A REVIEW OF THE LITERATURE ON NEW GUINEA *IMPATIENS*

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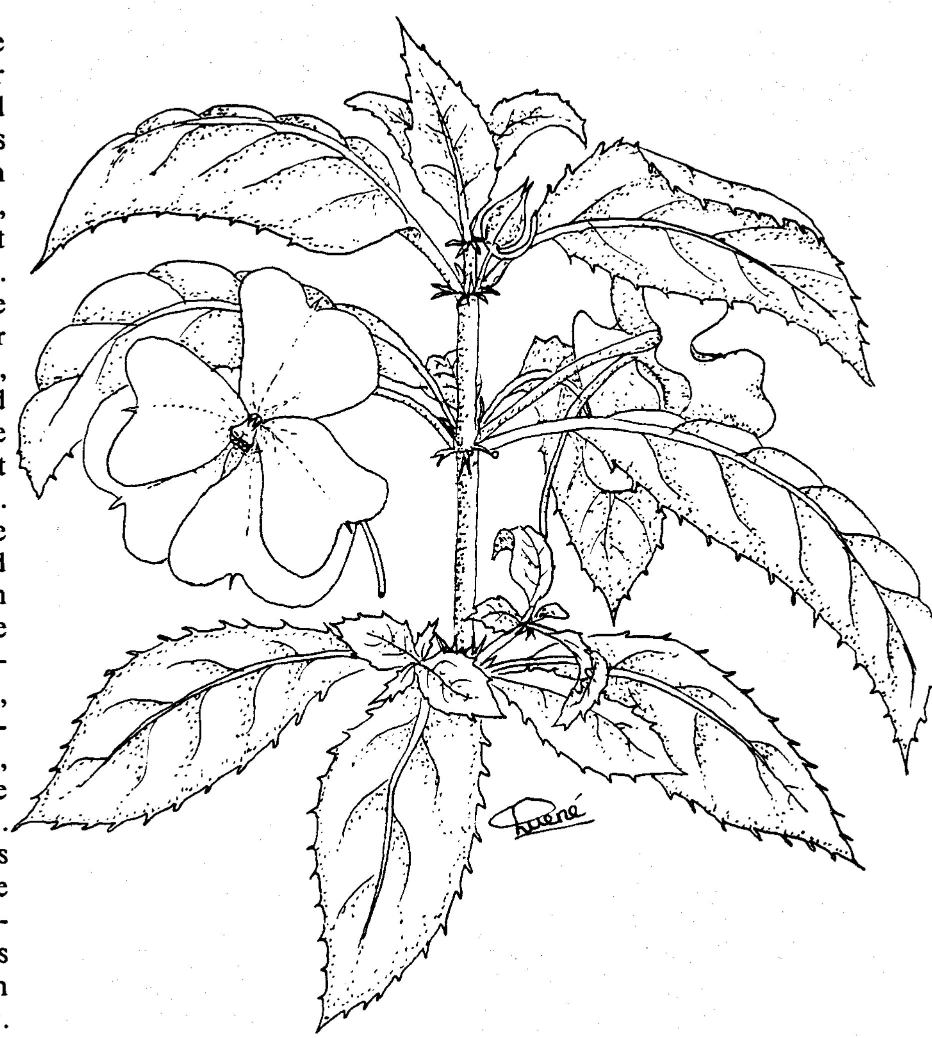
Taxonomy

Impatiens: with 850-900 species which are native to Eurasia and Africa, and 6 species which are native to North and Central America.

New Guinea *Impatiens* belong to the family Balsaminaceae DC. This family consists of only two genera: *Impatiens:* with 850-900 species which are native to Eurasia and Africa, and 6 species which are native to North and Central America. *Hydrocera:* which consists of only one species, is native to Indomalaysia. Some authors recognize two other genera: *Impatientella* (1 species in Madagascar) and *Seneiocardium* (1 species in Indomalysia).

Impatiens are annuals or perennial herbaceous plants with watery, translucent stems. Leaves are alternate or opposite, simple, and usually are without stipules. Flowers are bisexual and irregular in form. The calyx consists of 3 free, usually petaloid sepals, the lower one is spurred. Sometimes there may be 2 small additional sepals present on the flower. The corolla consists of 5 petals. The dorsal petal is free but the lateral ones are fused in pairs (in *Hydrocera* all the petals are free). There are 5 stamens, with introse anthers which are more or less fused and forming a cap over the ovary. The ovary is superior, consisting out of 5 fused carpels that contain numerous anatropous ovules on axile placentas. There are 1-5 more or less sessile stigmas. The fruit is an explosive capsule (in *Hydrocera* fruit is indehiscent and berry-like). The seeds are without endosperm (Hickey et al., 1981).

The fruit is an explosive capsule.



The *Impatiens* from New Guinea were initially split into 12-14 species (Mack, 1989) but according to Grey-Wilson (1980) there was not enough evidence to separate the New Guinea *Impatiens* into different species. He stated that the New Guinea *Impatiens* is probably a highly variable species. He was however able to distinguish 15 groups within this species, although these were not given a formal taxonomic rank. The groups were divided on a geographical basis. The earliest name for this taxon is *I. hawkeri* Bull, published in 1886.

New Guinea *Impatiens* is probably a highly variable species.

New Guinea *Impatiens* occur throughout the island except for the lowlands of the north and south. They are found from 200-3150 m. Their habitat is in the moist mountainous and submontane forests; rarely in the alpine region or at low altitudes. They usually grow in damp sites in full sunlight or partially shaded areas along the margins of streams and rivers, by roadsides and along tracks, in ravines and creeks and amongst moist rocks. The New Guinea *Impatiens* complex occurs on the Island of New Guinea and extends eastward into the Bismarck Archipelago and the Solomon Islands.

The fact that the different groups of New Guinea *Impatiens* easily cross with each other and produce fertile offspring, supports the classification of New Guinea *Impatiens* as one variable species. In this paper the species *I. hawkeri* is implied when 'New Guinea *Impatiens*' is referred. New Guinea impatiens have also been able to hybridize with species from Java (2n=16) and Celebes (2n=8), but the offspring of these crosses are often sterile. Hybrids which were produced in the USA are known under a variety of specific and cultivar names, and the nomenclature and taxonomy of both these and the genus in the wild is needed to prevent further confusions and uncertainties (Grey-Wilson, 1980; Royen van, 1982).

Impatiens hawkeri Bull

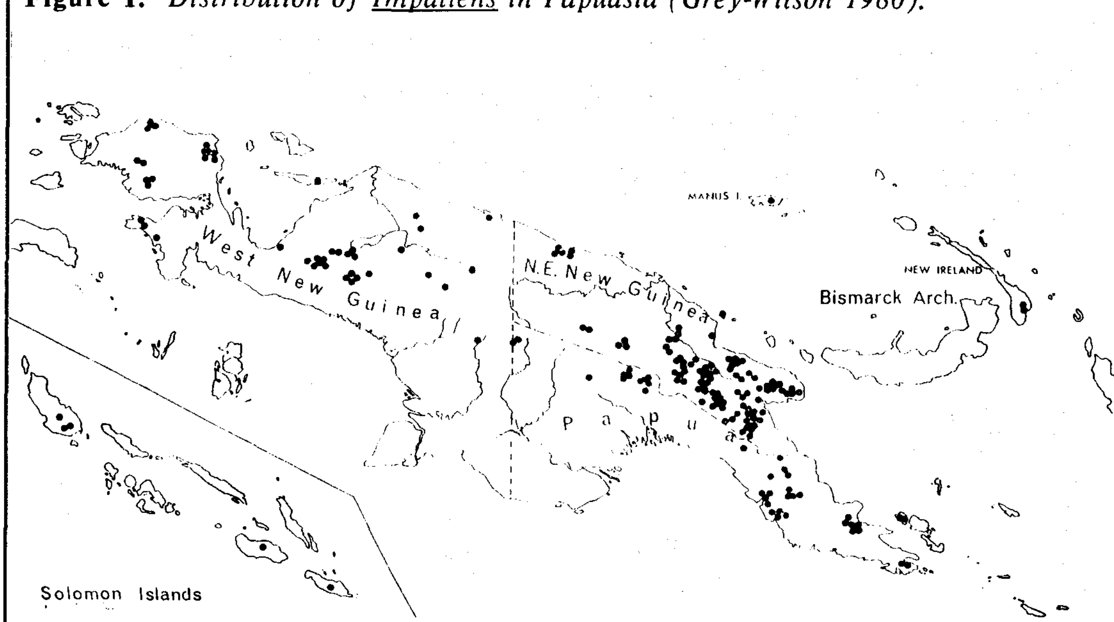
The earliest name for this taxon is *I. hawkeri*.

First described in Bull, Catlal. 8 (1886) & in Gard. Chron. (1886)25: 760, fig. 168.

Synonyms:

Impatiens herzogii K. Sch. (1888)
Impatiens herzogii Hooker (1911)
Impatiens klossii Ridley (1916)
Impatiens lauterbachii Warburg (1905)
Impatiens linerifolia Warburg (1905)
Impatiens mooreana Schlechter (1913)
Impatiens nivea Schlechter (1917)
Impatiens polyphylla Warburg (1905)
Impatiens rodatzii Warburg (1905)
Impatiens schlechteri Warburg (1905)
Impatiens schlechteri Grey-Wilson (1976)
Impatiens trichura Warburg (1905)

Figure 1. *Distribution of <u>Impatiens</u> in Papuasia (Grey-Wilson 1980).*



The New Guinea *Impatiens* complex occurs on the Island of New Guinea and extends eastward into the Bismarck Archipelago and the Solomon Islands.

Plants were first cultivated outside of their land of origin at the Adelaide Botanic Garden.

Description of *Impatiens hawkeri* Bull
(from van Royen, 1982)

Herb, 10-110 cm high, simple or branched, solitary or in large groups. Stems usually green, but often wine red or purplish, often at first finely densely to sparsely pubescent, sometimes glabrescent, rarely entirely glabrous, decumbent to erect. Leaves 3-7 - whorled, 5-32 cm long, limb finely pubescent on either side or sometimes glabrous above, lighter and often grayish or silvery shiny below, often variegated, often along margin and nerves red, dark pink, white or green; ovate-elliptic, linear, linear-elliptic, elliptic, elliptic-oblong, oblong, or oblanceolate, 4-26 by 1-6.3 cm, tip acute to long-acuminate, base attenuate or cuneate, midrib flattened above, prominent below, lateral nerves 4-14 on either side of midrib; margin slightly crenate, the crenation's with scarcely developed filiform appendages, 1-2 mm long, sometimes finely to coarsely serrate or crenate-dentate and lower teeth terminating sometimes in filiform appendages, 3-5 mm long. Petioles often reddish, 0.5-6 cm long, glabrous. Pedicel's red, green, purplish brown, light to dark pink, orange or scarlet, 2-7 cm long. Calyx white, main nerves green or only tips green, lanceolate-linear, 4-15 by 1-6 mm, tips acute. Spur white, tip light green, 2.7-10 cm long. Corolla pink, very light lilac, purple, snow white, often tinged with pink on back, vermillion, orange, scarlet, salmon-pink, or bright orange. Lateral united petals 2-lobed, upper lobe broadly obovate to oblong, 1.9-4.2 cm long, tip obtuse or shortly 2-lobed, lower lobe broadly elliptic, apiculate to rounded. Upper petals suborbicular to quadrangular, 16-31 by 11-25 mm, slightly to deeply 2-lobed at tip and often apiculate between the lobes. Anthers white, dark green at base, or red, 2-4 mm long. Ovary glabrous. Capsule ellipsoid to fusiform, 1.8-4 cm long. Pedicels elongate up to 12 cm.

New Guinea *Impatiens* have been widely cultivated in their land of origin.

History and early breeding of New Guinea *Impatiens*

New Guinea *Impatiens* were first collected by J.D. Hawker. These plants were first cultivated at the Adelaide Botanic Garden, and sent by Dr. Schomburgk in 1884 to Mr. Bull of Chelsea. The New Guinea *Impatiens* was described as *Impatiens hawkeri* Bull, in Bull's Catalogue of 1886. Later in the same year a more detailed account, together with a fine illustration appeared in the Gardeners Chronicle. The first herbarium specimen was derived from these cultivated plants and was deposited at the Kew Herbarium. Since then, New Guinea *Impatiens* were frequently seen in botanical gardens of Europe, mostly under the name of *Impatiens hawkeri*, but occasionally as *Impatiens herzogii* (Grey-Wilson, 1980).

One of the main reasons why they were not introduced to horticulture is that seeds are difficult to find where the plants grow naturally. This is due to the way *Impatiens* plants disperse their seeds. The mature capsules explode at the slightest touch, scattering the seeds in all directions (Winters, 1973).

New Guinea *Impatiens*, however, have been widely cultivated in their land of origin: New Guinea; especially in the Western and Eastern Highlands and in the districts of Morobe and Madang. They are frequently planted around, or within the confines of, villages and along pathways. Many forms are grown, especially those with large, brightly colored, flowers and those with reddish, purple or variegated leaves (Grey-Wilson, 1980).

New Guinea *Impatiens* became important to western horticulture only after a number of specimens were collected in 1970 and brought back to the U.S.A. In 1970 H.F. Winters and J.J. Higgins of the Agricultural Research Service went on a plant exploration to New Guinea to collect species of *Begonia*, *Hoya*, *Rhododendron*, ferns and other species. The expedition was cosponsored by the Agricultural Research Service, USDA, and the Longwood Foundation. During their trip they noticed large numbers of different *Impatiens* growing in the jungle. Also when they climbed the mountains in search of rhododendrons, a number of different types of *Impatiens* with more highly variegated foliage were discovered. The collectors, with help of the natives, collected as many specimens as possible, and from these plants 25 specimens survived the trip back to the U.S.A. (Arisumi, 1976; Armstrong, 1974; Kaczperski et al., 1989; Mack, 1985; Martin, 1984; Winters, 1973).

After nearly two years in quarantine, the U.S. Department of Agriculture released cuttings in 1972 of the New Guinea *Impatiens* collection to research stations, commercial growers and breeders (Arisumi, 1989; Mack, 1989; Kaczperski et al., 1989).

Before the cuttings had been released by the U.S.D.A., The Longwood Gardens had already received propagations of the collected plants and the first breeding work was done by R.J. Armstrong. He made crosses in the winter of 1971-1972 and during the winter of 1972-1973. The first cultivars were released in 1972 and included ten different cultivars. These cultivars were known as the 'Circus series'. Many of these cultivars have variegated foliage. The main use of these cultivars was for outdoors as bedding plants during the summer (Winters 1973; R.J. Armstrong, 1974; Martin, 1984).

Dr. Toru Arisumi, plant geneticist at the Agricultural Research Center in Beltsville, Maryland released a number of hybrids after he had intermated each of the collected plants with each other. These plants were again hybridized by other plant breeders (Mack, 1989).

In 1974 Iowa State University introduced the 'Cyclone Hybrids'; also known as the 'Star series'. They all have variegated leaves and deep violet flowers. These plants were obtained by Allen R. Beck and his staff, with support from the Society of Iowa Florists. The most praised cultivar from the 'Cyclone Hybrids' was the cultivar 'Star Fire'. It forms well branched plants and year round flowering. Most of these cultivars grow best in light shade (Woodroffe, 1975; Martin, 1984).

The California-Florida Corporation in Fremont, California were successful with their American Indian Series, named for Indian tribes. These cultivars all have large and abundant flowers.

In 1975 the Bicentennial series of New Guinea *Impatiens* were released by Mikkelsen's Inc. of Ashtabula, Ohio. These cultivars represented a distinct stage of development in cultivar improvement or in breeding of New Guinea *Impatiens*. Instead of resembling the original collections, which were spindly, weak and poor blooming plants; these new cultivars were compact, floriferous, vigorous and long-lasting plants. These cultivars were named after historical figures such as 'Betsy Ross'. Their new breeding goals were to develop cultivars with bicolored blossoms and highly variegated foliage. It did not take long before Mikkelsen's Inc. came up with an even better series than the Bicentennial series of cultivars: the Sunshine series. These cultivars flowered abundantly in sunshine, and were striking because of their variegated leaves (Martin, 1984; Mack, 1989).

In 1977 the Longwood Gardens issued a second set of hybrids. The new set had somewhat larger flowers, and up to twice as many blossoms on each plant than the first set (Martin, 1984).

Another big break through in the breeding of New Guinea *Impatiens* occurred in 1987 when Ludwig Kientzler of Kientzler Jungpflanzen in Germany introduced his Kientzler cultivars which were named after French butterflies. His breeding goals were more focused on the European Market which preferred bright, fluorescent, single colored blossoms and very dark, single colored foliage. Later his selecting criteria also included bicolored flowers and variegated foliage (Mack, 1989).

Public and private efforts in breeding improved New Guinea *Impatiens*, which combined the desirable characters of several types and species into a single cultivar, have led to the increasing popularity of New Guinea *Impatiens* the

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First breeding work in the U.S. was done by R.J. Armstrong.

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industry has seen from the early 1980's to the present. New Guinea *Impatiens* are popular because the compact plants come in a wide variety of flower colors and shades (from vibrant bright to very dark), the flowers can be quite large, up to 7 cm (>2.5") in diameter, and they are adaptable to many different environmental conditions ranging from full sun to partial shade. They are attractive for their several foliage types which consist of different forms: slightly rounded to lanceolate with smooth to serrated edges and the colors of the leaves range from green, burgundy or variegated. New Guinea *Impatiens* can also be used as houseplants. They can either be grown in normal pots or in hanging containers. An important character of New Guinea *Impatiens*, when grown in pots is the that they have a tendency for self-branching (Martin, 1984; Kaczperski, 1989). Insects and mites can cause problems in growing New Guinea *Impatiens*. The pest which causes the most problems are spider mites. The symptoms are mottled leaves; and in advanced stages, webbing covers the top of the plants. During warm weather spider mites can multiply quickly and devastate a crop of New Guinea *Impatiens*. Sabri et al. (1982) found a

Plants come in a wide variety of flower colors and are attractive for their several foliage types.

Table 1. *List of breeders of New Guinea Impatiens and some of their developed cultivars*

Year	Breeder	Series and Cultivars
1972	R.J. Armstrong Longwood Gardens	Circus series I: 'Bozo', 'Carousel', 'Harlequin', 'Cotton Candy', 'Lollipop', 'Big top', 'Charmer', 'Orange Crush', 'Painted Lady', 'Stop light'
1974	A.R. Beck Iowa State University	Cyclone hybrids; Star series: 'Star Fire', 'Orange Chiffon', 'Blue Velvet', 'Star Dazzle', 'Star Dancer', 'Star Burst', 'Purple Silk', 'Pink Satin', 'Arctic Star', 'Summer Star', 'Morning Star' and 'Rainbow star'
1975	Mikkelsen's Inc. Ashtabula, Ohio	Bicentennial series: 'Betsy Ross'
1970's	California-Florida Corporation, Fremont	American Indian series: 'Mohave', 'Pawnee', 'Shawnee'
1970's	Mikkelsen's Inc. Ashtabula, Ohio	Sunshine series: 'Sundazzle', 'Sunfire', 'Sunglow', 'Sunregal', 'Radiance', 'Star Wars', 'Antares', 'Gemini', 'Telstar', 'Orbitor'
1977	R.J. Armstrong Longwood Gardens	Circus series II: 'Calliope', 'Cannonball', 'Fortune Teller', 'Chariot', 'Juggler', 'Magician', 'Ringmaster', 'Roustabout', 'Trapeze'
1987	L. Kientzler Kientzler Jungplanzen	Pure Beauty series: 'Anaea', 'Aurore', 'Caligo', 'Celerio', 'Delias', 'Jasius', 'Momas', 'Selenia', 'Sesia', 'Vulcain'
1980's	Fischer, Pelfi	Bull series: 'Inge', 'Anna', 'Suzanne', 'Mathilde'
1980's	Fischer, Pelfi	Danziger series: 'Danlight', 'Waltz', 'Doerte', 'Danshir', 'Flamenco', 'Lambada', 'Dansera', 'Danova', 'Danhill', 'Dangal'

Problems can be overcome with in-vitro propagation.

variation in susceptibility to the two-spotted spider mite between different genotypes of New Guinea *Impatiens* occurred. It was shown that the resistance was significantly correlated with the cuticle content. The resistant plants all contained P.I. 354259 (P.I. = Plant Introduction) in their pedigree; probably P.I. 354259 contains a dominant resistant gene. The cultivar 'Tangerine' has been observed to be highly susceptible to the spider mite. From our own observations 'Tangerine' was also highly susceptible to white flies so perhaps the resistant gene against spider mites also induces resistance against white flies and other sucking insects.

Propagation

New Guinea *Impatiens* are usually propagated by stem tip cuttings. They root easily in perlite, sharp sand or vermiculite in 7 to 21 days depending on the cultivar. It is best to keep them under intermittent mist and constant temperatures ranging from 20°C (70°F) to 24°C (75°F). Impatiens seeds, germinate in 2 or 3 weeks and the seedlings can be transplanted when they are about 2 cm. It takes about 10 to 14 weeks from seed to first bloom in the greenhouse at 24°C (75°F) day- and 18.3°C (65°F) night-temperatures (Arisumi, 1976; Kaczperski et al, 1989).

Cutting production often becomes limiting on New Guinea *Impatiens*. A disadvantage of taking cuttings is that flower bud initiation and development occur throughout the year and that reproductive shoot tips root more slowly than vegetative shoot tips. These problems can be overcome with in-vitro propagation (Koenigsberg et al., 1976, Stephens et al., 1985). The advantages of in-vitro propagation are:

- able to produce a continuing source of vegetative shoots
- produce many more shoots per unit time than a traditional propagation method
- provide a rapid method of propagating desirable genotypes from a breeding program (Stephens et al., 1985)
- if the stock plants have a virus it is possible through meristem culture to obtain virus-free plants.

Stephens et al. (1985) found that high levels of kinetin stimulated multiple shoot production and that the presence of NAA inhibited shoot production. They also found differences between genotypes in the micropropagation potential and that interspecific hybrids had a higher propagation rate in-vitro than both of their parents.

Cytology and genetics of New Guinea *Impatiens*

A number of people have been doing research on the cytology of *Impatiens* species, including New Guinea *Impatiens*. Jones & Smith (1966) did a cytogeographical survey of a number of *Impatiens* species. They were able to show that chromosome variation in the genus showed distinctive patterns of geographic and perhaps ecological distribution. The Himalayan region represented the center of origin for the genus as it is richest in species. It contains two basic numbers (x=7 and x=10). From this region *Impatiens* diverged to the south and north. They presume that x=7 is the base for the genus, and that evolution has been mainly by chromosome increase. The *Impatiens* of Europe and America have x=10, while the *Impatiens* of Africa and SE Asia mainly have x=8. They sampled 8 different plants from New Guinea of which 6 (they named *I. schlechteri* and 4 unknown species) were tetraploids (2n=32; x=8); and 2 were hexaploids (2n=48; x=8: *I. hawkeri* and 2n=66; x=11; *I. mooreana*). *I. platypetala* from Java was a diploid (2n=20; x=10); while another collection of *I. platypetala* from Sarawak was a tetraploid (2n=32; x=8). They stated that the high frequency of polyploid species in the New Guinea region formed a positive indication of the role of hybridization in the

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evolution of species in *Impatiens.* SE Asia forms a geographical boundary of the genus, as no *Impatiens* are found in Australia. According to Jones & Smith (1966) hybridization and polyploidization was of importance in extending the geographical boundaries of the genus. Polyploid species, compared to diploid species, are thought to be more successful. Polyploid species have a greater adaptability, vigour, 'thermal preadaptation', hardiness, tolerance to water logging, genetic discontinuity with related diploids and a capacity to store variation. Probably the most important reason for their success is that polyploid species are of hybrid origin (Jones & Smith, 1966).

New Guinea *Impatiens* are a highly variable species.

New Guinea *Impatiens* are a highly variable species. This variability may be the result of polyploidy (tetra or hexaploids), which may have developed from hybridization of different species. Another reason for the high variability, may be that New Guinea *Impatiens* are widespread on the island (New Guinea is 2400 km from end to end) and over such a wide area genetic isolation is bound to occur. Also the effects of altitude must be taken into account. Grey-Wilson (1980) states that the New Guinea *Impatiens* have reached a point in diversification in which groups are beginning to emerge to closely allied species (Grey-Wilson, 1980).

Toru Arisumi did a cytological research on the New Guinea *Impatiens* collected by Winters and Higgins (USDA Impatiens). Chromosome counts of 14 plants showed 13 plants with 32 (2n=32) and one plant with 64 (2n=64) chromosomes. With some exceptions the 32-chromosome plants were self- and cross-fertile. The plant with 64 chromosomes was self-fertile but did not set any seed when it was crossed with the species with 32 chromosomes (Arisumi, 1973b).

A.R. Beck et al. (1974) looked at the breeding behavior and chromosome numbers among New Guinea (P.I. 349586) and Java *Impatiens* (*I. platypetala;* P.I. 349629) species, the cultivar 'Tangerine' (= *I. platypetala aurantiaca* Steen from Celebes) and cultivated varieties of *I. holstii* Engl. (= *I. walerana* Hook. f.) which originates from East Africa, and their interspecific hybrids. They found that all crosses were successful except those made with *I. holstii.* The New Guinea impatiens (P.I. 349586) had 2n=32 chromosomes, *I. platypetala* (P.I. 349629) and *I.holstii* had 2n=16 chromosomes, 'Tangerine' had 2n=8 chromosomes, which indicates a new, lower genome number of 4 for *Impatiens.* Chromosome counts of the hybrids were midway between the respective parents. The chromosomes of the SE Asian *Impatiens* all indicated a similarity in chromosome morphology and size. The chromosomes of *I.holstii* were clearly different in morphology and size, which may be the reason why this parent did not cross with the other species.

Zinov'eva-Stahevitch and Grant (1984) determined chromosome numbers of 44 taxa of *Impatiens.* The chromosome numbers ranged from n=4 to n=24. They confirmed that the species from New Guinea (which they named *I. linearifolia* and *I. schlechteri*) had 2n=32 chromosomes. For *I. platypetala* ssp. *aurantiaca* from Celebes they observed a cytotype of 2n=14 which confirmed the results of Khoshoo (1955). Arisumi (1975) and Beck et al. (1974) had found a chromosome number of 2n=8 for the same species. On the other hand, they confirmed that Arisumi's (1975) artificial interploid hybrid between *I. platypetala* ssp. *aurantiaca* (2n=8) from Celebes and *I. platypetala* ssp. indeterminate (2n=16) from Java, indeed had a chromosome number of 2n=12. The karyotype consisted of four large and eight small chromosomes.

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The original New Guinea hybrids were unable to flower until the plants were quite large. Also they rarely flowered under hot, dry conditions. *I. platypetala* from Java and *I. platypetala aurantiaca* from the Celebes possessed both of these characters so therefore crosses between these species and the New Guinea *Impatiens* were made. Beck et al. (1974) and Arisumi (1974) found that it was possible to make interspecific hybrids between diploid and tetraploid species from Celebes (2n=8), Java (2n=16) and New Guinea (2n=32); indicating a relationship between these species. The chromosome numbers of the interspecific hybrids had the expected midparent values. The hybrid phenotypes were midparental for most traits and showed dosage effects in some traits. Although the different species had different chromosome numbers the intra- and interploidy crosses functioned as diploids to each other. The diploid by tetraploid crosses produced little or no seed and nearly all triploid offspring were sterile. Amphidiploid and autotetraploid seedlings were pollen and seed fertile. Allotetraploids with 4 genomes were seed sterile. Some of these hybrids were considered ornamentally superior to their parents (Arisumi, 1974, 1978a) and had the ability to bloom under hot, dry conditions. A problem with these interspecific hybrids is that most of the hybrids are sterile so they could not be used for further breeding purposes. This sterility needed to be broken as the New Guinea flower colors were recessive and all hybrids had the flower colors of either their Java parent (magenta) or their Celebes parent (orange). The Celebes orange flower color was also completely dominant to the Java pigment. Methods of overcoming the interspecific sterility barriers are amhidiploid production, utilization of the random assortment principle, congruity backcrossing and naturally developing pollen fertility (Pasutti et al., 1980, Weigle et al. 1976).

A possible way to get fertile plants is amphidiploid production. After treating *Impatiens* cuttings and seeds with colchicine, Arisumi obtained tetraploids and octoploids of New Guinea cultivars, 2 interspecific hybrids between New Guinea and Java species, 2 New Guinea hybrids, and 2 clones of a Java species. He compared these tetraploids with diploids for differences in morphology and fertility. The tetraploids were larger than the diploids and in general had greater percentages of abortive pollen and less fertility than the diploids. A wild New Guinea specimen (New Guinea 13) with 2n=64 did not cross with 2n=32 plants but it did cross with the 'New Guinea' hybrid tetraploids (2n=64) showing perhaps that this specimen was a natural tetraploid. The octoploids were sterile and ornamentally inferior to diploids or tetraploids (Arisumi, 1973a).

Arisumi (1975) phenotypically analyzed selfed and crossed progenies of colchicine induced and natural amphididiploid cultivars of New Guinea and Indonesian *Impatiens*. It was shown that the ampidiploids were comparable to inbreds. The seedlings within progenies were identical in nearly all of the floral, foliage, and plant characteristics. The most frequent variation occurred in patterns and intensity of flower colors. This lack of variability for many characters in the offspring of many doubled interspecific hybrids tends to hamper breeding progress. Arisumi (1975) stated that the method of creating amphidiploids from diploids is useful when parental species or cultivars become sterile or difficult to breed when converted into tetraploids (Arisumi, 1975).

Congruity backcrossing is a hybridization scheme which is used to form an infertile gene pool by using both parental species of an interspecific hybrid as recurrent parents in alternate generations (Haghighi and Ascher, 1988). Although congruity backcrossing has not

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Table 2. *Chromosome numbers of Impatiens spp. from New Guinea, Java and Celebes*

Species	Origin	Chromosome no.
Impatiens hawkeri	New Guinea	2n = 32; 2n = 64
Impatiens platypetala (P.I. 349629)	Java	2n = 16
Impatiens platypetala aurantiaca cv. 'Tangerine'	Celebes	2n = 8
Impatiens platypetala cv. 'Tangoglow'	Java x Celebes	2n = 24

The most promising approach to overcome interspecific sterility is to look for naturally developing pollen fertility.

Due to these fertile hybrids, it is now possible to transfer desirable characteristics, from the Java and Celebes species into the New Guinea material.

Species within the New Guinea-Indonesian group are much more closely related with one another than species within the Indian and African group.

been used in the development of interspecific hybrids of *Impatiens*, this methods has been very successful in the development of fertile interspecific hybrids of bean (*Phaseolus vulgaris*, *P. acutifolius* and *P. coccineus*). This method offers a very promising way to develop new interspecific hybrids with desirable traits (i.e. drought tolerance) from less aesthetically appealing *Impatiens* species.

Pasutti et al. (1976) utilized the random assortment principle. This technique involves making large numbers of crosses in hopes of finding one of the random occurrences in which all the cell's chromosomes, or all the chromosomes of either parental genome, migrate to one pole and form a stable gamete. Successful crosses were limited to the Celebes cultivar, 'Tangerine', (2n=8) x Java 'P.I. 349629' (2n=16) hybrids, giving 2n=12 progeny which appeared sterile. When a large number of crosses with these progeny were made with the cultivar 'Tangeglow' (a 24-chromosome amphidiploid produced by doubling a Java *Impatiens* (P.I. 349629) and crossing it with the 8-chromosome 'Tangerine'), numerous progeny resulted, some of which proved to be fertile in subsequent crosses. When it was backcrossed with 'Tangerine' only three progeny resulted with 2n=8, 9 and 12. When backcrossed with the Java parent five progeny resulted, all with 2n=20. Use of the random assortment principle however, becomes impractical when sterile hybrids of high chromosome number are used because of the large numbers of pollinations required to form a single stable gamete (Pasutti et al. 1976, 1980).

The most promising approach to overcome interspecific sterility is to look for naturally developing pollen fertility. Passutti et al. (1980) conducted a cytological study on the pollen-bearing clones and progeny of a number of Java x New Guinea *Impatiens* interspecific crosses. Viable pollen-producing hybrids from these crosses were obtained and were crossed with a 24-chromosome amhidiploid 'Tangeglow' resulting in 2n=34 chromosome hybrids. One of these hybrids was again crossed with a Java *Impatiens* (P.I. 349629) 2n=16, producing two offspring, one with 2n=24 chromosomes, and one with 2n=30 chromosomes. The 30-chromosome hybrid showed a continuing tendency for production of viable partially unreduced gametes. Due to these fertile hybrids, it is now possible to transfer desirable characteristics, including precocious flowering under hot, dry conditions and the ability to flower when the plants are quite small, from the Java and Celebes species into the New Guinea material (Pasutti et al., 1980, Weigle et al. 1976). Stephens et al (1988) demonstrated that by using fertile interspecific hybrids the dominant orange-flowering pigment could be deleted from inbreds of the original orange-flowered hybrids.

The species within the New Guinea-Indonesian group are much more closely related with one another than species within the Indian and African group. Intraspecific crosses within and between these groups showed that all of the 30 interspecific crosses of the New Guinea-Indonesian group were compatible, but none of the interspecific crosses of the Indian group and only four of the 72 crosses within the African group were compatible (Arisumi, 1980a). None of the crosses between groups were shown to be compatible. These results show that from an evolutionary point of view, the African and Indian species are probably much older than the New Guinea-Indonesian species. The African and Indian species show wide morphological differences and strong barriers to crossability between most species. The New Guinea-Indonesian species have many similar morphological traits and can cross easily among themselves regardless of differences in basic chromosome numbers. The seed capsules of incompatible crosses abscised within 4-7 days (it takes 28-35 days for seeds to mature). In some incompatible crosses however the seed capsules were abscised after 7-14 days, which might be long enough to grow the embryos out in vitro. *I. flaccida alba* and *I. hookeriana* from

India and the African species *I. uguenensis* (=*I. sodenii*) were superior as seed parents to the New-Guinea-Indonesian species (Arisumi, 1980b).

Arisumi (1985) uses ovule culture instead of embryo culture to obtain interspecific crosses, as young embryos are extremely difficult to isolate for culture in-vitro. The percentages of ovules ultimately recovered as established seedlings in soil ranged from 0% - 16.5%. A major cause of post-germination losses was the abnormal development of seedlings in vitro. About 75% of the seedlings were abnormal. Poor germination and abnormal development was probably caused by cultural as well as by genetic deficiencies. The hybrids showed morphological characteristics of both parents, and were sterile (Arisumi, 1985).

Arisumi (1987) studied a number of interspecific hybrids obtained by conventional breeding methods and by ovule-culture in vitro. The hybrids among African, Indian, and New Guinea *Impatiens* were all euploids and sterile. Only a few of the hybrids developed into normal mature plants. Phenotypic analysis of the parents and hybrids revealed that the parental species, except for the New Guinea species, were homozygous for most traits. Seedlings of selfed New Guinea cultivars segregated for various plant, leaf, and floral traits. The flower colors and flowering habitat of the hybrid was mainly intermediate to the parental species. In overall size of plants, leaves, and flowers, the hybrids generally resembled the smaller parent. The following phylogenetic trends may have been conditioned by dominant or partially dominant genes: from equal to unequal petals, flat to hooded dorsal petal, racemose to epedunculate inflorescence, nearly free to markedly fused lateral petals, and lower sepal and a filiform spur to bucciniform or saccate lower sepal. Leaves arranged spirally was dominant over whorled leaves. Progenies of *I. uguenensis* (= *I. sodenii*) were among the last plants to wilt when water was withheld for 12 to 24 hours and two hybrids *I. uguenensis* (= *I. sodenii*) x New Guinea or *I. flaccida*, were considered to be potentially useful for combining drought tolerance with other ornamental qualities. Other useful crosses in ornamental breeding were *I. auricoma* x *I. sultani* 'Elfin White' or New Guinea species for yellow flowers and *I. flaccida* x for *I. repens* or 'Elfin White' for double flowers (Arisumi, 1987).

Final Remarks

New Guinea *Impatiens* are an important crop and probably will get more important as both a pot and bedding plant in the near future, therefore a lot of breeding work still can be done. In our opinion the genetic base with which the plant breeders in the United states have worked with until now is much too small. All the cultivars trace back to those 25 plant introductions which were brought back from New Guinea by Winters and Higgins in 1970. Arisumi (1978b) identified somatic mutations which affected leaf color, variegation and plant shape in certain hybrid clones and species of New Guinea *Impatiens*. Some of these mutations were shown to be heritable. Only one heterozygous genotype of *Impatiens platypetala* from Java (P.I. 349629) and one genotype from Celebes (the cv 'Tangerine') is available to breeding programs in the United States. Weigle et al. (1983) attempted to induce mutations in the Java genotype to obtain more genetic variety. After seeds were treated with 0.08M ethyl methansulfonate (EMS) he found individuals in the M_2 generation with a dwarf plant type. A genetic investigation indicated that this character was controlled by a single, recessive gene (Weigle et al., 1983). But as the Indonesia/New Guinea *Impatiens* are such highly variable species it is easier to get more genetic diversity by collecting more genotypes from the areas were these species grow. There are still unlimited ornamental and important horticultural characters available in the genepool of the species in New Guinea which are just waiting to be utilized. We should use some different species from Africa like *I. sodenii* or India (50% of the identified species grow in India) to use genes for

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tolerance to heat and drought required for outdoor plants or genes for tolerance to low levels of light and humidity required for indoor plants. Species on the other Indonesian islands or islands around tropical India might function as bridges between the New Guinea *Impatiens* and other species (Arisumi, 1978).

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