SOME ECOLOGICAL FACTORS INVOLVED
IN SUCCESSFUL LYCHEE CULTURE

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In speaking of some of the environmental factors which play so large a part in successful lychee transplant work I am encouraged in the outlook for success in this part of the world with this high quality fruit. Certainly Florida's horticultural leaders must be conscious of the possibilities of the lychee or I would not have been invited to present this paper. Indeed, the lychee may yet prove, in spite of its very narrow climatic range, China's distinctive contribution to Florida's peace-loving, plant-loving people in the post-war world of our generation.

The Hazards of Plant Introduction

The plantsman who throughout his entire life has lived in one place has slight concept of the hazards involved in successful plant introduction. He enthusiastically accepts, for culture within his own area, new species of plants introduced by government, nurserymen, or some interested individual. He gives slight thought to those specific delights in the edaphic nature of the soil, in the regional and local climatic factors, and in the biotic relationships which these new plants enjoyed within the borders of their native homes. And giving new plants the conditions one happens to possess, without modification, is usually not giving them well-being, but is merely inviting disaster.

The difficulties of this haphazard type of plant introduction are in these days fully manifest to the average scientific plantsman. As a matter of fact many long introduced exotic species, known within our cultural areas, are in reality inborn varieties, hybrids, or polybreds from the originally introduced material. Many of these crosses are made with related forms from our own and other areas. By this method forms which will meet our local requirements are developed. This, no doubt is the direction in which to work; but in Litchi there are but one or two good species within the genus. Then, too, in the case of lychee here in Florida there are but few surviving introductions. And only one near relative, the longan, is present in our cultivated flora.

In these days of rapid communication and widespread travel there is less excuse than formerly for lack of knowledge of the native habitats of the species of plants which we are endeavoring to grow. Herein is an ideal field of approach, when peace again dawns, for the horticulturally minded botanist. In this field he will have a worthwhile mission to carry out with the people of many other lands. And when the ecologists organize this world field systematically and carry out their surveys, as have the taxonomists, then more intelligent procedure with the culture of new plants will be possible.

In the meantime one must proceed in a vicious circle with most new plants, for he has neither the knowledge of adequate exploration nor of scientific experimentation. Our experiment stations generally refuse to consider new crops for experimental tests until planters have demonstrated their commercial value. When finally an experimental program is projected years elapse before bulletins relating to the new plants are published. How unfortunate that from the start we are not more fully informed of the native habitat of a newly acquired plant, and of the cultural methods long practiced by the peoples of the land in which
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it is indigenous or where it has been highly
developed in cultivation!

These hazardous experiences have been
very largely true of the lychee. This year
marks the sixtieth anniversary of the fruiting
of lychee in Florida. The so-called 'Brewster' lychee, widely recognized as a
most valuable introduction from Fukien pro-
vince, China, has been here for thirty-six
years. Experimental work with this fine fruit
has been sporadic and not at all serious.
No monographic bulletins have been pub-
lished from within the mainland of the
United States. One appeared in Hawaii in
1917. And today the only orchard planting
of lychee within Florida of any commercial
promise is that of Colonel Wm. R. Grove
at Laurel in Sarasota County.

The History and Native Environmental Fac-
tors of Introduced Plants usually are
Insufficiently Known

In distributing new plants government
agencies and nurserymen generally record
the original home of the plant with such
terse phrases they have seen in botanical manuals, as: 'Native to China', or 'Native
to Brazil'. But China and Brazil, like the
United States, are continental in area.
These, and other great national boundaries,
include diverse range of latitude, altitude,
soil, light, temperature, and wind factors.
And plants, within their natural distribu-
tional range, have also all manner of rela-
tionships to insects, birds, and animal life,
to lower soil organisms such as bacteria and
fungi, and to one another in plant associ-
ation. As the result of these ecologic fac-
tors, working in varied combinations, plants
gradually develop their own morphological
and physiological characters so as to meet
the environment of which they are a part.
Thereby new varieties and sometimes new
species are created.

Since the time of Linnaeus, in 1753, the
diagnoses and names of new plants described
by taxonomists have been in Latin termin-
ology. This has been conducive to more
effectual international intercourse and stand-
ardization in the plant field. Native plant
names, however, are often ignored. They
are sometimes invaluable links in our chain
of knowledge of a plant, especially in the
investigation of cultural methods and eco-

nomic uses in the areas where the plant is
best known. Purely local names are usually
the only one known to the people who have
been long associated with the plant. Many
essays and monographs on the lychee, for
example, have appeared in Chinese writing
only, without any association whatsoever
to its botanical name or to botanical liter-

ature.

From indigenous species and varieties of
plants found in the wild, in which the bot-

anist is primarily interested, there have
emerged under the care of man those culti-
vated plants of chief concern to the horti-
culturist. Some of these, though included
in floristic enumerations, have never been
found in a state other than in cultivation.
This, for example, is true of the Sweet Or-
ge, Citrus sinensis, first described as a
distinct species by Osbeck in 1757.

Most of the cultivated varieties of plants,
developed by man, have never been diag-
nosed and named in Latin, but only record-
ed in vernacular languages. Specimens are
rarely found in herbaria.

This descriptive work in the field of bot-
any is usually carried out in centers thou-
sands of miles removed from where the
plants were collected. Taxonomists generally
describe plants from dried specimens. The
data recorded on the herbarium specimens,
filed away so carefully for future reference,
rarely includes any information relative to
the ecology of the area where the plants
were collected; or to what is known regard-
ing them by the people living in the region.

No wonder the explorer for new plants
knows only too well that even though he
may have located a species new to science,
and though his living material has survived
transit and quarantine, the battle for suc-
cessfully establishing the introduced plant
in a new home is scarcely half won!

The plant explorer, too, in his eagerness
to cover ground often is content with such
brief habitat description of plants he collects as: 'In tropical forest', 'On barren, sandy hillside', 'In thicket along roadside', 'In marsh lands along-stream', or 'In field cultivation'. Remarks such as these are almost as useless to the cultivator of a new plant as is the taxonomist's morphological description. No wonder the practical plantsman so often ignores strictly botanical writings concerning plants.

The Historical Background of the Lychee

The lychee is an excellent illustration of a highly cultivated plant with a long history, a good Latin name based upon the Chinese name, and considerable published economic data.

Ts'ai Hsiang's Li Chih P'u is believed to be the earliest horticultural monograph extant. Ts'ai Hsiang was a famous Chinese scholar, calligrapher, and engineer from Fukien province, the original home of our 'Brewster' lychee. His work was compiled in 1059 A. D. and was variously carved on stone, on wooden blocks for printing, and was often carefully copied on silk as a rare gift to a friend. It has been the model upon which many subsequent fruit and flower monographs appeared in China. And there followed in Chinese more than a score of other treatises on the lychee, written in later centuries. Although these works cannot be considered scientific, for they are full of folklore and sometimes superstitions, nevertheless we must confess that they contain more information on the ecology of the subject than do many descriptive botanical writings.

Some of the early western travellers to China also gave us information regarding the lychee of the kind we are discussing in this paper. The great pleasure of eating fresh lychees in China was recorded by Gonzalez de Mendoza in Spanish as early as 1585. Michel Boym, in 1656, writing of lychee and lungan, recorded that the trees are known only in the southern provinces of China. He told how the Chinese claim that when the fruit is wild it has a very large seed, scanty flesh, and sub-acid taste; but that if it is transplanted and cultivated the seeds soon decrease in size, and the flesh becomes sweet and abundant. His drawing of the tree and fruit of lychee, carefully labeled with Chinese characters, was probably the first figure of the tree published in the West.

Pehr Osbeck of Sweden, who in 1767 gave the accepted latin name to the Sweet Orange, saw lychees when visiting Canton and briefly recorded them in his 'Voyage to China and the East Indies'. His description, however, from a taxonomic point of view was insufficient to allow him credit as the author of the name he suggested in the 1765 edition of this work, Laetjii chinensis. Osbeck's ship anchored at Whampoa, near Honan Island below Canton, a country environ I know intimately, having spent many happy hours there visiting lychee growers. Times have changed in two hundred years, though the beautiful landscape with lychee trees bordering the dykes is doubtless as it has been for centuries. But Osbeck was in China too early to enjoy much more than the formal hospitality of the Chinese. Intimate friendship is necessary to learn deeply of their knowledge.

Pierre Sonnerat, a Frenchman, in 1782, in 'Voyage aux Indes Orientales et a la Chine', made the first careful and complete description of the lychee. Sonnerat's name, Litchi chinensis, possibly following Osbeck's suggestion, is indeed most fortunate. It has priority over eight or ten less appropriate synonyms published later. The authentic Chinese literary name for the South China fruit is written with two Chinese characters, the romanization of the Cantonese pronunciation of which is 'lychee'. The symbols or radicals of which the characters are composed signifies that the fruit is severed from the tree with knives, leaving a portion of the branch attached to the fruit cluster. Sonnerat latinized this name 'lychee' to Lithi and gave it generic standing. He then added chinensis as the specific name. Fortunately the genus Litchi of Sonnerat has stood the test of time, though many authors
to modern times placed lychee within the genus *Nephelium*. But the distinctive characters of the flowers from those of *Nephelium* make valid the name *Litchi*. Thus the Chinese name ‘lychee’ is happily preserved for all time in international and botanical literature by the Latin name *Litchi*. The specific name, *chinensis*, indicates the country of origin. Some more restricted geographical name, such as *manzayensis*, from Marco Polo’s ‘Manzay’ for South China, or *lingnanensis*, the Chinese name indicating ‘south of the range’ would have indicated that the lychee is a strictly southern plant from China.

Some idea of the extent of the published literature on the lychee is revealed in my compilation of Chinese and Western bibliographies (3). There are nearly one hundred standard Chinese works which have dealt with the lychee. And there are nearly two hundred and fifty references to lychee in Western literature.

The Genetic Point of View Relative to Transplants

Having thus indicated some of the botanical and historical aspects of the problem of successfully understanding the inherent nature of this Chinese subtropical fruit, the lychee, let us now turn to some strictly scientific experimental transplant work. According to both theory and practice what shall we expect when we remove plants from their native environ and endeavor to establish them within a new home?

Plant geneticists and physiologists generally believe that a substantial plant species, in its inherent morphological character, will be unaltered by environment. But I have often noted with interest that experienced Chinese fruit growers do not labor under the opinion that the quality of the fruit is unaltered when a variety is transplanted from one area to another. They believe so thoroughly that the place where grown determines the value of a fruit that they are usually in the habit of referring to it not only under its varietal name, but under both its district and varietal name. Thus they would speak of a Polk Valencia as distinct from an Indian River Valencia, or Hillsborough Valencia Orange. The ‘Hanging Green’ (‘Kua-lu’) lychee has for centuries been one of the most renowned varieties of the Canton area. Tribute of this fine fruit from Tsangsheng district in Kwangtung province, in the days of the Empire, was sent annually by fast runners to the court at Peking. The ‘Kua-lu’ from other districts invariably was considered inferior. In receiving a gift of one or two fruits of this variety, neatly packed in a little red box, one would first most carefully note if it was labeled ‘Tsangsheng Kua-lu’. One would not wish to send a friend merely a ‘Kua-lu’. Fundamentally there is slight difference of opinion in this respect between the scientist and practical plantsman when in their discussion morphological and physiological characters are clearly differentiated.

From the Chinese point of view, when one considers the lychee in that state of being moved from one geographical area to another there seems a mystic handicap to success. Even within famous lychee districts the trees may refuse to flourish within given localities. The Chinese of the most outstanding lychee producing regions of Fukien and Kwangtung provinces, which areas also happen to be those in China which have sent more emigrants abroad than any other, tell us that the lychee is one of those eccentric plants that refuses to be accustomed to a new home. Chinese emigrants, largely peasants, have never had any large measure of success in transplanting lychee trees to their new homes. However, lychee introduction is gradually succeeding in a number of world areas. The Calcutta area of India was one of the first in which the lychee was successfully grown. And I am told by missionaries of India, who spend the early summer months in the foothills of the Himalayas, that there they enjoy some high quality lychee fruits. Trees have also been reported as fruiting successfully in Hawaii, Florida and California, the West Indies, Brazil,
South Africa, and Java. Therefore, we have reason to believe that the lychee will succeed in carefully chosen new areas when the evolutionary history and inherent nature of the species are fully understood. Within these new areas, no doubt, there must be modification of any climatic and soil factors unfavorable to the lychee.

Before considering such modifications of wind, water, frost, and soil factors necessary to meet the cultural requirements of the lychee, let us first clarify the genetical aspects of any plant transplant program. It was my very good fortune some years ago, while I was in California, to have been included in a trip into the high Sierra mountains with the late Dr. H. M. Hall of the Carnegie Institute of Washington, D. C., Dr. E. B. Babcock, Professor of Genetics of the University of California, and the late Sir Arthur Hill who at the time was Director of the Kew Gardens in England. Dr. Hall was carrying out some significant transplant work with complex species of Potentilla, Achillea, and Artemisia which are found over a large part of California from near sea level to areas of 11,000 feet altitude. Bonnier, in Europe, as early as 1895, had reported that lowland plant forms could be changed into alpines by simply transferring them to an alpine environment. But Kerner, 1891, and Turesson, 1925, found that lowland and alpine forms remain distinct when grown side by side in a uniform environment. Dr. Hall wished to check these observations by experimental transplants. Dr. Hall passed away shortly thereafter, but his experiments were carried on, and the findings published, by Clausen, Keck, and Hiesey (1). These were considered sufficiently significant to the Symposium on 'The Species Concept' to be included in Biological Symposia IV, 1941 (2). In this work these scientists raised such fundamental questions concerning the nature of climatic forms as: "Are they due to the direct impact of the environment, and hence to be regarded as modifications, or are they hereditary in nature?" Again, "Is it possible to change lowland forms into alpines by transferring them to the alpine environment as Bonnier (1895, 1920) reported, or do lowland and alpine forms remain distinct when grown side by side in a uniform environment as Kerner (1891) and Turesson (1925) found?" Furthermore, "If the differences are hereditary, what is their nature? Are they purely morphological, or are physiological characters also involved? If so, is each climatic belt populated with a race especially fitted to survive there?" And more complex questions than these, raised by cytologists and geneticists, are also involved.

The discussions on the trip into the high Sierras were certainly most enlightening to one interested in world plant exchange. I have often reflected upon them. I must leave the details of the published conclusions of Dr. Hall's associates to those of you sufficiently interested to consult the papers. But let me quote a few pertinent statements from the conclusions of the authors and state how I believe these relate to the lychee.

(a) "... The genetic-physiological differentiation of a plant group is correlated with the climatic zones it occupies."

I shall endeavor later to show the application of this statement to the botany of the four important Sapindaceous fruits of the subfamily Nepelieae.

(b) "From the point of view of fitness to the environment it is evident that the ecologically important unit is not the species, but the regional climatic race, or, to adopt Turesson's term, the ecotype ... Such monotypic species occupy a narrow climatic belt and show little variation and adaptability."

The genus Litchi has only two accredited species, one from South China and one from the Philippines. The former bears the most highly developed of all the edible fruits of the family Sapindaceae. In line with the above conclusion I believe that Litchi chinensis is a distinct climatic race or ecotype. If this is the case it is easy to account for the narrow climatic belt of the lychee and
its slight adaptability to extended cultivated areas. I shall also later deal with this hypothesis.

(c) "Evolutionary processes have left plants arranged in groups of various order and separation, such as populations, ecotypes, species, and species complexes. These groups indicate stages in evolutionary differentiation, and they have evolved only where there is a diversity of environments."

The diversity of environment of forms of the genera Nephelium, Euphoria, and especially Litchi, from hot tropical areas to the frost-bordered subtropics, accounts I believe for the evolutionary differentiation of the lychee and lungan from the rambutan and pulassan.

(d) "We have no evidence that the direct influence of environment produces fundamental hereditary changes in species, but major alterations in environment provide new habitats and refuges from the products of nature's continual experimentation among all the plant species that populate a given area."

We may be assured, therefore, that the hereditary morphological characters of the lychee, and other fruits, do not change in moving them from one area to another. However, there may be physiological modifications which may somewhat alter the pomological features, or which may help the plants adapt themselves to their new habitat.

With these points of view of the geneticist in mind, derived from experimental transplant work, let us be assured that we are not working in vain while searching for a suitable habitat here in Florida for acclimatized forms of the delicious lychee. These we may introduce direct from China, from Hawaii, Guatemala, Cuba, and from more distant lands whence in times past they have been carried. And as with many other cultivated fruits, as the peach and the apple, citrus fruits, and the mango, we may select new strains from desirable varieties of Lychee already fruiting in Florida.

The Visible Influence of Latitude and Temperature upon the Isolation of Lychee from Its Close Relatives in Nephelieae

I am here advancing the theory that it was because of the influence of the north range habitat upon the flowering and fruiting characters of members of Nephelieae that the lychee developed its distinctive morphological features and became isolated from the larger group. Some contradiction may seem to appear between this hypothesis and the above statement (d) that we have no evidence that the direct influence of environment produces fundamental hereditary changes in species. But herein we are considering changes of generic standing brought about by the working of nature thru long periods of time.

The family Sapindaceae, composed of about 130 genera and 1,000 species of trees, shrubs, and climbers, is mainly tropical. Its members are in large part Asiatic, with minor representation American, chiefly of the genus Sapindus. The subfamily Nephelieae with about 13 genera and 100 species, however, is largely confined to the Malay Peninsula, including Siam and Indo-China, but extending southward throughout the Malay Archipelago to Australia, northwestward into Ceylon and India, and, in a lesser numerical extent, northward into China where we find only the lychee and lungan.

It is entirely within this subfamily Nephelieae that there are found, in genera Nephelium, Euphoria, and Litchi, the most acceptable edible fruits of the group. These are the rambutan, the pulassan, the lungan, and the lychee. The tropical rambutan and pulassan have ever remained within the genus Nephelium, which is the largest in the subfamily, having about 30 species. The center of distribution of Nephelium, considered in its narrower sense, is distinctly Malayan, extending northward and eastward only as far as Indo-China, and northward and westward into Burma and India. The lychee and lungan, however, now separated from Nephelium, and placed within the genera Litchi...
and *Euphoria*, respectively, are the only species native to the southern provinces of China. The three genera are closely allied from a botanical standpoint.

The special point to note here is that *Nephelium* does not have members extending as far north as winter freezing temperate areas. The rambutan and pulassan are most of all common to the hot, moist, low country of Malaya. But other members of the genus *Nephelium* tend to extend a little farther northward into the cooler, subtropical hilly areas of Siam, French Indo-China, Burma, and India. Fruits of some of these are often eaten by the natives, but only the rambutan, *Nephelium lappaceum*, and the pulassan, *N. mutable*, are of any commercial importance.

It is farther northward into the South China provinces of Kwangtung, Fukien, and to a lesser extent in Szechuan, where we find the lychee, *Litchi chinensis*, and lungan, *Euphoria longana*. But these species are by no means widespread within these subtropical provinces. They are restricted to cultivation within only a few districts where summer temperatures are relatively high and winter temperatures relatively low.

In appraising characters of taxonomic value in *Nephelium*, *Litchi*, and *Euphoria* we note distinction in the number of leaflets and their veination. The floral character which separates *Litchi* from *Nephelium* and *Euphoria* is the absence of petals in the former. The cleft and imbricated nature of the sepals also distinguish the lungan from the lychee.

As to the fruit characters of the two commercially important species of *Nephelium*, the one of *Litchi*, and the one of *Euphoria*, of interest to both the pomologist and systematicist, the nature of the attachment of the flesh to the seed, the size and maturity of the seed, and the hairy, prickly, or smooth surface of the skin, as also the color are of major significance.

The extent to which the pearl colored, fleshy aril of the fruit is attached to the seed is of key importance in the classification of the two members of *Nephelium*, the rambutan and pulassan, the Chinese member of *Litchi* and that of *Euphoria*. The fleshy, edible portions of the fruits, found within the leathery skin much like in a grape, are somewhat smaller in appearance in all four of the fruits. The layers of sweet, ripe pulp completely surround the seeds. But in the lychee and lungan this part of the fruit, known botanically as the aril, is practically free from the seed while the rambutan and pulassan have their arils adherent to the seed. In the two latter tropical fruits the flesh is also a bit more raggy than in the subtropical lychee and lungan. There is also distinction in sugar content and flavor. The lychee attains the highest quality of juicy sweetness and fragrance. The flavor of the lungan is distinctly vinous, and the pulp of the flesh, when dried and pressed, is of medicinal virtue and is often found in Chinese herb shops.

A highly valued character of the lychee under intensive culture is the immaturity of seeds which appear in some varieties. The Chinese refer to these as ‘chicken-tongued’ seeds. This approach to seedless fruits, as in such favored varieties as the Canton *No mai* and *Kuei-wei*, is most eagerly sought by both the cultivator and the connoisseur. This desirable character is now appearing also in some bearing trees of ‘Fukien Brewster’ here in Florida. But no definite strain of a seedless *Brewster* as yet has been isolated by careful selection and asexual propagation.

The most interesting and distinguishing surface character of the fruits of the four species under consideration is the hairy to tubercular excrescences covering the outer surface of the skin. These may reach to 2 inches in length in the rambutan, where they are distinctly hairy in nature and of a red, yellowish, orange, or almost black color. In the pulassan these setae are more rigid and strong, and are usually red. In the lychee the hairy protuberances of *Nephelium* have been reduced to prominent, some-
what angular tubercles. In some varieties, as No mai, these are greatly smoothed down, while in others, as Kwei-wei, they are bluntly prickly. The surface of the skin of lychee is usually a bright rose-doree red in color, although some varieties tend to light green or yellow spots, streaks, or lines. The lungan has the smoothest skin of all the four fruits, the tubercles being more flattened out and not so distinct as in the lychee. The color of the skin of the lungan is a yellow-brown.

A Singapore Chinese, intimately acquainted with all four of the commercial fruits of Sapindaceae, described their differences in appearance in terms of the barber’s art. He said: “The rambutan is the long-haired gentleman of the group. He has flowing locks. The pulassan has his hair cut modern style. The lychee has had the clippers applied to his head. And the lungan, with head closely shaven, is the Buddhist priest of the group.”

Within the temperate areas of our country it is widely recognized that our best apples are produced toward their northern limit of range, as in New York, Pennsylvania, and the state of Washington. It is also generally accepted within the tropics that the members of Citrus usually produce fruits with higher skin color and greater sugar content within their more extended subtropical range. It is interesting to note that this is also definitely true of the members of Nephelieae we are considering. Litchi chinensis is distinctly the most brilliantly colored, sweetest, and most pleasing edible fruit of the group. Euphoria longana likewise has developed virtues as an edible fruit within the cooler, subtropical range of habitat. Thus it is that the South China coastal provinces, as also Florida and California, are ideal fields for man-directed introductions of some of the edible fruits of the Asiatic and American tropics.

The Lychee is Essentially an Ecotype

The lychee in its long history has been awarded many distinctive honors. The Chinese have long considered it their most unique gift fruit. The earliest monograph on any horticultural subject deals with the lychee. Martinio in 1655 called the lychee ‘the King of Fruits.’ Olfert Dapper in 1670 wrote that the tree in fruit seems to be decorated with ‘purple hearts’ which melt like sugar in the mouth, and that rightly the lychee should be called ‘the Queen of Fruits.’ Grosier in 1795 claimed for the lychee that ‘it is the most tasty and beautiful that God has created in the Universe.’ And a writer on nature subjects in modern times, Robert Sparks Walker, said that anyone who examines the lychee and notes the beauty and sanitary method by which the fruit is preserved must admire it as ‘one of the daintiest packages that have ever been wrapped by nature’s hands.’ Now from botanical and ecological points of view also it seems that the lychee deserves added prominence as one of the few cultivated fruits that essentially can be considered an ecotype.

In view of that which we have noted of morphological characters and distribution within the species of Nephelium, Litchi, and Euphoria under consideration it is logical to ask: What appraisement in morphological development, gradation, and taxonomic grouping, as also in the pleasing pomological changes in color, sweetness, and skin surface may we justifiably attribute to the cooler South China regions in which the lychee and lungan were first created by nature and cultivated by man?

From the point of view of autecology, or the possible evolutionary changes in morphology and distribution taking place within the edible Nephelieae, as differentiated in two species of Nephelium, one of Euphoria, and one of Litchi which we have considered, I believe we have tangible evidence of the influence of the cooler South China habitat. The loss of petals in Litchi, its ability to grow luxuriantly on the drier, northern range, and to fruit successfully only where winter temperatures are periodically relatively low as compared to the usual habitats of Nephelium are quite sig-
significant. These attributes are all within the requirements of an ecotype.

The varieties and forms of Litchi chinesis, largely developed in cultivation within a narrow range of habitat, constitute that which Hall and his associates call 'a regional climatic race'. In accord with their requirements for an ecotype the lychee occupies a relatively narrow climatic belt and reveals only slight variations and little adaptability in wider distribution.

The only contradiction that arises in advancing the lychee to the position of an ecotype is the fact that one other species, Litchi philippinensis has been described and assigned to the genus. To be a true ecotype the genus should contain a single species, i.e., be monotypic. Unfortunately we have little first hand knowledge secured in the field of Litchi philippinensis. The few attempts to bring it into culture in experimental plots and botanical gardens have repeatedly failed. The species was described by the German botanist, and authority on Sapindaceae, Ludwig Radlkofer in 1913. It is variously reported as a tree of great height and girth growing on the hills and mountains in the Philippines at altitudes of 100 to 1,700 feet. A specimen which I examined in the Bureau of Science of Manila some years ago was collected in Zambales Province, Luzon in April, 1905, by W. M. Maule. A quotation from Radlkofer, attached to the specimen, stated: "These fruits seem really partly to split by exsiccation, but nevertheless the plant is from floral and anatomical characters a true litchi." Regarding this species Dr. E. D. Merrill, Administrator of the Botanical Collections of Harvard University, and an authority on the plants of the Philippines and Malay, writes in a recent letter: "The species has never been found outside of the Philippines, but in the Philippines it is widely distributed, a sylvan species, never cultivated — in Luzon from Zambales, Bataan, Pangasinan, Camarines and Albay, also in Sibuyan, Samar, and Mindanao (Surigao, Agusan, Davao)." It is most surprising in view of the close proximity of the Philippines to the South China coast, that Litchi philippinensis has not appeared on the Asiatic mainland, or that Litchi chinensis has made so little progress as a cultivated fruit in the Philippines.

The lungan, Euphoria longana, is in a somewhat different category from the lychee in that no distinctive morphological changes took place in its northern habitat that would raise the species to generic rank, distinct from the other 10 or more species of the genus recorded from the Asiatic tropics. However, only Euphoria longana, like the lychee native to South China, has gained prominence as a cultivated fruit of economic worth. Dr. Merrill writes: "I found one old lungan tree in Manila, though never producing fruits. It might have been 40 or 50 years old."

Here we are taking the position that the wild lychee of the Philippines and the cultivated lychee of South China are very distinct species of the genus Litchi, readily separated taxonomically from other members of the subfamily Nephelieae of the family Sapindaceae. The one insular and the other continental seems to indicate that they are quite detached in their origins. In their absence of petals, and particularly because of their slight adaptability in distribution, both bear documentary evidence of ecotypic genesis. It is possible that both developed along parallel lines in their distinctive habitats. Altitude in the Philippines and latitude in China produced the cooling influences of climate, as the result of which Litchi developed out of some of the warmer loving Nephelieae.

**Latitude, Altitude, and Temperature Factors As They Affect the Culture of the Lychee**

The lychee is distinctly heat-loving, and yet relatively cool winter temperatures, such as it enjoys in its South China home, are necessary to bring the trees into bearing. In warmer, tropical areas the trees flourish in vegetative growth, but they refuse to bear. In areas where winter freezes appear,
the trees are killed to the ground; but unless the ground freezes, the roots remain alive. A large, well established tree makes remarkable recovery of new growth after a freeze, and a few years thereafter it will bear again.

The heat-loving nature of the lychee is not surprising when one considers the Malayan origin of its ancestry. In vegetative growth the trees respond vigorously to the high summer temperatures, and to the high humidity of the rain forest regions. But on its more northern range the lychee, after the trees are once established, becomes most happily adjusted to the drier grasslands of the hills, when these have been plowed and cultivated by man. With a dense covering of foliage the year around, the trees send forth from their tip growth, at any season, one flush of delicate pink to yellow green leaves after another. On the far northern range this tendency to flush is hazardous, much young growth being thus blasted by cold weather. As Dr. Walter T. Swingle (6) very early pointed out, this lack of winter dormancy and low zero point of growth of the lychee are limiting factors to its growth here in Florida, unless some measure of protection is afforded by fires or slat houses. Any temperatures below 32 degrees F. may blast the young tip growth. To be successful with the lychee we therefore must assure it long hot summers, relatively high temperatures, and yet drops in temperature below 40 degrees F. periodically in order to stimulate the trees in flowering and fruiting.

Thus the first requirement of the lychee is moist heat in summer; and the second is cool, non-freezing winters, preferably those on the dry side. Periodic cold snaps in winter, namely between 30 and 40 degrees F. seem to give the lychee the physiological changes necessary for fruit bearing. Where winter temperatures never go below 50 degrees F., the area is not conducive to fruit bearing of lychee. It has long been noted that while the lychee may make beautiful vegetative growth where winter temperatures are most pleasing to humans, the trees seldom bear. This has been true in the Philippines, and in Guatemala at lower altitude levels. Many areas in Hawaii and Cuba are handicapped by too moderate winter temperatures to make lychee culture a commercial success.

The question is often asked as to what is the lower limit of temperature for the lychee. The inability of the lychee to withstand snowfall is recorded in many early Chinese writings. In travelling throughout the hills of South China one notes a very distinct line of demarkation where lychee trees begin to disappear from the landscape. Inhabitants in these areas invariably tell one, when he has come to this line, that light snowfall is not uncommon in winter. Careful observations made in China reveal large lychee trees killed to the ground at 24 degrees F. In Saharanpur, India, lychee trees have been recorded as enduring a freeze of 21 degrees F., with loss of only a few leaves. In Florida some early records (1888 and 1890) at Oviedo indicated that a temperature of 27 degrees F., cut back a lychee tree but little, while 21 degrees F., killed it to the ground. At Lake Wales 21 and 24 degrees F., severely winter killed the branches. At Estero, below Fort Myers, an unusually cold night, said to be approximately 18 degrees F., killed lychee trees to within one foot of the ground. Various records of 28 degrees F., record the lychee as unaffected except possibly a little tip burn. One should be prepared to fire a lychee grove when the temperature drops to the freezing point.

Considering Canton, China, as an ideal area for lychee culture, a table of summary figures of Canton temperatures taken over a seven year period, as published in 'The Lychee and Lungan,' (3) will be of interest compared with similar mean temperatures of places in Florida, as published by Mitchell and Ensign (4). In the table the Florida localities were chosen with a view to possible lychee range within the
state when fire protection is afforded against freezing temperatures.

March and April are the usual months when the lychee flowers in both South China and Florida. April to July are the months when the fruits are developing and in possible lychee areas in Florida than at Canton, these areas are nevertheless much more subjected to periodic winter freezes. In the Canton Delta the temperature drops below 32 degrees F. rarely indeed. Temperatures in the low thirties, while hazardous, will stimulate the trees to fruiting. Although costly, protection with fires is essential almost anywhere in Florida. But the prospective lychee grower will no doubt do well to choose midway positions, such as in the vicinity of Venice, Avon Park, and Palm Beach, where he will not need to fire as frequently as farther north. Mitchell and Ensign (4) state the date of first and last killing frosts for each respective locality, from which we summarize frost free years as shown in table on next page. Temperatures being largely influenced by both latitude and altitude, let us note the relation of these to lychee culture.

Along the China coast to the Tropic of Cancer, latitude 23½, cuts across the lower end of Formosa (Taiwan), and enters the mainland at about Swatow. Canton is about a half degree south of this line, and Foo-

TABLE OF MEAN MINIMUM AND MAXIMUM TEMPERATURES

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heat and moisture are so essential. These months are therefore the ones to carefully compare localities as to total heat units. The mean minimum spring and summer temperatures of above places in Florida are generally higher. St. Augustine is the only place on the table where mean minimum temperatures are lower than Canton. Vero Beach would have been a better point to have chosen for the East Coast had readings of temperatures there been recorded by Mitchell and Ensign.

Maximum winter temperatures are generally higher at the places under study in Florida than at Canton, China. There may therefore be a greater tendency of the lychee to winter flush in Florida. Winter freezes are the chief limiting factor to the long life of lychee trees. While minimum winter temperatures are generally higher
chow about 2½ degrees north. The lychee flourishes on a large commercial scale in various places within the Canton Delta, is never protected by fires, and very rarely shows any effects of freezing weather. Henghwa district, in Fukien province north of Kwangtung, is the only other famous lychee producing area in China. This area, west of Foochow, is largely in the hills. Here the lychee periodically suffers severe freezes. This is the famous lychee center from which Florida's variety 'Brewster' was introduced. The island of Hainan, off the southeast coast of Kwangtung, is in latitude 18 to 20 degrees. In Hainan island, especially in the hills, some very fine lychees are found. Southward, in Indo-China and Siam, lychees are rarely grown. North of Fukien in China they are never found. Havana, Cuba, is in the latitude of Canton, but Canton has much colder winters. The Sarasota-Sebring-Palm Beach line in Florida is the most desirable one to keep in mind for maximum success with the lychee within the area of the United States. This line is about 4 degrees north of the Canton and Havana line, approximately in the latitude of Henghwa, Fukien. This may account for the fact that Brewster's Henghua lychee has grown so well in Florida.

The effect of altitude upon the lychee is to extend its range within the warmer latitudinal belt, and to restrict it in the cooler. Most of the hill country of the southern provinces of China has too low winter temperatures for successful lychee culture. The lychee, however, succeeds tolerably well in protected places in Szechuan, and in southern Kwangsi. Yunnan province is generally too high. Taken as a whole, the lychee seems to have succeeded at higher altitudes in other lands than in China. For example, H. F. Macmillan's 'Tropical Gardening and Planting', 1935 edition, records: "It thrives up to 3,000 feet, giving two crops a year, in May and December." The lychee is also reported from high altitudes in Java. I believe Hawaii and Cuba will attain greater success with the lychee when culture in the hills rather than along the coast is attempted.

It should be noted especially, from this discussion of temperatures favorable to the lychee, that one of the great advantages to its culture here in Florida is the fact that here are found the low winter temperatures the lychee demands for flowering and fruiting. With the experiences in firing citrus which most Florida growers possess, there should be no great difficulty to work out technique for the protection of lychee trees in orchard formation. Careful observations in Florida have revealed that Brewster lychee is more cold resistant than most mango and avocado varieties.

Rainfall, Humidity, Irrigation and Drainage as Factors in Lychee Culture

The lychee, doubtless, also has acquired its moisture loving nature from its ancestors in the tropical rain forests of Malaya. Ample supplies of water are highly necessary for the satisfactory growth of lychee; and the higher humidity the more flourishing is the appearance of the foliage. In China lychee trees are not often irrigated, as rainfall is adequate. Drainage for the lychee, as we shall see, is not a serious consideration.

In the native home areas of the lychee, though rainfall is present practically every month of the year, there is, nevertheless, a
distinct wet and dry season. Fortunately the months of April, May, and June, the season when the trees are developing their fruits, are months of fair rainfall. Spring rains are not nearly so delayed along the coast of China as they are inland in Kwangtung and Kwangsi, and as they are in so many sections of Florida. The hottest months in South China, as in Florida, are July, August, and September. These are the best growing months for the lychee, and the higher the rainfall and humidity at this time the better will the trees grow. October to March are comparatively dry months. During this season the grower, especially if he is in a locality where temperatures are likely to be low, desires to winter hard on his trees to as great dormancy as is possible. Accordingly he keeps his trees in as dry a state as possible.

Some idea of the comparative rainfall of the Canton, China, and Florida lychee areas is revealed in the following table, compiled from 'The Lychee and Lungan' (3), and from Mitchell and Ensign (4).

As to rainfall, the most striking difference between Canton and Florida localities is in precipitation from March to June, the time when lychee trees need a great amount of moisture. In Florida the Homestead area has the highest annual rainfall as also the highest precipitation during the spring months.

In active growth the lychee thrives in a high humidity atmosphere. The appearance of flush and mature foliage changes materially as the moisture in the air increases. Canton summers are noted for their high humidity which is never below 80 and frequently above 90, both night and day. The summer weather in Florida is also very humid, but in the hot sunlight and drier sandy soils the humidity tends to drop more quickly than at Canton. In addition to the well being of a rapidly growing lychee tree, humidity is important also in lychee propagation, and in preventing the leathery skin of the fruits from bursting open, thus ex-

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posing the fleshy aril to insect attack and disease.

A very large percentage of lychee propagation is by the method known as Chinese air-layering or marcottage. This method of multiplying plants is hazardous unless the atmosphere is moisture laden. April to August are months of high humidity at Canton. It is during these months that the layering operation upon the lychee is usually carried out. In growing seedlings one should germinate the seed as quickly as possible after removing from the fruits, and thereafter maintain the seedlings under as high atmospheric humidity conditions as possible.

Lychee trees fruiting in very moist atmosphere do not split open the fruits. The high humidity of Florida summers thus assures great advantage in lychee production here. California is not so fortunate. It has been noted frequently in California, in proximity to the desert areas, that fruiting lychee trees bear fruits that tend to dehisce. This is due to the hot, dry air sweeping in from the desert, and is a great detriment to lychee production. This bursting of fruits is inherent within the family. In fact botanists differentiate the genera within the lychee and rambutan groups from a third which they call the Titoki group upon a basis of ‘fruits indehiscent’ in the two former, and ‘fruits dehiscent’ in the latter. The Titoki tree and its relatives, including in all 5 genera and about 28 species, is Australian and vicinity in origin and distribution. There are no representatives on the Asiatic mainland. The desert-influenced habitats have doubtless led to dehiscent fruits. And the lychee, under similar conditions, seems to reveal a trend toward this method of seed dispersal.

When rainfall is not ample for the lychee, irrigation becomes necessary. On higher ground, of moderate slope, the furrow system is ideal for irrigation of lychee trees in orchard formation. On uplands, with proper planting and culture, lychee trees develop deeper root systems than in lowland culture where the water table is relatively high. If the soil is periodically soaked in its subsurface layers it is much better for the trees than more frequent surface applications. In California I have noted lychee trees, near flowing wells, seriously retarded in growth by the continual trickle of water around the trees, without reference to season or the condition of the trees.

The nature of the irrigation water here in Florida seems to be something of a problem. On the lower east coast the high lime content of the water has been reported as unfavorable to nursery plants continually watered thereby. But in calcareous pockets of rocks, filled in with ample layers of muck or humus soil, and with good rainfall most of the year, the application of these lime waters in periods of drought seems quite satisfactory. The high sulphur content of the waters of some of the shallow wells along the west coast apparently has no ill effect upon the lychee. Such waters may possibly be beneficial. The lychee will not grow well when subjected to any considerable quantity of salt sea water. Lychee trees along the dykes of the Canton delta, during the dry, winter months, are subjected to a slight content of salt, the tides at that time carrying farther inland the salty sea waters to be mingled with the outflowing river water. Nearer the sea, where year-round salt waters are present, the lychee disappears.

Lychee trees endure relatively high ground-water levels, but this does not mean that they make their maximum growth under such conditions. Reference to my pictures reveals how much larger and more vigorously the trees in China grow on high ground than on low. Trees planted along the dykes of the Canton delta are subjected in flood season to submersion of the root systems for ten days to two weeks without serious injury. But in appearance such trees seem dwarfed when compared to those grown on higher, better drained soils.

The lychee, therefore, under ideal cultural conditions, should have ample, seasonable rainfall, and high humidity atmosphere, sup-
implemented in periods of drought by irri-
gation. Drainage, though not absolutely neces-
sary, is beneficial.

Wind and Its Effect Upon the Lychee

The trunk and root system of a lychee are built to withstand the high intensity, typhoon storms blowing across southeast China from the tropics. These, fortunately, usually appear in summer after the lychee crops have been harvested. If earlier, they may cause serious loss by whipping the fruits from the trees. But trees are sturdy that will withstand winds of from 75 to 100 miles per hour, sometimes even higher; and I have often noted, after one of these two or three day storms, that while many other species of trees have been blown down, or torn by the winds, the lychee has suffered little damage. Trees of great age show some tendency to butressing, thus revealing their protective nature against winds.

Florida, with the so-called Caribbean hur-
ricanes, is subjected to the same type of
storm as those Oriental typhoons. Fortun-
ately, these usually appear, as in China, after the middle of July, at which time all lychee fruits have been harvested. However, the soils of Florida are generally much lighter in character than are the more compact soils of lychee areas in China. Both here, and to a lesser extent in China, when trees are young, or newly transplanted, they may be uprooted by a strong gale. Colonel Grove, at Laurel, is admirably overcoming this by anchoring with wire braces from three sides all newly planted trees.

Winds in South China have a more marked seasonal shift than they seem to have in Florida; but the day and night direction of the winds is not so marked as it is here. In China, in addition to the typhoon winds of summer, the countryside is yearly sub-
jected to the steadily blowing, cold, monsoon winds of winter, coming in from the land areas to the north. Dust from the Gobi des-
ert is sometimes carried in with these winds even to the areas in the far south. A lychee grower in China desires to shelter his trees as much as possible from these northern

winds. He therefore plants them on the south side of a hill, or he provides protec-
tion for them by other trees. On the other hand lychee trees planted along the dykes of the Pearl River are terribly blasted by these winds, and yet they carry heavy crops of fruit. But you will note from my pictures of such plantings that the trees are not only dwarfed, but that they are also not nearly so dense in branches and foliage as are the larger, inland, protected trees.

In Florida greater wind damage, I believe, is occasioned by the earlier spring winds blowing across strips of sandy soils. These winds carry with them sand grains, the abrasive force of which terribly blasts the foliage. This, no doubt, accounts for a very large percentage of the tip burn in leaves which in years past has been a sub-
ject of concern here. Lychee orchards in Florida will doubtless bring the best results when planted in blocks, surrounding which are Casuarina or Melaleuca windbreaks on four sides, as one often sees with other plantings on the Everglades or in the Red-
lands. Lychee trees suffer from winds more when young and newly planted. When large, and in orchard formation, they protect one another.

Light Intensity and Lychee Culture

Light intensity is a factor to be con-
sidered in lychee culture though we have little data upon which to base an opinion. Young lychee trees especially show unfavor-
able reaction to intense sunshine and light. Here again they reveal their natural forest origin. Seedlings for the first year or two should not be subjected to the full glare of the sun, as are those of Citrus species in nursery rows, for example. At Canton we always germinate our lychee seeds, for seedling stocks in inarching, under the full shade of mature lychee trees. The beds remain there a full year or more before the young plants are transplanted into a semi-sunny position. The same is true with regard to newly established layers. These should remain in slat houses, or in some shady position under trees, until they are
hardened off and set out in field plantings. Although I have been resident in Florida for a very short time, one of the outstanding noticeable differences of climate in South Florida, as compared with that of South China, is the sunshine factor and light reflection. I note, for example, in my photography that the exposure meter registers considerably higher readings here than at Canton. Moreover, in the Canton-Hongkong area, in early spring, there will be frequently a month or more of cold, cloudy weather, when one may not see the sun for a month or six weeks. From that which I am told no such condition exists in Florida.

The sunlight of the summer, autumn, and early winter months in Florida and South China seem quite similar. Although the glare upon the eyes seems greater here, one seems able to bear sunlight better without the traditional helmet of the Asiatic tropics. Early residents of the Far East claimed that there was something peculiar in the actinic rays of the sunlight which residents of these days more or less ignore. But last year I was much impressed in Sarasota County with the favorable reaction of young lychee trees to overhead, cheesecloth protection. And Colonel Grove has some two to four year old lychee trees interplanted with Rangpur lime. The lychee seems most happy under the semi-shade protection of the larger limes; but trimming and gradual elimination of the latter requires continual attention.

In setting out a large lychee orchard I have wondered if it might be practicable to use Albizia or Erythrina trees, alternated with one or two rows of lychee, to render some shade to the latter until they become well established. This is a practice we noted in Siam in connection with the culture of the famous Siam pummelo. The growers near Bangkok, largely Chinese, claimed advantages from this practice not only from the shade provided by the faster growing legumes, but also in soil improvement as a result of the addition of humus and plant food resulting from the fall of leaves and seed pods.

Soils and Edaphic Relationships in Lychee Culture

The climatic factors, edaphic factors, and biotic factors are those usually considered in fruit ecology. Edaphic relationships deal largely with the more local influences, especially those of soil in their chemical composition and physical nature. Tillage and fertilizing of course influence soils greatly.

The lychee is an infinitely more plastic plant in its relation to soils than to climate. With this fact I have been particularly impressed since coming to Florida. In comparing the basic soils of Florida with those of South China, one notes especially the high sand content of many of the soils of this state, and the high muck or humus content of others. The lychee, when properly fertilized, when provided wind protection, and given ample water supply, seems to grow well in both of these groups, but preferably in soils with relatively high humus content.

In South China soils favorable to lychee are either the alluvial deposits of streams, as in the Canton Delta, or they are the laterite soils of the hills. Neither of these drain very well, but in both the lychee thrives well under good cultivation.

A study of climatic factors and related vegetation in the tropics shows that the so-called 'laterites' correlate in their distribution with regions of high temperature and very heavy rainfall. Herein, the lychee and its relatives have spread admirably. These laterite soils are characterized by their high content of hydrated oxides of iron and aluminum. They are almost completely deficient in alumino-silicates, the silica other than quartz having been entirely leached away. Thus the decomposition products of the primary minerals of these soils have been determined largely by the climate. The characteristic red colored, acid soils of many of the upper slopes of the Southeast Asia mainland are predominately these laterites. They drain poorly, and bake
and crack when puddled and dried, but the lychee grows admirably in them under the right cultural methods.

South China has very little muck soil, such as Florida enjoys in so many places, but the lychee seems to thrive in highly organic soils and when fed with organic fertilizers. Chinese gardeners overcome humus deficiency in their soils primarily by means of intense applications of liquid fertilizers, chiefly night soil and urine, other animal wastes, peanut and soybean cake, and guano when obtainable. They practice very little composting or mulching, except in restricted localities where grasslands are uprooted or burned off to mix with sea mud, algae, and miscellaneous wastes for compost. Green manures are grown in some localities. Cultivation and ground cover in the lychee orchards, especially on the hills, is given careful attention.

We have much to learn regarding the application of commercial fertilizers to lychees, and Florida is an admirable place in which to study it. The high humus soils of Florida, while providing nitrogen for vegetative growth, may lack phosphates and potash and essential minerals to bring the trees to successful fruiting. On the Everglades, for example, there are lychee trees of considerable age and beauty which never have borne fruits. This condition can scarcely be climatic, as winter temperatures in this locality are as low, or lower than, elsewhere. The poorly drained soils, occurring especially along the East and West Coasts of Florida, and commonly referred to as 'low', 'palmetto', and 'grassy' flatwoods, can doubtless be adapted to lychee culture as they have been to citrus. But the subsoil and underdrainage of these soils is not so advantageous for long-lived trees with good root systems, in my opinion, as are some of the better drained soils, as for example the Norfolk series.

With the very old and large hill-type lychee trees of the laterite soils of South China in mind, these Norfolk soils of the lower Ridge area of Florida have long intrigued me. For a summary regarding these I quote Dr. Peech (5): "Norfolk Soils represent the well-drained, undulating to rolling 'high pinelands' and 'blackjack oaksland'. They are characterized by about 4 to 6 inches of yellowish-gray or dark-gray sand underlain by a yellow sand which passes into compact sandy clay beds at varying depths below the surface. These soils grade from a coarse sand (Norfolk sand) containing very little organic matter, commonly called 'blackjack oaksland' to a much finer sand (Norfolk fine sand), the surface layer of which is gray to dark-gray, usually having a higher content of organic matter and frequently referred to as 'High pineland'. Some of the better Norfolk soils (Norfolk fine sand, hammock phase) have a hammock or predominantly hardwood growth. The Norfolk soils are the most extensive soils planted to citrus in the State."

From Lake Wales to DeSoto City, where I understand these Norfolk soils predominate, the lychee seems most happy. Mr. E. L. Wirt's trees near Babson Park are in lower soils of higher humus content than these Norfolk soils. But Mr. Vissering has had some trees on a slope in the same vicinity which have made admirable growth with very little attention. The two lychee trees along the roadside, near the gateway to Mountain Lake grounds, reveal how well lychee trees grow on relatively cold, light, and wind exposed hillsides when they become established. These trees have had little fire protection, were subjected to freezing temperatures once or twice, but always came back admirably. And no lychee enthusiast should fail to see the old and very well established 'Fukien Brewster' lychee at DeSoto City, a dooryard tree on the place of Mr. C. R. Tyson. This tree has been bearing hundreds of pounds of fruit nearly every year for some time. It now begins to reveal the full nature of a high quality lychee under hill culture when it has attained middle age. I believe it has scores of years of fruitful life ahead of it, pro-
vided no accident befalls it. I have seen lychee trees in China on the hills which, I was told, were more than a hundred years old, and the girth of which I could not span with outstretched arms.

It would thus seem that varied localities and soils in Florida offer promise for lychee culture. But in planting and cultivating it is important to differentiate between lowland and hill lychee culture. And I am of the opinion that wherever subsoil deposits of the sandy-clay beds, approaching the Norfolk series, appear it is there that lychee root systems will finally establish themselves under a most happy subsoil and drainage condition, and will produce really fine trees of great age and fruitfulness. Correct fertilizer practice is of utmost importance. We are having some difficulties with so-called 'multiple buds' and 'tip burn', both of which are possibly some nutritional deficiencies. Regarding these there is still much to learn.

**Birds, Bats, and Rodents as Lychee Pests**

Ts'ai Hsiang, in his Li Chih Pu, as early as 1059 A.D., wrote of some of the problems associated with the ripening season of lychee which Florida growers have already encountered. He relates:

“When the ripening season comes all fruits should be picked from the tree; then neither insects nor birds will dare to come near. If the fruit is only partially gathered from the tree, it will become infested with bats, bees, and grubs, the latter eating into the tree. In order to drive off these pests the orchardist or gardener places four posts around the tree and on top of these he builds a small house. During the night someone dwells in this place in order to startle these various pests when they come to plunder or destroy the fruit. Another method is to gather some bamboo reeds which are from five to seven feet long, and sway them continually back and forth. This latter method is to drive off pests like the bats.”

I do not know whether you will wish to follow these methods of bird, bat, and rodent control, but vigilance is as important here as in China. Bats are particularly troublesome in China. Large nets are often thrown over a highly prized tree to protect the fruits. Plate XVI of my work 'The Lychee and Lungan' (3) shows photographs of a stockade, bamboo fence, and net for the protection of the ripening lychees not only from birds and rodents, but also from all animal life, including man. In China no effort is too much trouble to attain the full benefit of a beautiful fruiting lychee tree. Thus far in Florida squirrels and rats have seemed particularly troublesome.

**Insect Pests of Lychee and Beneficial Pollinators**

Of beneficial insects the most outstanding group are the bees which work industriously upon the flowers in spring. Where lychee trees are plentiful they gather immense stores of very high quality lychee honey. In China I have seen very large honey industries established in lychee orchards. Many species of flies and other insects hover about the flowering panicles of lychee during early morning hours. They doubtless also aid in pollination. I have noted all these insects at work in Florida as well as in China.

Through the scientific observations and rearing projects of our entomologists in China we now know considerable regarding a number of very serious lychee insects. Chinese writers of the old school very rarely referred to insect enemies and diseases of lychee. Their category of enemies usually consists of negligent husbandmen, frost and snow, unfavorable winds, salt water, bats, and one insect which anyone acquainted with lychee in China will recognize at once by both sight and smell.

The most widespread and destructive species of insect attacking lychee in China as a highly decorated Pentatomidae, Tesseratoma papillosa. This is a highly colored 'stink bug' with the brilliant red markings of a ripe lychee fruit. This species, with a number of generations each year and wintering in the adult form amidst lychee foliage, lives entirely upon lychees and is a
limiting factor in production. The industry has completely failed in many regions because of lack of cooperative control by the villagers within a community where lychees and this insect pest are found. The entomologists of Lingnan University have carried out considerable work with it, and their findings are published in the pages of the Lingnan Science Journal.

This Chinese species, living especially upon lychee, has never appeared in Hawaii, or upon the American mainland. Our quarantine upon entering lychee plants is fully justified upon a basis of this one devastating insect alone. I have been somewhat concerned to hear one lychee grower in Florida remark that he had noted some common melon ‘stink bugs’ giving attention to lychee and this summer I have also noted the same. If not on our guard, we may in time develop a Florida species of this most formidable lychee pest.

Growers of upland lychee in China are also troubled with several species of Scarabaeidae related to our so-called ‘June bugs.’ In South China hundreds of acres of gravel lands are in close proximity to lychee orchards. The sod of these lands provides an ideal home for the larvae of these insects which emerge in spring and attack the leaves and flower buds of many species including lychee.

In South China there is also a lychee ‘leaf-gall’ species of Eriophyes which injuriously affects the foliage. The visible symptom is a thickened, wrinkled leaf. The affected portions consist of brown, hairy, velvet-like spots in which the galls are embedded. Unfortunately the insects which produce these galls have already found their way into the Hawaiian Islands where within a few years they became a serious pest upon the lychee.

Cerambycidae and other tree borers are serious in trunk and branches of lychee in China. Their work is readily manifest by the debris left upon the bank. The Chinese sometimes make ‘hisser’ firecrackers which they hold at the entrance of the holes, thereby burning or suffocating these insects when they are in the larval stage. More often they use long wires with which to pierce their bodies in the tree holes.

The larvae of various fruit insects are sometimes found within the fruits and flower stems of lychee. Scale insects may also attack the lychee. Neither of these have been considered very serious within the Canton area. In Hawaii the lychee is generally grouped with the banana and pineapple with respect to immunity to the Mediterranean fruit fly.

Fortunately not any of these injurious insects, or any others, have seriously troubled the lychee in Florida. The tough leathery foliage of the lychee is usually clean, and no spraying program whatsoever has thus far been recommended.

**Plant Pests of Lychee**

In China lichens are very common on the trunks of lychee trees. A number of unidentified species of algae also appear on trunk, branches, and leaves. Minor, superficial fungi can be found on leaves, but no lychee diseases have been reported. The thick, tough, glossy nature of the leaves makes their susceptibility to fungi very slight indeed. Whatever of these organisms may appear on the trees are associated with the subtropical habitat in which the lychee is found and they have slight apparent ill effects upon the trees.

**The Influence of Man Upon the Lychee thru Selection and Cultural Methods**

We now come to the highest, culminating influence of all the ecological factors affecting the development of the lychee. Man plays a very important part in the ecology of fruit production. It is he who studies the natural environments of various fruit species, and alters and extends their range by selection and culture. Man has done this with the lychee.

We have referred only indirectly to seed dispersal in lychee. The most outstanding feature herein is the short period of viability of the seeds. Many a traveller to the Far East has attempted to extend lychee
distribution by tucking away in his pocket a few seeds from some delicious fruits he has eaten. Alas! he is doomed to failure. The seeds are viable for but a few days. They must be germinated promptly under high heat and moisture conditions. Propagation by cuttings, buds, and grafts is accomplished quite rarely, the difficulties being far greater than with many other fruit species, but layered branches root easily. When layers are well established and carefully packed for transport, as in Wardian cases, they can be carried over a long distance. Air transport of course makes a vast difference these days or will after the war.

We have seen that the early origin of lychee ancestry is Malayan, Litchi chinensis is a native to China in somewhat the same respect as is the Sweet Orange. Both are known in cultivation but not in the wild. I have noted an herbarium specimen of Litchi chinensis collected in forest habitat, far removed from the habitation of man. We have collected in the East River Country of Tsangsheng district, Kwangtung China, many so-called 'Hill' or 'Mountain' lychee (Shan chih) in a semiwild state within forests not distantly removed from Chinese villages. These no doubt represent seedlings and are escapes from cultivation rather than indigenous in nature. Whence these, and others like them, came we may never know. The origin of the species Litchi chinensis may long be clouded in mystery, but that man has had a large part in extending its range so far north seems indisputable.

The fruits of these 'Mountain' lychees, when secured from trees growing in this wild and semi-wild state, are somewhat sour, large-seeded forms, vigorous in both germination and habit of growth. Large, mature trees, in these semi-forest habitats, are sometimes taken over by Chinese cultivators, grafted by them to commercial varieties with immature seeds, such as the 'Homa'; and thereafter fertilized and cultivated. They prove very profitable. Seedlings of some of these semi-wild forms have been grown in our lychee orchards at Lingan University, from which seeds were introduced into this country for stock purposes. Such seedlings under cultivation bear sweeter, more fleshy fruits than are the fruits of those in the wild. From these seedlings some highly desirable commercial varieties in due time may be selected. For example in the Royal Palm Nursery, Oneco, Florida, two of these Kwangtung seedling 'Mountain' lychee trees are growing immediately adjacent to Fukien 'Brewster.' As the result of possible cross pollination seedlings produced from the seed of these trees may upon maturity result in some very desirable new varieties much better adapted to Florida's climate and soil than are the standard varieties from China.

I believe the Chinese deserve full credit for the development of the lychee to the stage in which today we find it. Chinese gardeners and farmers, without science but nevertheless for centuries practicing practically all of the arts of fruit cultivation known to the western world, are sufficiently experienced to have brought the lychee to its present advanced stage of perfection. However, with regard to the origin of this fine fruit which we now speak of as Chinese, we must be realistic, and give credit to whom credit is due for finding and isolating the species from other plants in the wild and for introducing it into cultivation.

When the Chinese sage, Confucius, compiled the classics about 500 B.C., the Chinese dominion did not extend far south of the Yangtsz river. The country in which lychee, apparently not then known to the Chinese existed bordered Annam and to the Chinese was known as Nan Yuch. It was not conquered until the Han Dynasty period, B.C. 206-A.D. 25. At that time the Capital of China was established at Chang-an near the present Sianfu in Shensi province. The illustrious reign of Emperor Wu Ti, 140-86 B.C., in Chinese history is celebrated for its military conquests. It was
at that time the large area to the south, now comprising the present-day province of Kwangtung, including Hainan Island, as also Tonquin (a part of French Indo-China) farther south, and Kwangsi and Kweichow provinces to the northwest came into Chinese hands. Kwangtung, the present center of lychee distribution, was inhabited at that time by a race akin to the Annamese. The Chinese settlers from the north into this southern climate must have been greatly impressed with the tropical plants there, reporting thereof in glowing terms to the northern court, for Emperor Wu Ti built at Changan a garden or arboretum for the culture of some of the newly introduced plants from the southland. The palace or temple of this garden was known as ‘Fu-li-kung’ meaning ‘the temple to uphold the lychee.’ Thus we have some estimate of the high esteem with which the Chinese regarded the lychee even before the time of Christ. The historical records of Wu Ti’s interest in lychee further relate that ‘a hundred or more’ lychee trees were planted in this garden, not one of which grew. The Emporers repeated his lychee introductions several times, and finally one tree is said to have grown and flourished. Wu Ti greatly loved this tree but after a short period it also died. The story concludes with the tragic statement that ‘several tens’ of husbandmen were accused of having neglected it and were killed.

There is further some slight attempt by one Chinese writer to trace the lychee under a different name, as far back as 1766 B. C. It is evident that the inhabitants of Malayan descent and the aborigines living in the hills of the country, which the Chinese in their earlier history called ‘Nan Yueh’ and ‘Ling-nan’ — meaning ‘South of the Range’, knew and loved the lychee for centuries prior to the time of Christ.

The Chinese in turn when they entered this country doubtless improved varieties and cultural methods. And may we of the West, who so recently have received the species from China, make some further advance in lychee culture thru our knowledge of science and experimental approach! Some benefits to the Chinese may thus in turn accrue from their gift to the western world of Litchi chinensis, even as they are now beginning to benefit from our possession for so many centuries of Citrus sinensis, the Sweet Orange.

We shall not deal in detail with the methods of lychee culture practiced by the Chinese. One feature which we should briefly mention is the intensive, raised-bed system of fruit culture carried out within the Canton Delta area. This system of digging ditches and building up beds over low-lying, flat areas, providing numerous canals for irrigation and drainage, is one that might lend itself for fruit culture within the Everglades country of Florida. Upon these beds in China are found not only lychee trees, but interplantings of many other fruit species in association with the lychee. These include oranges, pummelos, wampis (Clusia spp.), Chinese white- and black-olives (Canarium spp.), carambolas, sugar-apples, and guava. Various species of Prunus, including the peach, are also sometimes found on the higher dykes.

The terraced hillsides, or ladder system of cultivation, is sometimes developed on steep, sloping hillsides of the more interior areas of southern China. Soil erosion is thus prevented. And here the culture of the lychee is found in association with that of lungan (Euphoria sp.) Chinese-olives, persimmons, Oriental-apricots (Prunus mume) of numerous varieties, and chestnuts (Castanea spp.).

The Chinese have been masters in fruit selection, but they have not practiced breeding. In fact we of the West have not made much progress in fruit breeding. But modern science has much to contribute to Chinese fruit production. Many of the fruits we have received from the Chinese can be improved by us by breeding and selection, and then the new forms returned to China. It is both our responsibility and opportunity to do so.
The contributions western horticulturists will make to future lychee development remains to be seen. Certainly in the botany of the lychee western botanists have contributed greatly. In propagation some slight contributions have been made. In extending the range of the lychee into other lands western workers have had some measure of success. In the knowledge of lychee insects and their control trained entomologists have contributed. And there have been interesting findings in some symbolic relationships of the lychee, particularly the late Dr. F. V. Coville’s observations of mycorhizal fungi upon the roots.

Conclusion
The lychee is an excellent illustration of the hazards involved in plant introduction. For success in this field we need to supplement our taxonomic knowledge of plants with that to be secured by world surveys in the field of ecology. Of the origin of the lychee little is known, except in its distant relationships. The species, Litchi chinensis, has never been found in the wild. It is very closely related to the numerous species of Nephelium, the center of distribution of which is in Malaya. Considerable information is now available concerning the habitat of the lychee, and of the climatic, edaphic, and biotic factors associated with its distribution and culture. Plant geneticists have indicated the generic changes that may take place thru extended transplant. There seems visible influence of latitude and temperature in the final isolation of Litchi from species of Nephelium. As forms of the Nephelium-Litchi group moved northward into southern China, either thru natural distribution or in the hands of man, changes in flower and fruit characters appeared. The lychee grows but does not fruit successfully within its more southern range. Freezing temperatures mark the northern limit of its range, but the finest quality fruit is produced where winter temperatures are relatively low, as in Florida. Litchi is not strictly monotypic in that Litchi Philippinensis has been described from the Philippines as well as Litchi chinensis from China. An ecotype is usually monotypic but we believe the lychee deserves the distinction of being one of the few cultivated fruits in the world that is in major respects an ecotype. Mankind, particularly the Chinese, has played an important part in adapting the species to climate and to his needs.

What tragedies have swept across the beautifully landscaped countryside of China since the invasion of that great land in 1937! What disasters have accompanied the social and economic disruption occasioned thereby! How disheartening to have seen huge loads of lychee firewood entering Canton city after the war had come upon China! May the lychee ever remain a tree of beauty upon the landscape of southern China! And may it appear more and more upon the landscape of Florida! May our war-time obligations to China soon be succeeded by a peace-time, golden opportunity in greater American-Chinese reciprocity in the field of plant exchange!

Literature Cited