TAXONOMIC CONSIDERATIONS
The allocation of broomrapes and parasitic figworts to separate families (Orobanchaceae and Sorophulariaceae) is a time-hallowed taxonomic liberty taken by most taxonomists, although in reality, it is very difficult to draw a clear line between the two families (Kuijt, 1969). Lathraea through years has been tossed back and forth from Orobanchaceae to Scrophulariaceae - Rhinantheae, leaving one with a certain feeling of uneasiness about this familial distinction. Hyobanche, Harveya and Buchnera have similar difficulties.

The justification of Orobanchaceae as a separate family has been seriously disputed. Further study, in greater detail, has not dispelled these doubts but has magnified them (Kuijt, 1969).

Whether the parasites within Sorophulariaceae form a discrete natural unit is by no means clear. It can be only said that all parasites belong to one of the two tribes, Rhinantheae (some times called Euphrasiae) or Gerardieae (some times called Buchnereae). Whether all the members of these tribes are parasites is not known and the systematic significance of parasitism within the Sorophulariaceae
remains an open question. The various facets of continuity between the two groups have been summarized by Kuijt (1969) and are as under:

1. **Loss of photosynthetic capacity and increased host dependence:**

   It has been regarded to be, perhaps, the most obvious result of parasitic evolution. It has run its full course in the broomrapes, where no chlorophyll is known. It is true also of *Lathcraceaea* and *Hyobanche*. However, *Striga gesnerioides* and *Tozzia* are well advanced in this direction. By losing chlorophyll, parasites become more completely dependant upon their hosts.

2. **Fleshiness of stem:**

   The green figworts are slender stemmed. In some *Harveya* and *Striga* species the base of the stem has become stout and succulent. It is more evident in non-green figworts and the Orobanchaceae. In *Aeginetia* the slenderness of the stem is a derived condition.
3. **Phyllotaxis opposite to alternate**:  

This trend exists even within a single individual. All Orobanchaceae have alternate phyllotaxis but the trend has exceptions in the opposite arrangement of leaves in *Lathraea* and *Tozzia*.

4. **Longevity**:  

The perennial condition is really an advanced feature. *Orobanche*, however, is annual. *Lathraea*, *Boschniakia*, *Jonophys* and *Opunpus* are perennial; so are the species of *Pedicularis* (present study). *Aeginetia* may become so, and *Tozzia* is intermediate. The advanced nature of perennial species is thus more clearly visible in parasitic Scrophulariaceae. The short life cycle of *Orobanche*, *Epiphagus* and many other broomrapes (*Orobanchaceae*) may, in fact, be a case of reversion.

5. **The shift from secondary lateral haustoria to primary terminal ones**:  

In *Orobanchaceae*, the radicular apex of the seedling becomes directly transformed into the haustorial organ. This process is anticipated
in the germination of *Striga*. In Orobanchaceae, there is a trend towards the elimination of haustoria on the secondary roots, even these roots themselves, leading to the condition found in *Boschniakia*.

6. **Anther evolution**:

Anthers are rather uniform throughout these parasites, but in *Buchnera*, one of the two anther cells has decreased somewhat in size (Pennell, 1935). In *Harveya* of South Africa one cell has become a sterile spur, and the same in true of *Aeginetia* and *Christisonia*. Kuijt (1969) does not suggest that the above sequence is necessarily an evolutionary one, yet, in the context of other evolutionary trends, Kuijt takes no serious objections to the possibility that *Christisonia*, and perhaps even *Aeginetia*, are derivatives of *Harveya*. Should this conception be accepted as valid, the familial status of Orobanchaceae would be further undermined.
7. **Placentation:**

Nearly all Orobanchaceae have unilocular ovaries; the bilocular ones are characteristic of Sorophulariaceae. The ovary of *Christisonia* (Orobanchaceae) is two celled below and one celled above. In parasitic Sorophulariaceae a tendency towards the one-celled condition has been noted in *Lathraea*, *Orthocarpus* and others. Indeed the same trend appears in other parasites as well (Boeshore, 1920).

Placentation has shifted from axile to parietal position from Sorophulariaceae to Orobanchaceae, the trend being supported from *Orthocarpus*. The parietal placentae of some Orobanchaceae like *Aeginetia* and *Christisonia* are elaborately branched, in others, simply bilobed. The shift to parietal placentation is, of course, corollary of the disappearance of the septum.

8. **Reduction of the embryo:**

The parallelism between advancing parasitism and decreasing seed size seems to hold true generally, but the large seeds of *Rhinanthus*, *Melampyrum*, and even *Lathraea* and *Tozzia* are
exceptions.

The degree of differentiation of the embryo reinforces the trend in seed size. In all normally photosynthetic parasitic Scrophulariaceae, the embryo has fully differentiated cotyledons and a radicle with root cap. The embryo of Orobanchaceae is a small globe of parenchymatous cells; cotyledons and root cap are never distinguishable.

9. Number of seeds:

With the exception of several genera, the number of seeds increases with more advanced parasitism. The Orobanchaceae are at the summit of this evolutionary development, producing astronomical number of seeds per fruit.

10. The need for a host stimulant in germination:

In most parasitic Scrophulariaceae, germination does not seem to require stimulus by the host, although other rather complicated environmental conditions may occasionally be necessary. Some known genera like Lathraea, Tozzia, Alectra and Striga (Heinricher, 1894, 1901, 1930;
Botha, 1948; Sunderland, 1960 a, b) are among the most advanced parasitic scrophs.

Scrophulariaceae is a cosmopolitan family with 210 genera and 3,000 species. Engler (1909) recognised the family into 12 tribes distributed in 3 sub-families: Pseudosolanoideae, Antirhinoideae and Rhinanethoideae. Rendle (1925) and Hutchinson (1959) evaluated the tribe Selagineae of the family Scrophulariaceae to the rank of family Selaginaceae. Pannel (1943) raised the subtribe Veronicae into a separate tribe within the family Scrophulariaceae.

Certain Orobanchaceae and Scrophulariaceae are quite similar in habit, appearance, and flower structure. This is also true of the development of the male and female gametophytes, endosperm and embryo. The formation of endosperm haustoria is common to both and the structure of seed coat is also very similar. All these characters speak for a close alliance between the two families (Tiagi, 1952 a, b).

From a general study of the morphology, the Orobanchaceae and Scrophulariaceae (Boesmoot, 1920)
has produced overwhelming evidence that direct and distinct continuity can be established from non-parasitic through semi-parasitic Sorophulariaceae to the most degraded parasites of the family. Furthermore, these show direct continuity with the still more adapted and condensedly parasitic types of Orobanchaceae and that "the two types should be treated in continuous descending series from the highest to the most degraded genera". Glisic(1929) also concluded that the Sorophulariaceae and Orobanchaceae agree so thoroughly in their endosperm development that it will not be wrong to unite the two families into one.

Cassera (1935) similarly found that the flower structure of Orobanchaceae strongly suggests that of Sorophulariaceae. The main features of affinity between the two families lie in the development of the gametophytes, endosperm, embryo and seed formation.

While a number of types and variations are met with in the Sorophulariaceae, the mode of endosperm development in the Sorophulariaceae, (Tiagi, 1956) is essentially similar to that
observed in the Orobanchaceae. Besides this, 
_S. orobanchoides_ (Tiagi, 1956), a representative 
of Scrophulariaceae, resembles Orobanchaceae in 
some of the important aspects, namely, the chalazal 
megaspore curved towards the funiculus leading to 
the curvature of the embryo sac. Endosperm haustoria 
are essentially similar to those found in the 
Orobanchaceae. Embryological development is of 
Crucifer type and there is considerable similarity 
in seed structure. But the derivation of Orobanchaceae 
from sub-family Rhinanthetaeae through forms like 
_Striga orobanchoides_ offers difficulties (Tiagi, 1963).

Both Orobanchaceae and parasitic Scrophulariaceae are predominantly temperate in distribution. Both groups of parasites include annuals and perennials. Some genera are annual (with an occasional exception such as _Striga, Rhinanthus, Euphrasia, Melampyrum_
and _Orobanche_). Others are predominantly or 
entirely perennial such as _Castilleja, Pedicularis, 
Sopubia, Lathraea, Boschniakia_ and _Conopholis_.

The alternate arrangement of leaves, a 
characteristic of Orobanchaceae, is a logical 
extension of a trend in parasitic Scrophulariaceae
In both Lathraea (usually placed in Scrophulariaceae, but not always; Hutchinson (1959) and Christisonia (Orobanchaceae) there is an imperfect partition of the ovary. In the latter genus the partition reaches only half way up the ovary (Kuijt, 1969). Arekal (1963 a) has noted a tendency to unilocularity and parietal placentation in Orthocarpus luteus. The former trend has been noted in the fruit of several non-parasitic Scrophulariaceae (Pennell, 1935). In the parasites, at any rate, the unilocular condition would seem to be an advanced one (Kuijt, 1969).

On the basis of the presence of a well developed endosperm, the nature of placentation, and the development of loculicidal capsules, Bremekamp (1953, 1955) regarded the sub-family Nelsonioideae
of the Acanthaceae (Lindau, 1899) as closely related to the Rhinantheae. He, therefore, transferred the Nelsonioideae to the Scrophulariaceae placing it as a tribe near Rhinantheae. However, Jonri and Singh (1959), on the basis of their observations on the embryology of two members of Nelsonioideae (Elytraria and Nelsonia), suggested that the tribe should be retained in the Acanthaceae. This is also supported by Arekal (1963 a) and Mohan Ram and Masand (1963). It has been observed that these genera show an asymmetrical growth of the endosperm and possess a rudimentary jaculator— which are definitely acanthaceous characters and are absent in the Rhinantheae.

Moreover, the persistent and ruminate endosperm in Elytraria and Nelsonia has also been observed in Andrographis and Haplanthus of the Acanthaceae which further supports the relation of Nelsonioideae to Acanthaceae (Maheshwari, 1963; Maheshwari and Kapil, 1966).

Tsiagi (1956), who considers the derivation of Orocanthaceae from Rhinantheoideae
through forms like *Striga orobanchoides*, observed an evolutionary trend within the family Orobanchaceae itself from more primitive forms like *Boschniackia tuberosa*, through Cistanche and Orobanche to highly advanced forms like *Aeginetia*.

The investigated members of *Rhinantheae* are quite uniform in their embryology. The genus *Pedicularis* is closely related to *Euphrasia* (Arekal, 1963a) especially in the disposition and structure of ovules; in the presence of a small, cylindrical nucellar column on the chalazal side of mature embryo sac; in the differentiation of a smaller chalazal endosperm haustorium, and in the presence of a single lateral extension of the micropylar haustorium.

*Melampyrum*, a genus under *Rhinantheae*, stands apart from others in the tribe (Arekal, 1963a) differing in the following features: 1) Only four ovules per ovary 2) Ovules with long funicle and a vascular bundle 3) Raphe short 4) Placenta not massive 5) Embryo sac tetrasporic and seven nucleate 6) Embryo sac tubular with 6 - 8 delicate micropylar extensions 7) Integumentary tapetum hypodermal in origin 8) No fusion of polar nuclei 9) Primary
endosperm nucleus arises by fusion of male nucleus and micropylar polar nucleus, and 10) Endosperm proper is differentiated into three regions.

However, on the basis of present observations on Pedicularis (P. pyramidata and P. elephantoides), there is a disagreement with the criterion number 10, since in the present material also, the endosperm shows 3 regions. Moreover, P. pyramidata shows the presence of small tubular extensions of the embryo sac in its micropylar region and in this feature it is closely related to Melampyrum lineare.

The embryo development of Pedicularis species corresponds to the Onagrad (Johansen, 1950), Crucifer (Schnarf, 1929), or Caryophyllad (Berg, 1954) type. In many other genera like Boschniackia (Tiagi, 1963) and Aeginetia (Tiagi, 1952b). This suggests how little taxonomic reliance can be placed on such embryo typologies (Kuijt, 1969).