CHAPTER - III
REVIEW OF LITERATURE

3.1 TAXONOMY

Taxonomy is the basic foundation for our total knowledge of plants. It concerns with the classification, identification, nomenclature and description of plants. Lawrence (1951) has stated that taxonomy is dependent on many other sciences and in turn all are equally dependent on it. Stace (1980) stated that plant Taxonomy is regarded as the barometer of the state of our total knowledge of plants and the means of directing future researches. Various workers undertook the taxonomic studies in family Scrophulariaceae. A brief review of important works is given as follows:

Prain (1891) in worked on Pedicularis from the Indian Empire and its Frontiers, reporting about 70 species, which he also described and keyed out.

Blatter and Hallberg (1918) worked on some species of Indian Scrophulariaceae, described them taxonomically and made notes on their order. They deal with about 26 species in 11 genera.

Blatter (1928 - 29) has recognized and described 8 genera and 38 species (including Lathraea which is now kept in separate family). The key to species is also given.
Pennell (1943) worked on the Scrophulariaceae of Western Himalaya, and reported about 36 genera containing 165 species. He gave the description of about 33 species, but has framed the key for all the 165 species.

Li (1949) made a revision of the genus *Pedicularis* in China and gave the keys at species as well as at variety levels.

Sell and Yeo (1970) revised the North American species of *Euphrasia*. They gave the morphology, chromosome number, ecology and distribution of few species. They further provided the taxonomic description, along with key, of 18 species of this genus.

Yamazaki (1970 a) described *Lindenbergia bhutanica, Pedicularis annapurensis, P. armatoides, P. breviscoposa*, and *P. chamissonoides* as new and noteworthy plants of Scrophulariaceae in the Himalaya.

Yamazaki (1970 b) described *Pedicularis elervatogaleata; P. ingentoides, P. kansuensis, P. lamjungensis, P. muscoides, P. nodosa, P. saipalensis, P. sectifolia, P. tamureusis, P. tsoongii; Phtheirospermum tenuisectmn, P. glandulosum; Veronica emodi* and *Wulseniap nepalensis* as new and noteworthy plants of Scrophulariaceae in the Himalaya.

Yamazaki (1971) reported 29 species of the family from Kashmir Himalaya and treated them as new and noteworthy.


Javied and Naqshi (1973), while analysing the flora of Kashmir University campus, reported 6 genera with 9 species in this family.
Kachroo et al. (1977), while studying the flora of Ladakh, reported 7 genera with 22 species in Scrophulariaceae.

Dhar and Kachroo (1983) published the ‘Alpine Flora of Kashmir Himalaya’, and reported 12 genera with 85 species of Scrophulariaceae from this region.

Polunin and Stainton (1986), in ‘Flowers of the Himalaya’, reported 51 species belonging to 18 genera.

Hooker (1884) worked out Scrophulariaceae in the Flora of British India and gave the taxonomic description of about 55 genera, isolating the genera into tribes and subtribes.

Singh and Kachroo (1987), while analysing the flora of Srinagar, reported 7 genera with 18 species in this family.

Chauhan, et al. (1990) made a census of the Scrophulariaceae in the Northwest Himalaya and reported 34 genera with 102 species belonging to this family.

Tahmeena and Qaiser (1991) revised the genus Euphrasia from Pakistan and its adjoining areas. They reported 34 taxa, which include 7 new species and 3 new records, in this region. Seed morphology of 29 species has been studied and 4 seed groups recognised. They also studied pollen grains of 27 species, while 25 taxa were surveyed for phenolic constituents.

Singh and Kachroo (1994), while studying the flora of Pir Panjal, reported 5 genera with 17 species in Scrophulariaceae.

Gantait et al. (1999) made a census of the Indian Scrophularia and listed 14 species and one subspecies from this country.

3.2 ANATOMY

Anatomy, or the internal structure of plants, provides useful characters which may be used in taxonomic and phylogenetic
Wood anatomy is an aid to the solution of many taxonomic problems at family and subfamily levels. Floral anatomy is also used to provide evidences for the solution of various morphological problems (Puri, 1952); the vascular anatomy of flowers offers a better character for understanding generic relationships than does the wood anatomy.

The family Scrophulariaceae is anatomically distinguished from the other families of angiosperms by its collateral (not bicollateral) vascular bundles in the stem and by the absence of intra-xylary phloem. Various aspects of anatomy in family Scrophulariaceae have been studied by many anatomists from time to time, starting with the important work by Solereder (1908).

Solereder (1908) suggested that the order Scrophulariales differ from other orders in the absence of intraxylary phloem, presence of external glands and in the covering of stomata by three or more epidermal cells. The main anatomical characters of Scrophulariaceae as described by Solereder (1809) are: vessels with simple perforations and bearing simple pits, absence of true medullary rays, pericycle with varied differentiation, rare excretion of oxalate of lime, common occurrence of carotin and protein crystals in mesophyll, unicellular or multicellular hairs, peltate glands of characteristic structure in Euphrasia, Bartisia, Melampyrum, Pedicularis, Rhinanthus and Tozzia, hypoderm is in some species of Veronica, and xylem forming an invariably dense, closed cylinder.

The detailed structure of the leaf of a considerable number of shrubby species of Veronica has been described by Adamson (1912), who has also investigated the formation of cork cells at the
points of exsertion of leaves in this genus. He reported anticlinal walls in the epidermis of *Veronica*, and stomata as raised above the epidermis in *Verbascum thapsus*.

According to Holm (1924) hydathodes are usually situated in the teeth at the leaf margin in *Digitalis* and *Veronica*, and the hypodermis is known to occur only in *Veronica*.

An important feature of xylem of Scrophulariaceae is the absence of medullary rays; however, conspicuous rays in *Verbascum thapsus* were reported by Holm (1924), and uniseriate rays in *Euphrasia munroi* by Betts (1920) and Sabris (1921). Pith is at first septate and then fistular. Secretory elements are absent. Vessels are small (*Veronica*), medium-sized (*Scoparia dulcis*), or large (*Wightia gigantea*). Parenchyma is usually absent. Fibres are thick-walled and septate.

Rendle (1925) suggested that the frequently developed hairiness of stem and leaf of Scrophulariaceae resemble that of Labiatae.

Interspecific differences in certain genera, based mainly on hair structure, have been described by Spoerri (1930), who divided the species he examined into seven groups exhibiting different types of hairs.

Metcalfe and Chalk (1950) studied the anatomy of stem, root and leaf, and reported that the most important feature of Scrophulariaceae is the absence of intraxylary phloem. The main anatomical features of this family as described by these authors are: root hairs often numerous and exhibiting a considerable diversity in form, cork often absent in herbaceous species, endodermis often conspicuous and commonly provided with casparian thickenings.
in *Antirrhinum*, *Euphrasia*, *Linaria*, *Scrophularia* and *Veronica*, vessels numerous and crowded in radial rows (*Digitalis purpurea*), trichomes simple and calcified in *Euphrasia*, and branched and multicellular in *Verbascum*, glandular hairs with unicellular or uniseriate stalks of varying lengths and heads usually composed of 1 - 4 cells in *Antirrhinum*, *Cymbalaria*, *Digitalis*, *Euphrasia*, *Limosella*, *Linaria*, *Lindernia*, *Mazus*, *Mimulus*, *Pedicularis*, *Scrophularia*, *Torenia*, *Verbascum*, *Veronica* and *Wulfeniopsis*. Metcalfe and Chalk (1950) further remarked that the stem anatomy of *Scrophulariaceae* is like that of *Solanaceae* except that intraxylary phloem is absent from the former.

Raman (1968) studied the trichomes on the outer surface of the corolla, which are only glandular (as in *Misopates orontium*, *Maurandya bascianana* and *Linaria* spp.), or both glandular as well as uniseriate simple (as in the genera *Antirrhinum* and *Ehaenorhinum*). Presence of the membrane structures on the glandular trichomes forms the species character for *Maurandya barclaiceana*.

Datta and Aratideb (1974) studied the floral anatomy of 24 species of *Scrophulariaceae*, and showed that the taxa can be differentiated from each other on anatomical basis. The trichomes present in this family were described as purely glandular to non-glandular, dendroid or unbranched, or unicellular thick-walled types. They further supported the Pennell’s classification of subfamilies.

Raman (1990) analysed the forms of hairs in *Scrophulariaceae* tribe *Antirrhineae*, and found that on the inner surface of the corolla usually unicellular hairs are present, and also
drumstick-like hairs, which form the characteristic feature for the family Scrophulariaceae, and were not observed in the neighbouring families.

Shah, (1990) studied the distribution of trichomes in Pedicularis pyramidata and P. elephantoides, and found that these include uniseriate and multiseriate glandular trichomes with capitate heads.

Stead and Ford (1990) made a structural study of the floral epidermal hairs in Digitalis purpurea, using electron and X-ray microscopy. The said hairs are reported to appear like cytoplasmic strands with peripheral cytoplasm and a large central vacuole. In the young flowers before corolla opening, the cytoplasm is more abundant and occupies the centre of the cell.

Juan, et al. (1996) studied the microcharacters in fruits and seeds of 7 taxa of Antirrhinum from Southwest Spain. These studies have shown that the said taxa can be differentiated on the basis of fruit features, while seeds showed a considerable uniformity.

Juan et al (1997) studied morphological and anatomical features in fruits of 12 species of Veronica from Southwest Spain, using scanning electron and light microscopy. They found that these taxa could be differentiated on the basis of anatomical and morphological features. They also gave the key to different taxa.

Nels, R. et al (1997) noted the presence of foliar idioblasts in some species of Scrophularia. These idioblasts contain tannin.

Battacharyya and Johri (1998) have summarised the anatomical characters of Scrophulariaceae as follows: vessels numerous and very small, occasionally ring-porous, parenchyma usually sparse or absent, rarely abundant; rays either absent or
when present, 1-9 cells wide, homogeneous or heterogeneous; leaves usually dorsiventral, stomata mostly of Ranunculaceous type; hairs numerous on the vegetative parts and exhibit a considerable diversity of forms; crystals not so frequent.

3.3 EMBRYOLOGY

Embryology plays an important role in the taxonomic as well as phylogenetic studies. Many workers have studied various embryological aspects of family Scrophulariaceae. They have contributed a lot to the knowledge of embryology of this family, and found that embryologically it is one of the most variable families.

Various workers have studied the development of endosperm in Scrophulariaceae (Hofmeister 1859, Schmid 1906, Srinath 1934, Iyengar 1937, and others). These workers have thrown light on the nature of endosperm and its haustorial processes, and also indicated phylogenetic relationships in different genera of Scrophulariaceae.

Yamazaki (1935 a, b; 1954 a, b; 1957 a, b) worked extensively on several genera of Scrophulariaceae, and established phylogenetic relationships and affinities in different genera on the basis of morphological and embryological characters.

Iyenger (1937-42) suggested that although the chalazal haustorium usually comprises a single binucleate cell in Celsia, in Verbascum it is tetra-nucleate, and in Vandellia and Sopubia it has two uninucleate prongs, which may later fuse to form a single binucleate cell (in Torenia and Pedicularis this cell is tetranucleate). Secondary haustoria are seen in Veronica, but they arise from chalazal region of haustoria.
Iyenger (1941) observed that in some members of Scrophulariaceae the endothelium is a repository of food material during pre-fertilization stages. Its subsequent behaviour, however, varies in many plants (Kapil and Vasil 1963).

Maheshwari (1950) suggested that the occurrence of endosperm haustoria, both at micropylar and chalazal ends, is a universal feature of Scrophulariaceae. Chalazal haustorium is present in Chaenorrhinum minus and Linaria genistaefolia. Haustorial development, however, is absent in some genera of the family (Davis 1966).

The formation of a cellular type of endosperm is a characteristic feature of the family Scrophulariaceae (Banerji 1961).

A suggestive feature of the egg of Torenia is that a continuous wall is present only around the micropylar half of the cell, the chalazal half being covered by the plasma membrane alone (Vander Pluijn 1964).

Presence of the tetrasporangiate anther and occurrence of suspensor haustorium in Pedicularis pyramidata is also the characteristic feature of the family (Varghese 1964). The tapetal cells in the family are uni- or bi-nucleate, or sometimes multinucleate (Faju 1973a, b), and the nuclei may often fuse. A multilayered tapetum has also been reported in Anticharis linearis (Joshi and Varghese 1963). The occurrence of a multilayered tapetum has, however, been regarded as an abnormality, having an adverse effect on the development of pollen (Steil 1949; Vasil 1957a, b, 1962). The ovules in Scrophulariaceae range from anatropus, hemianatropous to campylotropous. The embryo sac is monosporic, 8 - nucleate, Polygonum type (Maheshwari 1950).
Chandra (1987) investigated the development of male gametophyle in 10 species of Scrophulariaceae—*Verbascum phlloidae, Angelonia angustifolia, Antirrhinum orontium var. indicum, Linaria bipartit, Collinsia heterophylla, Russelia equisetiformis, R. sarmentosa, Mimulus luteus, Lindenberga indica*, and *Veronica anagallis-aquatica*. The development of anther wall follows the dicotyledonous type, and it consists of a layer each of epidermis, endothecium, middle layer and tapetum of glandular type. Pollen grains dehisce at the bicelled stage, and have three germ pores.

Yang (1989) isolated and identified the integumentary tapetal wall sac in *Antirrhinum* L. He et al. (1991) suggested that in *Antirrhinum majus* no Atpase activity is observed in the egg apparatus, but some of it occurs in the polar nuclei, cytoplasm, and plasma membrane of the central cell. Between the embryo sac wall and the cuticle surrounding it, there is a gap where some filament- and vesicle-like structures were demonstrated by conventional staining methods and numerous Atpase particles found in the nuclei, plasma membranes, and in the thick and loose wall of the hypostase cells.

Battacharyya and Johri (1998) summerised the embryological features of Scrophulariaceae as follows: the family is multipalynous, in majority of its members the pollen grains are tricolporate and 2-celled at the dispersal stage; ovules anatropous hemianatropous, or campylotropous, unitegmic, tenuinucellate; embryo sac Polygonum type, 8-nucleate at maturity; endosperm formation of the cellular type.
3.4 PHYTOCHEMISTRY

The plant chemistry supplies data which are helpful in establishing plant relationships, as the related plants will have similar chemistry. Some taxa of Scrophulariaceae are known for their uniform and extreme bitterness. Glycosides are the constituents of various species.

Breinholt, et al. (1990) isolated and identified, in addition to known iridoid glycosides-antirrhinoside and the cyanogenic glycoside prunasin, two new iridoid glucosides from Chaenorrhinum minus. One of these was found to be 10-glucosy bartsioside, and the other was named Chaenorrhinum.

Weinges et al. (1990) isolated the following new compounds from the aqueous sodium carbonate extract of Picrorhiza kurrooa after acetylation: crystalline acetates, penta-acetylene-6-cinnamoylcatapol, hexta acetylene-6-cinnamoylcatapol, hexa acetyl-6-vanillyl-catapol, and hexa acetyl Icatapol.

Jia et al. (1992) isolated a new phenylpropanoid and iridoid glycoside, pedicularioside I and longifloriside alongwith six known compounds: cistanoside D, cistanoside C, Verbascoside, geniposidic acid, mussaenoside and loganic acid from Pedicularis longiflora.

Jain et al. (1992) reported that picrolive, a heptoprotective agent prepared from Picrorhiza kurrooa, seems to be devoid of clastogenic activity.

A tripertene glycoside, scrokoelziside B, was isolated from Scrophularia koelzii by Bhandari et al. (1992).

Hoelz et al. (1992) reported the storage of cardiac glycosides in mesophyll cell vacuoles of Digitatis lanata. They further concluded that D. lanata cardinolides are stored solely as primary
glycosides, whereas secondary glycosides found in leaf-extracts are either biosynthetic intermediates or degradation products.

Ikeda et al. (1992) determined the lanatoside ‘C’ and digoxin in *Digitalis lanata* by HPLC. Cardenolides were also isolated from *D. lanata*.

Singh et al. (1992) studied the effect of picroliv on protein and nucleic acid synthesis. When standardized fractions of root and rhizome of *Picrorhiza kurrooa* were given to rats, they showed stimulation of nucleic acid and protein synthesis in rat liver.

Trepathi et al. (1992) showed the hepatoprotective activity of picroliv against alcohol.

An iridoid glucoside was again isolated from *veronica anagallis-aquatica* by Lahloub et al. (1993).

Popov (1993) isolated from the aerial parts of five *Linaria* species (*L. genistifolia*, *L. dalmatica*, *L. simplex*, *L. pelisseriana*, and *L. vulgaris*) a novel iridoid glycoside, 5-0- allosylantarrrinoside, along with the known antirrinoside lanarioside and 5-0- glucosyl lantirrinoside.

Seven cucurbitacin glycosides have been isolated from *Picrorhiza kurrooa* by Stuppner and Wagner (1993).

Aoshima et al. (1994) isolated phenylethanoid glycosides from *Veronica persica* and three new phenylthaniiod triglycosides from *Veronica undulata* and elucidated their structure using chemical spectroscopic evidence.

Hayashi et al. (1994) found 6-methoxybenzoxazolinone (MBOA) to be present in all parts of *Scoparia dulcis*, with the highest concentration being observed in younger leaves.
Rastogi, et al. (1994) found a new triterpenoid saponin, the saponin mixture, from *Bacopa monniera* and characterised it. Vohora et al. (1997) isolated a new triterpene, Bacosin (I), from the aerial parts of *B. monniera* and found it to have analgesic effect.

Handjieva et al. (1995) reported five new iridoid glucosides, from *Kickxia elatine, K. spuria, and K. commutata*. The five new iridoids are: *Kickxioside, antirrinoside, linarioside, antirride* and *mussacnosidic acid*. The latter two iridoids were found for the first time in *Kickxia* species.

Li et al. (1995) isolated four new iridoids - the glucoside 3-butoxy-3, 4-dihydroaucubic, 6-0-butylaucubic, and 6-0 butylepian cubic, together with pedicularis-lactone from the roots of *Pedicularis chinensis*. In addition, the known glucosides aucubic and bartsiolid, and an iridoid lactone were also isolated. These compounds were identified mainly on spectral evidence.


A phytotoxic iridoid glycoside was isolated from *Verbascum thapsus* by Pardo et al (1998).

### 3.5 CYTOLOGY

While cytology forms the important basis for understanding the mode of speciation and evolution, the chromosome number is usually an important character to distinguish the taxa at generic, sectional and specific levels. It is, therefore, mostly a reliable taxonomic character, and has proved useful in taxonomic and phylogenetic interpretations.

Love and Love (1976) remarked that the basic number of chromosomes, their size, and morphology are of great importance
for grouping at generic level. Dissimilarity in all these characters is a reasonable indication of heterogeneity, but the similarity in all these characters is not necessarily an indication of close relationship.

In Scrophulariaceae the reported basic chromosome numbers vary from 6, 7, 8, 9, 10, 11, 15, 18, 26, 30, and 40. The numbers 3, 7, 9, and 13 were considered as principal basic numbers (Darlington and Wylie 1955).

The base numbers of some genera, and some species of Scrophulariaceae are given in following two tables.

<table>
<thead>
<tr>
<th>Table : Basic chromosome numbers of some genera of Scrophulariaceae</th>
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<tr>
<td><strong>Genus</strong></td>
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<td>Antirrhinum</td>
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<td>Chaenorhimum</td>
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<td>Doparium</td>
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<td>Kickxia</td>
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<td>Lagotis</td>
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<td>Limnophilla</td>
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<th>Table : Basic chromosome numbers of some species of Scrophulariaceae</th>
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<tr>
<td><strong>Name of the species</strong></td>
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<tr>
<td>Antirrhium majus L.</td>
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<td>A. orontinum L.</td>
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<td>Centranthera hispida R.Br.</td>
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<tr>
<td>Species</td>
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<tr>
<td>Chaenorrhinum minus Lange.</td>
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<td>Cymbalaria muralis L.</td>
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<td>Digitalis lanata L.</td>
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<td>D. purpurea L.</td>
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<td>Kickxia ramosissima (Wall.) Janchen.</td>
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<td>K. spuria (L.) Dum.</td>
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<td>Lagotis glauca Gaertn.</td>
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<td>Limosella aquatica L.</td>
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<td>Mazus rugosus Lour.</td>
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<td>Pedicularis verticillata L.</td>
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<td>Scoparia dulcis L.</td>
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<td>Scrophularia nodosa L.</td>
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<td>S. umbrosa L.</td>
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<td>Torenia cordifolia Roxb.</td>
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<td>Verbascum blattaria L.</td>
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<td>V. thapsus L.</td>
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<td>Veronica agrestis L.</td>
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<td>V. anagallis-aquatica L.</td>
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<td>V. arvensis L.</td>
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<td>V. beccabunga L.</td>
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<td>V. biloba L.</td>
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<td>V. campylopoda Boiss.</td>
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<td>V. didyma Tenore</td>
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<td>V. oxycarpa Bios.</td>
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<td>V. persica Poir</td>
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<td>V. verna L.</td>
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Matsuura and Suto (1935) reported the chromosome counts for *Pedicularis*. Love and Love (1961), Zhukova (1966), Gill (1972), Love (1972), and Roose (1973) indicated a common base number of $n = 8$, except for $n = 6$ in *P. verticillata*. Some polyploids are also known. The relative uniformity of chromosome number supports Li's (1948 - 1949) belief that the genus is of recent origin.
3.6 RESOURCE POTENTIAL

Scrophulariaceae is economically an important family. Some of its included taxa have been used chiefly for their medicinal and ornamental value for thousands of years. The medicinal and ornamental importance of various species of this family is given separately as follows:-

3.6.1 MEDICINAL VALUE

Various species of Scrophulariaceae are well known for their medicinal properties, and are used as tonics, cardiac stimulants, febrifuges, and as stomachies. Some species are diuretics, and some others are used for the treatment of skin diseases, dyspepsia and rheumatism; few species, the active principles of which reside in the sap of roots, stems and foliage, are known for their bitterness.

*Picrorhiza kurrooa* yields the drug Picrolive, obtained from its dried rhizomes. The roots are bitter, acrid, stomachic, cardiotonic, antipyretic, anthelmintic and laxative. The bitter principle is due to the presence of glycoside named picrorhizin (Dymock *et al* 1934). It also contains kuthin, kurrin, vanillic acid, kutkiol as acetate, and kutkiserol. The drug promotes appetite, and is useful in treating billiousness, bilious fevers, urinary discharges, asthma, hiccough, blood troubles, burning sensations, leucoderma and jaundice. The root of the white variety is very bitter, pectoral and laxative. This is useful in curing paralysis, liver complaints, menstrual disorders, epilepsy, pain in joints, biliousness, ringworm's, scabies, most fevers, and in bites from rats and dogs. The root of the black variety is less bitter. It is used as purgative, expectorant, antipyretic, and as emmenagogue; also used in purgative preparations, and is good for gums and teeth. The rhizome is a favourite remedy for bilious dyspepsia and fever in
China and Malaya. It is also a remedial measure for snake bites and scorpion stings. Recently it has been found to be a valuable hepatoprotective and immunomodulator. It is also used for horses in Kashmir. Gentiana kurrooa of Gentianaceae found in Himalayas, has similar properties and often mixed with P. kurrooa. The common vernacular name 'kutki' has been applied to both (Datta and Mukherjee 1950). Picrolive showed both hepatoprotective, and anticholestatic activity (Sarasw et al. 1997).

Engels et al. (1992) showed that apocynin, a drug isolated from the roots of Picrorhiza kurrooa, possesses anti-inflammatory properties. They further stated that besides its therapeutic effect in inflammatory conditions, apocynin might also be a valuable tool in the development of new anti-inflammatory or anti-thrombic drugs.

Chander and Dharwan (1992) suggested that Picrolive, Picroside - I, and Kutkaside from Picrorhiza kurrooa are scavengers of superoxide anions.

Dorsch et al. (1991) suggested that Picrorhiza kurrooa have antiasthmatic effect. They also added that in the Ayurvedic medicine Picrorhiza kurrooa is used in the treatment of liver and lung diseases.

Saraswat, et al. (1993) suggested that the picrolive, active hepatoprotective principle of Picrorhiza kurrooa, have also anticholestatic effect.

Kapahi et al. (1993) reported that the crude drug Kutaki (Picrorhiza kurrooa) is a potent drug for the cure of various ailments. It is especially used as a hepatoprotective, an antiasthmatic and an immunomodulating agent, and is one of the major ingredients in therapeutic Ayurvedic formations. Visen, et al.
(1993) showed that the picrolive possessed a marked anticholestatic effect, and Picrolive is found to be more potent than silmarin, a standard hepatoprotective agent.

Puri et al. (1992) reported the immunostimulant activity of picrolive, the iridoid glycoside fraction of Picrorhiza kurrooa, and its protective action against Leishmania donovani infection in hamsters.

Saksena et al. (1994) indicated protective effect of picrolive against rifampicin—an antitubercular drug, and its induced hepatotoxicity in rats.

Jain and Sethi (1992) showed that picrolive, a hepatoprotective agent prepared from Picrorhiza kurrooa, is devoid of clastogenic activity.

Stuppner Wagner (1989) isolated seven new cucurbitacin glycosides from the roots of Picrorhiza kurrooa.

Cymbalaria muralis is used in typhoid fever, and its powdered stem is used to stop nose bleeding (Agarwal 1986).

The drugs obtained from Digitalis lanata are used for heart complaints, mainly as cardiac stimulant and tonic. The leaves of this species contain lanatocide A, B and C.

Stem leaves and fruits of Antirrhium majus are used in typhoid fever. Powdered stem is used to stop nose bleeding.

Digitalis purpurea yields digitoxin, a drug of commerce. It is used mainly for its effects on the cardiovascular system, increasing the force of systolic contraction and the efficiency of the decompensated heart. It slows the heart rate and reduces cardiac oedema with diuresis. It is used as myocardial stimulant in congested heart failure.
*Digitalis* has been recently shown to increase the coagulability of blood, and to antagonise the anticoagulant action of heparin in the body. It is a diuretic, useful in dropsy and renal obstructions. An ointment of *Digitalis* glycosides is said to be useful for cleansing wounds. In case of burns, it is more selective than other substances, and it preserves the cells damaged by heat (Chopra 1922; Chopra and Chouhan 1934; Kraemer 1944).

Groves and Bisset (1991) dealt with the use of tropical *Digitalis*. They reported that the drug digitalis glycoside is used in skin diseases, and is capable of exerting physiological activity.

The active constituents present in *Digitalis* are several glycosides, such as digitoxin, gitoxin, and gitalin, which have been isolated from the leaves. Digitoxin and gitoxin are now known to be derived from Purpurea glycoside A and Purpurea glycoside B, which are preserved in the leaves of *D. purpurea*. Besides glycosides, it also contains tannins, inositol, luteolin, and gallic, formic, acetic, lactic, succinic, citric and benzoic acids (Kreamer *et al.*, 1933). The leaves of *Digitalis lanata* produce the characteristic physiological effects of *Digitalis*, the effect being considerably stronger and less cumulative. They are used as the source of digoxin, an active cardiac glycoside, not reported from any other species of the genus. Fresh leaves of *D. lanata* contain three natural glycosides: Lanatoside A, B, and C.


The roots of *Lagotis glauca* have similar properties as those of *Picrorhiza kurrooa*, and are sometimes used as an adulterant with the latter.

*Verbascum thapsus*, commonly called in Hindi and Punjabi as Gidhar tamaku and Ban tamaku, has roots, which are employed as a febrifuge. They yield oligosaccharides, heptaose, octaose, nonaose and verbascose, aucubin and catapol (Chopra *et al.* 1959, 1967). The root is used in North India as a febrifuge, and its decoction is administered for treatment of cramps and migraine. The seeds on extraction yield fat, which contains esters of the fatty acids, such as stearic, palmitic, oleic and linoleic, sitosterol and non-steroidal yellow substances (Pande *et al.* 1960). The leaves are hot, dry, anodyne, and narcotic to fish, useful in chest complaints, gout, rheumatism, diarrhoea, and cough. In Western countries, the woolly leaves are much valued as demulcents and emollients, used in treatment of catarrh and diarrhoea, and as an external application for hemorrhoids. Leaves contain several saponins. (Kirtikar and Basu, 1988). Dried leaves smoked in ordinary tobacco pipes control asthma and spasmodic coughs, when made in cigarettes. Leaves, warmed and rubbed with oil, are used as an application for inflamed parts. Flowers contain crocetin (Kirtikar and Basu 1988) which is useful in cases of pulmonary diseases, coughs, bleeding of lungs, and in bowls. A conserve of flowers is used against ringworms. Seeds are considered aphrodisiac and narcotic. They are used for poisoning fish. In Europe, the oil is a popular remedy for frostbites, bruises and piles. Mullein oil is a good bactericide, used in the diseases of ear. The oil is also used as a remedy for enuresis afflicting children. The tincture made from
fresh herbs, with spirit of wine, is used for treatment of migraine. The plant is a trusted popular remedy for pulmonary consumption. It eases phthisical cough, has the power of checking phthisical looseness of the bowels, and gives great relief to dyspepsia.

Warashina et al. (1992) isolated five iridoid glycosides from the fresh whole plant of *Verbascum thapsus*. *V. chinensis* is medicinally used in dysentery and as a sedative. *Kickxia ramosissima* is used a remedy for diabetes.

The leaves of *Pedicularis bicornuta* yield a medicine called ‘turnserpo’, which is used in burns, rheumatism and gout. The inflorescence and stem of *P. pectinata* is used as a sedative, and also as a medicine for backache and body ache. The plant is used as diuretic in Punjab, and for haemotysis in Kunawar.

Vohra et al (1991) reported for the first time that the analgesic effect of *Bacopa monnieri* is due to the presence of Bacosine 1. Ellangovan et al. (1995) reported that *B. monnieri* plant extract has anticancer property. Giri and Kaleem (1996) reported that *B. plant* has been extensively used in the Indian Ayurvedic medicine as a nerve tonic.

Tripathi et al. (1996) reported that *B. monniera* - an Ayurvedic medicine-is clinically used for memory enhancing, epilepsy, insomnia, and as mild sedative.

*Scoparia dulcis* is diuretic, and antidiabetic. Roots are used in diarrhoea, dysentery, and also for tanning purposes. The leaf is used in fever, cough, bronchitis, and in gargles in toothache. Seeds have cooling effect.

Nishino et al. (1993) reported the antitumor-promoting activity of scopadulcic acid B, isolated from *Scoparia dulcis* by
inhibiting the effect of tumor promoter. Hayashi and Morita (1990) isolated from scopadulin, a novel tetracyclic diterpene, from S. dulcis. Ahmad and Jasmin (1990) isolated two new diterpenes, closely related to scopadulcic acids and scoparic acids, from S. dulcis.

Freire, et al. (1996) studied the sympathomimetic effects of Scoparia dulcis and catecholamines isolated from the plant extracts. They further reported that S. dulcis is used in Brazilian folk medicine to treat bronchitis, gastric disorders, hemorrhoids, insect bites, and skin wounds; and in oriental medicine to treat hypertension. A previous study has shown that extracts of S. dulcis have analgesic and anti-inflammatory properties. However, this sympathomimetic activity is unrelated to the previously reported analgesic and anti-inflammatory properties of the plant extract, but it may explain its effectiveness upon tropical application in the healing of mucosal and skin wounds.

Veronica anagallis-aquatica is antiscorbutic and diuretic. It is used in burns, ulcers, skin diseases, piles, and for blood purification; whereas V. arvensis and V. beccabunga are diuretic and alterative. They yield glycosides-rhinanthin and aucubin, which are used as a remedy for scurvy, ulcers, burns and scrofulous infections, and also for blood purification. V. beccabunga is used against abdominal dropsy (disease called Bungen Sucht or Trommelsucht).

Wulfeniopsis amheristiana is used for the treatment of high fever.
3.6.2 ORNAMENTAL Value

Some species of this family have desirable beautiful flowers, and are recognised among ornamental plants due to their various shaded flowers of different shapes and sizes.

*Antirrhinum majus* is one of the oldest plants raised ornamentally in Africa, Britain, Western Himalayas, Punjab and Kashmir. *A. orontium* is an ornamental plant of Europe. *Linaria vulgaris* is a garden flower. *L. dalmatica*, yellow-flowered plant, beautifies the mountain slopes, and is also grown as an ornamental in many flower gardens. *Digitalis purpurea*, is raised as an ornamental at many places now. *D. lanata* and *D. grandiflora* can also be raised as ornamental plants due to their beautiful shape and colour of flowers. According to Polunin and Stainton (1986), both *D. purpurea* and *D. lanata* have locally naturalised from gardens in Kashmir.

Various species of *Pedicularis* (e.g. *P. punctata* and *P. pectinata*) add to the beauty of slopes, meadows, and other places where they are present. These species can also be raised ornamentally.

*Verbascum thapsus* is a valuable garden plant of many places in Afghanistan.

Apart from their medicinal and ornamental values, some species have adverse effects on the living world. An infusion of leaves of *Verbascum thapsus* was found toxic, because the leaves contain rolenone and couramine. The over dosage of the drug digitalis proves toxic. It can lead to headache, fatigue, malaise, drowsiness, and even to death.
3.7 POLLINATION

The flowers in Scrophulariaceae are adapted for pollination by insects. Nectar is secreted by the disc around the base of the ovary, or by specialized nectaries on the under side. The differences in the form of the corolla are associated with the visits of different classes of insects, e.g. the open flower with short tube of *Verbascum* or *Veronica*, where the nectar is more exposed; the long wide tube of *Digitalis*, where the stigmas and stamens are placed so as to touch the back of the visiting insect (a large bee); the closed flower of snapdragon, requiring a certain amount of strength to separate the lips; and the flowers with loose powdery pollen and appended anthers in *Euphrasia* and some others, which when disturbed shake out the pollen on the visitor's head. In species of *Mimulus* and some others, the stigma is sensitive to contact in such a way as to favour cross-pollination by visiting insects. There is also generally means for ensuring self in default of cross-pollination, cleistogamic flowers occasionally occur, as in *Linaria vulgaris*.

Pollination in this family usually takes place by insects like bumblebees. Weed (1884) suggested that nectar foraging bumblebees are the most effective pollinators. The nectariferous glands, bright colour of various shades of corolla, two-lipped condition of flowers, and papillar bilobed stigma facilitate pollination by insects in *Euphrasia* and *Gerardia* (Pennell 1935), *Melampyrum*, *Rhinanthus* and *Orobanche* (Kuijt 1969). It is an interesting fact that *Pedicularis* and *Bombus* are co-existing geographically (Sprague 1962 a, b).

Wind pollination does not seem to occur in this family. Birds sometimes function as pollinators (Kuijt 1969). The humming birds
pollinate some species of *Pedicularis* (e.g. *P. grayi*), which was documented by Macior (1970), but the bumblebees also seem to be active in this species. Bird pollination has also been reported in some species of South African *Harveya* (Marloth 1932) and *Castilleja* (Grant and Grant 1966). In addition to this, various species of *Veronica, Linaria, Scrophularia, Verbascum,* and *Mazus* are pollinated by wasps, ants, blisters, beetles, moths, small flies, bees, or butter flies. Bumblebees (*Bombus* spp.) also pollinate species of *Digitalis*.

The flower of *Euphrasia* is evidently entomophilous, and in Europe the main visitors are hoverflies (*Diptera, Syrphidae*) and bees (*Hymenoptera, Aphidae*) (Muller 1883, Wettstein 1896, Yoe 1966). The flowers of *Euphrasia* in Europe are cross-pollinated.

The flowers in most of the species of *Scrophulariaceae* are protandrous, a few genera, such as *Scrophularia* are protogynous. Self-pollination occurs in many species of *Veronica*.

Macior (1978) reported that *Bombus queens and bumblebee workers pollinate Pedicularis oederi*. The pollination studies by Macior in North America (1982, 1983, 1986a, b, c), Japan (1988) and in the Kashmir Himalaya (1990), have established the general pattern of pollination in the genus *Pedicularis*, which is primarily associated with bumblebee pollen vectors. These studies also indicated that the floral diversity in species of *Pedicularis* is closely related to the form and behavior of their pollinating insects foraging for nectar and/or pollen. The divergence in sympatric species of *Pedicularis* is almost surely due to a high degree of specificity of their visiting insects (Li 1951).
Macior (1990), while studying the pollination mechanism in *Pedicularis punctata* in the Kashmir Himalaya found that the long tubed, rostrate and nectarless flower of this species was pollinated by a variety of *Bombus*.

The extent of involvement of Lepidoptera in pollination is unknown, but it is likely to be considered in the long tubed *Pedicularis longiflora* ssp. *tubiformis* (Pennell 1943, 1948), and perhaps in *Euphrasia* in New Zealand (Kuijt 1969). *Orobanche lutea* and *O. purpurea*, not withstanding their bright colours, are said to lack nectar (Hegi 1907, 1931).

### 3.8 DEHISCENCE AND DISPERsal OF SEEDS

In Scrophulariaceae the fruit, which is a capsule, dehisces loculicidally or septicidally; it is poricidal in very rare cases (*Antirrhinum*), or may even remain a dry indehiscent capsule (*Heben strethis*). In *Pedicularis* species, sutures develop at the septa at the time of dehiscence and reach far below the middle of the capsule. In *Rhinanthus*, only the apex opens (Kuijt 1969). In *Striga*, the capsule opens on wetting. In *Lathraea*, the seeds are violently expelled (Beckv. Mannagetta 1930). In *Veronica* species, the capsule opens because of the pressure caused by large sized seeds (Sernander 1906).

The size and the number of seeds vary from species to species, e.g. in *Pedicularis* species the number of seeds varies from 10 - 15 per capsule, while the size varies from 2-5 mm. The New Zealand species of *Euphrasia* produce only two seeds per flower (Du Rietz 1931). Each capsule of *Pedicularis elephantoides* and *P. pyramidata* contains an average of 15 seeds compared *P. silvatica*, which has the smallest number of seeds (Lange 1870-71, Berg 1954).
In *Veronica*, the number of seeds per capsule varies from 1-6 (Sernander 1906). The reduction in seed number is often accompanied by an increase in the size of remaining seeds.

The characteristic feature of the seeds of *Pedicularis* is the presence of elaiosome, which acts as a seed disjunctor. Some authors consider it synonymous with carnuncle or strophiole (Netolitzky 1926). This peculiar structure has also been described in a number of species belonging to families Amaryllidaceae, Aristolochiaceae, Juncaceae, Papaveraceae, Resedaceae and Violaceae (Sernander 1906).

A number of agents help in the dispersal of seeds, e.g. wind, rainwash, melting snow, birds, and insects, such as ants. Plants dispersed by ants have a small and reduced number of seeds in each capsule (Sernander 1906).

The Scrophulariaceae include a wide variety of seeds. *Veronica* and its allied genera show evolutionary tendencies in seed morphology. The seeds are numerous or few, small or large, ellipsoidal or flattened, reticulate or cochlidiospermous.