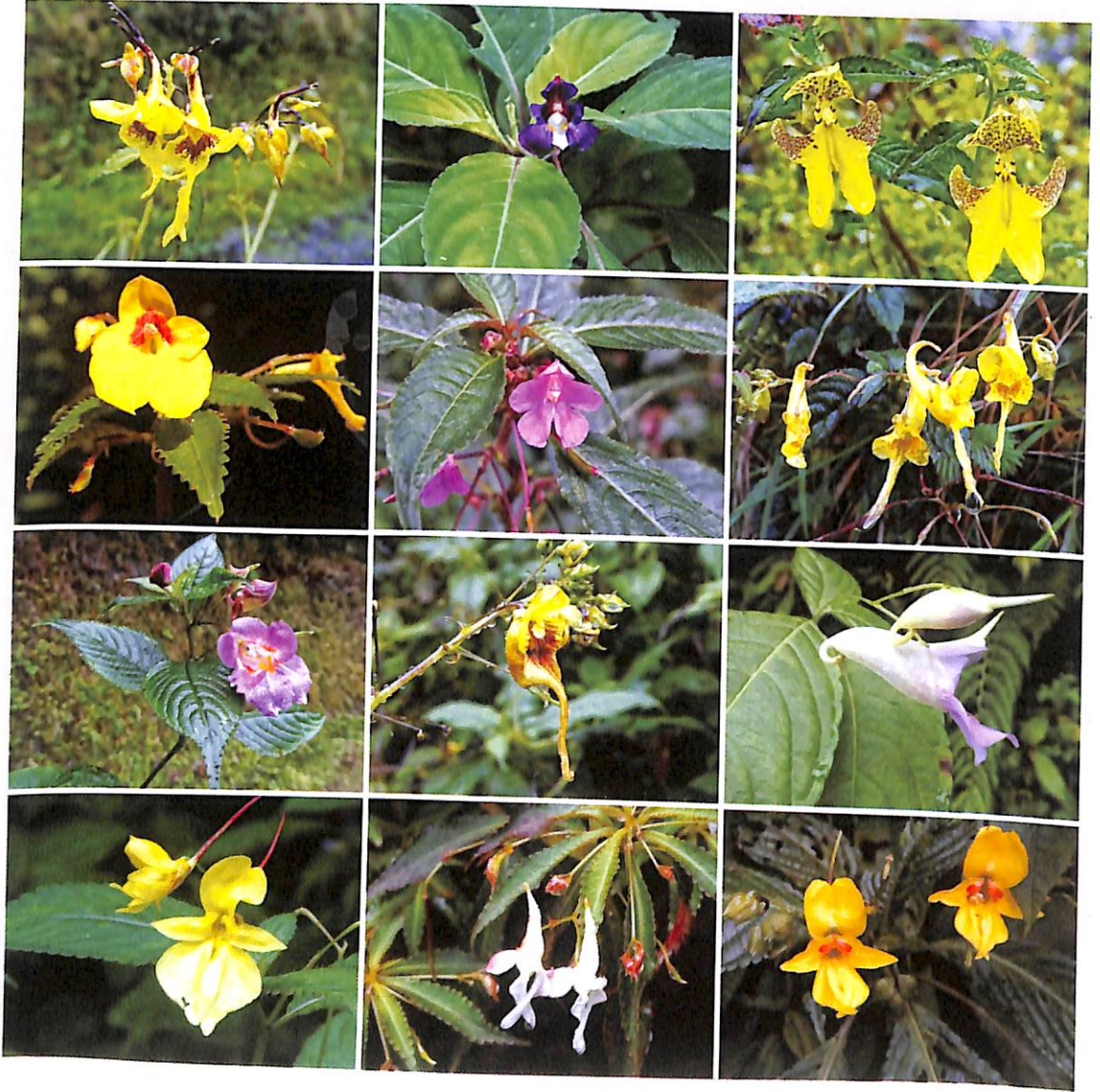


BALSAMS OF EASTERN HIMALAYA

A REGIONAL REVISION



BOTANICAL SURVEY OF INDIA

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INTRODUCTION

The family Balsaminaceae include two genera, the monotypic *Hydrocera* and the prolific *Impatiens*, commonly referred as the balsams or “jewelweeds”. The two genera are easily distinguished from each as *Hydrocera* has free petals with an indehiscent “berry like” capsular fruit, whereas *Impatiens* has four lateral petals connate in pairs and a characteristic, rather explosive, dehiscent five-valved capsule. *Impatiens* with more than 1000 species is one of most species-rich genera of angiosperms consisting of both annuals and perennial herbs (Stevens, 2001; Fischer, 2004; Yu & al., 2016). Members of this genus, predominantly distributed in the tropics and subtropics of the Old World; a few reaching to temperate regions of Eurasia and North America and south to Panama (Elias, 1967; Grey-Wilson, 1980, 1981; Fischer, 2004). The evolutionary history reveals that, the genus separated from *Hydrocera* in late Eocene and dispersed in the early Miocene to the adjacent regions (Janssens & al., 2009). It is assumed that, *Impatiens* originated in south-west China (Janssens & al., 2007, 2009, 2012; Utami and Ardiyani, 2015; Shajitha & al., 2016; Yu & al., 2016), and diversified to neighbouring continents in the early Pliocene (Yuan & al., 2004).

Observations from recent studies reveal that, the genus known to have five distinct diversity hotspots i.e. Tropical Africa, Sino-Himalayan region, southern part of India, Madagascar and South-East Asia (Toppin, 1920; Grey-Wilson, 1980; Bhaskar & Razi, 1981; Chen, 2001). Conducive environment, long term taxonomic isolation in preferred typical stable habitats have allowed to facilitate active speciation to continue for evolution of new species, thus contributing to higher number of endemic plants in these regions. These processes possibly laid a way for high species diversification (Janssens & al., 2009). The trend of local endemism, can be inferred from the fact that, more than 80% of Indian species of *Impatiens*, 90% of species from Madagascar, and 82% of Chinese species are endemic (Singh & al., 2015; Fischer & Rahelivololona, 2002, 2004, Yu, 2012). Interestingly the more and more species are added to these hotspots, with extended exploration in these fragile ecosystems.

Eastern Himalaya with diverse climatic conditions, varied topography and ecosystems diversity is known as one of the centres of diversification of the genus *Impatiens*. In the present study, attempt is being made to document the *Impatiens* diversity in Eastern Himalaya, particularly in the state of Sikkim and Arunachal Pradesh. The authors made extensive exploration tours in almost all habitats of Arunachal Pradesh and Sikkim, examined the earlier collections lodged in different herbaria (BM, K, E, CAL, ASSAM, ARUN & BSHC). During the study, many species new to science were published (Gogoi & Borah 2013a, 2014, 2015a, 2015b, 2015c, 2015d, 2015e, 2017a, 2017b; Gogoi & al., 2017a, 2017b, 2017c; Hareesh & al., 2016a, 2017a, 2017b;

Moaakum & al., 2017; Zeng & al., 2015); discovered new distributional records for Indian flora (Gogoi & Borah 2013b; Borah & al., 2015; Gogoi & al., 2015a, 2015b) and made rediscoveries (Gogoi & al., 2013, Odyuo & al., 2015, Verma & al., 2016), and also resolved many taxonomical problems (Gogoi & al., 2016; Gogoi & Arisdason, 2016; Karthigeeyan & Gogoi, 2016; Arisdason & Gogoi, 2017; Rasingham & al., 2016). The new discoveries made by other authors (Hareesh & al., 2016b; Hareesh & Sabu, 2017a, 2017b; Liden & Bharali, 2017; Sumanth & al., 2016) were also taken into consideration while preparing the manuscript. The book presents the details of 80 species, one variety, one naturalized species and two cultivated species out of which 42 species and 1 variety are from Arunachal Pradesh, 24 species from Sikkim and distribution of 16 species common for both the states. Among the 80 species 25 species were also reported from Bhutan of which 24 species are common with Sikkim and 16 species with Arunachal Pradesh.

STUDIES ON BALSAMS IN INDIA

The perusal of literature reveals that earliest description of any *Impatiens* species from India was published in “Hortus Indicus Malabaricus” (Rheede 1689). This pre-Linnaean work includes brief descriptions of five species in Latin in six plates (Nicholson & al., 1988; Dessai & Janarthanam, 2011). Linnaeus (Sp. Pl. 1753) described seven species of *Impatiens* including *I. triflora* which was later transferred to *Hydrocera*. Of these seven species described by Linnaeus, three *I. latifolia*, *I. oppositifolia* and *I. triflora* were from India. After Linnaeus, major contributions from Peninsular Indian *Impatiens*, were given by de Candolle (1824), Wight & Arnott (1834), Arnott (1835), Wight (1837, 1844, 1845, 1846, 1850) and Beddome (1859, 1868-1874).

Taxonomic studies of Himalayan *Impatiens* were initiated by de Candolle (1824), Roxburgh (1820–24), and Don (1825). Royle (1834) described several *Impatiens* from the western Himalaya based on his own collections. J.D. Hooker and T. Thomson (Hooker & Thomson, 1859) in their classical paper “*Praecursores ad Floram Indicam – Balsamineae*” dealing with historic expeditions to Sikkim and Khasia Hills. Hooker (1875) presented the species of *Impatiens* of Indian sub-continent in an organised way in “Flora of British India”. However, Hooker was well aware of the imperfection of the material he had worked for the group of Balsams (*Impatiens*) in Flora of British India. He devoted more than nine years of his life (1901-1911) in this rich and inexhaustible field and presented contribution to Indian and South east Asian *Impatiens* (Hooker 1904-1906, 1908a, 1910a, 1910b, 1911).

After Hooker the botanical impetus on Himalayan *Impatiens* slowed down though documentation of various floristic and regional inventories continued. Many noteworthy publication of early or mid-20 century, by Cooke (1901) from Bombay Presidency; Gamble (1915) & Fischer (1930, 1931, 1934, 1935, 1936, 1938) from Madras Presidency, Toppin (1920) from nowadays Myanmar, Burkill (1924) from North-East Frontier Agency, Fyson (1932) from South Indian hill stations, Blatter (1933) and Santapau

(1967) have contributed from Western Ghats. Ghara & al. (1982), Ghara & Ghara (1987, 1993), Ghara (1997), Chakrabarty (2009), Srivastava & al. (2009) and Govaerts & Chakrabarty (2011), Singh & Chauhan (1998, 1999), Singh & Sanjappa (2011) have extensively contributed balsams from Northeast India. Vivekananthan & al. (1997) published the family Balsaminaceae in Flora of India.

Bhaskar (1975-2012) studied for more than 40 years and published a series of publications on taxonomy account, cytology and reproductive biology of the species of *Impatiens* from South India (Bhaskar 1980, 1981, 2006; Bhaskar & Razi 1973, 1974, 1978, 1979, 1983). His life time work published as a monograph on *Impatiens* of Western Ghats (Bhaskar, 2012). This piece of work greatly revived the interest in *Impatiens* study of the region and in the subsequent years between 2013-2017, eighteen new species were described (Narayanan & al., 2013; Hareesh & al., 2015; Prabhukumar & al., 2015a, 2015b, 2017; Ramasubbu & al., 2015a, 2015b, 2017; Chhabra & al., 2016; Bhaskar & Sringeswara 2017; Joe & al., 2017; Lali & Bhaskar, 2017; Mani & Thomas, 2017; Manudev & al., 2017).

In the adjacent region, mainly in Nepal the study of *Impatiens* was revived in the middle of last century by Hara (1965, 1972); Akiyama (1987, 1991, 2017); Akiyama & al. (1991, 1992); Akiyama & Ohba (1993, 2000, 2004, 2015a, 2015b, 2016). While the Chinese *Impatiens* were studied by Handel-Mazzetti (1929) & Y. L. Chen (Chen 1978, 1986, 1988, 1999, 2001). The family Balsaminaceae dealt by Chen & al., 2007 in "Flora of China" is one of the largest contribution to the genus from the country with highest number of species. This publication provided new impetus and a score of new species discovered further. (Tan & al., 2015; Zeng & al., 2015; Ding & al., 2016, 2017; Guo & al., 2016a). Similarly, a number of species of *Impatiens* were also described and studied from Southeast Asian nations (Ruchisansakun & al., 2014, 2017; Souvannakhommane & Suksathan, 2015; Tanaka & al., 2015; Kiew 2016; Cho & al. 2017; Yang & al. 2017). Several species were found out of earlier known distribution (Chinh & al., 2015; Guo & al., 2016b; Hoang & al., 2016). Grey-Wilson (1991) enumerated the diversity of the genus in Bhutan.

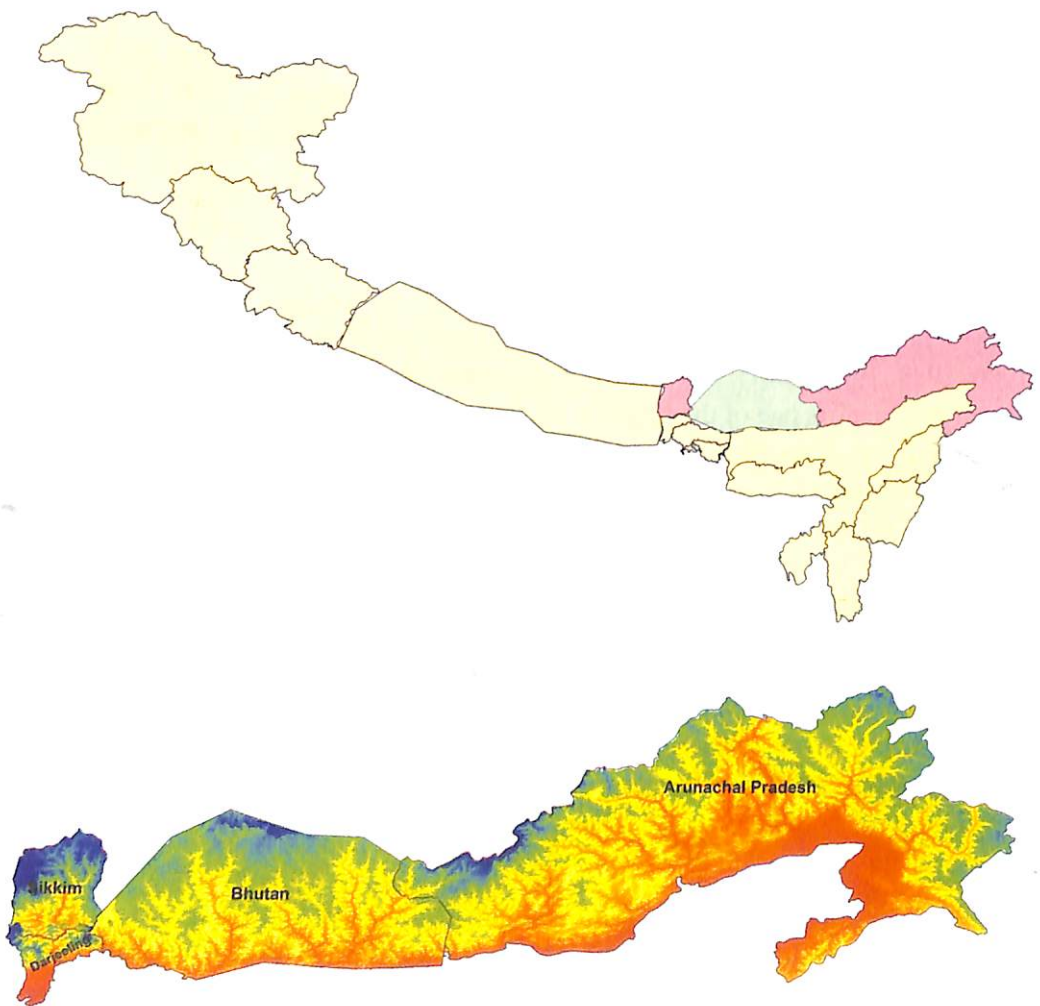
AREA OF STUDY

The present study area comprises of the Bhutan, Sikkim, Darjeeling Hill region of West Bengal and Arunachal Pradesh. The region is one of the most young, fragile and complex eco-system in the world with great variety of habitats and rich floristic diversity. It has also been included among Earth's biodiversity hotspots, endowed with a rich variety of gene pools and species and also supports a high level of endemism (Singh & al., 2015). It is estimated that the Eastern Himalaya harbours more than 8500 species of flowering plants, nearly 50% of the total flowering plants in India (Singh & Dash, 2015). The region also supports world's richest alpine flora with maximum endemism (Tse-ring & al., 2010).

VEGETATION

The vegetation and forests of Eastern Himalaya may be broadly grouped under following categories based largely on the altitude, rainfall, humidity and species compositions.

Tropical forests range up to 900 m above a.s.l. and mainly consist of tropical moist deciduous to semi evergreen elements as a dominant species. Along Teesta and Rangeet valley, pure chir pine forests seen dominated; while in Arunachal Pradesh in low altitudes *Dipterocarpus retusus* (Hollung) and *Terminalia myriocarpa* (Holluck) are dominant trees.



Map 1. Digital elevation map of Eastern Himalaya (Sikkim, Darjeeling, Bhutan & Arunachal Pradesh)
(Not in scale)

- The shady and moist river slopes with close canopy, dense ground flora along with other herbacious members is also a luxuriant habitat for *Impatiens*. Many species like *Impatiens infundibularis*, *I. laevigata*, *I. latiflora*, *I. marianae*, *I. paramjitiana*, *I. siangensis*, *I. toppinii*, *I. trilobata*, *I. tripetala* are found in this zone.

Subtropical Vegetation is found predominately between 900-1800 m. This forest can be characterized by its evergreen and dense nature. The forest has uniform species composition without any exclusively dominated species. The trees occupied the top storey are mixture of semi-evergreen and deciduous species. The semi-evergreen species are more dominant than the deciduous elements. Forest patches with humid and exposed areas, ferns and fern allies growing in moist shady places are the ideal habitat for luxuriant growth of balsam in this region. *Impatiens jurpia*, *I. lohitensis*, *I. nicolsoniana*, *I. parkinsonii*, *I. pathakiana*, *I. pseudocitrina*, *I. siculifera*, *I. vidyae*, *I. walongensis*, *I. xanthina*, *I. zironiana* etc., are found commonly in this range.

Broad-leaved Temperate Vegetation is found between 1800 and 2800 m along interior valleys, upper slopes Lesser Himalaya. This type of forest is characterized by mostly *Laurales*, *Quercus*, *Acer*, *Castanopsis*, *Magnolia* and different species of *Rhododendron*, with low proportion of deciduous species. Ground flora with rich in



Impatiens xanthina H.F.Comber in its natural habitat. a moist stream sides in Dalai valley, Chaglagam, Arunachal Pradesh



Temperate forests of Yarlung,
West Siang: habitat for a variety of species of *Impatiens*

herbaceous species makes a conducive habitat for *Impatiens*. Many species like *Impatiens racemosa*, *I. radiata*, *I. sikkimensis*, *I. spirifera*, *I. tatoensis*, *I. tropaeolifolia*, *I. uncipectala* etc. are found here.

Cool Temperate (Coniferous) Vegetation forests mainly occur between 2800 and 3500 m along the upper slopes of lesser Himalaya. This type of forest is characterized by the mixed population of *Tsuga-Pinus-Taxus* series of conifers with higher abundance of *Rhododendron* species. The different types of this mixed population in the cool temperate zone in Eastern Himalaya area are *Tsuga-Abies-Rhododendron*; pure stands of *Cupressus*; *Abies-Taxus* or *Picea-Larix-Abies* are found in many areas. The *Rhododendron* species commonly found in these forests are *R. anthopogon*, *R. barbatum*, *R. campanulatum*, and *R. cinnabarianum*, etc. While the dominant temperate coniferous species are *Tsuga dumosa*, *Abies densa*, and *Taxus wallichiana*. While in the ground vegetation *Impatiens kingii*, *I. leptocarpa*, *I. longipes*, *I. pradhanii*, *I. prainii*, *I. pyrorrhiza*, *I. recticalcarata*, *I. scabrida*, *I. scitula*, *I. serratifolia*, *I. stenantha* etc. are common.

Subalpine Vegetation is restricted in the higher elevation ranging from 3500 to 3900 m. The lower elevations of this zone support shrubby species of *Rhododendron*, *Berberis*, *Cotoneaster*, *Euonymus*, *Gaultheria*, *Salix* and *Vaccinium*, etc. while *Rhododendron anthopogon* and *R. pumilum* form dense tussocks near the sub-alpine mountain tops. Among the herbaceous flora, species of *Aconitum*, *Caltha*, *Cassiope*, *Pedicularis*, *Potentilla*, *Polygonatum*, *Primula*, *Rhodiola*, etc. are common in this zone.

The diversity of *Impatiens* is less in this zone. Very few species like *Impatiens sulcata*, *I. tuberculata*, *I. urticifolia* etc. are found in this type of forest.

Alpine Vegetation: At higher elevations, as one move above 4000 m in eastern Himalaya, the vegetation comprises typical alpine type where tree growth is completely arrested. The stunted bushy growth along these slopes consists of tough clumps of *Juniperus* spp., *Rhododendron lepidotum*, *R. anthopogon*, *Salix zangica*, *Sorbus microphylla*, *Berberis angulosa*, *B. macrosepala*, *Rosa sericea*, etc. Most of the alpine plants collected from the district have more affinity with Tibetan than Himalayan flora. Rarely *Impatiens* grow in this type of forest but *I. occultans* and *I. tuberculata* are found in this zone.

HABITAT DIVERSITY

The preferential habitat of *Impatiens* are characteristic element of tropical and subtropical or temperate forests such as open or shaded areas, stream sides, shady forest margins in subtropical and temperate region, rocky and shady mountain slopes in mixed broad leaved temperate forest, temperate *Rhododendron* mixed forest etc., between 150–4000 m, even sometimes extending upto 4300 m.

During the present study it is observed that the major concentration of the species are from upper sub-tropical to temperate areas with some species confined to subalpine zone. Most of the species of *Impatiens* cannot endure persistent drought or extended



Temperate to sub-alpine areas of Zuluk, East Sikkim
an ideal habitat for many species of *Impatiens*

exposure to direct sunlight. As a result *Impatiens* species are typically confined to stream margins, moist roadsides, waterside boulders, near waterfalls and wet montane forests.

It is observed that there was certain range of geographical distribution or habitat specificity of the species in both the states of Arunachal Pradesh and Sikkim. In Arunachal Pradesh *I. toppinii*, *I. pseudocitrina*, *I. pathakiana*, *I. tropaeolifolia*, *I. siculifera*, *I. citrina*, *I. dalaiensis* are localized in tropical to subtropical forests of Lohit and Anjaw districts; *I. adamowskiana*, *I. albopetala*, *I. ashihoi*, *I. spirifera*, *I. stenantha*, *I. uncipetala*, *I. rugosipetala*, *I. fugongensis* are distributed from upper subtropical evergreen forest to mixed temperate forests in Dibang valley region; *I. arunachalensis*, *I. longipes*, *I. scitula*, *I. siangensis*, *I. tatoensis*, *I. urticifolia*, *I. prainii* are recorded from tropical to temperate forests of Siang Valley area; *I. xanthina* is recorded from Anjaw and Lower Dibang Valley districts; *I. vidyae* has a localized distribution in evergreen tropical to subtropical forest in Kurung Kumey district; *I. bracteolata*, *I. chungtienensis*, *I. duclouxii*, *I. gammiei*, *I. pseudolaevigata*, *I. racemosa* are common mainly in the subtropical evergreen forests to mixed temperate forests in West Kameng District; *I. tricornis* and *I. pyrrohiza* are recorded from upper temperate to subalpine rhododendron forests in Tawang and West Kameng districts; *I. zironiana* and *I. jurpia* are seen in localized areas in subtropical forests of Lower Subansiri district; *I. latiflora* is commonly found in Papumpare, East Siang, West Siang, Tirap and Changlang districts; *I. marianae*, *I. porrecta*, *I. drepanophora* are recorded from Eastern Arunachal Pradesh bordering to Assam in lower elevations; *I. tripetala* is a common species in the low



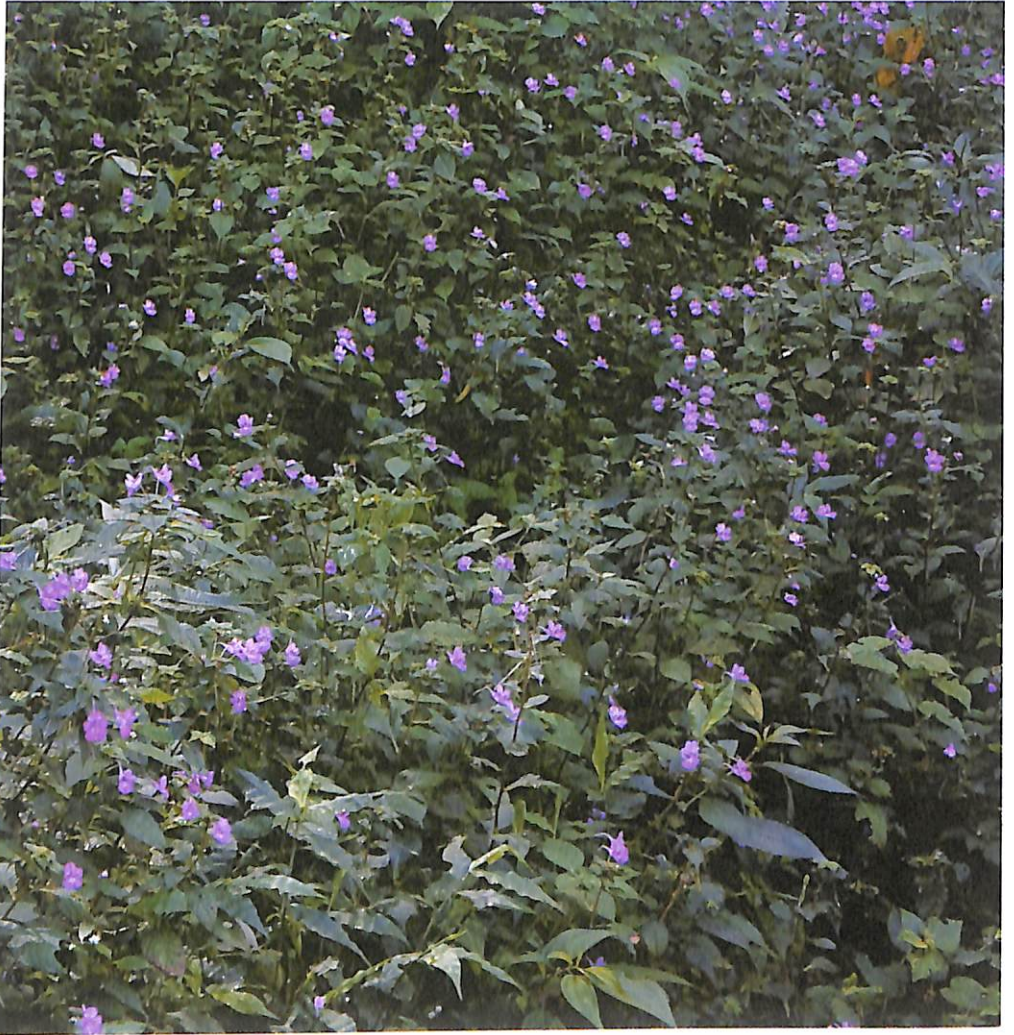
Lofty mountain ranges of Eastern Himalaya constitutes many isolated micro habitat pockets for members of *Impatiens*

altitude areas from 150-1000 m, and presence of *I. arguta* was observed almost in all the districts at altitude range of 1200-2000 m; *I. pulchra* and *I. nicolsoniana* are confined mainly in Tirap and Changlang districts of the state and *I. paramjitiana* found growing in Upper Subansiri district in tropical forest margins, moist road/stream sides; *I. pathakiana* having ability to thrive in less moist sub-rocky environment in the hilly slopes near Dalai Valley of Anjaw district.

While in the state of Sikkim *I. arguta*, *I. exilis*, *I. racemosa*, *I. cathcartii*, *I. drepanophora*, *I. stenantha*, *I. uncipectala* are common from tropical to subtropical forests of Gangtok, Bhusuk, Lingtum, Chungtang, Ravangla, Assamlingep, Pangthang, Maenum WLS, Palling, and Ravangla to Namchi road. *I. stenantha* demonstrates a high range of adaptability to thrive in colder regions of temperate to subalpine forests. The species is collected from places like 15th Mile area near Chango Lake, below Lachung and Lachen, Zuluk area. *I. decipiens* is a most common species found in tropical forests and quite often found along roadsides of Kabi, Mangan, Gangtok to Bhusuk, Assamlingzey, Dikchu, Lower Polok. *I. florigera* is endemic and only located in upper tropical forests of Lower Yuksam of West Sikkim. *I. pradhanii* is another typical species from Sikkim Himalaya that found commonly in upper subtropical to temperate forests above Ravangla, upper reaches of Maenum WLS, 9th Mile to above way to Changu Lake, Okhrey and Bershey Rhododendron Sanctuary. *I. falcifera*, *I. cymbifera*, *I. radiata* occur along moist roadside forest margins or in rocky stream or mountain slopes of the temperate or subalpine forests of 9th mile to 15th mile way to Changu lake, Zuluk and upper zone of Maenum WLS, Barshey Rhododendron Sanctuary. *I. sikkimensis* was only recorded from subtropical broadleaved forest of Tendong RF. *I. kingii* and *I. recticalcarata* are recorded with localized distribution in Changu lake area in the upper temperate to subalpine forests in the rock crevices or within moist boulders. *I. spirifera* also has a restricted distribution in temperate forests of Chungthang and Lachen. *I. sulcata* grows commonly in upper temperate forests of Lachung, Lachen of North Sikkim and Mementsu Lake area of East Sikkim. *I. scabrifera* grow as a weed in fallow lands or abandoned forest clearances in Temperate region of Lachung and Lachen. *I. hobsonii* is an endemic species grows abundantly in moist hilly slopes in the temperate Rhododendron mixed forests of Barsey Rhododendron sanctuary. *I. puberula* and *I. graciliflora* are recorded from temperate forest margins of Okhery of West Sikkim. *I. puberula* is also collected from 5th mile area on way to Changu lake of East Sikkim.

DISTRIBUTION

During this study, the distribution of *Impatiens* species along altitudinal gradient is analyzed. The range of distribution of all the 80 taxa is presented in Table 1. In Arunachal Pradesh the members of the genus are distributed between 150 m to 4000 m. Species like *I. tripetala*, *I. porrecta*, *I. laevigata* var. *laevigata*, *I. laevigata* var. *grandifolia*, *I. marianae*, *I. siangensis*, *I. latiflora*, *I. toppinii* are recorded from lower altitude in between 250 m to 1200 m altitude mainly in tropical forests. *I. bracteolata*, *I. citrina*, *I. duclouxii*, *I. haridasanii*, *I. jurpia*, *I. vidyae*, *I. tatoensis*, *I. tropaeolifolia*, *I. walongensis*, *I. xanthina* and *I. zironiana* are elements of subtropical forests found between 900-2200 m altitude while *I. dibangensis*, *I. albopetala*, *I. rugosipetala*, *I. adamowskiana* occurs between 2600-3000 m altitude in temperate forest. *I. anjawensis*,



Luxuriant growth of *Impatiens decipiens* Hook.f. in and around Mangan, North Sikkim

I. pyrorrhiza, *I. tricornis*, *I. urticifolia* are found between 3200-4000 m in higher reaches of Anjaw district, Tawang, West Kameng, Kurung Kumey and West Siang districts.

While in Sikkim, *I. exilis*, *I. tripetala*, *I. trilobata*, *I. florifera* are found between 400-800 m in low altitudinal tropical forest margins, stream sides, near waterfalls. *I. cathcartii*, *I. decipiens*, *I. infundibularis*, *I. drepanophora*, *I. stenantha* are distributed in the upper tropical forests to broadleaved subtropical forest margins, between 600-2400 m. *I. racemosa* also has an exclusive altitudinal range of distribution between 1700-3000 m. *I. sikkimensis*, *I. spirifera*, *I. arguta*, *I. uncipectala* are species found in subtropical to broadleaved temperate forests ranging between 1200-2400 m. In Sikkim, *I. cymbifera*, *I. falcifera*, *I. gamblei*, *I. gammiei*, *I. hobsonii*, *I. kingii*, *I. recticalcarata*, *I. sulcata*, *I. serratifolia* are found in temperate to subalpine regions between 1800-3600 m and *I. tuberculata*, *I. occultans* and *I. wallichii* are found in the high mountain slopes of East and west Sikkim in ranges between 3000-4350 m.

Table 1: The altitudinal distribution of *Impatiens* L. in Eastern Himalaya

Sl. No.	Name of the species	Altitude – Meters (m.) above sea level
1	<i>Impatiens adamowskiana</i>	3000-3150
2	<i>Impatiens albopetala</i>	2100-2850
3	<i>Impatiens anjawensis</i>	3000-3900
4	<i>Impatiens arguta</i>	1150-3000
5	<i>Impatiens arunachalensis</i>	1150-2550
6	<i>Impatiens ashitai</i>	1150-2600
7	<i>Impatiens bracteolata</i>	1050-1950
8	<i>Impatiens calicutii</i>	550-2000
9	<i>Impatiens chungtienensis</i>	1150-3600
10	<i>Impatiens citrina</i>	1050-2000
11	<i>Impatiens cyclosepala</i>	2100-3000
12	<i>Impatiens cymbifera</i>	2650-3800
13	<i>Impatiens dalatensis</i>	1350-2100
14	<i>Impatiens dibangensis</i>	2100-3150
15	<i>Impatiens decipiens</i>	750-2000
16	<i>Impatiens discolor</i>	1500-3000
17	<i>Impatiens dorjeeekhandui</i>	1550-2300
18	<i>Impatiens drepanophora</i>	1050-2000
19	<i>Impatiens duclouxii</i>	900-2100
20	<i>Impatiens exilis</i>	450-1400
21	<i>Impatiens falcifera</i>	2250-4050
22	<i>Impatiens florigera</i>	1500-2700
23	<i>Impatiens fugongensis</i>	1750-2700
24	<i>Impatiens gamblei</i>	1750-3800
25	<i>Impatiens ganniei</i>	2100-3600
26	<i>Impatiens graciliflora</i>	2100-3000

Sl. No.	Name of the species	Altitude - Meters (m.) above sea level
27	<i>Impatiens haridasanii</i>	1100-2100
28	<i>Impatiens hobsonii</i>	1650-2850
29	<i>Impatiens idumishmiensis</i>	1650-2550
30	<i>Impatiens infundibularis</i>	1650-2100
31	<i>Impatiens jurpua</i>	750-2100
32	<i>Impatiens kangii</i>	1650-2850
33	<i>Impatiens laevigata</i>	1100-2100
	var. <i>laevigata</i>	1100-2100
	var. <i>grandifolia</i>	1100-2100
34	<i>Impatiens latiflora</i>	300-1350
35	<i>Impatiens laxiflora</i>	1650-2850
36	<i>Impatiens leptocarpa</i>	2850-3750
37	<i>Impatiens lohitenis</i>	1650-2850
38	<i>Impatiens longipes</i>	1650-2850
39	<i>Impatiens maritanae</i>	2400-3600
40	<i>Impatiens nilalohitae</i>	1350-2400
41	<i>Impatiens nicolsoniana</i>	1650-2850
42	<i>Impatiens occultans</i>	1650-2850
43	<i>Impatiens paramejitiana</i>	1650-2850
44	<i>Impatiens parkinsonii</i>	1350-1550
45	<i>Impatiens pathakiana</i>	450-1200
46	<i>Impatiens porrecta</i>	300-1200
47	<i>Impatiens pradhamii</i>	1650-2850
48	<i>Impatiens pratii</i>	1650-2850
49	<i>Impatiens pseudocitrina</i>	2400-3900
50	<i>Impatiens pseudolaevigata</i>	1500-2700
51	<i>Impatiens puberula</i>	1650-2850

MORPHOLOGY

Morphology, particularly the foliar and floral characters plays an important role in segregating the species in genus *Impatiens*. All the members of *Impatiens* are invariably annuals (e.g., *I. arguta*, *I. tripetala*, *I. radiata*, *I. trilobata*, *I. porrecta*, *I. uncipectala*) or perennial herbs (e.g., *I. lohitensis*, *I. laevigata*, *I. pseudolaevigata*, *I. marianae*, *I. latiflora*, *I. adamowskiana*); however, occasionally some species are found growing as sub-shrubs.

The plants are mainly succulent in nature with thick, fleshy and translucent stems. The stems are mostly variable, erect, procumbent and often with swollen nodes, occasionally with adventitious roots at lower nodes.

The leaves of *Impatiens* are generally fleshy, membranous very much susceptible to external damage. As a ground rule, the shapes of the leaves are ovate to lanceolate with serrated margin, but the size is highly variable. Different shapes of leaves are observed in members of *Impatiens* of Eastern Himalayas are shown in Plate i & ii. There are two major types of leaf arrangement, i.e. alternate and opposite, however verticillate arrangement is also observed in some selected species (*I. adamowskiana*, *I. paramjitiana*). All the species occurring in Eastern Himalaya, have alternate arrangement, except *I. florigera*, *I. trilobata* and *I. tripetala* which are with opposite leaves.

Floral Morphology

The flowers of *Impatiens* are fleshy and quite delicate in nature. The complex floral morphology in *Impatiens* is an important criterion for taxonomic delimitation. The bizarre floral morphology has attracted a good numbers of workers over the years (Wight, 1846; Hooker & Thomson, 1859; Henfrey, 1860; Warburg & Reiche, 1897 etc.). Based on the overall morphology several types of inflorescences can be distinguished within *Impatiens*, but the relationships among these groups remain unresolved. The taxonomic difficulties are probably due to the existence of a large number of intermediate groups and taxa (Grey-Wilson, 1980a). For determination not only the interpretation of floral structures but also the positions of the various floral organs are important (Grey-Wilson, 1980; Bhaskar, 2012). The inflorescences of the members of the present study are highly variable. For convenience, we have recognised following types of inflorescence (after Akiyama & Ohba, 2000) with some modifications.

a. Ascending Racemose Inflorescence: This type of inflorescence is characterized by a long staring ascending peduncle with few to numerous flowers. This type of inflorescence is common in *I. drepanophora*, *I. racemosa*, *I. stenantha*, *I. scitula*, *I. adamowskiana*, *I. albopetala*, *I. parkinsonii*. (Plate iii a.)

b. Pendulous Racemose Inflorescence: This type inflorescences is the typical many-flowered racemose with the peduncles and rachis pendulous and the bract at the base of pedicels. This type is commonly found in *I. jurpia*, *I. longipes*, *I. urticifolia*, *I. dibangensis*, *I. hobsonii*. (Plate iii b.)

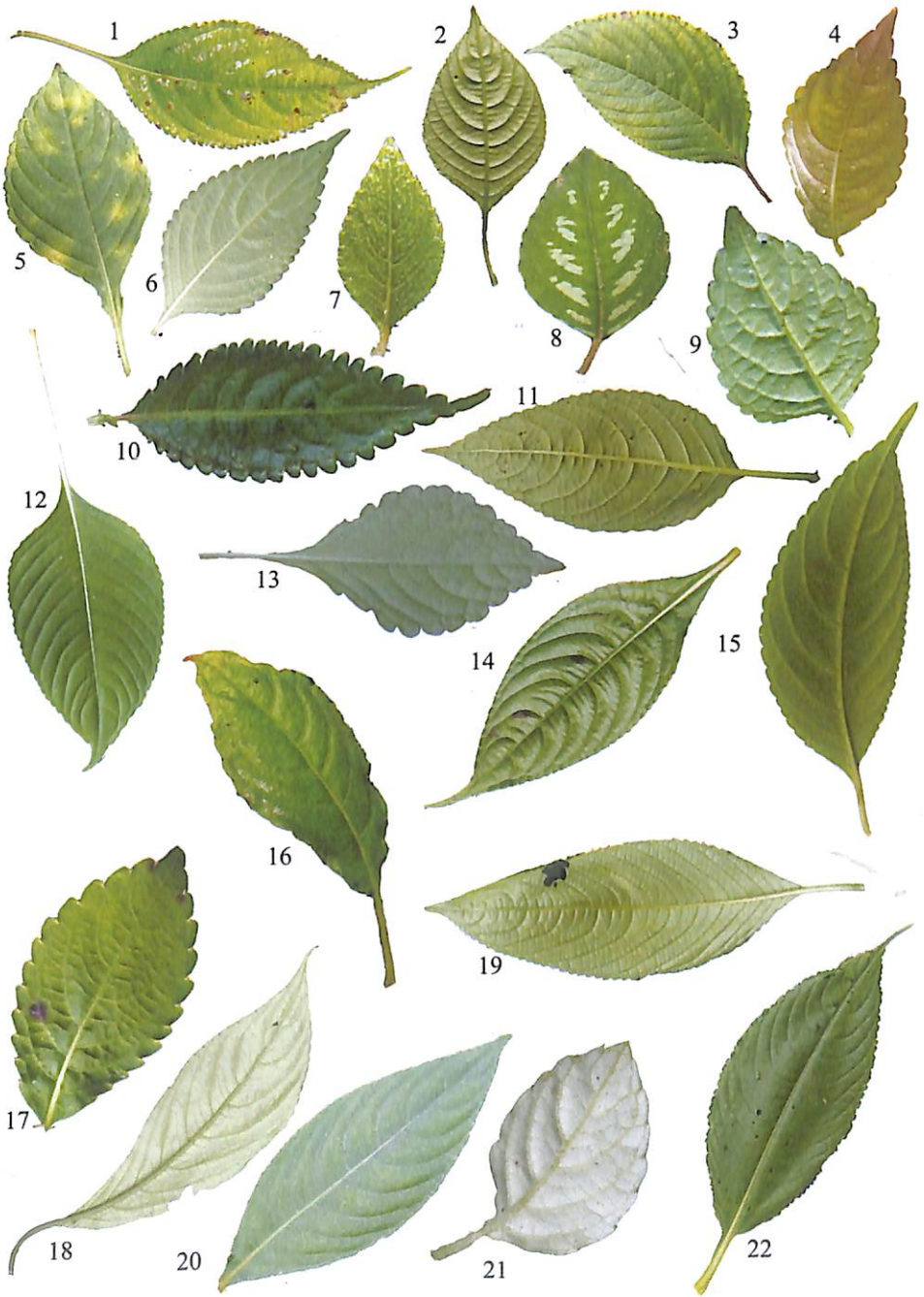


Plate i. Representative leaf types in different species of *Impatiens* of Eastern Himalaya: 1. *I. albopetala*; 2. *I. arguta*; 3. *I. cathcartii*; 4. *I. dibangensis*; 5. *I. decipiens*; 6. *I. drepanophora*; 7. *I. haridasanii*; 8. *I. marianae*; 9. *I. recticalcarata*; 10. *I. stanantha*; 11. *I. sulcata*; 12. *I. tripetala*; 13. *I. anjawensis*; 14. *I. cymbifera*; 15. *I. discolor*; 16. *I. fugongensis*; 17. *I. kingii*; 18. *I. laevigata* var. *grandifolia*; 19. *I. lohitensis*; 20. *I. latiflora*; 21. *I. porrecta*; 22. *I. pradhanii*.



Plate ii. Representative leaf types in different species of *Impatiens* of Eastern Himalaya: 1. *I. puberula*; 2. *I. pulchra*; 3. *I. racemosa*; 4. *I. scabrata*; 5. *I. siangensis*; 6. *I. sikkimensis*; 7. *I. toppinii*; 8. *I. trilobata*; 9. *I. walongensis*; 10. *I. zironiana*; 11. *I. adamowskiana*; 12. *I. ashihoi*; 13. *I. dalaiensis*; 14. *I. falcifera*; 15. *I. hobsonii*; 16. *I. graciliflora*; 17. *I. idumishmiensis*; 18. *I. pathakiana*; 19. *I. prainii*; 20. *I. radiata*; 21. *I. rugosipetala*; 22. *I. xanthina*.



Plate iii. Different types of inflorescence: **a.** Ascending racemose inflorescence, **b.** Pendulous racemose inflorescence, **c.** Interrupted racemose inflorescence (radiate inflorescence), **d.** Fascicled flowers, **e.** Solitary flower without a middle bract, **f.** Solitary flower with a middle bract, **g.** A few flowers with middle bract, **h.** Sub-umbellate inflorescence.

c. Interrupted Racemose Inflorescence (Radiate Inflorescence): Here the inflorescence is racemose, many flowers arise from a common point (node) in whorls with a elongated pedicels. *I. radiata* and *I. dalaiensis* are two species under this category. (Plate iii c.)

d. Fascicled flowers: In this type flowers are axillary and each pedicel is subtended by a bract. The peduncles are short, though the inflorescence is a raceme, the rachis is not recognized and considered as axillary. In *I. tripetala*, *I. arguta*, *I. tatoensis* this type is commonly found. (Plate iii d.)

e. Solitary flower without a middle Bract: In this type of inflorescences, flowers are solitary and looks like bractless, however a bract is evidently situated at the base of pedicel. *I. spirifera* and *I. arunachalensis* are fall under this category. (Plate iii e.)

f. Solitary flower with a middle Bract: This type is having a solitary flower with a bract at the middle portion of the stalk (*I. siangensis*, *I. paramjitiana*). (Plate iii f.)

g. A few Flowers with a middle Bract: These are the axillary inflorescence with a few stalked-flowers. *I. scabrida*, *I. uncipectala*, *I. toppinii* are commons under this category. (Plate iii g.)

h. Sub-umbellate Inflorescence: The inflorescence is sub-umbellate and consisting of 4-5 flowers with an elongated pedicel. *I. pathakiana* and *I. pseudocitrina* are the two common example in this category. (Plate iii h.)

Flower structure: The floral structure of *Impatiens* is highly diverse, and information on the developmental and evolutionary patterns within the genus is sparse (Yuan & al., 2004). Flowers of *Impatiens* are very delicate and essentially 5-merous. The corolla consists of five petals: a large and often partly sepaloid one in the upper position called dorsal petal and four lateral ones, which are connate in pairs on the left and the right side of the flower with certain degree of modification called lateral united petals. The flowers are always zygomorphic and the zygomorphy can be described by 180° twisting of the pedicel (resupination) caused the posterior sepal to be positioned abaxially, which is assumed to be more favourable for the development of a relatively heavy nectar-producing spur, hence being the initiator of zygomorphy in *Impatiens* (Grey-Wilson, 1980). On the basis of lower sepal shape and modifications, the flowers of *Impatiens* can be recognized into four major categories as Bucciniform (Plate v. 1-11), Navicular (Plate v 12-25 & Plate vi 1-8), Tubular (Plate vi 9-12) and Spurless (Plate vi 13 & 14). The terminologies used for different floral parts in this work are depicted in Plate iv.

Lateral sepals: This is the outermost structure, most often small, sometimes could be very conspicuous and generally placed between the lower sepal and the dorsal petal: usually 4 (in 1 pairs bigger and 1 pair smaller), in many cases 1 pair completely absent or highly reduced, smaller pair positioned above or sometimes remains below the bigger pair.

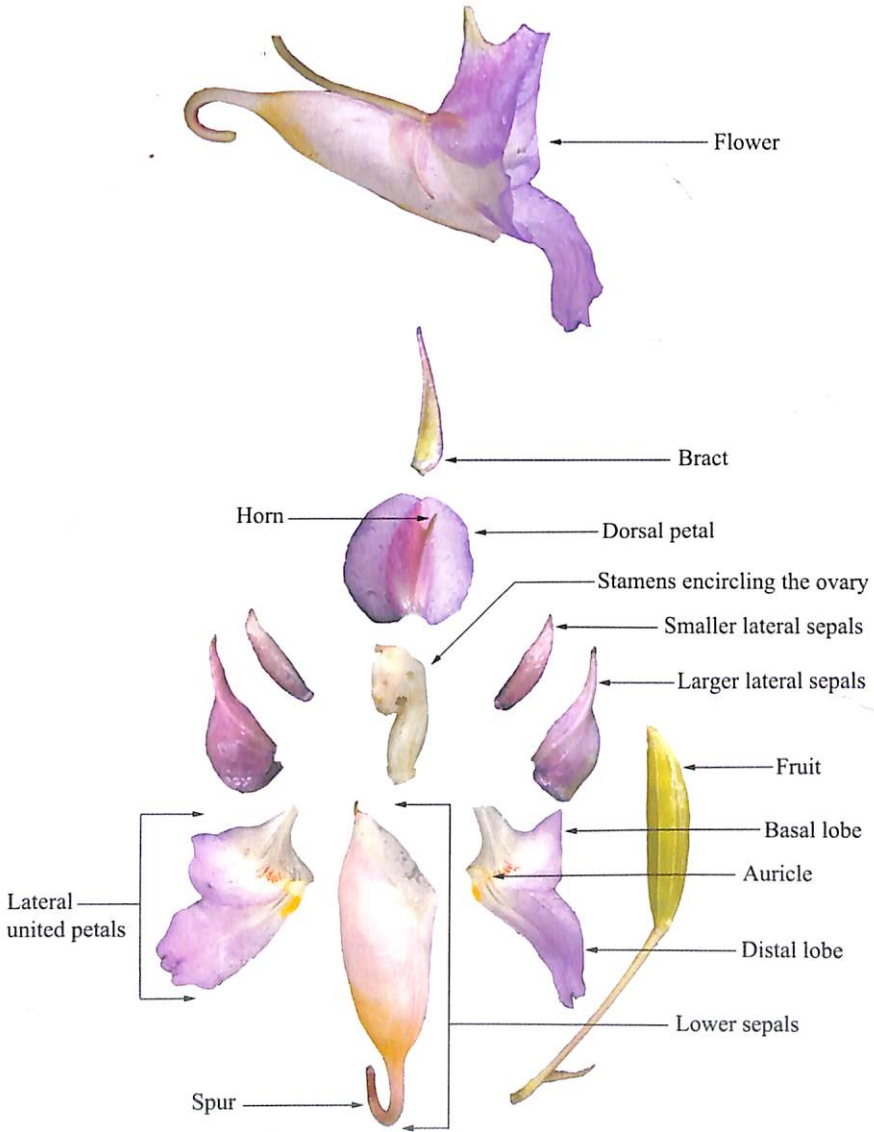


Plate iv. Different parts of typical flower of *Impatiens*



Plate v. Different types of flower in *Impatiens* species of Eastern Himalaya. Bucciniform flower (1-11): 1. *I. cathcartii*; 2. *I. discolor*; 3. *I. kingii*; 4. *I. sulcata*; 5. *I. tatoensis*; 6. *I. uncipectala*; 7. *I. urticifolia*; 8. *I. walongensis*; 9. *I. arunachalensis*; 10. *I. chungtienensis*; 11. *I. cymbifera*. Navicular flower (12-25): 12. *I. pradhanii*; 13. *I. tripetala*; 14. *I. adamowskiana*; 15. *I. citrina*; 16. *I. stenantha*; 17. *I. drepanophora*; 18. *I. rugosipetala*; 19. *I. decipiens*; 20. *I. falcifera*; 21. *I. graciliflora*; 22. *I. pathakiana*; 23. *I. sikkimensis*; 24. *I. toppinii*; 25. *I. xanthina*.

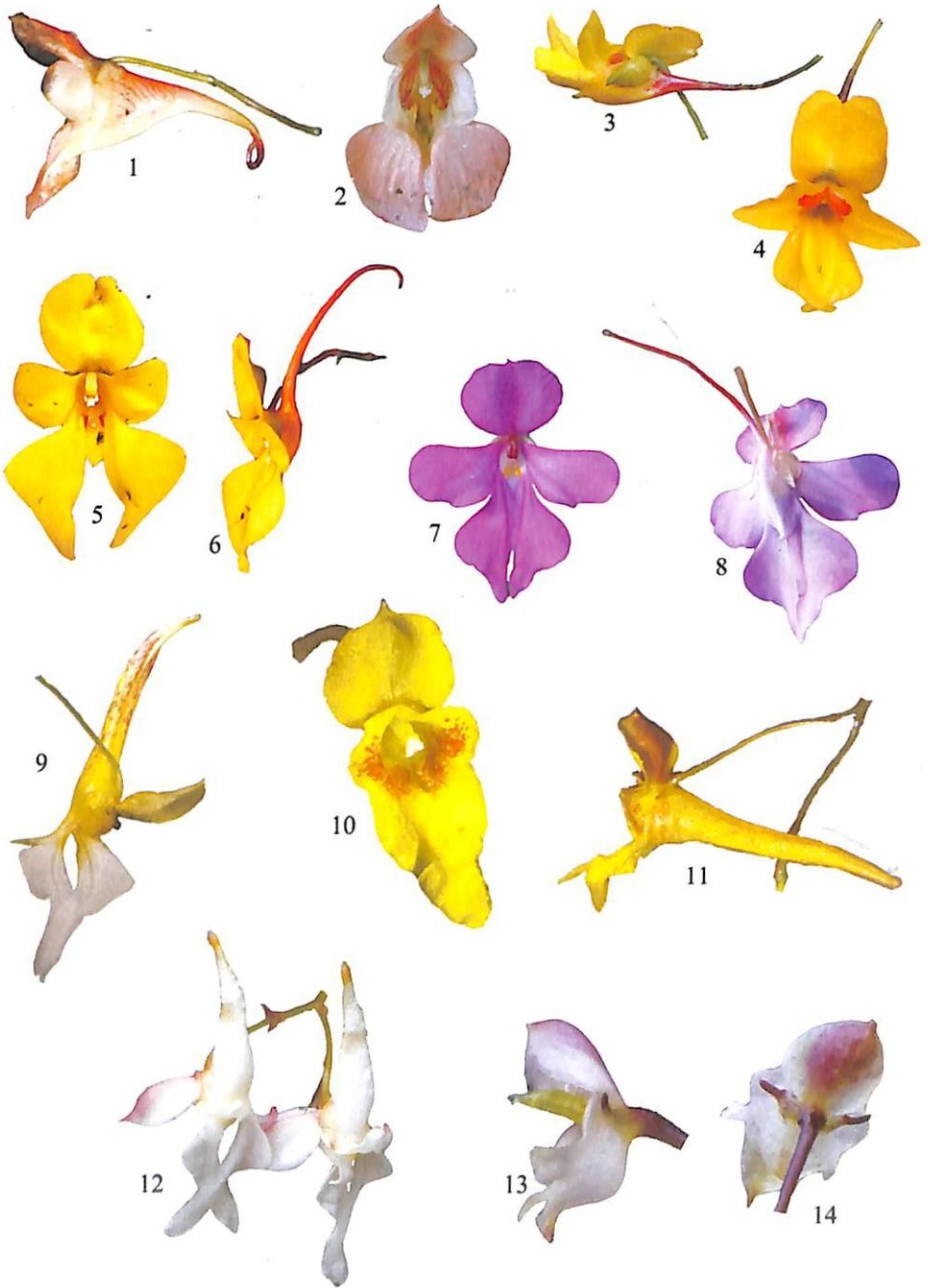


Plate vi. Different types of flower in *Impatiens* species of Eastern Himalaya, Navicular flower (1-8): 1-2. *I. pulchra*; 3-4. *I. lohitensis*; 5-6. *I. idumishmiensis*; 7-8. *I. latiflora*. Tubular flower (9-12): 9. *I. albopetala*; 10-11. *I. dibangensis*; 12. *I. prainii*. Spurless flower (13-14): 13-14. *I. gammiei*.