I. INTRODUCTION

The genus *Garinia* Linn. belongs to the family Guttiferae (plantae guttiferae or latex bearing plants) popularly known as mangosteen family. This has also been described as *Garinia* family (Lawrence 1967). Exclusively tropical or intertropical in distribution, 35 genera and 800 species are grouped in the family. According to Lorus and Margery Milne (1967), among the species included in the family because they show similarity in floral details, there is more variety that can be anticipated. Beauty leaf *Calophyllum inophyllum* L. is favourite among tropical sea shore trees for its nearly six inch glossy ever green foliage with blunt or notched tips. Mangosteen (*Garinia mangostana* Linn.) a small tree of 35 ft. and native of East Indies has gained its reputation from its delicious fruits. It is most well known among the species in the family. Inside the purple rind that maintains firmly the spherical or pear like shape are several segments of snow-white flesh, which are juicy, faintly acid and so delicate that shipment of fruit to distant markets is impracticable. Most probably the familiarity gained by mangosteen made Guttiferae known as the mangosteen family.

Among other genera, Ceylon iron wood (*Megua ferrea* L.), a sacred tree among Buddhists of India and Malaya, has been
planted outside most of Buddhist temples or to grace avenues in East Indies as far as Java. Its waxy leaves shimmer with reflected light underneath and so are its fragrant flowers collected to stuff in pillows for bridal beds. Traditionally, one of the five arrows of Indian cupid God 'Kamad́́va' is made of Ceylon iron wood, or at least tipped with it. In the rain forests of the new world tropics, many of the two hundred species of *Clusia* begin life as seedlings among Orchids and Bromelaiads on high limbs of giant trees. Gradually, their roots extend down the trunk of the supporting tree and envelop it and are known as "strangler trees" comparable to the strangler figs. *Guttiferae* is also referred to Clusioidea (Warming 1932, Hutchinson 1959). Among the Indian Florist T. Anderson (1874) was responsible for the treatment of the family *Guttiferae* in Hooker's *Flora of British India*.

**Genus - *Garcinia***:

The genus *Garcinia* Linn. was erected by Carl Linne in honour of French Botanist and a traveller, Laurent Garcin (1635-1752) who lived in India and collected plants in the eighteenth century (Maheshwari 1964). Linnean concept of *Garcinia* is in accordance with the presently accepted delimitation. It contains a vast group of 435 species and is native of old world tropics. The species are evergreen glabrous trees or shrubs and distributed
mainly in Tropical Asia, Africa and Polynesia. Being generally at home in the evergreen and semi-evergreen forests with a relatively wild monsoon climate they are usually found in areas below an altitude of 1000 m though some species may occur up to 1030 m. They are monopodial trees, symmetrical and medium sized, the straight trunk tapering to the tops of the conical crown. Branches are ternate, arranged in alternating pairs, arising from trunk at an acute angle and then curve horizontally or sag down. In the forest they are restricted to upper part of the trunk and the dead smags of lower branches persist for a long time as woody knobs. This habit together with the yellow (or white) resinous latex enables one to distinguish Garcinias from other small forest trees with opposite leaves. Wood is moderately hard, closely grained, yellowish white or red grey. Leaves are simple entire coriaceous or submembranous, very rarely stipulate, more or less lanceolate or oblong. Hairs often absent or simple unicellular. Crystals in mesophyll echinate or rarely in simple fascicles. Glands in mesophyll oonaliform rarely ellipsoid or spherical. Cuticle thick like in xerophytic species. Flowers polygamo-dioecious or pseudo-hermaphrodite, the female or pseudo-hermaphrodite flowers always in lesser number, axillary or terminal, solitary or in cymes, fascicled or paniculate, small or medium sized, hypogynous usually heterochlamydeous tetra or pentamerous. Sepals 4,
decussate or 5, imbricate, rarely 2. Petals 4, alternate with sepals, imbricate, seldom 5. Male flowers: stamens indefinite, rarely few (4 in *Garcinia tetrandra*), free or united at the base in one to five bundles or in an entire 4-5 lobed mass, usually surrounding a rudimentary pistil. Anthers various, erect or peltate, dehiscing from longitudinal slits, pores or circumcissile, sessile or on short thick filaments bilocular, rarely tetra- and plurilocular. Rudimentary pistil absent or variously formed. Female flowers: staminodes minute, various, free or united. Ovary superior, bi-to multilocular; ovule solitary, ane- or hemianatropous, erect or lateral; stigma sessile or subsessile, broadly peltate entire, radiately lobed or furrowed, smooth or tuberculate. Flowering is seasonal and nocturnal. They open at sunset and emit a powerful odour. Fruit an indehiscent berry; rind coriaceous; pulp juicy, whitish, enclosing several seeds. They differ in shape, size and colour and afford best means of identifying them relatively as compared to flowers that are dioecious and sometimes monoecious. Seeds appressedly covered with pulp which may be mistaken for the aril, oblong or ovoid. Embryo a solid homogenous mass (tigellus), cotyledons absent or minute.

There appear to be mainly two centres of origin, Malaysia with 225 species and tropical Africa with 115 species. The African species are predominantly endemic.
35 species are indigenous to India and found in southern and eastern India. None of them extend to western Himalayas and very few to north-east Himalayas.

Dioecism of sex makes the identification very difficult at interspecific level. Roxburgh (1832) and King (1890) described occurrence of male flowers as doubtful in *Garcinia mangostana* Linn. Pierre (1882) has examined more than 1500 plants of *Garcinia mangostana* Linn. without finding a single male flower. But he adds several species produce male flowers while young and female flowers at a later stage. Being one of the slowest growing trees known in tropics they are also very slow in coming into bearing. Mostly it might take 10-20 years to bear although in *Garcinia mangostana* Linn, Hume (1947) reports the fruiting may begin in 8 or 9 years after planting. Because of dioecism of sex it is suggested that most of the species of *Garcinia* are apomicts.

Parthenocarpy i.e. production of seedless fruit is also known in mangosteen (Horn 1940, Gustafson 1942). Mangosteen fruits generally contain 1 or 2 'seeds' but fertilization does not take place and growth is from primitive adventitious embryos or hypocotyl tubercles. According to Hume and Cobin (1946) swellings occur on opposite ends of the 'seed' and the shoot comes from one end and the root from the other. The primary root soon aborts and is replaced by adventitious root from hypocotyl after germination.
Need for further study:

The genus is badly in need of revision on a world-basis. Though many of the species are of medicinal and economic value yet much study on the genus is lacking. They provide to the human economy different products: wood, resins, or gamboge and above all fruits. Their slowness in growth and indigenous exploitation of fruits for local consumption has discouraged in attracting the interest of biologists.

Because of difficulty in germination of seeds, for transportation elsewhere, the culture of *Garcinia* has not met with much success. Consequently, less attention is being drawn by technicians for the improvement of quality of products in *Garcinia* although there have been several attempts towards this direction notably in *Garcinia mangostana* (Wester 1926, Poenoe Wilson 1928, Horn 1940), Naik and Rao 1944, Lindsay 1942, Hume and Cobin 1946, Hume 1947, Krishnamurthy and Madhvarao 1962 and Campbell 1966). Tixier (1955) attempted to make some observations relating to the germination of seeds in *Garcinia* species through anatomical studies.

Another reason that is obvious for the lack of study on the genus is due to the difficulty in collecting the material for investigation. Quite a good number of species have been discovered recently (Maheshwari 1964).
Changes in the conditions of forests due to felling and introduction of commercially important trees makes sometimes the identity of those species earlier existing difficult or almost lost. It is also an expeditious task to go in for exploration of the species in thick tropical forests.

The biological and growth aspects of the genus need to be thoroughly studied as the embryological, histological and cytological features of the infra generic taxa are likely to provide characters of great taxonomic importance. The gamboge or 'gummi-gutt' of a number of wild species in the genus merits phytochemical examination, its principle use being in miniature paintings and water-colours. In the present work an attempt has been made on cyto-and chemotaxonomical study of the genus and it may be useful to present these observations in relation to the inter and intraspecific delimitation.

**Taxonomic evaluation:**

Evaluation of taxonomic characters in the genus *Garcinia* is a matter of prime importance. The search for good key characters which can be used for the rapid separation of the species in the genus is needed. The species are often obscure and frequently difficult to classify even when complete material is available.
Frequently, two species will simulate each other in all superficial and gross characters, but an examination of the flowers and mostly fruit will show them belong to quite different sections of the genus. The leaves do provide sometimes diagnostic characters in identification of species, but separation of infra specific taxa is difficult and is usually accompanied by other characters that are to be more relied upon. However, their venation pattern reveals certain differences which are diagnostic. These differences consist in the number and distance of lateral nerves, their inarching near the edge to form an infra marginal nerve, prominent or distant, oblique or horizontal veins etc.

Very recently the review of the whole genus has been given by Engler (1925). Of late accounts on *Garcinia* Linn. have appeared in the "Flora of West Tropical Africa" by Keay (1954) as well as by Spirelet (1966), Demaret (1969) and Bamps (1969, 1970 a,b) in "Flore du Congo Belge et du Ruanda-Brundi" publication of I.N.E.A.C. Brussels which include mostly the species of *Garcinia* distributed in Africa. Contribution towards the study of American and Madagascar species of the genus has been given by Robson (1961) in "Flore Zambesiaca". On the Indian Floristic works accounts on the genus have appeared in various floras notably in Hooker's (1874) "Flora of British India", Cooke's (1903) "Flora of Bombay Presidency" and Gamble's
(1935) "Flora of Presidency of Madras". The latter two cover major portions of work on the species of the genus occurring in South India. Talbot's (1909) "Flora of Bombay Presidency and Sind" and Santapau's (1953) "The flora of Khandala on Western Ghats of India" cover the species distributed in South West India. An account of the genus is given in Vol. IV of the "Wealth of India" edited by Sastri (1956). About 30 species are reported occurring in India that are mostly of economic and medicinal use. The latest review on the genus is by Maheshwari (1964). He reports occurrence of 35 species in India which include the areas covering the islands of Andaman and Nicobar.

Carl Linnaeus (1753, 1754), who has been responsible for erecting the genus *Garcinia* figures one species *Garcinia mangostana* Linn. Choisy (1824, 1851), Roxburgh (1832), Wight (1839, 1840), Planchon and Triana (1861), Lanessan (1872, 1876) and Engler (1888, 1908, 1925) have mostly contributed to the knowledge of the genus. Most notable work on the family Guttiferae is the account of *Garcinia* Linn. by Pierre (1882, 1883) in "Flore Forestière de la Cochinchine". This work describes several species of *Garcinia* Linn. from Cochinchina and Malaysia.
Earlier workers were led to split the Linnean genus into a number of generic taxa due to heterogeneity in the male organisation of the flower namely as Mangosteen Gaertn., Cambogia Linn., Hebradendron R. Grahm., Oxycarpus Lour. etc. For example *Garcinia purpurea* Roxb. in Linn. Soc. Dodecandra and *Garcinia cambogoides* Grahm. in Linn. Syst. Monoecia Monadelphia have been described as medicinal plants by Murray (1881). The latter is renamed as *Garcinia morella* Desr. Similarly, *Cambogia gutta* in Linn. sp. pl. 728,1753 was name given for *Garcinia cambogia* Dear. However, there seemed to be no unanimity among the authors in describing the species under particular section and this resulted in taxonomic confusion for the genus. It can be elucidated as follows: *Oxycarpus gangetica* Buch. Ham. Wern. Soc. 5: 344, 1824 and *Stalagmitis cowa* G. Don. Syst. 1:621,1831 were named for *Garcinia cowa* Roxb. Like that there was duplication of nomenclature for many species.

The remarkable variety of the male flowers could be found particularly in the shape and nature of connective tissue. Similarly, the quinary arrangement of the floral parts in some species in contrast to the general binary arrangement induced Dr. Roxburgh (pl.coron.2:51.t.196.1805) to erect the
genus *Xanthochymus* Roxb. Subsequently Daniel Oliver (1868) described *Xanthochymus* Roxb. as a separate genus under the tribe Garcinieae and considered it distinct from the genus *Garcinia* Linn. for the presence of calyx having 5 sepals (rarely 4), filaments connate in 5, rarely 4 distinct pedicelled spatholate bodies, antheriferous at the top, free portions very short, incurved; anthers small didynamous. It was Joseph Dalton Hooker (1874) who was mainly responsible in reducing *Xanthochymus* Roxb. as one of the species of *Garcinia* Linn. and the same has been followed by Gamble (1935) in flora of Madras Presidency, Cooke (1903) in flora of Bombay Presidency and in other Indian floras.

Kurz (1874) has shown that *Xanthochymus* Roxb. cannot be kept distinct from *Garcinia* Linn. for both pentamerous and tetramerous flowers occur in type species *pictorius* Roxb. Metcalfe and Chalk's (1957) treatment for *Xanthochymus* Roxb. as separate genus is based on anatomical evidence. On the basis of the anatomy of leaf they consider it as distinct genus by the presence of Calcium oxalate crystals present in mesophyll. Hutchinson (1959) has also treated *Xanthochymus* Roxb. as a separate genus, but Robson (1961) recognised it as subgenus following Engler (1925). Thonner (1962) and
Maheshwari (1964) have again reduced *Xanthochymus* Roxb. as the species of *Garcinia* Linn.

In view of the fact that variations are restricted to the organisation of male flowers and these do not generally extend to female flowers and fruit, Maheshwari (1964), following Wight (1840), Pierre (1882-1883), Vesque (1893) and Engler (1925) consider the genus may be divided into sections in accordance with the relative value of several structural variations mentioned above. Since in *Garcinia* Linn. species occur which show an unusual high amount of convergent characters and resemble each other in a somewhat deceptive manner, its generic morphological pattern acts as a stratum on which actually many species groups (or sections) represent parallel segregations or homologous series.

Pierre (1882-1883) subdivided the genus *Garcinia* into 37 sections. These were later reduced to 33 sections by Engler (1925), who subdivided the genus on the basis of anther thecae, their mode of dehiscence, polyandry and synandry, synandrial lobes, filaments, gynaeceum etc. Earlier Vesque (1893) recognised 3 subgenera (*Eugarcinia* Vesque, *Rheediopsis* Vesque, and *Xanthochymus* T. Anders) and 9 sections under *Garcinia* Linn. In a subdivision of the family Guttiferae Engler (1925) has placed *Garcinia*
Linn. under subfamily Clusiodeae, tribe Garcinieae, to which besides Garcinia Linn. belong Allanblackia Oliv., Tsimatima Jum. and Perr., Rheedia Linn. Owataria Matsmura, Tetrathalamus Itbch; Tripetalum K.Schum., and Pentaphalangium Warbg. The tribe Garcinieae is characterised by a very short style with a sessile, peltate or radiating stigma; loculi of ovary with always one ovule, fruit an indehiscent berry, embryo symmetrical, undivided cotyledons absent or minute. T. Anderson has also placed Garcinia Linn. under tribe Garcinieae, based on similar characters, in Hooker's Flora of British India (1874). The tribe Garcinieae include two genera: Garcinia Linn. with calyx of 4 or 5 sepals and Ochrocarpus Thouars., with calyx closed in bud bursting into 2 valves. Cooke (1903) and Gamble (1935) have not subdivided Guttiferae into tribes and Garcinia Linn. appears as one of the genera of the family the other genera being Ochrocarpus Thouars. Calophyllum Linn., Megua Linn. and Pococlineuror Bedd. Bor (1953) has added one more genus Kayeae Wall. to the family. Talbot (1909) and Santapau (1953) follow Cooke (1903) and Gamble (1935) and have not subdivided Garcinia Linn. into subgenera or the family into tribes. Their work is based on the species occurring in South India.
The recent workers on the genus mostly favour subdivisions for the family and for the genus. Willis (1960) following Engler (1925) has placed the genus under subfamily Clusioideae along with the genus Clusia. Robson (1961) has not made any subdivisions in the family but he subdivided the genus Garcinia Linn. into 3 subgenera (a) Xanthochymus T. Anders. (b) Rheediopsis Vesque (c) Garcinia Linn. The subdivision is mainly based on the morphology of androecium. Subgenus Xanthochymus T. Anders. is recognised by stamen - and staminodes - fascicles 5 (rarely 4), filaments united for ⅓ of their length and inflorescence terminal. Subgenus Rheediopsis Vesque is recognised by stamen - and staminodes - fascicles 4, filaments united ⅔ of their length or less, stamens and staminodes free and inflorescence axillary. Subgenus Garcinia Linn. is recognised by stamen - filaments completely fused, anthers oblong, curved, fasciculodes absent and ligule inconspicuous. Garcinia livingstonei T. Anders. has been placed under subgenus Rheediopsis by him. Robson (1958, 1968) considers the genera Rheedia Linn. and Tsiamatina Jum. and Perr. from Madagascar and Tropical America do not appear to be satisfactorily separated from Garcinia Linn. and should probably be merged with it in any future monographic treatments. But the union of all these into one genus would involve about 30 new combinations for American and Madagascar species.
Fr. Thornier (1962) in a subdivision of the family Guttiferae has placed *Garcinia* Linn. under subfamily Clusioidae but has not proposed further subdivisions of the genus *Garcinia* Linn. like Engler (1925). He recognises *Rheedia* Linn. as separate genus and has not merged it with *Garcinia* Linn. as proposed by Robson (1961). *Xanthochymus* Roxb. has been reduced to one of the species of *Garcinia* Linn. and not elevated to subgeneric level as done by Anderson (1874) and Robson (1961). Also he has not elevated it to generic level as done by Roxburghii (1832) and others.

As regards recent Indian Floristic study on the genus *Garcinia* Maheshwari (1964) following Wight (1840), Pierre (1882-1883), Vesque (1893) and Engler (1925) reports following sections of *Garcinia* Linn. as generic taxa in accordance with relative value of their structural variations:


Coddampuli Adans. - Fam. 2: 445. 1763.
Bialadia Scop. - Introd. 232. 1777.
Mangostane Gaertn. - Fruct. 2: 105. t. 1790.
Oxycarpus Lour. - Fl. Cochinch. 647. 1790
Dioostigma Hassk. - in Flora 25(2), Beibl. 33. 1842.
Dactylanthera Welv. - in Annaes Conselh. Ultramar. 560. 1858
Rhinostigma Miquel - Fl. Ind. Bat. Suppl. 495. 1860.

Anatomical and other aspects:

Vesque (1889, 1893) made some contribution by studying anatomical and histological features of the leaves that yield useful characters in the delimitation of sections under the genus. These may be cited as the presence or the absence of hypodermis, presence of simple unicellular hairs, nature of foliar crystals, uniseriate or biseriate mesophyll, shape and size of stomata and stomatal pores, internal glands etc. The colour and quantity of juice
exuded from the bark is sometimes of use in separating the species. The role of xylotomy or wood anatomy in identification of infra generic taxa was also emphasized by Engler (1925). According to Pierre (1882), the wood is predominantly white to yellowish in section Mangosteen Pierre, yellowish to brownish or reddish brown or white in the section Hebradendron Pierre. One can thereby build up a complete system of organization within the genus from comparative anatomical investigation. Erdtman (1952) traced relationship between pollen morphology and taxonomy of about 35 species from 20 genera including Garcinia multiflora. So far there has been comprehensive taxonomic study on the Indian species of Garcinia only by Maheshwari (1964) which is based on morphological characters.

Apart from these treatments for delimitation of taxa in the genus no other treatment more comprehensive is given so far.

Cytotaxonomical aspects.

The role of cytology in modern approaches to taxonomy forms an outstanding feature and cytotaxonomy is a discipline which seeks to study variation and explain variational discontinuities and relationships in terms of cytology. A review of the foundations of the subject is given by Löve (1954, 1960), Stebbins (1959) and Darlington (1956).
We find today a vast literature pertaining to the subject. Cytological treatment could be considered more comprehensive and to a greater extent accurate as a special role is claimed for cytological data in taxonomy since the chromosomes are the seat of hereditary material. Warburg (1938) comments, this is true to some extent, since the chromosome number and morphology often give evidence regarding the origins of forms as in polyploids. This claim could be taken as justified when the chromosome number and morphology could be considered in relation to other kinds of taxonomic evidences (See Chennaveeraiah 1960, Davis and Heywood 1963, and Heslop-Harrison 1963).

Various features of karyotype are used in taxonomy for comparative purposes. These are mainly chromosome number and morphology. The most easily observable karyotypic differences are those involving chromosome number, particularly, where polyploidy is involved. Polyploidy has long been thought to be a major factor of evolution and is of importance to a systematist. Published estimates suggest that polyploidy has been involved in the formation of anything from a third to a half known Angiosperms (Stebbins 1947, 1950, Lóve and Lóve 1949). De Wolfe (1957) calculated on the basis of the counts reported in Darlington and Wylie's (1955) chromosome Atlas that about 2 percent of total number of species have been proved to be polyploid representatives (See also Davis and Heywood 1963). Lóve (1951) has given a treatment of
the taxonomic evaluation of polyploids by taking 30 different species from different families and orders. In most cases the classical taxonomists have obtained the distinct characters of polyploids and have described them as separate species. Such a treatment on the genus *Garcinia* is so far wanting and in the present work an attempt is made to understand the taxonomic delimitation of taxa investigated under the genus by making karyomorphological studies.

There have been reports on the chromosome numbers in some of the species of *Garcinia* Linn. The known gametic chromosome numbers are $x = 14$, Ca.27, Ca.29, Ca.38, Ca.40 and 48 (Robson and Adams 1968). They suggest $x = 8-9$ for *Hypericum* and its allied genera which means it could apply to *Garcinia* Linn. as well. Thombre (1964) suggested $x = 16$ for the genus *Garcinia* and his observations are based on only one species *Garcinia indica* Chois, worked out by him.

Detailed karyomorphological studies have not been made so far except in *G. hanburyi* where Tixier (1953) reports 3 categories of chromosomes (big, medium and small) having V type isobranchiate and heterobranchiate and U type isobranchiate chromosomes. Most of these studies are made by using older techniques especially from paraffin sections of somatic tissue and no meiotic studies are reported except in *G. indica* Chois. by Thombre (1964). Following are the chromosome numbers reported from different species.
### Table of Chromosome Numbers

<table>
<thead>
<tr>
<th>Name of the species</th>
<th>Chromosome number</th>
<th>Author</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Garcinia indica</em> Chois.</td>
<td>2n=Ca.54</td>
<td>Krishnaswamy and Raman</td>
<td>1949</td>
</tr>
<tr>
<td></td>
<td>2n=48</td>
<td>Thombre</td>
<td>1964</td>
</tr>
<tr>
<td><em>Garcinia mangostana</em> Linn.</td>
<td>2n=Ca.76</td>
<td>Krishnaswamy and Raman</td>
<td>1949</td>
</tr>
<tr>
<td></td>
<td>2n=Ca.96</td>
<td>Tixier</td>
<td>1955,</td>
</tr>
<tr>
<td><em>Garcinia speciosa</em> Wall.</td>
<td>2n=Ca.55</td>
<td>Krishnaswamy and Raman</td>
<td>1949</td>
</tr>
<tr>
<td><em>Garcinia cambogia</em> Desr.</td>
<td>2n=Ca.58</td>
<td>Krishnaswamy et al</td>
<td>1954</td>
</tr>
<tr>
<td><em>Garcinia xanthochymus</em> Hook.</td>
<td>2n=Ca.80</td>
<td>-do-</td>
<td>1954</td>
</tr>
<tr>
<td><em>Garcinia hanburyi</em></td>
<td>2n=Ca.44</td>
<td>-do-</td>
<td>1954</td>
</tr>
<tr>
<td></td>
<td>2n=Ca.48</td>
<td>Tixier</td>
<td>1953</td>
</tr>
<tr>
<td><em>Garcinia benthami</em></td>
<td>2n=Ca.48</td>
<td>Tixier</td>
<td>1960</td>
</tr>
</tbody>
</table>

In the present work investigations on different species of *Garcinia* have shown a polyploid series. Although these species are mostly tropical or subtropical and woody in habit, it goes against the earlier correlation that temperate floras would be expected to possess higher polyploidy because of a greater percentage of herbaceous species than a tropical flora with a higher percentage of woody species. These correlations about geographical distribution and frequency of polyploids have been discussed in detail by Manton (1950), Mesquita Rodrigues (1953), Love and Love (1957) and Reese (1961). However, as Swanson (1965) says,
any conclusion drawn concerning the extent and geographical distribution of polyploidy must be regarded as tentative. However, polyploidy could be shown to have decisive role in the delimitation of species in the genus *Garcinia*.

It is possible to establish the basic number in the genus by determining the chromosome numbers in different species of *Garcinia* supported by karyotypic and meiotic studies. Though in some species chromosome number has been determined by earlier workers detailed karyotypic studies have been wanting.

In the present work the somatic chromosome number is determined for the first time in six species and for the rest they are new reports. In *G. mangostana* Linn. (2n=96) and *G. indica* Chois. (2n=48) is confirmed. From the chromosome number determined here the basic number in the genus is established as $x = 8$ which is agreeable to the suggestion of Robson and Adams (1948) for *Hypericum* Linn. and allied genera basic chromosome number is $x = 8-9$ and not as $x = 16$ as suggested by Thombre (1964).

**Chemotaxonomical aspects:**

The connections between the chemistry of plant constituents and taxonomy has already a long history. Rochleder (1847) published a treatise on phytochemistry. In early days of scientific taxonomy the plants were classified largely according to their economic and
medicinal uses. Certain taxonomic groups were characterised by their essential oil, e.g. Rutaceae, Labiatae, or by pharmaceutically important substances e.g. Digitalis, Atropa etc. There is an extensive literature reflecting a large number of chemical investigations in plants and particularly on pharmaceutically important substances in plants and in certain cases they have provided a valuable data for taxonomists.

The fact that certain compounds are chemically related and may be characteristic of genera or even families is now well established. According to Erdtman (1956), these substances may be formed by certain metabolic processes in plants which were retained when the group in question underwent further evolution and differentiation. Bate-Smith (1959) discussed this aspect and considers that chemical processes in plants are probably the essential events distinguishing certain groups of plants from others, rather than the absence or presence of particular constituents.

a. Significance of free amino acids in taxonomy

Although amino acids are generally recognised primarily in their role as structural units of proteins it is considered that "non protein" amino acids may have an additional important role since cosmopolitan distribution of "protein" amino acids is generally regarded of little taxonomic significance. Bell (1966)
suggests the occurrence of high concentration of "protein" amino acids in plants may be of taxonomic value. It is possible that the variation in their concentration may be due to either genetically controlled differences or to differing environmental conditions.

Chromatographic investigations of free amino acids have been utilised by most of the earlier workers with emphasis for the systematic studies. Hicks (1936) made chromatographic investigation of amino acids mainly for zoological study and it yielded promising results. Alston and Irwin (1961) studied the comparative extent of variation of free amino acids and certain "secondary" substances among Cassia species using the technique of paper chromatography. Results reported therein show considerable taxonomic significance. They noted that definite differences did appear in the amino acid chromatograms of different species although the extent of variation was far less than that of fluorescent substances. Similar comparison has been made of free amino acids of the seeds of Baptisia species by Alston and Turner (1963) and results noted were very consistent within a species. Infact, they observed similar patterns among all the species examined in a genus. Further they have found the patterns of the free amino acids of the stem, leaves and flowers of different species in the genus are predictable and reliable with quantitative differences.
b. Significance of "secondary" substances in Taxonomy:

The potential value of "secondary" substances in biochemistry of plants with respect to systematics has attained more consideration for their restricted occurrence (Bate-Smith 1956, Pecket 1959). According to Erdtman (1956): "Taxonomically the most valuable substances seem usually to be those which are not involved in primary metabolic processes and which do not have any special task to fulfil. In short, natural products which have been regarded as unimportant and which are in their biological environment relatively stable by-products are often denoted by the term 'secondary constituents'." Riley and Bryant (1961) were able to separate nine species of Iridaceae by comparing ninhydrin positive spots and fluorescent patterns by paper chromatography. Alston and Irwin (1961) by studying "secondary" constituents in Cassia species found significant variation in phenolic compounds and from fluorescent patterns under UV among different species.

Various species of Garcinia Linn. are of medicinal and economic importance (See for details: Kirtikar and Basu 1933; Dastur 1953; Nadkarni 1927, Wealth of India (Sastri 1956) and Chopra et al. 1956). In view of this it becomes essential to make a chemical investigation on the genus. One of the species (G. indica Chois.) yields a valuable fat known in commerce as "Kokum butter". Kokam is reported to be imported to Zanzibar from India.
This is used as an edible fat, adulterant of ghee, in soap and candle manufacture, suitable for ointment suppositories and other pharmaceutical purposes.

The first report on chemical studies on the genus *Garcinia* has been the isolation of Cay-doc oil from *G. tonkinensis* (Heim 1918). Since then a vast literature is added to chemical work related to various species of *Garcinia*. Chemical compounds that have been isolated mostly include fatty acids, oils, xanthones, biflavonones and flavonoid pigments, gums or resins or antibiotics etc. Some of these chemical compounds are characteristic of the genus. The resins like 'mangostin', 'gambogic acid', 'morellic acid', 'neomorellic acid' and 'Garcinic acid' are isolated from *Garcinia mangostana* Linn., *Garcinia cambogia* Dehr., *Garcinia morella* Dehr. respectively. The pigments $\alpha$, $\beta$, $\gamma$, $\delta$-guttiferins are isolated from *Garcinia morella* Dehr. Antibiotic phenols like 'morellin', 'neomorellin' etc. are also isolated from the same species as well as from other species. These compounds are mostly isolated from seeds, fruits, heartwood and leaves of different species. Presently the chemists are engaged in their isolation and structural elucidation especially of xanthones and biflavonones.

So far no literature is cited on amino acid constituents of the genus. Also there has been no attempt
made for comprehensive taxonomic treatment of the genus *Garcinia* Linn., based on the chemical data obtained to date. In the present work the occurrence and behaviour of chemical constituents of *Garcinia* species on TLC have been studied with respect to the presence of free amino acids and 'secondary' substances. The variation of chromatographic patterns are evaluated for taxonomic delimitation at inter and intra-specific level.

For comparison of free amino acids of leaves and ripe fruits of *Garcinia* species here the technique of thin-layer chromatography has been employed. Results noted are consistent with almost similar patterns. Quite a few amino acids (mostly proteinaceous or usual and sometimes unusual) could be observed. The change in patterns in some taxa of different collections from different areas within the same species may be genetic or environmental. The studies on leaves provide a rather stable base for analysis at developmental stages since much difference could not be detected in number as well as quantity of free amino acids and secondary substances from old and young trees and in the same species under similar environmental conditions.

Biochemical differences represented by 'secondary' substances is impressive in *Garcinia* species studied here, particularly in direct comparison with amino acids under similar conditions. It was noted that the leaves showed
better resolution for 'secondary' substances on TLC as compared to fruits, showing less occurrence of these substances in fruits. All the species worked out show a variation in pattern although they are quite related for the presence of certain common spots. The intraspecific variation in 'secondary' substances observed may be due to environmental or genetic variations predominant among which are phenolic compounds detected by spraying with diazotized p-nitroaniline reagent.

The variation in chemical components go hand in hand with karyotypic changes within and among the species of *Garcinia* worked out. The variation could be attributed to changes in environment that are gene controlled. Species investigated here are from South India, in particular, and other parts in general.