m1½)	B(Lhvd)	R(p1)	L(d)	F(1c)	D(10)
Fumaria officinalis L.	W	+	-	-	-	0.7	H6bdvz	T (a1)	B(Fxzd)	R(p)	L(d)	F(2c)	D(1)
Lathyrus articulatus L.	W	+	-	-	-	0.7	H6bdvz	T (a1)	B(Fswd)	R(p)	L(d)	F(2d)	D(1)
Plantago psyllium L.	W	+	-	-	-	0.7	H7bdnz	T (a1)	B(Exwd)	R(p)	L(d)	F(2d)	D(1)
Torilis infesta Hoffm.	W	+	-	-	-	0.7	H7bdvz	T (a½)	B(le-d)	R(p1)	L(d)	F(2d)	D(9)
Vicia atropurpurea Desf.	W	+	-	-	-	0.7	H6bdvz	T (a1)	B(Fswd)	R(p)	L(d)	F(2d)	D(4)

TABLE 6. COMPARISON OF LIFE FORMS IN TWO CANARIAN PLANT COMMUNITIES.

Life form	Euphorbietum atropurpureae		Kleinio - Asparagetum	
	No. of species	Imp. value	No. of species	Imp. value
Microphanerophytes	1	0.6	1	1.4
Nanophanerophytes	6	21.4	5	45.7
Chamaephytes	14	26.8	9	19.0
Hemicryptophytes	4	4.3	1	2.3
Geophytes	2	1.2	2	8.3
Therophytes	17	45.7	26	23.3

TABLE 7. DISPERSAL TYPES IN TWO CANARIAN PLANT COMMUNITIES. FOR EXPLANATION SEE TABLE 3.

Type	Euphorbietum atropurpureae		Kleinio - Asparagetum	
	No. of species	Imp. value	No. of species	Imp. value
1. Sclerochores	23	48.7	20	29.7
4. Ballochores	1	0.6	3	6.5
5. Sporochores	2	1.2	-	0.0
6. Pogonochores	7	15.3	6	26.8
7. Pterochores	5	7.3	3	3.7
9. Desmochores	6	26.9	6	4.2
10. Sarcochores	-	0.0	6	29.1

TABLE 8. GEOGRAPHIC RANGES OF THE SPECIES IN TWO CANARIAN PLANT COMMUNITIES.

	Range	Euphorbietum atropurpureae		Kleinio - Asparagetum	
		No. of species	Imp. value	No. of species	Imp. value
E	Insular endemics	2	10.4	2	4.6
C	Canarian endemics	11	11.2	3	24.5
M	Macaronesian species	2	7.3	1	0.7
A	Afro-Canarian species	2	7.9	5	21.0
W	Mediterranean species	27	63.2	31	45.5
I	Introduced species	—	0.0	2	3.7

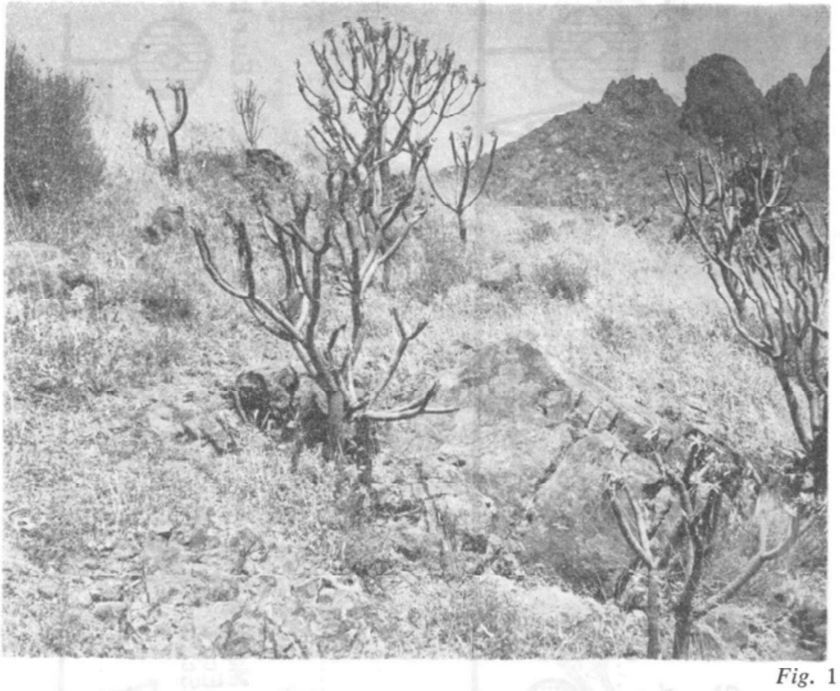

Fig. 1

Fig. 2

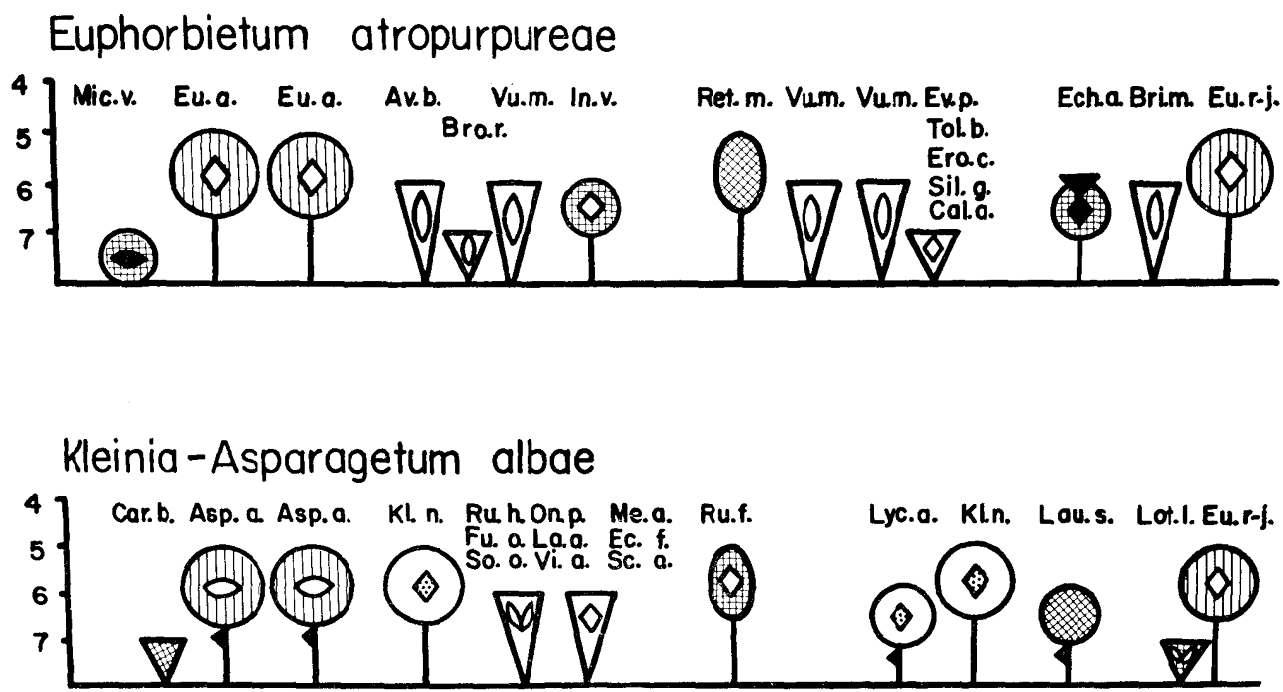
Euphorbietum atropurpureae
4
5
6
7
Mic.v. Eu.a. Eu.a. Av.b. Vu.m. In.v. Ret.m. Vu.m. Vu.m. Ev.p. Ech.a. Bri.m. Eu.r-j.
Bro.r.
Tol.b.
Ero.c.
Sil.g.
Cal.a.
Kleinia-Asparagetum albae
4
5
6
7
Car.b. Asp.a. Asp.a. Kl.n. Ru.h. On.p. Me.a. Ru.f. Lyc.a. Kl.n. Lau.s. Lot.l. Eu.r-j.
Fu.o. La.a. Ec.f.
So.o. Vi.a. Sc.a.

Fig. 3

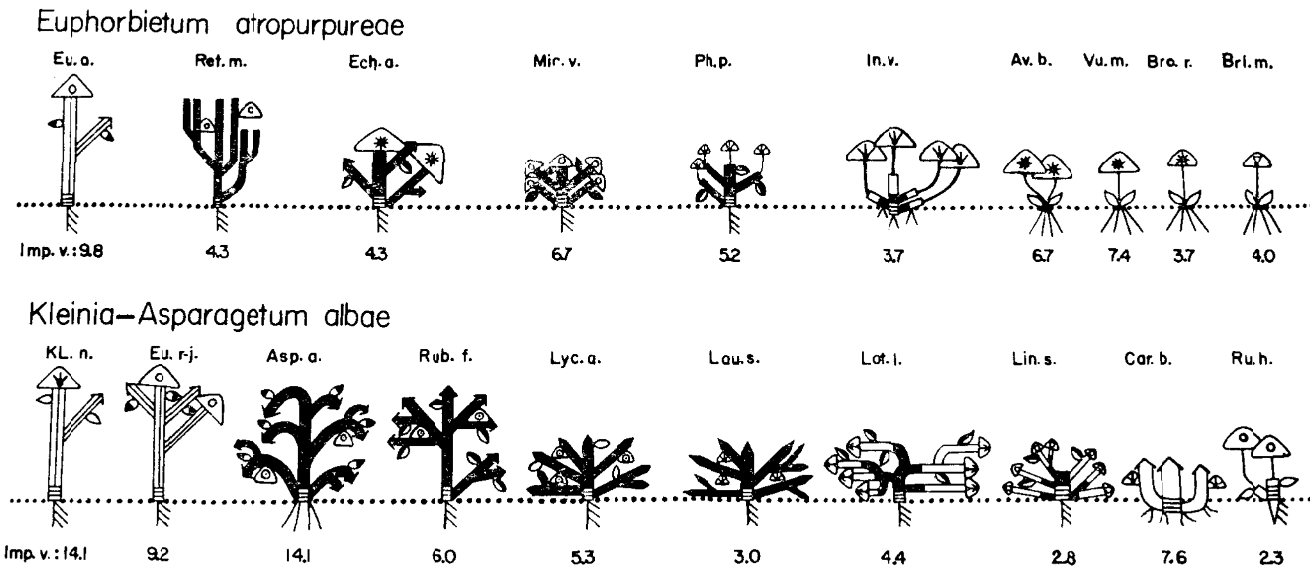
Euphorbietum atropurpureae
Eu. a.
Ret. m.
Ech. a.
Mir. v.
Ph. p.
In. v.
Av. b.
Vu. m.
Bro. r.
Bri. m.
Imp. v.: 9.8
4.3
4.3
6.7
5.2
3.7
6.7
7.4
3.7
4.0
Kleinia–Asparagetum albae
KL. n.
Eu. r-j.
Asp. a.
Rub. f.
Lyc. a.
Lau. s.
Lot. l.
Lin. s.
Car. b.
Ru. h.
Imp. v.: 14.1
9.2
14.1
6.0
5.3
3.0
4.4
2.8
7.6
2.3

Fig. 4

LEGEND FOR THE FIGURES

Fig. 1 — Community of *Euphorbia atropurpurea* at 1050 m, Santiago del Teide, Tenerife. *Retama monosperma* on the upper lefthand side.

Fig. 2 — Community of *Kleinia neriifolia* and *Asparagus albus* at 250 m, La Oliva, Fuerteventura, with *Caralluma buchardii.*

Fig. 3 — Comparison of physiognomy of two Canarian shrub communities, according to a system proposed by Dansereau (1958).

Fig. 4 — Comparison of the ten most important plant growth forms of two Canarian shrub communities, according to a system modified from Schmid (1956). Black: holoxylic axes, three lines: hemixylic, open: oligoxylic, single lines: axylic.