

THE TAXONOMY AND NOMENCLATURE OF
RUTACEAE-AURANTIOIDEAE¹⁾

by

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From the time of CORREA DE SERRA (1805), MIRBEL (1813), DE JUSSIEU (1815), ROEMER (1846), BAILLON (1855), and OLIVER (1861), a great stress is laid upon the number of stamens, locules, and ovules to the primary classification of the *Rutaceae-Aurantioideae*, but the importance of the presence of an inflorescence and its reduction of the number of flowers, the pinnate leaf and its reduction of the number of leaflets, venation of the leaf, its conspicuousness and the construction, the origin and development of the wing upon the rachis and the petiole, the number and the nature of thorns upon the branches, the fundamental number of the floral organs and its increase or decrease, the formation of pulp vesicles, the hardening of the rind of fruits, and other points affecting the universal affinity of plants as a whole, have been quite neglected in the past, the consideration of which would have helped the orderly development of the taxonomy of the subfamily. It is clear that the increased number of the floral organs and the development of the pulp vesicles are undoubtedly very important systematic features of the subfamily, but such are those out of many significant characteristics which take part in the classification of the whole group. A character like the increase or decrease of the number of locules, for instance, can occur even within one genus, as in the well-known case of *Citrus* and *Fortunella*. The ovules may be single, or binary, either superposed or collateral, or otherwise numerous in uni-, or biseriata arrangement: the gradation of this character is also continuous, as in the case of *Triphasia*, *Merope* and *Wenzelia*, all having similar floral characteristics but the last only has biseriata ovules. Unquestionably, the biseriata character is derived from collateral arrangement which is commoner in rather advanced groups. The increase of the number of filaments more than ten,

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occurs also in tribes not closely related, as *Aegle* (also *Feroniella*, and *Balsamocitrus* Section *Afraegle*), *Oxanthera*, and *Citrus* (also *Poncirus* and *Fortunella*), but the true pleiotaxy of stamens occurs only in *Aegle* and in the Section *Citrophorum* of the genus *Citrus*. The pulp-vesicle formation is also seen in various tribes widely divergent from each other, such as *Aegleae-Swingleinae* (*Swinglea*), *Lavangeae* (*Pleiospermium*), *Atalantieae* (*Atalantia* and *Severinia*), *Microcitreae* (*Microcitrus*, *Eremocitrus*, *Monanthocitrus* and *Pleurocitrus*), *Aurantieae-Citropsinae* (*Citropsis*), and *Aurantieae-Citrinae* (*Poncirus*, *Citrus* and *Fortunella*).

It is very clear that the starting point of the subfamily is represented by *Micromelum* and *Glycosmis*, both having pinnate leaves with alternate leaflets and unwinged rachis, many-flowered inflorescences, an ovary with less than 5 locules and one or two superposed ovules in each locule. Having dry fruits and contortuplicate cotyledons, *Micromelum* forms the most primitive tribe *Micromeleae*, somewhat analogous to the *Rutoideae-Cusparieae* of tropical America. The genera *Glycosmis*, *Murraya* and *Clausena*, altogether forming the tribe *Clauseneae*, have fleshy fruit, plano-convex cotyledons and unarmed branches with pinnate leaves, resembling the *Micromelum* in general appearance of the plant. It is worthy of note that the great reduction of the number of leaflets is seen in such species, as *Micromelum diversifolium* MIQ., *Clausena Guillauminii* TANAKA, and *Murraya stenocarpa* TANAKA (= *Chalcas stenocarpa* TANAKA), and the alate rachis is found in *Clausena Wallichii* OLIV., *C. Guillauminii* TANAKA and *Murraya alata* DRAKE. The reduction of the number of locules in *Murraya* is also to be noted. No thorn-bearing plants occur in these tribes, except in the doubtful species, *Clausena impunctata* HIERN, which has curved paired axillary spines, almost entirely opposite leaflets, and a distinctly winged rachis. The gradation of this tribe into the next tribe *Aegleae*, having hard-shelled fruits, is seen in the Malayan genus *Merrillia*, which has large flowers, reminding of *Murraya* (Subgen. *Euchalcas* TANAKA), and a winged rachis like *M. alata*, mentioned above.

The tribe *Aegleae* is characterized by the woody rind of the fruit, a large number of locules and ovules, frequent occurrence of trifoliolate leaves, occasional presence of appendages at the bottom of the filaments, resembling some members of the family *Simarubaceae*. The development of thorns of different type is first definitely seen in this tribe, as shown by curved paired thorns, like some members of the subfamily *Toddalioideae*, and in *Feroniella pubescens* TANAKA; straight double thorn in *Aegle* and *Balsamocitrus*; and straight single thorn in *Feronia*, and *Feroniella*

lucida SWINGLE. Oppositely pinnate leaves are first seen in this tribe, but in the preceding tribe, the tendency of becoming so in alternately pinnate species, like *Glycosmis pentaphylla* CORR., or *Clausena dentata* var. *robusta* TANAKA, is occasionally noticed. It is unquestionable that this tribe has manifold relationship to other tribes as shown by various instances, such as the great resemblance of *Aeglopsis* with *Pamburus* (Tribe *Lavangeae*) in the nature of the leaf and thorn, *Balsamocitrus* with *Lavanga* (Tribe *Lavangeae*) in various characters, and *Swinglea* with *Pleiospermium* (Tribe *Lavangeae*), also in general characters and especially in the shape and construction of the pistil. The tribe is divided into four subtribes: (1) *Merrillinae*, having alternately pinnate leaves with narrowly winged rachis, normal filaments, a long-stalked and many-ovuled quinquelocular ovary, (2) *Feroniinae*, having oppositely pinnate leaves with or without wing upon the rachis, slightly narrowed ovary at the base, appendaged filaments, and five, finally uniting locules, (3) *Balsamocitrinae*, having unifoliate or trifoliate leaves with unwinged or rudimentally fringed petiole, normal filaments, and a more than 6-loculed ovary sitting on the distinct disk, and (4) *Swingleinae*, having trifoliate leaves with narrowly fringed petiole, normal filaments, stalked hairy ovary with many locules, and numerous hairy seeds. The double number of filaments is found in *Feroniella* and in the subgenus *Afraegle* of the genus *Balsamocitrus*, but stamens are very numerous in *Aegle*. Hairiness of seeds is only found in *Aegle* and *Swinglea*.

It is next obvious that the main line of the subfamily, with soft-skinned fruits, develops into the oppositely pinnate-leaved Section *Aurantieae*, but there is a large side line which has a consistent tendency of reducing the number of leaflets. Among the latter, the tribe *Lavangeae* is related in many ways with the former tribe *Aegleae* in habit, as mentioned before, and the climber genus *Lavanga* has more or less hardened fruit rind. Obscurity of venation of leaves is also found in both tribes, as instanced by *Balsamocitrus Dawei* STAFF, *Aeglopsis*, *Pamburus* and *Lavanga*.

Trifoliate-leaved members predominate in the tribe, but *Pamburus* and *Pleiospermium littorale* TANAKA have unifoliate leaves. All members of this tribe have an ovary with 2 to 3, or 4 to 5 locules, each containing 1 to 2 ovules. *Lavanga* still has superposed ovules, and *Pleiospermium* has collateral or obliquely superposed ovules. The tendency of reducing the number of leaflets, however, develops into the large unifoliate group including three closely related tribes *Meopeae*, *Atalantieae* and *Microcitreae*, which are rather greatly divergent from the pinnate-leaved

group, descended straight forward from *Clausena*. Among these tribes, trifoliolate members rarely occur, as *Triphasia trifolia* P. WILS., but it does not amount much, as *T. grandiflora* MERR. of the same genus, is distinctly unifoliolate. The big difference of the tribe *Meropeae* from the tribe *Lavangeae* is the reduction of the number of flowers, but still a great majority of the genera of *Meropeae* have a 3- or 5-loculed ovary with one or two ovules, except in *Wenzelia*, which has locules more than 5 and biseriate ovules. Obscure venation of leaves is also frequent in the tribe *Meropeae*, though the general appearance of the genus *Wenzelia* very much approaches *Monanthocitrus* of *Microcitreae*. Binary thorns frequently occur in this tribe (*Triphasia* and *Echinocitrus*), but single thorns, either straight or curved, are also frequently seen. The genus *Paramignya* has a 3—5-loculed ovary with obliquely superposed ovules, somewhat like the case of *Lavanga*, and it is curious that both are climbing vines with curved simple thorns. No increase in the number of stamens and the formation of pulp-vesicles is found in this tribe.

In the next tribe *Atalantieae*, paniculate inflorescences predominate and still the unifoliolate tendency is very strong. Venation of the leaf is quite different from the former tribes, as veins are very frequently forming parallel netting. This characteristic is bringing down into the next tribe *Microcitreae*. In these tribes, pulp vesicles develop commonly, except in *Oxanthera*, in which stamens count more than ten and locules, more than five in number, containing many ovules, as in *Citrus* and its near members. Simple thorn predominates in these two tribes, but binary thorns are seen in *Monanthocitrus* and *Pleurocitrus inodora* TANAKA (*Citrus inodora* BAIL.).

Coming back from these unifoliolate tribes, the pinnate-leaved tribe *Aurantieae* plays an important role to the further development of the subfamily. This tribe is characterized by the great development of oil cells on the ovarial wall, common presence of wings on the rachis and petiole, and distinct broad reticulation of the leaf. Its subtribe *Hesperethusinae* is linked to certain extent to *Clausena* in having subulate filaments, thick short anthers, and dwarf styles, but it approaches more closely the African subtribe *Citropsinae*, having similar oppositely pinnate leaves, and a large oil-celled ovary containing a single ovule. The latter tribe approaches in turn to the subtribe *Citrinae* quite closely, in the leaf characters, vesiculate locules, and even in grafting affinity. The reduction of the pinnae in *Citropsis* is quite frequent, and even a unifoliolate species was found (*Citropsis citrifolia* TANAKA), which looks almost like *Citrus* in general appearance. Even in *Citrus*, trifoliolate individuals are occasionally found,

and from the progeny of a cross between *Citrus* and the trifoliolate genus *Poncirus* (Subtribe *Poncirinae*), a pinnate-leaved individual has arisen, so that the subtribe *Citrinae* probably has a pinnate-leaved member, like *Citropsis*, as its near ancestor. The paniculate inflorescence is also bringing down into a group of *Citrus* (Subgenus *Archicitrus*), and the solitary-flowered genera *Poncirus* and *Fortunella*, as well as a similar group of *Citrus* (Subgenus *Metacitrus*), are unquestionably later creations, as in the quite analogous case of *Severinia* versus *Atalantia*, with respect to the lack of paniculate inflorescences. It is also interesting to note that these solitary-flowered members are geographically more subordinate to China than to India. Double thorns are still present in *Citropsis* and no increase in the number of filaments occurs, though pulp vesicles are more or less well developed. This again tells, as in the case of *Oxanthera*, that the increase of the number of filaments, ovary and ovules, does not go parallel with the formation of the pulp vesicles. Members having tetramerous floral organs are common in *Clausena*, but these characteristics become essential in *Hesperethusa*, *Citropsis* and certain sections of *Citrus* (Subgenus *Archicitrus*, Section *Papeda* and Section *Cephalocitrus*).

With *Citrus*, the following systematic status can be given:

- (1) In both paniculate and solitary-flowered subgenera, large-winged sections are most primitive, (Section *Papeda* versus Section *Osmocitrus*) and both have broadest wild distribution.
- (2) From a geographical standpoint, *C. macroptera* MONT. is oldest in existence, as it nearly reaches Australia, where no *Citrus* occurs. *C. hystrix* DC. has narrower distribution and *C. latipes* TANAKA only occurs in the Eastern Himalaya.

These three represent the Section *Papeda*, with distinct inflorescences, but the following species represent the Section *Osmocitrus* having solitary flowers. *C. junos* SIEB. ex TANAKA has broadest wild distribution among all *Citrus* fruits found in China: It reaches almost the Burmese frontier and runs along the Yangtse River region, where *C. ichangensis* SWINGLE appears in smaller area.

- (3) The lime (Section *Limonelles*) and the shaddock (Section *Cephalocitrus*) are closely related to the *Papeda*, and all are very similar in climatological requirement.
- (4) The lime, *C. aurantifolia* SWINGLE, most frequently occurs wild in Southern India Peninsula. The shaddock, *C. grandis* OSBECK, occurs wild in eastern Himalaya, Burma, and perhaps in Yunnan. Both have no characteristic companions of distinct geographic

- independence, but local species are very abundant both wild and cultivated. The grape fruit from Barbados, *C. paradisi* MACF., is the most characteristic cultigen derived from the latter.
- (5) The lemon and citron (Section *Citrophorum*) are rather far from the above given fundamental groups, only related to the lime in fruit characters, though leaves and flowers are entirely different.
 - (6) The citron, *C. medica* LINN., and the Canton lemon, *C. limonia* OSBECK, have almost identical distribution as the shaddock, and they have rather few derivations, except such well known species like the Florida rough lemon, *C. jambhiri* LUSH. of India, which is the nearest relative of the latter. The lemon, *C. Limon* BURM. F., grows wild in the Western Himalaya, and the sweet lemon, *C. limetta* RISSO, is amongst its few relatives mostly of garden origin.
 - (7) The sour and sweet oranges (Section *Aurantium*) are not so distinct from the shaddock in the flower and the fruit. Development of carotinoid pigmentation in this section is greater than in the preceding ones.
 - (8) The sour orange, *C. Aurantium* LINN., and the sweet orange, *C. sinensis* OSBECK, grow wild in the Eastern Himalaya, and the latter probably reaches down to Burma and Yunnan. The former has a great number of derivatives in gardens, especially with the presence of the shaddock in the same locality. Natural crossings between them seem to be most easy, giving rise to distinct cultigens. Local wild species are also not uncommon, as in the case of *C. miaray* WESTER and *C. taiwanica* TANAKA & SHIMADA. The Tankan of South China and Formosa, *C. tankan* HAYATA, is one of the very few derivatives of the sweet orange.
 - (9) The solitary-flowered *Citrus* (Subgenus *Metacitrus*) are all loose-skinned, but the big-winged Section *Osmocitrus* can be excluded from the true loose-skin oranges (Section *Acrumen*), by having very large seeds with nearly white cotyledons and by a very distinctive aroma of the rind. In *Acrumen*, we see again the great development of carotinoid pigmentation.
 - (10) Very imperfect knowledge of the true loose-skin oranges (Section *Acrumen*) has caused in the past a great misunderstanding about the bearing and the nomenclature of the Linnean species in *Citrus*. It should be borne in mind, that a name like *C. nobilis* LOUR., should be limited to the cultigen first described by LOUREIRO at Hué in Annam, now known under various names as king orange, Kunembo or Pentikwang in America, Japan and China.

- (11) The king orange represents the large-flowered *Acrumen* (Subsection *Euacrumen*), resembles the Section *Aurantium* by the large-winged leaves and comparatively thick rind of fruits, but its fruits are oblate and the cotyledons are not purely white. *C. unshiu* MARC. is another well defined cultigen of the same section.
- (12) The small-flowered *Acrumen* (Subsection *Microacrumen*) are more distinct in having a ramose bushy habit, wingless smaller leaves and deep green cotyledons. It approaches *Fortunella* through the Subsection *Pseudofortunella*, having leaves with obscure venation, and the fruit with sweet rind.
- (13) There are very abundant indigens and cultigens of the subsection *Microacrumen* which includes many important indigenous species so far almost entirely neglected. The identification and the determination of the limit of species of this subsection are extremely difficult, but it is very clear that this can be settled by measuring the boundary of species by means of studying closely resembling wild species, having no identity in detailed characters and occurring with geographical independence. For this investigation, *C. tachibana* TANAKA and *C. depressa* HAYATA, growing wild in Japanese territory, will present an ideal example. The former is the species north of Sambok (Amami Oshima) and the latter is distributed in Luchu south of Sambok. Both are distinct in the shape of the leaf, the shape and colour of the fruit, and the number of locules, and they are all different in minute characters of the pulp vesicles, carpel wall, integument of seeds, and so on. But they are so close that still greater difference can be set forth, between many wild and cultivated units of the subsection. Among very simple *Microacrumen*, resembling these two species, clear specific distinction can be made, if the natural compass between the species of *Citrus* is concluded to be so narrow as shown by the example mentioned above. Among such small wild or semi-wild *Microacrumen*, one can enumerate Djeroek ragi of Java, *C. crenatifolia* LUSH., and Djeroek limoh of Java, *C. amblycarpa* OCHSE, or three distinct primitive cultigens of Southern China and Formosa, *C. sunki* HORT. ex TANAKA, *C. ponki* HORT. ex TANAKA, and *C. oleocarpa* HORT. ex TANAKA. Many other cultigens, widely divergent from these, of course, should be regarded as independent species, among which the Nagpur Suntara of India (Ponkan of Formosa), *C. poonensis* HORT. ex TANAKA, the Michieh or Kishu-mikan of China and Japan, *C. kinokuni* HORT. ex TANAKA, the

- Fuchieh or Dancy tangerine of China and America, *C. tangerina* HORT. ex TANAKA, etc., have very important systematic and economical significance.
- (14) The subsection *Pseudofortunella* is represented by a single well-founded species, *C. microcarpa* BUNGE, which is probably the most recent creation among *Citrus*, by having natural tetraploid variety.
 - (15) The genus *Fortunella* is characterized by smaller stature, smaller flowers and leaves exuding resinous substance underneath, greatly reduced number of carpels, sweet rind, and intensely green cotyledons.
 - (16) The common Kumquat orange belongs to the subgenus *Eufortunella*, which has two distinct wild members, *F. japonica* SWINGLE and *F. polyandra* TANAKA. Three cultigens, *F. margarita* SWINGLE, *F. crassifolia* SWINGLE, and *F. obovata* HORT. ex TANAKA, are also well defined. It is quite interesting to note that the most primitive-looking species, *F. Hindsii* SWINGLE, forming the monotypic subgenus *Protocitrus*, is the only tetraploid natural species of the *Citrus* fruits.

Judging from these facts, above mentioned, the systematic status of the *Citrus* fruits can be concluded as follows:

- (1) All members of *Citrus* should be named properly, for the species formation in *Citrus* through the process of compound hybridity (Zygotaxis), occurs both under wild or cultivated condition, in equal opportunity and frequency.
- (2) Although all representatives of the systematic sections of *Citrus* and *Fortunella* are found wild by the author's identification, minor species systematically unimportant also occur wild. More important members occur in cultivated condition, so that the question of wild and garden origin of species in *Citrus* does not mean much systematically to their validity as Linnean species. Naming of garden species (cultigens) is just as important as naming wild species (indigens), and in fact most of the present standard species have been named originally from gardens.
- (3) From geographical and taxonomic evidence, it is logical to state that the limitation of species in *Citrus* is extremely narrow-compassed and the grouping of these species into a few broad-compassed imaginary species is not permissible, as such must stand as a section or subsection of the genus.

- (4) All local Citrus fruits in the far East should be mobilized, properly classified and described, otherwise it is impossible to make the Citrus flora of these regions systematically clear. No identification of Citrus species can be made without the proper nomenclature of these numerous independent species.
- (5) The hesitation of naming these distinct units of the genus prevents the increase of knowledge of Citrus fruits and checks the progress of Citrus industry, as the cultural requirements of these species, especially in the scion-stock relationship and the disease resistance, are entirely different.

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