SUMMARY AND CONCLUSIONS

The genus Ceropegia is one of the largest genera of Asclepiadaceae. The genus is represented by about 200 species and is distinguished from its allied genera by its tubular corolla which is swollen at its base, funnel shaped above and corolla lobes are connate at tip. In last 3 decades about 30 new species have been described from various parts of world. This is one of the genera in which almost every year some new species are described. This is probably due to restristed distribution of many species to small areas which are not botanically well explored especially during rainy season.

Ansari (1984) in his revision on Ceropegia reported some 44 species from India out of which 28 are endemic to the country. It is interesting to note that out of 20 species reported from Maharashtra 17 are endemic to the state. Out of total endemic species to the country about 60% are from Maharashtra. It is also interesting to note that whatever new species of the genus described for the country after Hooker's flora are from Maharashtra. There is great possibility of getting many new species from south India if searched carefully.

Most of the species described from Maharashtra are restricted to small areas and they are endemic not only to the state but to a small area. In last two decades about 8 species have been described from Maharashtra. It is probably due to extensive field work and careful search for the species of Ceropegia by botanists of Botanical Survey of India.

Most of the species occuring in Maharashtra are restricted to small areas and are endangered because of edible tubers destroyed by man and animals, land slide and destruction of natural habitats. Thus there is great threat to the survival of Ceropegia species in the wild habitats. There is urgent need to conserve them either by protecting natural habitats or cultivation of species in botanical and home gardens. Cultivation and domestication of Ceropegia seems to be better conservation measure of this natural wealth.

C. attenuata, C. huberi, C. noorjahaniae, C. sahyadrica C. jainii, C. oculata and C. vincaefolia need immediate efforts to conserve them. C. huberi is restricted to Kolhapur district, C. noorjahaniae to Satara district while others are found in Satara, Kolhapur, Poona and Ratnagiri district. All the species have curious flowers and possess ornamental value. C. oculata and C. vincaefolia have beautifully coloured flowers. All the species of Ceropegia are worth of introducing in gardens. C. juncea is now grown in many home gardens as a succulent plant and its flowers are also attractive. Efforts have been made to domesticate these species in the botanical garden of the department and most of the species are thriving well.

Similarly Brachystelma is another interesting genus famous for its endemism and rarity. Like Ceropegia all the species of Brachystelma need efforts to conserve them. Most of the Indian species are not been collected since long time doubting their existence.

So far 12 species of Brachystelma are reported from India. Most of them are restricted to small areas in South India. Two species have been reported from Maharashtra. During extensive field work by author, he collected one new species of Brachystelma allied to B. edulis from Ratnagiri district. It is extremely rare and found growing in latevite crevices under bushes around Malwan. Author feels that careful search for Brachystelma especially in South India would prove to be fruitful.

In present work, 12 species of Ceropegia and 2 species of Brachystelma have been collected from natural habitats. Their external morphology have been studied in detail. The external morphological studies revealed that the genus possesses great diversity in its habit and habitat. Out of 13 species studied five showed erect habit and 8 showed climbing habit. Similarly it is interesting to note that nonsucculent, leaf succulent as well as stem succulent species occur in this genus. C. bulbosa and C. woodii show succulent leaves while C. juncea show succulent stem with reduced leaves or leaves are absent. All other species showed membranous nonsucculent leaves.

C. huberi has peculiar corolla and such type of corolla's are found in some African but not in Indian species of Ceropegia. Aponogeton satarensis found in Maharashtra has closely allied A. decaryi in Africa. Similarly Wiesneria triandra is found in Maharashtra as well as in Africa. All above mentioned plants are of restricted distribution. Thus many other such relic plants are found common to India and Africa and support connection of India and Africa in past.

All the species of Ceropegia possess well developed edible tubers, however in C. juncea tubers are reduced. It also shows hexaploidy and stem performs Crassulean Acid metabolism leaves are reduced to scale or absent. It grows in drier parts. Thus it is different from remaining species of Ceropegia in morphology, cytology distribution and photosynthesis. It is very clear that it shows these changes in response to xeric condition. C. bulbosa and C. woodii possess succulent leaves. It is found that the leaves of C. bulbosa show CAM. Thus it is interesting that in single genus Ceropegia all leaf CAM, stem CAM and C_3 plants are observed.

Flower of each species is peculiar and characteristic to the species. Every species shows some peculiarity in its flower. All the species of Ceropegia can be easily identified on flower and corolla characters. There seems to be a great variation in corolla and corona characters of flower and probably these are main flower parts involved in specialization in response to insect pollination. Length of corolla, color of corolla, bloching of corolla, presence or absence of hairs on different parts of corolla, outer and inner corona vary in different species & probably play important role in specialization and diversification in the genus.

Studies on 'Light Windows' of 12 species of Ceropegia revealed that 11 species have vertical strips of translucent tissues which illuminate corolla while C. vincaefolia showed most elaborate mechanism of illuminating essential organs.

Thus the studies on floral morphology revealed that the flowers of Ceropegia species are highly specialized and curiously formed. They come under the category of fly trap flowers. Most of the Indian species of Ceropegia belong to section Buprestis (13 spp.), Indopegia (9sp) and Tiloris (6).

Studies on stem anatomy revealed that the gross anatomical characters of stem remain same for all the species except C. juncea. The transection of stem shows single layered epidermis, parenchymatous outer cortex, cellulosic fibres in inner cortex, primary phloem patches followed by secondary xylem followed by primary xylem, intraxylary phloem, pith and laticifers distributed pith & associated with phloem and cortex. The thickness of cortex and extent of cellulosic fibres development varies with species. C. hirsuta showed a continuous cylinder of cellulosic fibres.

Amount of secondary growth varies with species. C. sahyadrica and C. maccannii showed good amount of secondary growth. In C. huberi and vincaefolia showed negligible secondary growth. Other species showed intermediate secondary growth between these two groups. Secondary wood consisted of tracheids fibres and varying amount of vessels. Intraxylary phloem was found in all the species. In some species it was deeply sited. Laticifers were found distributed mainly in inner cortex, pith and associated with secondary phloem & intraxylary phloem. They were found abundant in succulent species as compared to nonsucculent species.

C. juncea showed absence of cellulosic fibres, very reduced conducting tissue and major tissue of stem consisted of water storage chlorenchyma.

It is interesting to note that all the nonsucculent species except C. Sahyadrica showed starch grains of usual shape in cortex & pith however it was found absent in both leaf and stem succulent species. This was also observed in petiole and leaf anatomy. Therefore in addition to waterstorage parenchyma and reduced vascular tissues, absence of starch grains could be taken as anatomical character to distinguish CAM species from non CAM species.

Observations on stem anatomy revealed that C. sahyadrica and C. maccannii as most primitive and C. huberi and C. vincaefolia as most advanced species among species studied while C. juncea showed very different stem anatomy as an adaptation to xeric conditions.

Thus the presence or absence of trichomes epidermis, thickness of cortex and cellulosic fibres, presence or absence of cellulosic fibres, abundance and distribution of laticifers, amount of secondary growth, abundance of vessels and presence or absence of starch grains are found to be anatomamical characters of taxonomic value, however, they alone can not used to distinguish species and are of secondary value in identification. Species of Brachystelma showed stem anatomy similar to nonsucculent species of Ceropegia.

Petiole anatomy revealed that species of Ceropegia have similar gross anatomical characters. Transection of petiole is usually a concave-

convex structure. The amount of collenchyma varies with species. The vascular system consists of three vascular traces but in some species additional lateral vascular traces are found. The lateral bundles are small and surrounded by starch sheath. The central vascular bundle is crescent shaped and is bicolateral. Starch sheath is found below dorsal phloem. Laticifers are usually found inbetween ventral collenchyma and ventral phloem. The different species of Ceropegia can not be identified on petiole anatomy. It is of secondary importance in identification. Brachystelma also showed similar petiole anatomy but there were additional lateral vascular bundles.

Leaf anatomical and cuticular characters are found to of diagnostic value in Ceropegia and Brachystelma species. All the membranous leaved nonsucculent species of Ceropegia under study possessed hypostomatic and dorsiventral leaves, while all succulent species of the genus possessed amphistomatic and isobilateral leaves. Species of Brachystelma possessed amphistomatic dorsiventral leaves. Genus Brachystelma can be distinguished from genus Ceropegia by character of palisade. In Ceropegia palisade is single layered while it is 2-3 layered in Brachystelma.

Cuticular striations, presence or absence of trichomes on leaves and stomatal frequencies were found to be characteristic to the species. C. jainii and C. noorjahaniae possessed prominent and characteristic striations. Cuticular striations were found to be absent in C. media, C. oculata and C. vincaefolia. Trichomes on leaves were found to be present on all the erect species. All the succulent species of Ceropegia

showed cuticular striations and absence of trichomes. Species of Brachystelma showed prominent striations. Collenchyma was found to be absent from leaves of succulent species. The amount of collenchyma in leaf varies in different nonsucculent species.

If characters such as type of leaf-amphistomatic or hypostomatic, (isobilateral or dorsiventral), types of stomata and their frequency presence or absence of collenchyma, striations and their peculiarity and trichomes characters are combined together, all the species of Ceropegia can be identified. It is possible to make a key to the sterile materials of Ceropegia and Brachystelma.

Following are some of the important conclusions based on my study on morphology and anatomy of Ceropegia and Brachystelma species.

1. Genus Ceropegia and Brachystelma possess species which are mostly endemic to the small areas and are rare and need conservation measures. Cultivation and domestication seems to be best way of conserving them. Most of the species of Ceropegia have curiously formed flowers and possess ornamental value worth of introducing in gardens.

2. The genus shows great variations in morphology especially in response to xeric conditions. The genus possesses stem succulent, leaf succulent and nonsucculent species.

3. Corolla and corona of flower seems to be major floral parts involved in specialization and diversification in the genus. C. vincaefolia has most elaborate way of illuminating corona.

4. Stem anatomy revealed that C. sahyadrica and C. maccannii as a primitive species and C. hubei and C. vincaefolia as advanced species. Stem anatomy is of secondary importance in identification of species.

5. Petiole anatomy is not of much value in taxonomy of these genera.

6. Leaf anatomy, cuticle and trichome characters are of diagnostic value and different species of the genera can be identified.

7. Morphological and anatomical studies revealed that the genus Ceropegia has species adapted to different climatic conditions. Leaf succulence, stem succulence have evolved in response to environment. The development of CAM features in the stem tissue of C. juncea and leaf tissue of C. bulbosa represents a major metabolic adaptation to environment. Various forms of flowers are evolved in response to insect pollination. There is great possibility of getting CAM features in other succulent species of Ceropegia such as C. dichotoma, C. fusca, C. illegitima, C. superba and C. woodii.