

THE SPECIES PROBLEM IN CITRUS¹L. Materials for Chinese Rutaceae (V)

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Citrus, a genus of south eastern Asia and the vicinity, kinds of the more economic value are now widely cultivated in all warmer parts of the world. The cultivated and also the wild species are believed to be native of subtropical regions of south eastern Asia, few authors believed that the region from south China to the mountain slopes of north eastern India as the center of origin. Botanical evidences indicate that the *Citrus* originated in the drier monsoon area rather than in the tropical rain forest. This is rather reasonable though more or less putative, as Pursglove (1977) pointed out that the plant exhibits periods of dormancy and the water-storing cells (pulp vesicles) would help to nourish the seed in such an environment, further more, *Citrus* do not grow well either in the very humid tropics and under the shaded forest or in the colder climate. While Simmonds (1976) argued that "the main center apparently being eastern India, and relationships can be trace through the eastern India, central China, Japan and even Africa". This is somewhat like that of Tanaka (1954) had proposed but more amplified.

The cultivated species are believed to be acquired in remote times, the earliest record in Chinese literature is in the book "Yu Gong", published since 2500 years ago, in which the pummelo and mandarin were mentioned in brief. The earliest archaeological evidence from China goes back to approximately 2200 years before, a large scale of seeds were found in an ancient tomb of the Duke named Tai near Changsha City, Hunan Province—lies at about 28 N.L. 113 E—, the more or less deteriorated seeds which with the size between pummelo and sour orange and with strongly ribbed, were identified as *Citrus junos* Sieb. et Tanaka by professor Hoo Shan Wen, director of the Hunan Institute of Pomology.*

Citrus and its nearer relatives are represented by 28 genera in the tribe *Citreae* of the orange subfamily. The most closely allied genera with *Citrus* are *Poncirus* and *Fortunella*, the former is a monotypic genus with trifoliolate deciduous shrub or small tree, the evergreen individuuous ones were found in south eastern Yunnan and west northern Hunan provinces in these later years. It is growing wild but more common in cultivation in central China and being used as a root stock in the area of higher latitude due to its extremely cold-resistance, the deep-root system also provides as a good material for drought-resistance, and other proper charact-

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eristics. While the *Fortunella*, is also native to China, where 3 are found in wild of the total 5 species it composes. These wild species are growing well on the open slopes in area south to 25 N.L. in south China including some islands along Chejiang, Fujien, Guangdong provinces and Hongkong. They are of elements representing the subtropical monsoon evergreen forest.

The taxonomy of *Citrus* is confused, in spite of many authors have paid more effort to the classification of the genus than other groups of the tribe *Citreae*. Because of its economic importance, works from phytochemistry, physiological biochemistry, cytogenetic, cytology and other fields, but the more is the classical morphology, although scores of papers have been published from every aspects, each effort to solve the problem has not only been reached the agreement to the specialists and taxonomists as to the number of species involved, but also made the situation more complicated.

The author of this paper will not discuss in detail about the problems of species formation and the specific delimitation or furthermore, those three most close relationship genera established by Swingle, i.e. *Fortunella*, *Eremocitrus* and *Microcitrus* should combine into one with the genus *Citrus* L. under the conception of *sensu lato*, or works of other fields on this complex genus.

The system of Swingle (1948) and his successor, Reece (1969) so far as they recognized 16 species and a few varieties, while Tanaka (1954) proposed 145 species, fifteen years later, increased to 159 species (1969), and afterwards raised to 162 species (1977). Another compromised classifications including among 36—40 species have been proposed by various authors, such as Hodgson (1961), Singh and Nath (1969), Nath and Randhawa (1969). Further more, Tseng (1960) splitted the genus into five genera.

The different points in endless debate reflected two familier problem: no rules can be made for standardization about delimitating species and, whether supposed hybrids among naturally occurring forms should be recognized as species rank even hybrids of known origin are often assigned as cultigens. The inconsistency of various treatments is a very real problem and results from disciplinal differences between horticulturists, pomologists and systematists even among taxonomists themselves of different concepts they held.

Wolfe (1959) has criticized both Swingle's conservatism and Tanaka's splitting system. From the point of view of a biosystematist, some species that have long been in cultivation were recognized as valid species by Swingle were thrown open to question by Stebbins (1969), such as sweet orange to sour orange, grape-fruit to pummelo for examples. There are no evidence of sterility barriers between closely related taxa. While in the point of view of a horticulturist, perhaps Tanaka is the one representative, he had laid strong emphasize upon the practical condition for these economic plants, seeing that those fruits which differ from each other clearly by outward appearance at first sight that he would made cultigens with minor but distinctly morphological differences as good species.

Mechanism of the breeding system in *Citrus* is very complicate. The basic number of chromosome is $x=9$ throughout and all species are diploid except one species of the related genus, i.e. *Fortunella hindsii* is an autotetraploid, although now and then polyploid aberrants also arise in *Citrus*, such as tetraploid Lisbon lemon and others, but entirely confined to the cultivated forms when crossed artificially.

Some taxa of *Citrus* took process by means of sexual reproduction, others by asexual, and still others by both sexual and asexual reproduction even at the time in a same plant. The group reproduces in the way by means of sexual reproduction could be hybridized naturally and artificially between species or genera even trigeneric, the citrusquat is a product of a threegenus hybrid, *Fortunella margarita* \times (*Citrus sinensis* \times *Poncirus trifoliata*), this hybrid was found that it still produces 9 bivalents. In the group of asexual reproduction, it produced seeds without fertilization, is called agamospermy. The embryos of this type arise directly in the ovules of the mother sporophytes in the form of nucellar, this is called adventitious embryony, reproduction of this type though associated with pollination but not necessary fertilization, this is called apomictic. The result is the formation of seeds containing embryos which are genetically identical with the maternal parent. These agamic forms are most common in garden species, such as oranges, mandarins, tangerines grapefruits and etc.

But in fact, of course, completely obligate agamospermous apomicts may not occur in *Citrus*, since some small degree of sexuality always present, therefore, most cultivated forms of *Citrus* are facultatively agamospermous, i. e. both reduced and unreduced embryo sacs may exist side by side, so that in the same tree even in the same seed can produce some embryos which by asexual means reproduce exact copies of the maternal genotype, and others which through sexual reproduction give rise to either genetic segregants or new hybrids.

The combined sexual and asexual reproduction of many hybrids in continually producing new clones, some of them markedly different from their parents in respect of morphological distinction.

Mutations both somatic and genetic are also common in several cultivated forms of *Citrus*, cultigens from Satsuma (*Citrus unshiu*), grapefruit (*C. paradisi*) and etc. were obtained through mutation have been reported. In fact, gene mutation and chromosomal aberrations may accumulate during the continued asexual mode of reproduction. Their number will be further raised by the extreme temperature and ageing of the parental plants, environmental influences that also work in nature.

Tanaka had laid much stress on mutation and considered it to be the main cause of species formation in *Citrus*, but in fact, a lot of so called "Species" proposed by him and his colleagues were hybrid origin either natural or artificial.

It is also not all the polyploids must be regarded as to the specific ranks particular to those of cultivated plants (communed with F. Ehrendorfer).

Owing to the fact that *Citrus* trees are of great economic importance, from

the remote time, they have been planted under different environments and various conditions, the effects of the extreme habitat disturbance created by men have in the genus been further compounded.

The combined effects of hybridization, asexual reproduction, mutation and disturbances by cultivation affected on the species formation in *Citrus* caused the problem much complicated.

To consider the past and the present, the species delimitation and their number in *Citrus*, there is still no agreement as to future treatment of this apomictic group, this, is what Stebbins had claimed "there is no correct or incorrect system of classification" for the genus *Citrus*.

It seems necessary that in order to reach a complete and perfect system for the genus *Citrus* is still need of a synthetic researches including multidiscipline although some aspects have been discussed to some extent in former paragraphs in this paper.

In turn, at last, the author inclines to adopt Swingle's system while in compiling a local flora, because it is a little simplicity and, simplification is always a merit in compare with complicity when we treat with a most difficult group. On the other hand, as for the practical purposes, which we often encounter with, a certain number of species published by the earlier authors and recognized by Tanaka would be accepted, such as the Canton lemon (*Citrus limonia* Burm.f.) and the fragrant orange (*C. junos* Sieb. ex Tanaka). It is because they were found in the field naturally, where they grow well and set fruits without human aids. The former (*C. limonia*) was found even growing wild on the slopes along the dry river valleys of Red-Water River of Guizhou Province and common in bush of southern Yunnan Province. While the latter (*C. Junos*) was also found wild at the high altitudes in Ta-Ba Mountain, Sichuan Province. Furthermore, they possess different essential characters such as morphological aspects, ecological habitats and physiological demands, all of these will give significant informations for practical purpose to the horticulturists.