Chapter I

INTRODUCTION

1. INTRODUCTION
Globally 36 biodiversity hot spots have been identified, out of which 3 are located in India viz., Eastern Himalayas, Western Ghats and Andaman & Nicobar Islands. India has been recognized as one of the 14 mega-diversity centers in the world and nurtures enormous plant diversity with more than 47,000 plant species. Of which 17,500 are representing flowering plants and thus accounts for 7% of the worlds known flowering plants (Singh and Chowdhery, 2002). Out of that 33% are endemic to this sub-continent. Unfortunately, this plant wealth is declining at a faster pace due to habitat loss, fragmentation of populations, over exploitation, invasion of exotics, reproductive constraints, pollution, climate change etc., (Rathcke and Jules, 1993). Singh and Khurana (2002) reported that, about 25% of the higher plant species is expected to disappear in the next few decades and another 25% may be lost by the end of the 21st century.

The growing awareness of the importance of plant diversity and their rapid decline has given an unprecedented impetus for monitoring and conservation. There are several approaches and techniques have been proposed and implemented for both in-situ and ex-situ conservation of plant resources. The ex-situ approach finds more application for economic plants while in-situ approach generally practiced for wild species. However, the existing conservation strategies do not guarantee an effective protection of the rare, endangered and threatened (RET) taxa of the country and therefore seek alternate approaches that could be complementary for the existing ones.

India ranks 6th for having the largest number of threatened plant species (IUCN, 2004) due to habitat loss, degradation and reproductive syndrome. Therefore, the best way to go about conserving any forest biodiversity resources is to make a
scientific study on population dynamics (ecology) of plants, animals, microbes etc. and to assess their physical fitness in the community for their survival. Most importantly the reproductive dynamics of forest dwelling plants needs to be focused since the herbivores directly depend on them. There is great worldwide interest in the study of rare, endangered and threatened plants these days because of the chances of them becoming extinct due to various reasons (Pandurangan and Pushpangadan, 1997). It is necessary to understand the biology of such species to ascertain the causal factors which lead to reproductive failures. A species become rare due to its narrow range of habitat, low climate tolerance, specialized adaptation for pollination, poor dispersal strategies, low fruit and seed set coupled with poor viability.

Plant reproductive dynamics plays an important role in understanding post pollination events, species recruitment, fitness and evolution. It is the study of the mechanism and processes of sexual and asexual reproduction in plants which include floral biology, pollination mechanisms, gene flow, genetic variation between and within population etc. By studying their life history traits one could predicts the distribution of genetic diversity within and between populations (Hamrick and Godt, 1996; 1996a). Therefore, adequate knowledge on reproductive biology is essential for conservation, management and recovery of endemic and endangered species. By studying the reproductive biology of RET species, we can understand the exact causal factors inducing rarity and can overcome these factors through scientific intervention, so as to protect the species from endangerment and also provide an insight of the reproductive constraints, a species faces in the nature.
Fragmentation of populations, habitat degradation, narrow distribution and overexploitation are the most apparent causal factors for population reduction of many endemic species. Habitat loss and fragmentation have become great concerns to conservation biologist as anthropogenic activities and environmental deterioration have broken large, continuous populations into small and isolated ones (Kang et al., 2005). Populations in fragmented habitats are considered more vulnerable to demographic, environmental and genetic stochasticity and therefore face a higher risk of local extinction (Boyce, 1992; Tilman et al., 1994; Lande, 1999). In general, Plant species in fragmented populations may lose allelic richness or genetic diversity. Any potential disturbances in pollinator service and seed dispersal have increased population differentiation due to genetic drift and inbreeding depression (Jennerstean, 1988; Rathcke and Jules, 1993; Kwack et al., 1998; Buza et al., 2000; Spira, 2001; Shea and Furnier, 2002; Tomimatsu and Ohara, 2003). Over the time, this can lead to increased inbreeding, lower reproductive success and disrupted gene flow (Ellstrand and Elam, 1993; Steffan-Dewenter and Tscharntke, 1999).

Population genetic information is a prerequisite in understanding the species survival possibility in the short term, so that an effective conservation strategy for long term survival can be formulated and implemented. In certain cases, the failure of reproductive process due to environmental changes is often the fundamental reason for species loss. Sexual reproduction is the only natural process that incorporates variability and ensures survival of a species under adverse condition (Monika and Bhatnagar, 2007). Sexual reproduction is based on the phenomenon of syngamy and double fertilization. Successful
fertilization is dependent on effective pollination. Therefore, pollination studies can provide a lot of information about the population reduction of many species, because it is the fundamental step in plant reproduction. Successful pollination is an essential prerequisite for survival of plants in natural communities and is dependent on many biotic and abiotic factors. Plants have co-evolved with their pollinators and any ecological changes can decouple the process of flowering and breeding cycles.

The balsams are beautiful plants bearing curious and variously colored flowers with peculiar floral structure. The members are annual or perennial herbs with flowers that exhibit a remarkable diversity (Janssens et al., 2006), which is supposed to be one of the largest groups among the flowering plants (Pandurangan, 1996; Sreekala et al., 2007; Kulloli et al., 2008). The family Balsaminaceae comprising more than 1,000 species with two genera, the monotypic Hydrocera Blume and the large genus Impatiens L. (Fischer, 2004). The members are popularly known as Balsams, Jewel weed, Snap weed or Touch-me-not (Willis, 1973) busy-lizzy (Caris et al., 2006).

The sister group relationship between Hydrocera and Impatiens is also confirmed by recent molecular analysis (Fujihashi et al., 2002; Yuan et al., 2004). Based on the overall morphology and distribution of several groups can be distinguished within Impatiens, but the relationship among these groups remains unresolved. Though the two genera are similar, several features distinguished them. Hydrocera has five sepals and five free petals, while Impatiens usually has three sepals and always five petals, four of which are united into two lateral petals. In addition Hydrocera produces an indehiscent pseudo berry
(Grey-Wilson, 1980; Raghuveer et al., 1993), whereas *Impatiens* has an explosively dehiscent capsule.

*Impatiens* is mainly distributed in the tropics and subtropics of old world, but several species occur in temperate Eurasia and North America (Caris et al., 2006). Native species are absent from South America and Australia. A high diversity of *Impatiens* is found in five conspicuous hotspots: Tropical Africa, (ca. 109 species; Grey-Wilson 1980), Madagascar (ca. 120 species; Fischer and Rahelivololona, 2002), Southern India and Sri Lanka (ca. 150 species), the eastern Himalaya (ca. 120 species) and South East Asia in its broad sense (including Burma, Thailand, Southwest China, Indo-China peninsula and Malesian archipelagos (ca. 250 species) (Yuan et al. 2004). Many new species are still to being described from these regions (Chen, 2000; Shimizu, 2000; Fischer et al., 2003; Huang et al., 2003). High proportions of local endemism are associated with these hotspots, for example, as many as 91% of the Southern Indian species are endemic (Rao et al., 1986), and almost all the native species of Madagascar are endemic (Fig. 2).

In India, the concentration of *Impatiens* is remarkably local and occurs in three well defined regions viz., the Western Himalayas, hills of North Eastern States and the Western Ghats. Two hundred and ten species have been found in India (Pandurangan, l.c.; Vivekananthan et al., 1997; Dessai and Janar thanam, 2008; Sreekala et al., 2008; Kulloli et al., 2009) which represents approximately 21% of *Impatiens* species globally (Fig. 1). Most of them found in the Western Ghats and Western Himalayas are endemic to the country or are restricted to a number of provinces (Pandurangan, 1996). The geographical distribution of *Impatiens* is very localized and endemic (Tian et
al., 2004). In Peninsular India, there are 94 species of *Impatiens* currently reported, out of which 86 are endemic and confined to the Western Ghats (Rajalal et al., 1996; Kulloli et al., 2009a). Due to their restricted distribution and island biogeography, nearly 30 species are already in threatened category with uncertain future (Vajravelu and Daniel, 1983; Pandurangan and Pushpangadan, 1997; Sreekala et al., 2007).

Though the ideal climatic conditions prevailing in the Western Ghats region provide suitable habitat for *Impatiens*, their populations are rapidly declining due to various reasons such as habitat destruction and degradation resulting fragmentation of populations in their narrow environmental niche where reproductive constraints increases by elimination or reduction of pollinators. Detailed information on the reproductive dynamics of the plant species is essential for developing effective strategies for their conservation and sustainable utilization. Against this background, the reproductive dynamics and conservation strategies of 3 *Impatiens* species viz., *Impatiens gardneriana* Wight, *I. grandis* Heyne ex Wall., and *I. verticillata* Wight were selected for the present investigation. These species are not only endemic to Western Ghats but also endangered in their habitats and hence the investigation assumes a great significance in understanding their reproductive problems/success in nature as well as provides first hand information on reproductive capacity and reasons for rarity and waning in their natural habitats. The study focused on phenology, pollination, pollen-pistil interactions, plant-pollinator interactions, breeding systems, stigma receptivity, seed and fruit dispersal, seed germination, recruitment etc. This will facilitate to prioritize there species to
include in the conservation programme, which eventually pave the way for improving the populations in the long term.

1.1. Western Ghats

Western Ghats, a chain of mountains in the western peninsula of India extending from Tapti River in Gujarat to Kanyakumari in the Tamil Nadu, is about 1600 km long in the North-south direction. The only gap in this chain is the Palghat gap. The region lies between 8° 20’-21’ N latitudes and 73°-77° E longitudes. Their height varies from 300-1500 m excluding certain isolated peaks. The highest point is Anaimudi peak at 2695 m, the south of Himalayas, situated in Kerala State. The Western Ghats, one of the 34 mega biodiversity hot-spots of the world (Myers et al., 2000), covers 5% of India’s land area, yet contains more than 5000 or 30% of the country’s total plant species. From north to south the Ghats passes through the states of Gujarat, Maharashtra, Goa, Karnataka, Tamil Nadu and Kerala (Fig. 2).

Western Ghats receives about 60% of the annual rainfall during south-west monsoon (June-August), 25% during north east Monsoons (September-November) and the remaining 15 % during summer months. The average rainfall varies from 2500 mm in the north to 7000 mm in the southern region. This is due to delayed arrival of South-West monsoon in the north and an earlier withdrawal, cutting short the rainy days. The mean annual temperature is around 25°C in the north and in the south, where rainfalls is more; the mean annual temperature is about 21°C. The hot and humid tropical climate complimented by heavy precipitation from southwest monsoon and favorable edaphic factors create and ideal condition for the luxuriant growth of plant life, which can be seen only in few parts of the world. There are
seven main soil types found in the region viz., laterites (high and low), red loam, medium black soils, hill soils, red gravelly soils, alluvial soils including coastal alluvium, mixed red and black soils (Champion, 1936; Shetty and Vivekananthan, 1971).

Floristically, the Western Ghats is one of the richest areas in the country, which harbours as many as 5000 species of flowering plants of which 2100 species representing 56 genera are endemic. Due to its geographical position, variation in altitudinal and latitudinal ranges and influence of both the monsoons favour varied type of vegetation, including tropical evergreen forests, scrub jungles, sholas, montane grasslands etc. Botanically, the region falls under Malabar Province of erstwhile British India (Hooker, 1907). The flora of the area are well studied by various workers: Hooker (1872-1897), Nairne (1894), Cooke (1901-1908), Bourdillon (1908), Rama Rao (1914), Fyson (1915), Gamble (1916-1936), Fischer (1921), Fyson (1932), Barnes (1939); Santapau (1960), Subramanyan and Nayar (1974), Pascal (1988), Manilal (1988), Nair (1991), Vivekananthan et al. (1997), Hajra et al. (1997), Swaminathan et al. (2001), Sasidharan (2004), Daniel (2005), Nayar et al. (2006), Daniel and Venkatesan (2008).

1.2. Geographical distribution of the genus *Impatiens* L.

*Impatiens* is a sub-cosmopolitan genus belonging to the family Balsaminaceae, and its major centers of diversity are the highlands and mountains of the old world tropics and subtropics (Mani, 1974; Grey Wilson, 1980; Bhaskar, 2012). It occurs mainly in the montane regions of tropical Asia and Africa and also reported from Myanmar, Jawa, Madagascar, Philippines, Sri Lanka and Sumatra (Bhaskar, 1981) (Fig. 1). Hooker and Thomson (1860) pointed out that *Impatiens* attains its maximum
development in India and that Western Ghats is the most prolific area. Barnes (1939), who made extensive collection on the high ranges of Kerala and published an account of the genus under the family Geraniaceae. He recorded 12 species of *Impatiens* endemic to high ranges and also found more than 30 species concentrated within a radius of 16 km of Munnar and most of them continued in a smaller geographical area (Fig. 3).

The Peninsular balsams are distributed in contrast to the Himalayan and Myanmar (Burmese) ones. Of the 2 main groups of the genus namely the short capsule and long capsule, not even one of the latter form is to be found in the Western Ghats (Latitude 22° 06’ to 8° 04’ N). The two sections such as Scapigerae and Epiphyticae are confined to Peninsular India and Srilanka only. Seven species, namely *Impatiens barberi*, *I. denisonii*, *I. goughii*, *I. lawsonii*, *I. ligulata*, *I. parviflora* and *I. viscidia* belonging to three different sections have the dorsal auricle of wings produced into spur of lip. Of the 94 Peninsular Indian species, not even one has two additional lateral sepals, a features that is frequently seen in Himalayan and Burmese species, only 2 species namely *I. balsamina*, *I. chineneis* are common to Himalaya and the Peninsula India. Regarding the distribution of balsams in various parts of the Western Ghats, Hooker (1910) has pointed out that the Palghat Gap acts as the chief dividing factor. From their present distribution pattern, it seems that, the scapigerous balsams originated in the Western Ghats, North of the Palghat Gap and the caulescent pedunculate species to the South.

According to Chatterjee (1939) *Impatiens* is undoubtedly the largest genus in British India (including Myanmar, but excluding Malaya, Sri Lanka and Tibet) with about 241 species.
Bhaskar (1981) studied the genus in South India and stated that it contains over 200 species in India and half of which occur in south India. According to Bhaskar (l. c.), it is phytogeographically a unique genus which has its greatest development in the Indian region. In India, the concentration of species is remarkably local and occurs in two well defined regions, viz; the Himalaya in the North and Western Ghats in the South. Impatiens has limited geographical amplitude and at-least 90% of the Indian species are restricted to the hills due to insufficient dispersal mechanism found in the genus.

The balsams are mostly herbaceous annuals, completing their life cycle in the monsoon period itself, while some are ephemerals. They are growing in montane niche-specific areas like wet dripping rocks, ravines and clefts, rocky crevices, cushions of moss on wet rocks, margins of running streams, beds of rocky streams, marshes, swamps, boggy places, undergrowth in evergreen and shola forests, wet places in open low level grasslands, high level grasslands, epiphytes on moss clad tree trunks or growing in areas that are exposed to monsoon condition for large part of the year.

Idukki district, a major part of the Anamalai high ranges, forms a center of endemism as far as balsams are concerned. It is the type locality for more than 25 species of Impatiens. The high range is one of the richest areas in the Western Ghats with respect to the species of balsams. The highly undulating mountainous configuration and the formation of a well marked upland shola forest with very high rainfall provide suitable habitat for Impatiens (Barnes, 1939). Many species of Impatiens found restricted to specific altitudinal zones and most of the exclusive endemics are found restricted in isolated pockets in the high
altitudes (2000m) of Western Ghats. According to Bhaskar (1981), the high rate of endemism in this genus is due to its orophytic nature, extreme adaptation to some particular micro climate. Most of the Indian *Impatiens*, particularly in the Western Ghats are narrow endemics and confined to specialized ecological habitats. Their colonizing abilities and regenerative capacities are very poor due to human interference and hence they become extinction prone. When the habitat is disturbed or destroyed, these endemics may become, vulnerable, endangered or even extinct. Several factors, therefore, may be responsible for the distribution and subsequent establishment of balsams in the Western Ghats.

1.3. **Endemism and rarity**

Understanding rarity has been an important task among plant ecologists. There are many ways by which a species become rare and the process has diverse ecological consequences. According to Reveal (1981), plant rarity is two fold concept associated with the biology of the species and the ecology of the area. A thorough understanding of the reproductive dynamics, identification of the biological and ecological constraints leading to reduced fitness and restricted distribution of the species is very significant to analyze the causes of rarity. Most of the species of flowering plants endemic to Peninsular India are confined to the Western Ghats (Nayar, 1980). Subramanyam and Nayar (1974) considered that, the summits of the Western Ghats are comparable to islands regarding endemic species. Endemic species are of great interest to taxonomists as some of them may be very ancient in origin while others may be comparatively new. They make phytogeographical zones distinct and unique. It is well known
that the endemic plants determine whether a region has a typical or characteristic flora or not. The high percentage of endemic elements shows that the Western Ghats have a typical flora of their own.

The *Impatiens*, a non-endemic genus, is one of the largest genera among the flowering plants and has more than 1000 species in the world (Grey-Wilson, 1980; Sreekala *et al*., 2008). It is interesting to note that such a non-endemic genus having considerable number of endemic species make the Western Ghats phytogeographically a significant zone in India. Majority of the *Impatiens* species are endemic to India. As mentioned elsewhere, out of the 94 species available in Peninsular India, 86 have restricted distribution in Western Ghats. Based on the concentration of these species three endemic areas viz., Anamalai (Anaimudi), Kodagu (Coorg) and Nilgiris were identified (Pandurangan, 1996; Nayar, 1997). Taking into account, the Kerala high ranges have maximum number of endemics and it is well accounted by Barnes (1939), Rathakrishnan *et al*., (2005), Nayar *et al*., (2006). According to Vajravelu and Daniel (1983), 30 species of balsams are in threatened category including 19 critically endangered ones. Endemics being closer to rare groups, they are more vulnerable for extinction.

The main causes of rarity appear to be fragmentation of population, habitat degradation, biological problems etc. Several factors may be responsible for disturbing and destroying habitats. Some may be natural such as land upheavals, landslides, drought, forest fire etc., while others are man-made which include deforestation, developmental activities, excessive exploitation and indiscriminate collection (Jain and Sastry, 1980). According to them (l.c.) “if endemic species are eliminated from our country it
mean they will be eliminated from the whole world, will be last to science, will be struck of the roll of biological resources of this earth”. Recent studies on *Impatiens* for the Flora of India revealed that India harbours 210 species (Vivekanandan et al., 1997; Dessai and Janarthanam, 2008; Kulloli et al., 2009). Of these, about 137 are endemic to India including 86 species from the Western Ghats and adjoining areas Nair (1991). According to him (l. c.), in India there are more than 6 well defined regions of distribution as far as *Impatiens* concerned. The distribution pattern, individuality of northern and southern species, narrow endemism, neo-endemics etc. are contributed to make *Impatiens* a key genus for phytogeographical studies.

1.4. **Origin and evolution**

It is believed that the genus *Impatiens* is a Northern one. The greatest development and concentration of the *Impatiens* in the humid Eastern Himalayas and Myanmar (Burma) supports this view. The strong development of the genus in the Peninsular India is considered to be due to its discontinuity (Chatterjee, 1939). The most striking feature is that not even a single species is common to the Himalayas and Peninsular India although both the areas contain a number of endemic species except *Impatiens balsamina* and *Impatiens chinensis* which are wider distribution. According to Chatterjee (l. c.) the two groups (Himalayan and the Peninsular India) must have been separated from each other for a very long time, and have developed along parallel lines, each producing its own set of endemic species. Due to its varying conditions in the uplift of the Himalaya, the common progenitor could have become extinct or even changed into new ones.

The high incidence of endemism in *Impatiens* in the Peninsular India is remarkable and is an indication of the active
evolution which has occurred; and which is still occurring in the mountains. In addition to the habitat, the two regions differ in the degree of divergence, the number of species each contains and specialization in the morphology and extent of the distributional ranges of their constituent species. The morphological evidences also show that introgressive hybridization has acted as means of the origin of a number of species in the peninsular Indian balsam. The concentration of diploids, primitive radial pollen grains and shrubby habit support that, Peninsular India contains most of the primitive or phylogenetically old species when compared to any other geographical region (Huynh, 1966; Shimizu, 1969; Bhaskar, 1974; Jones and Smith, 1966).

Subramanyam and Nayar (1974) stated that, the high percentage of endemism in the Western Ghats is due to their being protected by sea along the Western Ghats and Vindhya and Satpura ranges on the Northern side and semi-arid Deccan plateau on the Eastern side. The region thus bounded has been like an oceanic Island in the development of endemic species. Therefore the evolution of the species in Peninsular India is comparable to that of island flora. Preponderance of ployploides in *Impatiens* in regions like Malaya, South East Asia, New Guinea and Thailand supports this view and the restriction of lower chromosomes numbers in Peninsular Indian species indicates Western Ghats as a place of origin of *Impatiens*.

Jones and Smith (1966) believed that the Himalayan region represents the centers of origin of the genus containing at least two basic chromosome numbers (x=7 and x=10) and presumed it to be the area when these have diverged to the South and North respectively. Although n=10 is also preponderant in the south Indian species of *Impatiens*, it is not certain that Himalayan
species have migrated southwards during the Pleistocene glaciations, because none of the North Indian species with either n=7 or n=10 are present in the south Indian hills or vice versa (Warburg 1938, 1938a; Khoshoo, 1955, 1957, 1966; Krishnaswami et al., 1969; Bhaskar and Razi, 1972-1973; Rao, 1972-1975; Bhaskar, 1975; Pandurangan, 1996; Larsen, 1981; Zinov'eva-Stahevitch, 1981; Zinov'eva-Stahevitch and Grant, 1984; Arisumi, 1973). Blasco (1971) also believed that the orophytic flora of south India has a strong individuality and that its affinity with that of Himalaya is not at all well marked. But there are no evidences for the southward migration of balsams from Himalayas. Hence, it may be assumed that the Peninsular Indian species may have had an independent origin and that the Travancore High Range which is known for the abundance of balsams (Barnes, 1939; Pandurangan, 1996) could be considered as the home of these species. This means that the Himalaya has not been a migratory track for an orophyte like *Impatiens* entering Peninsular India from Asia.

**1.5. Conservation (in-situ and ex-situ) and restoration**

Conservation is one of the most significant applications of the Biome. Understanding the extinction process and developing conservation strategies to keep them at natural rates are the major objectives of a biological conservation programme (Angermeier, 1995). Developing strategies for conservation after studying the ecological and biological parameters of a species, particularly a rare one will help in providing the sustainable supply of resources, as well as a promising long term conservation programme. Conservation of tropical forests is vital for preservation of biodiversity and the best way to ensure the fullest possible protection of biodiversity is to pursue its
conservation *in-situ*. This method enhances and ensures the long term survival of plant species in their habitats and with greater genetic variability.

However, in the case of species at risk due to various reasons, the rarity could be overcome by applying *ex-situ* methods. This method of conservation is gaining momentum nowadays because of dwindling populations and shrinking of natural habitats. It also acts by providing ready materials for experimental or evaluation purpose. Though the *ex-situ* method has its own merits especially to overcome the risk of depletion, this method should be resorted to only as a part of crisis management. Efforts to rear the plants in *ex-situ* conditions or in restoration, adjacent to their concentrations will help to secure their status to safe level and ensue their sustainable supply (Paul and Choo, 1993; Jose and Pandurangan, 2000). Propagation and multiplication of plant materials as easily and as possible and at lower cost is one of the solutions to retain the rare and endemic plants for the benefit of the people. For any scientific evaluation, or for commercial programmes, bulk production of stock plants is very essential. The ecological evaluation of the endemic plants with a link to conservation strategies and domestication trials in their homelands or in other suitable habitats can be taken as the plausible breakthrough to save these plants.

Growing as many endemic plants as possible on a large scale through seed collection, raising seedling orchards and seed storage will help to maintain genetic variability. This will ensure long term supply of materials as well as production of large number of ramets through stem cutting/ layering, graft etc. using conventional nursery techniques for sustainable conservation of endemic flora (Harry, 1979; Nair, 1986). Reproduction of plants
by vegetative means is an important way for genetic improvement and providing materials of desired characters. This method of propagation is also considered as the most important technical aid in modern conservation oriented programmes, where no alteration in the genetic system is desired. Therefore, studies on conservation through vegetative propagation of the endemic species have greater potential for their large scale multiplication for future purpose.

Among the different strategies available to maintain the biological diversity, seed germplasm conservation is considered to be a reliable and important one. Seed storage and germination studies are comparatively less expensive for maintaining valuable germplasm until plantations are established (Bonner, 1990; Jose and Pandurangan, 2000). In this context seed studies of rare and endemic plants especially of *Impatiens* to the conservation programme become vital. Various aspects such as optimum maturity for harvest seed, processing for storage, moisture content, percentage of germination, storage conditions, periodic viability tests, seedling establishment etc., have to be analyzed for effective conservation. Achieving success in extending viability of seeds of recalcitrant types, meant for rare plant conservation programme, is praiseworthy, as their viability is lost in a very short span, under ambient conditions. Conservation through ecological restoration, either by reintroduction or by restocking has become an increasingly viable strategy for helping species recover from the brink of extinction (Primack and Drayton, 1997). The process will help to create new populations or rebuild the degraded populations of a species, in their natural habitats.

1.6. Definition of the problem
The family Balsaminaceae has its greatest development in the Indian region and is remarkably local. The group has 210 species in Indian sub-continent of which 94 occur in Peninsular India and more than 86 are endemic and confined to Western Ghats (Fig. 3). Since endemics are close to the rare category due to their limited populations and subsequently prone for extinction because of both man-made and intrinsic reasons.

In this context, a detailed study on reproductive dynamics and conservation of three rare and endemic balsams viz., Impatiens gardneriana Wight, I. grandis Heyne ex Wall., and I. verticillata Wight were carried out. The result of the present study helps to understand the ecological and biological requirements which bearing on conservation of rare and endemic balsams in India. The present investigation definitely serves as an important model system for achieving twin objective of conservation and sustainable utilization of wild balsams, which are at present on the road to extinction. It will also help in raising the viable seedlings from improved seed output and thus a better recruitment in the natural condition. Therefore, the present investigation had been focused comprehensively on the reproductive dynamics and conservation aspects of these rare and endemic balsams covering the following disciplines.

- Phenology with special reference to flowering
- Floral biology-Pollination mechanisms
- Advertisements and rewards
- Nectar dynamics and Pollinator behaviours
- Pollen- pistil interactions
- Biochemical analysis of stigmas
- Breeding systems
- Fruit and seed development