

LOGICAL ANALYSIS AND ANGIOSPERMIC FAMILIES

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SUMMARY

Angiospermic families are considered by the author as distinct evolutionary sets, directly issued by sexual segregation from the vegetative proliferation of green matter which covered Earth by the end of the Mesozoic geological period.

These family sets may, and consequently must, all be fitted to a common mathematical scheme, made of a Mendelian trinomial expansion through successive, interdependent but independent, evolutionary periods in each of which has become segregately fixed a functional character.

So all taxa are precisely located by means of a discontinuous numeration, whose gaps, substitute to missing links, measure dissimilarity between the actually existing forms.

This discontinuity can also be translated in cartesian coordinates corresponding to morphological degree of adaptative specialization (+ or - x), simplifying involution (y), recessive diversion (z).

Families then can easily be compared, for each of their evolutionary periods as well as in totality, inside the standard, mathematical or graphical, scheme in which is expressed the comparative pressure of past and present environmental conditions.

'There are knowledge of two kinds; whereof one is knowledge of facts; the other knowledge of the consequence of one affirmation to another. The former is nothing else than sense and memory, and is absolute. . . . The latter is called science, and is conditional' (Hobbes, 1651, pp. 1, 9).

No affirmation can be made as long as the facts it underlies have not been collected and weighed up. Nowadays biosystematicians are faced with a tremendous number of names, each of which theoretically applies to a taxon: species, genus, etc. Considered from the viewpoint of the splitter, these names and taxa must all be known before any general classification is attempted, and they are innumerable; so, geographically or morphologically partial analysis and the dichotomous keys based on it must be considered as a longlasting necessity. Considered from the viewpoint of the lumpner, more than 90% of such names are mere synonyms, and the census already made, at least in the angiosperms, allows one to search for natural laws with a reasonable probability of success.

Progress must, like man, walk on two legs. For biosystematics, splitting is one leg and lumping the other one. Unfortunately, since I first heard of these two tendencies, some 30 years ago, splitters have become very numerous and lumpers very scarce. For instance, 8904 new names of tropical African plants have been published in a recent decennium (Léonard, 1965)! Actually, far too many of so-called new species, genera or even families should be relegated to a subordinate rank if not wholly weeded out. So I believe systematic biology nowadays to be lame. Yet, a return to lumping would not be the correct cure for the present excess of splitting: it would simply end in a transfer of lameness to the other side of the body of biosystematics. What has to be done is not a matter of dogmatism but of logic. To the international rules of nomenclature must be added, as a systematic background, international laws of taxonomy.

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Kingdom, subkingdom, class, subclass, order, suborder, family, subfamily, tribe, subtribe, genus, subgenus, species, subspecies, variety, subvariety, are generally considered as the actual descent of a single bisexual or dual unisexual ancestors. Beginning with a primitive individuality, this orthodox classification of taxonomic ranks ends with each of the individuals at present alive. Now, from a systematically biological standpoint, much needs to be said about this notion of taxonomic individuality: in it eleven different categories, at least, must be distinguished (Roberty, 1946). The true 'biont', born of an egg and able by itself to lay such an egg, is very different indeed from the pure 'topont', issued from a cutting and bearing sterile fruits. Among the toponts, apparent individuals, some may be collective, and others eunuchs, more are unisexual and so partial, very few are actual bionts. From a dynamic and thus an evolutionary viewpoint, individuality belongs to the hive and not to the bee.

Let us now consider, as far as Angiosperms are concerned, the primitive individual. Corner (1949) grants to it a maximum of archaism and complexity. This is necessarily true as we primarily know, or at least conceive, the whole evolution of living beings to operate along two complementary ways: one being the organic simplification of individuals, one their correlative diversification. Yet, personally, I should rather describe this common ancestor as collective. When reasoning about bionts and toponts within evolutionary sets, one must keep in mind that a much greater difference does exist between autotrophy and heterotrophy than between the vegetable and animal kingdoms. In the whole of living beings, notwithstanding quantitative differences in the differentiation of sexual organs, or in alternation and development of diploid and haploid structures, biological individuality relies on sexuality which appears to play a constant part if considered as compulsory to the full renewal of the true individual's life-cycle. So may the role of sex be summed up as the condensing of life-specific potentialities within a reduced and dormant structure, able to survive under adverse conditions and await their betterment. Angiosperms are autotrophic. Adverse conditions remained unknown to them as long as Earth remained enclosed by a thick and dense layer of tepid clouds (Roberty, 1962). Sexuality became a necessity for them with the appearance of climates and seasons, in the early part of the Tertiary period. Previously, sexual multiplication was possible but not indispensable, as is now in many taxa vegetative multiplication. Phanerogams are either Gymnosperms or Angiosperms. The former have appeared in the Palaeozoic period but were then closely linked with Pteridophytes, especially by their sexual or protosexual organs (Gaussen, 1944). The latter may be said to have no fossil ancestors (Delevoyras, 1962, p. 171). I believe that Angiosperms at least proceed from a large bulk of green matter, haphazardly and reversibly diversified by vegetative processes.

No taxonomy, at least in the present sense of the word, can be conceived apart from orthogenesis, *id est* irreversibility of more or less adaptive specialization. The way in which specialization is acquired constitutes the main field of biosystematical discussions. Doubtless, prejudice and pride have played too prominent a part in these discussions. Linnaeus, Lamarck, Darwin, have been forced into sharp controversy much too often. Even now, it seems impossible, without personally assuming an excess of unreasonable risks, to introduce objectivity among the old weapons of this fierce battlefield. Yet, fathers of biosystematics, so much respected as they are criticized, were ignorant of most of present knowledge, for instance the laws of heredity. And apparently the leaders of present-day debates ignore the laws of logic.

For argument sake, let us begin by casting away the facts: 'commençons par écarter les faits' (Rousseau, 1754). Then only affirmative interpretations remain and are much

too often conflicting. For as long as man has reflected, throughout all the areas of reflection, such useless and virulent conflicts have appeared. Nowadays botanists need not believe that disagreements between them spring from a professional and infinite malediction! Two thousand years ago, Epictetus used to say 'what is important is not the things in themselves but our opinion about them'. Now, if no common opinion exists on the same set of things or facts, this simply demonstrates any set can be observed from more than one viewpoint, either proximate as in genetics, or faraway distant as in paleontology: the scale of observation creates the phenomenon (Lecomte du Noüy, 1948). In other terms, prehensibility of nature and prehensivity of one's brain are identical. This being granted, evidence is given of the necessity for a general explanation of nature, especially in the field of biosystematics, to be probabilistic and not dogmatic.

Coming back to facts, we have now to examine how they can be classified according to the mathematical laws of probability. No registry office existing for angiospermic taxa, their delimitation is not easy. The only clue is morphological similarity: there belong to the same taxon plants less different one from another than from any other plants belonging to any other taxon. Unfortunately, every plant, every Angiosperm at least, is a collection of vital functions served by various organs, whose morphological details are each supported by a gene or genetical determinant now and then active or idle. Functions, organs and morphological details are named characters. Chromosomatic topography of individual genes has been thoroughly studied. Functional collectivities of individual genes must exist, but neither microscopic investigation nor statistical analysis of hereditary factors have up to the present given evidence in their favour. So tradition, based on the fame acquired by leading botanists of the past, remains the sole support of the taxonomic value granted to morphological characters in classical floras. Such characters are too large a complex from the genetical viewpoint. From the physiological viewpoint, they are but serving parts of one or more vital functions.

Initially the hierarchy was uniform in all Angiosperms: primarily divided according to their double or single cotyledon; secondarily by their apetalous, dialypetalous or gamopetalous flowers; subsequently by the number of parts in floral verticils. We all know this to be an 'artificial system', with the exception of double or single cotyledon, maintained in primary rank by a majority of present botanists, including myself. To this have been opposed 'natural systems'. All of these rely upon natural sets of evolution, named families, but have nearly nothing else in common; this may appear to the man-in-the-street as rather disheartening. By the way, it would be judicious to definitely drop these classical terms: the greek word *systema* and the latin word *artificium* are mere synonyms; so 'artificial system' is pleonastic whilst 'natural system' is contradictory and strictly speaking senseless. By '*systema naturae*' Linnaeus actually meant a practical approach, not a dogmatic one, towards a logical classification of nature.

Nowadays, in my belief, a major cause of misunderstanding springs out of the word character taken in a too wide use. Consequently, in my own system a character groups all the organs cooperating to a same adaptative function; each of the morphological details particular to an adaptation being named a characteristic.

What are adaptative functions? Well, the first thing to insist upon is their scarcity, at least in Angiosperms. These in their presexual complication had only three struggle-for-life problems: to grow, to proliferate and to last. With sexualization have appeared three supplementary needs: protection of ovules, attraction of pollen, dispersion of seeds. In the primitive patrimony of each family, cooperating organs were partly fixed and partly not. Classic frontiers between different families are built upon their different fixed parts.

All authors of local and general floras know how difficult it is to discover and define such frontiers: 'natura non facit saltus' (Leibniz, 1703, pp. 4, 16). Absolutely speaking, they do not exist and Linnaeus knew it (Baehni, 1957). Families, as well as genera or species, are naught but pragmatic conveniences if considered with a static lack of perspective. They only become actual taxa if dynamically identified to evolutionary sets or subsets.

Of course, in my own system families remain generally defined by one or more common features but not without prejudice, chiefly on two points. First, most of such features can be found in more than one family. Second, apparent or actual exceptions nearly always do exist. Let us take the case of Fabaceae: they have in common a leguminous fruit and a papilionaceous corolla. This type of fruit exists in all other Fabales (Leguminosae) but may be samaroid, as in *Aubrevillea*, or drupaceous, as in *Cordyla*; these two are linked to proper legumes by complex and practically continuous transitions. As far as the butterfly-like flowers are concerned, some can be found, more or less achieved, in Polygalaceae which are in all other respects very different from Fabaceae. Among innumerable examples of the same type, I shall give only two more, chosen within families we shall more thoroughly discuss further on. The ochrea is given as a typical feature of Polygonaceae but eighteen of their genera only have this peculiar kind of stipular sheath whilst nineteen have not. Distemony is said to be typical of Oleaceae but out of twenty-seven probable genera in this family nineteen respond to this condition; five number two, three or four stamens; two always four; one four to eight!

In my opinion, a much more secure difference between families can be provided with the evolutionary sequence of their characters, this word being here and henceforth understood as meaning an adaptative function plus the organs serving to its adaptation. Every familial set of evolution is made of successive periods, each of which ends with the irreversible diversification of all characteristics initially and adaptatively variable in the corresponding character.

This implies that but one character can be used to differentiate the taxa upon each hierarchic and evolutionary level of intrafamilial diversification.

Any homogeneous group of living beings may then be conceived as a foliated set of interdependent but independent characters, each of which in succession responds to one taxonomic determinist by a segregated actualization of its initial potentialities; this leading to a loss of all but one of them in every characteristic. In the field of general biology, such a conception is not a new one. Teilhard de Chardin (1955) has illustrated his paleontological major scheme by an exfoliating process compared to that of a bulb. Lwow (1943) has directly observed the loss of useless functions in the physiological evolution of microorganisms. My own part is restricted to the field of angiospermic taxonomy.

Now, in this restricted field, what is a potentiality and how does its actualization occur? Let us have an example. Preserved in rocky sites, archaic forms of *Cymbachne guineensis*, commonest and most variable of west tropical African grasses, have: along the south Saharan border, *C. guineensis* subvar. *tridentata*, massive and hairy pedicels; along the margins of rain forest, *C. guineensis* subvar. *doleriticola*, thin, long and glabrous ones. Between these two limits, *C. guineensis* subvar. *gayana*, the *Andropogon gayanus* of most authors if not exactly of Kunth, has massive and glabrous pedicels (Roberty, 1960). Potential variation affects the development of the spike skeleton. Actual modification fixes its hairiness, maximum in arid sites and minimum in humid ones, as well as its gracility, minimum in sunny sites and maximum in shady ones.

This example concerns the first supraspecific evolutionary level, yet unfinished and with its characteristics, at least some of them, subject to Mendelian variation. I should like to insist on the point: Mendelian variation segregates these forms, which have an actual adaptative value; consequently, and not as a cause, the surroundings interfere and select the best adapted.

In all the angiospermic families I have analysed, with very varied accuracy, four achieved evolutionary periods do always exist, generally agreeing with classical hierarchy of subfamilies, tribes, genera and species. Classical hierarchy, however, in its detailed application ere now, relies upon eruditional authority or local convenience; it does not rely upon a logical use of what we know about evolution.

Let us examine the normal distribution of sedimentary matter along a watercourse: it begins with the coarsest elements, ends with the finest ones. Similarly, the potential diversity of a character, as measured by the number of its characteristics, may in terms of mathematical probability be used to define the level of its corresponding period inside the familial evolutionary set. We all presume one subfamily to include various tribes, one genus to include various species: the finer is their definition, the more numerous are the taxa.

In agreement with Mendelian segregation and succession of distinct evolutionary periods, the simplest mathematical formula is the trinomial expansion: $(1/A + A/A + A/1)^n$, where $n = 2^{N-1}$; N being the ordinal number of the period; A standing for any characteristic of the concerned character; exponents of A symbolizing its three possible adaptative values, I mean the two extreme and one median results of Mendelian segregation. These exponents are -1 , 0 and $+1$. For convenience sake I add $+1$ to each of them. This leads me to general adaptation symbols which I write: 0 , 1 , 2 ; the italic type (or in manuscript an underline) draws attention to their descriptive quality, with no individual quantitative meaning. By convention, 0 will generally express adaptation to geologically primitive biotopes: humid and foggy. On the opposite, 2 will express adaptation to dry and sunny ones. Entomogamy and zoochory will be translated by 0 , whilst anemogamy and anemochory by 2 . . . and so on. I am fully aware of the dangers included within such extensive assimilations. In practice, no adaptative value will be settled without a thorough examination of the whole intrafamilial diversity, from both standpoints of biogeography and comparative morphology.

Abridged translation of this diversity, in symbols built up by means of a ternary numeration, requires two different categories of taxa. One is grounded upon the sum of values, 0 , 1 and 2 in a character, and expresses the biogeographical determinism. The other is grounded upon the sequence of these values and, as they are always given in the same order, describes the morphological characteristics of the taxon inside its biogeographical presumed signification. For instance, 02 will be the first, 11 the second, 20 the third, of morphologically possible arrangements whose total adaptative value equals 2 . They correspond, as 00 qualifies the first one, to the third combination, adaptatively neuter, of the second evolutionary period. They define, according to diversification of corresponding character, the three subtribes of the third tribe. In the first or subfamilial period, with but one characteristic, arrangement and combination are identical. In the third period, arrangement of four characteristics build up the morphological definition of what we commonly name a genus; I have named cohort the corresponding biogeographical taxon. In the fourth period, with eight characteristics, descriptive sequency leads to species and total adaptation value to selection.

This may appear much too new. It is not. Linnaeus (1751) was clearly conscious

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of an essential difference between the genus, major hereditary impulsion, and its species, minor adaptations to the pressure of surrounding conditions. Consequently, in *Species Plantarum* (1753, 1762) the specific epithets, very often indeed geographical or seasonal, are printed in extramarginal italics, whilst the names of genera are in block letters ahead of the paragraphs devoted to each of them. Nowadays, this has been forgotten and genus is no more than a gathering of species. A return to the primitive sense of these terms, as I attempted to do it (1954), compels far too many changes in usual nomenclature and so routine must in this case take precedence over logic.

Let us come back to the trinomial expansion. Potential numbers of taxa are equal to: $2n + 1$ in the biogeographical category, to 3^n in the morphological one. This means, from period to period, here a gentle increase and there a very steep one. In compensation, all biogeographical taxa by definition may exist, whilst the morphological expressions promptly become, in their enlarging majority, too complicated to be viable. Out of the eight families hereafter quoted, all possess their three sub-families whilst the number of their genera, ranging from fifteen in Ulmaceae to sixty-two in Convolvulaceae, remains extremely inferior to the theoretical maximum: 2, 187. Such a waste of potentialities must be considered as natural: just consider what happens to most individuals in pollen clouds of a pine-land during springtime, or in myriads of cottony seeds issued from a line of poplar trees when the fall comes. Unextensible Earth is much too narrow a goal for the indefinite expansion of life.

The blanks resulting from these important cuts in potential diversification are unequally distributed. Classical floras do not take this inequality in account: genera in the family, species in the genus, are numbered according to a continuous sequency, presumed to be the natural one. By contrast, an ordinal unequal sequency, taking in account the wideness or narrowness of biogeographical and morphological gaps between subordinate taxa inside their inclusive taxon, can be grounded on the descriptive numerical method I attempt here to demonstrate. Tables have been published for this purpose (Roberty, 1960).

These discontinuous sequences within all evolutionary periods can also be graphically translated according to a standard flabellate scheme. To this I grant the utmost importance, such graphs being easy to compare and when compared very instructive as far as the past and present biogeographical and morphological tendencies of each family are concerned.

The complete standard graph is a complicated one. Until now only partial representations have been published (Roberty, 1953, 1964b). In a two dimensional figure, o and z of the descriptive sequence will be numbered along an axis going from $+x$ to $-x$; x symbols have a zero value on this axis and will be numbered along the perpendicular one, which is irreversible as the flow of time and so extends from zero to y . Let us draw such a figure; something shocking at once will become evident. According to the theory, representative points of subordinate taxa have to be equidistant of the one representing their immediate inclusive taxon; this is easy to realize. But they have also to be equidistant from the common origin of all the evolutionary set; this is impossible to realize upon a plane. So the expansion must be represented within a three dimensional scheme, where evolutionary levels will appear as parts of concentric spheres. Rays of these spheres will measure the presumable distance, in biological time, of the period to the origin. We may assume the increment of this distance to go on decreasing as probable speed of diversification increases with the fineness of its results. The simplest reduction formula is in the sequence: $1, 1/2, 1/4 \dots$ and I have adopted it. If R is the sum of these distances for a

given period, cartesian coordinates of points representing the taxa fixed at the end of this period must be such as: $x^2 + y^2 + z^2 = R^2$.

These coordinates, x , y and z each have an evolutionary meaning.

The x values, which may be positive or negative, express the degree of morphological or biogeographical specialization.

The y values, which always are positive, reach their maximum with descriptive formulas excluding all o or z . This maximum corresponds to the formerly mean type of the taxonomic subset, ultimately becoming segregated and median; morphologically the simplest, this type retains a maximum of residual adaptative plasticity. The best word for this tendency towards simplification plus efficacy is, at the opposite of evolution, involution.

The z values, conventionally positive, must be calculated: $z = (R^2 - x^2 - y^2)^{1/2}$. They express what could be named, strictly speaking, evolution: I mean the divergence of successive characteristics in a character from the straight x or y axis. For instance, value of the z coordinate will be maximum in such a formula as the generic one $o2o2$, where the x and y equal zero: both o annulling both z and no x being present. I shall name the value of z : degree of diversion.

Tables giving the value of coordinates for taxa ranging from subfamily to genus will be found in the Appendix.

They give evidence of groups of taxa which, upon a same evolutionary level, have identical coordinates. This cannot be avoided. In nature there actually do exist wide syngamous complexes. Inside such complexes distinct genera or distinct species may neatly be defined as far as the commonest forms are concerned. All these however are linked by various and more or less continuous sequences of intermediate ones. For instance, such is the case for: $ooII = Ipomoea$ (*sensu stricto*), $oIOI = Batatas$, $oIIo = Pseudipomoea$, in Convolvulaceae.

Let us now, as a test, examine the results yet obtained with this analytic system. I admit the number of hereafter quoted families to be a very feeble one.

Urticales

This is the only order yet fully studied. Three family sets of evolution have been acknowledged: Moraceae, Ulmaceae, Urticaceae. According to the adaptative characters selected in each of these sets: *Barbeya* and *Eucommia* come under Ulmaceae as distinct family monotypes; Conocephaloideae, transferred by Corner (1962) from Moraceae to Urticaceae, appear as an artificial group, scattered among various tribes and cohorts of Moraceae Artocarpoideae; *Cannabis* and *Humulus* belong to a distinct tribe of Moraceae, Moroideae.

To the evolution of Moraceae may be assigned the following sequence of adaptative periods. The first or subfamily one ends with fused or free proliferation or propagation units: fig and breadfruit are collective; mulberries are single fruits, densely contiguous but, in each of their apparent collectivity, distinct from one another and all from the common axis. The second or tribal period has fixed the rules of growth into that proliferation: at the extremes, fused or free sympodia with unilateral (mostly apical) fruits, versus fused or free monopodia omnilaterally fertile. In the third or generic period, there has been selected the external and internal protection of ovules and seeds, both can be, at extremes, either inclusive and thick, or exposed and thin. Disposition, hence dispersion abilities, of more or less hidden and protected fruits or fruiting complexes, along

leafy or leafless twigs, branches or even trunks, may provide with its eight characteristics the fourth and specific period.

In their classical delimitation, Ulmaceae are but Ulmoideae. Monotypic Barbeyoideae and Eucommioideae form with them a complete evolutionary set whose first period has ended with adaptative specialization of ovary-protective surroundings: absent in *Eucommia*, short in Ulmoideae, large in drought-resistant *Barbeya*. During the second period, the fruit has become, at the extremes, either a succulent drupe or a winged nutlet. In the third period, pollen-producing flowers have specialized their main characteristics: campanular and gamotepalous with few stamens and perfect ovary at one extreme; versus, at the other extreme, narrowly dialytepalous with stamens at least twice more numerous than tepals and absent ovary. The fourth period, the specific one, is controversial. In my opinion, most of so-called species in larger genera such as *Celtis* or *Ulmus*, are no more than haphazard variations. The best euspecific characteristics may probably be found in the rhythm of apparition and maturation of the fertile flowers groups and parts as well, for instance their location over younger twigs or older branches and also the persistence or caducity of their stigmas.

Urticaceae have been divided during their first evolutionary period according to ovary protection by the perigonium which, at the extremes, can be gamotepalous as in *Boehmeria*, or dialytepalous as in *Urtica*. Here absence of perigonium is a simplification and not an adaptation: reduced ones may as well exist with their parts, either fused as in *Leucosyke*, or free as in *Gyrotaenia*; so apetalous genera must belong to the median subfamily, actually including both the most xerophilous *Forskohlea* and the most hygrophilous *Maoutia*. The second period has specialized the floral or perifloral parts surrounding the seed at maturity: coalescent and thickened versus distinct and thin. The third period has ended with the appearance of present genera, defined by their fecundation process: at one extreme, style and stigma wide and thick, stamen single in a closed perianth; at the other extreme, style and stigma long and thin, stamens four to five in a wide open perianth. The fourth and specific period apparently has acted upon the prolificity of fertile twigs and floral parts.

Comparison of the biogeographical evolution of these families, as deduced from their standard representative graphs, leads to the following conclusions.

With a mean generic involution degree, \bar{y} , equal to 0.35, Moraceae appear as the most archaic; Urticaceae, $\bar{y} = 0.54$, are a little more advanced; Ulmaceae, $\bar{y} = 1.15$, are much more so and amongst familial sets yet observed their involution degree is a maximum. Correlatively, \bar{z} , the generic mean diversion degree, is near to absolute maximum in Moraceae, 1.70 versus 1.75; very high too in Urticaceae, 1.66; lowest in Ulmaceae, 1.32. Moraceae, according to their mean generic specialization degree, $\bar{x} = +0.35$, are zoochorous and entomogamous. We knew it! Whilst Urticaceae, $\bar{x} = +0.05$, and Ulmaceae, $\bar{x} = +0.08$, may be said to be adaptatively neuter.

Inside Moraceae, Artocarpoideae are more specialized in zoophily than Moroideae, on the opposite side, in comparative anemophily; between these, Olmedioideae with four narrowly proximate genera, leave a wide gap; hence the family looks like a senescent segregating one.

Forskohleoideae, the median subfamily of Urticaceae, include five genera which is only one more than in Olmedioideae, but here they are evenly distributed. In addition, both specialized Boehmerioideae and Urticoideae have their own genera converging towards the middle plan (the $\bar{y}\bar{z}$ one) of the set. So does its prototype appear well adapted to presently existing biotypes. This too we knew, and that nettles are invading

pests! Nevertheless it may be a good thing to make it apparent through a standard schematic sketch.

Inside Ulmaceae, Ulmoideae, the median subfamily, is the only plurigeneric one. *Eucommia* of temperate China converges towards it. *Barbeya* of desertic Somaliland stands far apart. Both these extremes, specialized, monogeneric and unispecific subfamilies are plainly archaic: γ being here equal to 0.00 and there to 0.18; whilst in Ulmoideae \bar{y} rises up to 1.31.

Achradaceae (Sapotaceae)

These may have specialized their ovary protection in the subfamilial period: the mesocarp, primitively more or less fleshy, becoming at one extreme hard and thick, at the other one brittle and thin. The second period, the tribal one, has probably fixed the process of seed dispersion; this leading their placental scar to be, at adaptative limits, long and wide as in *Tieghemella* (= *Dumoria*) or quasi pin-point as in *Sideroxylon*. The third and generic period presumably determined attraction of pollen by shape and composition of androcoem and corolla. The fourth period has not yet been duly studied; growth of flowering twigs and floral parts may then have been fixed. The nicest feature of the resulting scheme is to locate *Tieghemella* of equatorial rain forest at the hygrophilous extreme of generic distribution, whilst *Argania* of arid south-western Morocco is in this distribution at the opposite, xerophilous, extreme.

Oleaceae

These, as we have previously seen, are insubstantial if considered as a part of Linnaeus' diandry. Yet from an evolutionary viewpoint their set is a valid one. The subfamilial character is in the general growing process of the fruit, which becomes either biglobose or long and flat; there belong to the median subfamily various intermediate forms, ranging from ovoid to discoid. Tribes have been defined by functional details of the fruit, hence by the dispersion of seeds, adaptative extremes being berry and samara. With genera there has been diversified the protection of sexual organs: at one extreme, the corolla is gamopetalous with imbricate aestivation and sessile anthers on its tubular basis; at the other extreme, stamens and pistil lay bare. The specific period has probably fixed the pollinating consequences of the third period achievements, either increasing their attractive characteristics such as colour or flavour, or simplifying the whole flower in order to facilitate anemogamy.

I am now examining the Rubiales and nearby families. At first sight and in agreement with Jussieu's opinion (1789), Asclepiadaceae have to be subordinate, as a subfamily, to Apocynaceae. Then three subfamilies, the third one being Plumerioideae, can be defined by their stamens: distant, contiguous or united (between themselves and to the apex of style). In return, polyspermic and oligospermic genera classically located in Rubiaceae must be considered as belonging to (at least) two distinct evolutionary sets.

Apocynales have to be considered as a valid order. Thence Plumerioideae, as here upon defined, become Plumeriaceae: quite a natural, familial, evolutionary set. Its subfamilial character relies upon dehiscence of the fruit, this implying minor versus major protection of mature seeds: major in non-dehiscent Pacourioideae, median in tardily-dehiscent Tabernaemontanoideae, minor in Plumerioideae *sensu restricto*. Tribal character relies upon propagation of the fruits: fleshy or spiny versus winged (*Cameraria*); and/or of the seeds: arillate or enclosed in fleshy pulp versus winged or plumose. Genera rely upon the

form of the corolla, more or less attractive to pollen-bearing insects. Species rely on plant growth and general habit.

Some doubt remains about the rest of the order. Apocynaceae *sensu restricto* (Echitoideae of too many authors) may be a family or a subfamily, defined by its granular pollen but with the anthers fastened to the gynoeceum apex whilst these are free in Plumeriaceae. According to the decision not yet reached, *Periploca* with open spoon-like pollen translators, and *Asclepias* with closed pollinia, will typify a distinct family or one of the two subfamilies linked with the above-mentioned eventual one.

Loganiaceae, including all their classical genera plus *Pagamia* and *Gaertnera*, appear as a valid evolutionary set, far apart from Oleaceae, very near as a previous approach to Rubiaceae *sensu lato*. Here, subfamilies are defined by the corolla aestivation, tribes by the propagation of seeds, genera by the calicinal ovary protection, species by the pollen dispersion and attraction.

Mimosaceae

These have been separated at the end of their first evolutionary period by the flower-bud protection, the calyx becoming then, either imbricate down to its base, or valvate up to its top. The valvate calyx represents here an adaptative extreme towards anemophily, and the Mimosioideae it defines have fully expanded their adaptative potentialities outside the familial probable birthplace, inside rain forest. In contrast, imbricate as in *Pentaclethra* of such a forest, or semi-imbricate as in *Parkia* which includes forest species and savanna ones as well, calyx aestivation appears here to be an imperfect approach towards achievements of nearby Caesalpiniaceae or Fabaceae. So, owing to struggle for life, the previously quoted genera both are nowadays the only representatives of their subfamily. During the second period, stamens, originally variable in coalescence and number have specialized towards either oligo-gamo-stemony or poly-dialy-stemony. In the third one, struggle for life pressure has acted on seed dispersion, hence, at the adaptative extremes, units of propagation, either fruits or free seeds: long, heavy, thick and attractive (spiny, fleshy or brightly coloured); versus short, light, thin and mobile, more or less wing-like. Classical *Acacia* hence become a tribe of at least five genera, neatly distinct by their fruits which are, for instance: indehiscent and thickly fusiform but light in *Vachellia farnesiana*; dehiscent with half of the seeds supported by each of the two, separate and pseudowinged, thinly papyraceous valves in *Senegalia senegal*. In the whole family, species are diversified by their sexual proliferation: the disposition and also the composition of their flowers. For instance, *Faidherbia albida* differs from *F. sieberiana* by the inflorescences, here in spikes and there in heads; whilst *Senegalia senegal* differs from *S. catechu* by its petals free almost to their bases, instead of being fused up to half their length.

Combretaceae sensu stricto

These are but one subfamily, comparatively xerophilous, of their own evolutionary set. They may, as such, be defined by their fruit: always and doubtlessly inferior. Fruit is superior in Strephonemoideae, reduced to a single genus of equatorial rain forest. Median subfamily may be that of Rhizophoroideae, whose fruits, either entirely or partially inferior or superior, germinate before falling down. In these will take place mangrove trees such as *Rhizophora*, *Bruguiera* and *Ceriops*. Other genera nowadays classified as Rhizophoraceae appear not to belong here from an evolutionary viewpoint. Nor do they constitute a natural group. For instance: *Anisophyllea* takes its logical

place in the subset of Melastomataceae Memecylonoideae; *Anopyxis* most probably has to go inside Meliaceae; little known *Cassipourea* may be Linaceae.

As far as Combretaceae are concerned, the tribal period ends with definition of calyx growth: at one extreme with receptacular bases deepened and free limb enlarged; at the other extreme, with compressed bases and caducous apex. In Rhizophoroideae, these oppositions neatly separate Rhizophoreae, with shallow calicinal bases, from Bruguereae with deep and turbinate receptaculum. Genera will be defined by the architecture of the flowers: highly entomogamous with tubular and sessile calyx limb, large and bright petals; versus anemogamous with wide open and stipitate calyx limb, minute and dull if not absent petals. Morphological details and location over the branches of mature fruits may be used to define the eight characteristics of the specific character.

Convolvulaceae

These (Roberty, 1964a) have their propagation units, fruit with or without accompanying calyx or epicalyx: at one extreme edible by birds or little mammals, succulent or hazel-nut like; at the opposite extreme, they are winged; in both extremes they are indehiscent, whilst they are dehiscent or, at least, with brittle epicarp in the median subfamily. Tribes, at the end of the second period, have become defined by the specialization of styles and stigmas; at the extremes, the distinction lies between a single style with massive and widely coalescent stigmas versus, either the style more than once divided with minute stigmas, or sessile and flat but deeply lacinate stigmas in the very particular and maybe controversial case of *Erycibe*. At first sight, this tribal character may appear as an adaptation to pollen attraction; actually it has in some genera such an adaptative consequence; its cause, however, depends on the pistil proliferation, either apocarpic as clearly apparent nowadays in *Dichondra* and *Falkia*, or syncarpic. In the third period, present genera have fixed the architecture of their corolla. Here again the apparent function is attraction of pollen-bearing insects; but ovary protection is the actual function of the characteristics correlated in this character. General opposition at extremes can be termed as follows: corolla with perigynous stamens and subsequent thickening near its basis, hypocrateriform, undivided; versus corolla with hypogynous stamens and practically no basal thickening, shallowly infundibuliform, deeply lobed. The eight correlated characteristics of the specific period can be found in the disposition along the flower-bearing twigs, leafy, condensed, etc. versus leafless, lengthened, etc. of large, glabrous and brightly coloured corollas versus little, villous and dull-coloured ones. Here, doubtless, the adaptative function is attraction of pollen.

Polygonaceae

These (Roberty and Vautier, 1964) appear neatly divided into three subfamilies, differing by their general process of growth: monopodial with stipular ochreas, sympodial with involucre flowers, primitive or at least median without ochreas nor involucre. Tribes, in the second period, have specialized towards pollen attraction with, at the extremes, adaxial and reduced versus terminal and large stigmas. In the third period, have been fixed the fundamental architecture of the fruits or fruiting complexes and consequently the protection of maturing seeds. Hence the enlarging parts become at the opposite extremes of generic diversification: inclusive, conerescent, convergent, hardened or thickened; versus widened out, separate, divergent, membranous or at least thin. Dispersion of seeds in its main lines follows the preceding character but has been fixed in its details during the fourth or specific period, the resulting diaspores being, at the

extremes, opposed as follows: densely contiguous, sessile, heavy, spiny or succulent, in terminal and leafless spike-like cymes; versus lax, long-pedicellate, light, membranous or villous if not winged or woolly, in axillary corymbs hidden by the leaves.

Poaceae

These (Roberty, 1960) have been classically separated in Panicoideae and Pooideae, whose mature spikelets fall included or not by their glumes. From an adaptative standpoint, this characteristic is correlated with the protection actually granted: a good one if glumes are larger than fertile glumellae; if they are smaller a poor one. So, in the system here followed, protection by the glumes of ovary and seed has been diversified during the second or tribal period.

In the first and subfamilial one, the adaptative character with but one characteristic doubtless is the spikelet growth: either stopped on the first fertile flower, or on a further one; a median solution is provided with those spikelets whose rachis growth does not stop on a fertile flower but on a more or less reduced male or sterile one. This leads to three subfamilies, Panicoideae, Chloridoideae, Pooideae, in agreement with Prat (1936) whose classification is based upon leaf and culm anatomy, but in thorough discrepancy from Pilger's scheme (1954) which, in its main lines, appears to me much too complicated.

In the third period, genera have been diversified according to the proliferation of culms, peduncles and pedicels, bearing fertile or sterile flowers. In the fourth period, which may be yet partially uncompleted in some genera or even tribes, struggle for life acts upon the dispersion of seeds.

Dicotyledons and Monocotyledons are, in my general system, involutive major sets appearing as pseudocycles in the general succession of families, consecutive but distinct. Hutchinson (1959) admits sixty-nine families in Monocotyledons and 342 in Dicotyledons. Gundersen's figure (1950) for Dicotyledons only, is a lower one; this comes near my own estimate. Mathematically, 360 different arrangements are possible in the sequence of the six fundamental characters upon the four first levels of intrafamilial evolution: subfamily, tribe, genus, species. This provides the biosystematician with quite a sufficient amount of theoretically different adaptation to variation of the general surroundings in familial sets of Dicotyledons and Monocotyledons; even if we assume that many possible families have disappeared or simply not appeared, owing to antagonism between their ecological potentialities and the ecological conditions of their accidental birthplace in space and time.

According to the laws of probability, the first evolutionary sets to appear, starting from a definitely sexualized ancestor, must have been segregated inside the most abundant of presexual forms: those whose morphology was best adapted to surrounding conditions which no longer exist but in the dampest of rain forests. This takes us back to the Durian theory. The latest appeared ones, in my opinion *Poaceae*, had then very little chance and, correlatively, very little representation; just as they have now in such tepid, humid and shady conditions.

Fully built up, compared and corrected, a definite synopsis of Angiosperms will have to come into agreement with paleoclimatology. In return, it will complete our knowledge of this science, doubtless fundamental to the historical study of the biosphere.

Another advantage of the proposed system relies upon the fact that each taxon, once correctly located in its mathematical frame, possesses significative coordinates of

specialization, involution and diversion (see above, p. 355). These, if properly used, may give hints towards what may be hoped for from artificial selection inside of them. For instance, if my work on Andropogoneae is correct, tentative improvement of their comparative value as pastures will give the best results with *Schizachyrium* = *IIII*, maximum of involution; better ones with *Sorgum* = *II2I* than with nearby *Chrysopogon* = *IO22*; no results at all with *Vossia* = *2200*, maximum of diversion.

Much more may be gained, in various fields, by such an introduction of mathematical expressions in biosystematics, but objections to it have to be examined and, at first, I must confess that applications of the system are often more different than have until now been shown.

Surevolution of Gaussen (1944, 1947) has not yet been studied enough. It appears independent of the general evolution versus involution process, and narrowly linked to chromosomes irreversible duplication, either in numbers or in mass, within evolutionary sets or subsets. This results in a relay of phylogenesis by ontogenesis and often upsets the regular progression of evolutionary periods: creating inside of them a badly defined succession of involutive, I mean of simpler and simpler, morphological sublevels. Often it is possible to have but one definition by generic formula; owing to surevolution sometimes it is impossible. For instance, in Polygonaceae the generic formula *I222* applies to a winged concrescence of hypanthium plus perianth in *Bilderdykia*, *Reynoutria*, and *Podopterus*, respectively belonging to Polygoneae, Rheae and Calligoneae; but if the formula *0I20* applies in *Exem*, Polygoneae, to spinescent concrescence of the same organs, in *Centrostegia*, Eriogoneae, it applies to that of an external and free involucre.

I must also confess that identity between organ and function is not always absolute. For instance, in rambling *Combretum*, *Poivrea* and *Cacoucia*, the basal part of the calyx is protective and the apical part attractive. In this example, the term calyx-limb may be used to differentiate these parts and functions; in various cases the problem may prove a quite difficult one to solve.

In return, I shall refute that such a system neglects the facts. In it, actually, an discrepancy between available information and systematic frame soon becomes evident by itself. Compared to systems or, strictly speaking, lack of system now in use it comes into the position of a double entry book-keeping towards a single account of encashments and payments.

Practically, one has first to compile and tabulate dichotomous oppositions used in classical floras. This table drawn, repartition of the compiled particular characteristics into the general adaptative characters will require some keen logical analysis of actual or potential use. Absolute correlations, positive and negative as well, between characteristics in one character will lead to their coincidence. In return, it will often be necessary to divide classic functional units. Respect of the theoretical series, 1, 2, 4, 8 . . . will appear in some cases as an excess of artifice. I know it, but no simpler or more complex one agrees better with the whole of our present biological knowledge.

What nature is in living beings I do not know. Nevertheless, either evolution of living beings proceeds from a law of nature which, as any other one such as universal gravitation, must have a single, simple and mathematical definition, or it is just haphazard and all attempts of approach to a natural system of classification are vain. I prefer the first term of the alternative. I do not say my systematic frame is the correct one. I simply say that, if such a frame exists, it must have a mathematical expression.

Time being given and God helping, sooner or later, the correct mathematical frame will be adapted progressively to all evolutionary sets of Angiosperms. As long as one will

not apply, delimitations and definitions will have to be corrected. I have shown (1964a, pp. 153-156) these methodical corrections to be constructive and easy: each attempt either eliminates a blind alley or puts forth a new working hypothesis.

So doing, systematic botanists will be lead, beyond technical erudition, to knowledge in its wider sense, in obedience with what may be the major and nobler impulse of mankind: 'not merely the need to do but also the need to know what I do' (Shaw, 1905).

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APPENDIX

Coordinates of isolated or isotopically grouped taxa

Initial number is the ordinal one of, in succession, subfamilies, tribes and cohorts. Following number (in parentheses) is that of non-specialized characteristic values, 1, in the descriptive numerical definition of the concerned taxon or taxa.

For instance: 139 (020) = 0.II.2222
 225 (112) = 1.0I + 10.0II2 + 0I2I + ... + 2II0
 346 (013) = 2.I2 + 2I.III2 + ... + 2III

	x	y	z		x	y	z
100 (0..)	+1.00	0.00	0.00				
110 (00.)	+1.50	0.00	0.00	120 (01.)	+1.35	0.35	0.54
111 (000)	+1.75	0.00	0.00	121 (010)	+1.60	0.35	0.61
112 (001)	+1.73	0.10	0.24	122 (011)	+1.58	0.45	0.59
113 (000)	+1.68	0.00	0.49	123 (010)	+1.53	0.35	0.77
(002)	+1.68	0.18	0.47	(012)	+1.53	0.53	0.66

	<i>x</i>	<i>y</i>	<i>z</i>		<i>x</i>	<i>y</i>	<i>z</i>
114 (001)	+1.60	0.10	0.70	124 (011)	+1.45	0.45	0.87
(003)	+1.60	0.23	0.68	(013)	+1.45	0.58	0.79
115 (000)	+1.50	0.00	0.90	125 (010)	+1.35	0.35	1.08
(002)	+1.50	0.18	0.88	(012)	+1.35	0.53	0.98
(004)	+1.50	0.25	0.87	(014)	+1.35	0.60	0.93
116 (001)	+1.40	0.10	1.04	126 (011)	+1.26	0.45	1.14
(003)	+1.40	0.23	1.02	(013)	+1.26	0.58	1.07
117 (000)	+1.32	0.00	1.15	127 (010)	+1.18	0.35	1.25
(002)	+1.32	0.18	1.13	(012)	+1.18	0.53	1.18
118 (001)	+1.27	0.10	1.20	128 (011)	+1.12	0.45	1.27
119 (000)	+1.25	0.00	1.22	129 (010)	+1.10	0.35	1.31
130 (00.)	+1.00	0.00	1.12	130 (02.)	+1.00	0.50	1.00
131 (000)	+1.25	0.00	1.22	131 (020)	+1.25	0.50	1.12
132 (001)	+1.23	0.10	1.24	132 (021)	+1.23	0.60	1.09
133 (000)	+1.18	0.00	1.20	133 (020)	+1.18	0.50	1.19
(002)	+1.18	0.18	1.28	(022)	+1.18	0.68	1.10
134 (001)	+1.10	0.10	1.36	134 (021)	+1.10	0.60	1.22
(003)	+1.10	0.23	1.34	(023)	+1.10	0.73	1.15
135 (000)	+1.00	0.00	1.44	135 (020)	+1.00	0.50	1.35
(002)	+1.00	0.18	1.42	(022)	+1.00	0.68	1.26
(004)	+1.00	0.25	1.41	(024)	+1.00	0.75	1.22
136 (001)	+0.90	0.10	1.50	136 (021)	+0.90	0.60	1.38
(003)	+0.90	0.23	1.48	(023)	+0.90	0.73	1.31
137 (000)	+0.82	0.00	1.55	137 (020)	+0.82	0.50	1.46
(002)	+0.82	0.18	1.54	(022)	+0.82	0.68	1.39
138 (001)	+0.77	0.10	1.57	138 (021)	+0.77	0.60	1.45
139 (000)	+0.75	0.00	1.58	139 (020)	+0.75	0.50	1.50
140 (01.)	+0.65	0.35	1.31	150 (00.)	+0.50	0.00	1.41
141 (010)	+0.90	0.35	1.46	151 (000)	+0.75	0.00	1.58
142 (011)	+0.88	0.45	1.45	152 (001)	+0.73	0.10	1.59
143 (010)	+0.82	0.35	1.50	153 (000)	+0.68	0.00	1.61
(012)	+0.82	0.53	1.45	(002)	+0.68	0.18	1.60
144 (011)	+0.74	0.45	1.51	154 (001)	+0.60	0.10	1.64
(013)	+0.74	0.58	1.47	(003)	+0.60	0.23	1.63
145 (010)	+0.65	0.35	1.59	155 (000)	+0.50	0.00	1.68
(012)	+0.65	0.53	1.55	(002)	+0.50	0.18	1.67
(014)	+0.65	0.60	1.51	(004)	+0.50	0.25	1.66
146 (011)	+0.55	0.45	1.60	156 (001)	+0.40	0.10	1.70
(013)	+0.55	0.58	1.55	(003)	+0.40	0.23	1.69
147 (010)	+0.47	0.35	1.65	157 (000)	+0.32	0.00	1.72
(012)	+0.47	0.53	1.60	(002)	+0.32	0.18	1.71
148 (011)	+0.42	0.45	1.64	158 (001)	+0.27	0.10	1.73
149 (010)	+0.40	0.35	1.67	159 (000)	+0.25	0.00	1.74
200 (1..)	0.00	1.00	0.00	220 (11.)	+0.35	1.35	0.54
210 (10.)	+0.50	1.00	1.00	221 (110)	+0.60	1.35	0.93
211 (100)	+0.75	1.00	1.22	222 (111)	+0.58	1.45	0.79
212 (101)	+0.73	1.10	1.15	223 (110)	+0.53	1.35	0.98
213 (100)	+0.68	1.00	1.26	(112)	+0.53	1.53	0.66
(102)	+0.68	1.18	1.10	224 (111)	+0.45	1.45	0.87
214 (101)	+0.60	1.10	1.22	(113)	+0.45	1.58	0.59
(103)	+0.60	1.23	1.09	225 (110)	+0.35	1.35	1.06
215 (100)	+0.50	1.00	1.35	(112)	+0.35	1.53	0.77
(102)	+0.50	1.18	1.19	(114)	+0.35	1.60	0.61
(104)	+0.50	1.25	1.12	226 (111)	+0.26	1.45	0.95
216 (101)	+0.40	1.10	1.30	(113)	+0.26	1.58	0.70
(103)	+0.40	1.23	1.18	227 (110)	+0.18	1.35	1.10
217 (100)	+0.32	1.00	1.40	(112)	+0.18	1.53	0.83
(102)	+0.32	1.18	1.25	228 (111)	+0.12	1.45	0.97
218 (101)	+0.27	1.10	1.34	229 (110)	+0.10	1.35	1.10
219 (100)	+0.25	1.00	1.41	230 (12.)	0.00	1.50	0.00
230 (10.)	0.00	1.00	1.12	231 (120)	+0.25	1.50	0.87
231 (100)	+0.25	1.00	1.41	232 (121)	+0.23	1.60	0.68
232 (101)	+0.23	1.10	1.34	233 (120)	+0.18	1.50	0.88
233 (100)	+0.18	1.00	1.42	(122)	+0.18	1.68	0.47
(102)	+0.18	1.18	1.28	234 (121)	+0.10	1.60	0.70
234 (101)	+0.10	1.10	1.36	(123)	+0.10	1.73	0.24
(103)	+0.10	1.23	1.24	235 (120)	0.00	1.50	0.90
235 (100)	0.00	1.00	1.44	(122)	0.00	1.68	0.49
(102)	0.00	1.18	1.29	(124)	0.00	1.75	0.00
(104)	0.00	1.25	1.22				

	<i>x</i>	<i>y</i>	<i>z</i>		<i>x</i>	<i>y</i>	<i>z</i>
236 (101)	-0.10	1.10	1.36	236 (121)	-0.10	1.60	0.70
(103)	-0.10	1.23	1.24	(123)	-0.10	1.73	0.24
237 (110)	-0.18	1.10	1.42	237 (120)	-0.18	1.50	0.88
(102)	-0.18	1.18	1.28	(122)	-0.18	1.68	0.47
238 (101)	-0.23	1.10	1.34	238 (121)	-0.23	1.60	0.68
239 (100)	-0.25	1.00	1.41	239 (120)	-0.25	1.50	0.87
240 (11.)	-0.35	1.35	0.54	250 (10.)	-0.50	1.00	1.00
241 (110)	-0.10	1.35	1.10	251 (100)	-0.25	1.00	1.41
242 (111)	-0.12	1.45	0.97	252 (101)	-0.27	1.10	1.34
243 (110)	-0.18	1.35	1.10	253 (100)	-0.32	1.00	1.40
(112)	-0.18	1.53	0.83	(102)	-0.32	1.18	1.25
244 (111)	-0.26	1.45	0.95	254 (101)	-0.40	1.10	1.30
(113)	-0.26	1.58	0.70	(103)	-0.40	1.23	1.18
245 (110)	-0.35	1.35	1.06	255 (100)	-0.50	1.00	1.35
(112)	-0.35	1.53	0.77	(102)	-0.50	1.18	1.19
(114)	-0.35	1.60	0.61	(104)	-0.50	1.25	1.12
246 (111)	-0.45	1.45	0.87	256 (101)	-0.60	1.10	1.22
(113)	-0.45	1.58	0.59	(103)	-0.60	1.23	1.09
247 (110)	-0.53	1.35	0.98	257 (100)	-0.68	1.00	1.26
(112)	-0.53	1.53	0.66	(102)	-0.68	1.18	1.10
248 (111)	-0.58	1.45	0.79	258 (101)	-0.73	1.10	1.15
249 (110)	-0.60	1.35	0.93	259 (100)	-0.75	1.00	1.22
300 (0.)	-1.00	0.00	0.00				
310 (00.)	-0.50	0.00	1.41	320 (01.)	-0.65	0.35	1.31
311 (000)	-0.25	0.00	1.74	321 (010)	-0.40	0.35	1.67
312 (001)	-0.27	0.10	1.73	322 (011)	-0.42	0.45	1.64
313 (000)	-0.32	0.00	1.72	323 (010)	-0.47	0.35	1.65
(002)	-0.32	0.18	1.71	(012)	-0.47	0.53	1.60
314 (001)	-0.40	0.10	1.70	324 (011)	-0.55	0.45	1.60
(003)	-0.40	0.10	1.70	(013)	-0.55	0.58	1.55
315 (000)	-0.50	0.00	1.68	325 (010)	-0.65	0.35	1.59
(002)	-0.50	0.18	1.67	(012)	-0.65	0.53	1.55
(004)	-0.50	0.25	1.66	(014)	-0.65	0.60	1.51
316 (001)	-0.60	0.10	1.64	326 (011)	-0.74	0.45	1.51
(003)	-0.60	0.23	1.63	(013)	-0.74	0.58	1.47
317 (000)	-0.68	0.00	1.61	327 (010)	-0.82	0.35	1.50
(002)	-0.68	0.18	1.60	(012)	-0.82	0.53	1.45
318 (001)	-0.73	0.10	1.59	328 (011)	-0.88	0.45	1.45
319 (000)	-0.75	0.00	1.58	329 (010)	-0.90	0.35	1.46
330 (00.)	-1.00	0.00	1.12				
331 (000)	-0.75	0.00	1.58	330 (02.)	-1.00	0.50	1.00
332 (001)	-0.77	0.10	1.57	331 (020)	-0.75	0.50	1.50
333 (000)	-0.82	0.00	1.55	332 (021)	-0.77	0.60	1.45
(002)	-0.82	0.18	1.54	333 (020)	-0.82	0.50	1.46
334 (001)	-0.90	0.10	1.50	(022)	-0.82	0.68	1.39
(003)	-0.90	0.23	1.48	334 (021)	-0.90	0.60	1.38
335 (000)	-1.00	0.00	1.44	(023)	-0.90	0.73	1.31
(002)	-1.00	0.18	1.42	335 (020)	-1.00	0.50	1.35
(004)	-1.00	0.25	1.41	(022)	-1.00	0.68	1.26
336 (001)	-1.10	0.10	1.36	(024)	-1.00	0.75	1.22
(003)	-1.10	0.23	1.34	336 (021)	-1.10	0.60	1.22
337 (000)	-1.18	0.00	1.29	(023)	-1.10	0.73	1.15
(002)	-1.18	0.18	1.28	337 (020)	-1.18	0.50	1.19
338 (001)	-1.23	0.10	1.24	(022)	-1.18	0.68	1.10
339 (000)	-1.25	0.00	1.22	338 (021)	-1.23	0.60	1.09
340 (01.)	-1.35	0.35	0.54	339 (020)	-1.25	0.50	1.12
341 (010)	-1.10	0.35	1.31	350 (00.)	-1.50	0.00	0.00
342 (011)	-1.12	0.45	1.27	351 (000)	-1.25	0.00	1.22
343 (010)	-1.18	0.35	1.25	352 (001)	-1.27	0.10	1.20
(012)	-1.18	0.53	1.18	353 (000)	-1.32	0.00	1.15
344 (011)	-1.26	0.45	1.14	(002)	-1.32	0.18	1.13
(013)	-1.26	0.58	1.07	354 (001)	-1.40	0.10	1.04
345 (010)	-1.35	0.35	1.08	(003)	-1.40	0.23	1.02
(012)	-1.35	0.53	0.98	355 (000)	-1.50	0.00	0.90
(014)	-1.35	0.60	0.93	(002)	-1.50	0.18	0.88
346 (011)	-1.45	0.45	0.87	(004)	-1.50	0.25	0.87
(013)	-1.45	0.58	0.79	356 (001)	-1.60	0.10	0.70
347 (010)	-1.53	0.35	0.77	(003)	-1.60	0.23	0.68
(012)	-1.53	0.53	0.66	357 (000)	-1.68	0.00	0.49
348 (011)	-1.58	0.45	0.59	(002)	-1.68	0.18	0.47
349 (010)	-1.60	0.35	0.61	358 (001)	-1.73	0.10	0.24
				359 (000)	-1.75	0.00	0.00

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LOGICAL ANALYSIS AND ANGIOSPERMIC FAMILIES

BY G. E. ROBERTY

Vaudevant (Ardèche)

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