SYSTEMATIC SIGNIFICANCE OF FOLIAR CHARACTERS IN THE DELIMITATION OF PASSIFLORA L. (PASSIFLORACEAE) AT THE LOWER TAXONOMIC LEVELS.

*VL Beena¹ and S Suhara Beevy².

1. Research Scholar, Department of Botany, University of Kerala, Kariavattom, Thiruvananthapuram, Kerala, India.
2. Assistant Professor, Department of Botany, University of Kerala, Kariavattom, Thiruvananthapuram, Kerala, India.

Abstract

Passiflora L, (Passifloraceae), commonly known as sour passion fruit, yellow passion fruit or granadilla belongs to the family Passifloraceae and consists of approximately 465 species distributed all over the world except in Arctic and Antarctic regions. The present investigation focused on the foliar morphological diversity of the widely variant genus, Passiflora, at the inter and intra specific levels, with a view to understand the significance of foliar features in the systematics of the genus. The study was undertaken in 27 accessions including 8 species, 5 varieties and 2 hybrids of Passiflora, for analyzing both the qualitative and quantitative characteristics of leaves and trichomes. The investigation revealed the significance of foliar characters in the delimitation of the taxa at the inter specific and intra specific levels in the genus. Diversity at species level was noticed in characters like shape and size of leaf margin, pattern of leaf lobing, size and shape of stipules, number of umbilical glands, length of petiole, type of stomata, and glandular and non glandular trichomes. However, intra specific diversity was evident from the nature of leaf lobing, and in the distribution of glandular and non glandular trichomes. A taxonomic key based on the foliar features was constructed in support of the systematics of Passiflora.

Introduction:

Passiflora L., the largest genus of the family Passifloraceae consists of about 465 species under 24 subgenera [1-2]. According to Feuillet and McDougal [3], Passiflora is a monophyletic group distributed in the subtropical and tropical regions of the world. The genus is distinguished by the herbaceous or woody climbers with characteristic three to five angled stem. Majority of the species possesses nectar secreting foliar and bracteole glands. Moreover, a wide range of diversity was observed in the foliar features of the genus.

Review of related literature revealed that the studies undertaken focused mainly on genetic diversity analysis [4-5] and cytological characterization [6]. Morphological and molecular variability in the wild species of Passiflora was
reported by Viana et al. [7]. Krosnick [8] suggested the role of floral morphology in discriminating the species of Passiflora. However, investigations on the foliar characteristics is sparse except that of Tangarife et al. [9] who reported foliar variations in a few species of Passiflora from Columbia. The significance of leaf morphological and epidermal characters in plant systematics has been proved in Alternanthera Frpsk. (Amaranthaceae)[10], Cassia sensu (Cesalpineaceae) [11], Senna (Fabaceae) [12] and Cassinae (Leguminosae) and in Hybanthus (Violaceae) [13]. The present investigation makes use of foliar features to evaluate the role of those characters in the delimitation of the genus at the inter and intra specific levels.

Materials and Methods:-
Leaf morphological and trichome characteristics of 27 taxa of Passiflora belonging to eight species, five varieties and two hybrids collected from different parts of the states of Kerala and Tamil Nadu were analysed for the study. The plants were maintained in the Botanical Garden, Department of Botany, University of Kerala for the investigation. Details of the accessions and the places of collection are provided in Table 1. Both the qualitative (28) and quantitative (11) characters were analyzed and each character state had been scored (Table 2). Fifth leaf of the flowering branch was examined for the study to ensure uniform treatment, and the mean value of 10 observations were analysed. The data were subjected to Analysis of Variance (ANOVA) at the level of significance p<0.05, and was used to test the significant differences among the taxa. Discriminant function analyses such as cluster analysis and scatter plot were carried out to check out the character differences among the taxa. Morphology of foliar trichomes and glands were examined with the help of Stereo microscopic (Olympus SZ) observations and a taxonomic key was prepared based on the findings.

Result and Analysis:-
Details of the qualitative characters analysed in the 27 taxa of eight species are are given in Table 3. Foliar variations at the inter specific and intra specific levels were evident from the qualitative data analyzed (Table 3 & Fig 1). Analysis of Variance performed on quantitative traits (Table 2) showed significant variations (P<0.05) at the inter and intra specific levels. Mean standard deviation, range, and coefficient of variation and F values of the qualitative traits were also undertaken (Table 3). A range of values were found as the average means of lamina length (6.03cm to 6.63cm), lamina width(4.88cm to 5.38cm), petiole length (2.23cm to 2.88cm), frequency of stomata in the upper and lower epidermis (74.92µm to 78.70µm and 33.76µm to 36.44µm), length and width of stomatal complex (16.97 µm to 17.82µm &13.42µm to 13.68µm), length and width of guard cells (18.14µm - 18.56µm & 5.09µm - 5.55µm), length and width of stoma (9.77µm - 9.97µm & 3.21µm - 3.98µm). Among these, laminar width (LMW) showed maximum coefficient of variation (38.3372%), whereas F value (155.274) and width of guard cell (WGD) had minimum coefficient of variation (16.12%) and F value (14.773).

The Principal Component Analysis (PCA) revealed that the characters were distributed among three principal axes (Fig 2) which accounted for approximately 99.672% of the total variance. The first principal component with Eigen value 17.432 explained 64.563%variance (Table 4). It was found that leaf lobing, leaf arrangement, petiole groove, leaf texture, leaf size, leaf shape, leaf margin, marginal sheath spacing, order of marginal sheath, lob tip gland, leaf color, tooth apex, sinus shape, leaf tip, leaf base, nature of hair, venation, stomata, and leaf pubescence were the highest loaded traits and had positive values. The second component accounted for 13% of the variability with dominance of characters like leaf lobing, leaf arrangement, petiole groove, leaf texture, leaf size, leaf color, leaf shape, leaf margin, order of margin sheath, marginal sheath spacing, leaf tip apex, sinus shape, leaf tip, leaf base, lob tip gland, nature of hair, and venation. The third principal component accounted for 6% of the variability with dominance of characters like leaf lobing, leaf color, leaf shape, leaf margin, order of margin sheath, leaf tip, leaf trichome and lobe tip gland. The most loaded characters that accounted for more variability in PC1, PC2 and PC3 included leaf lobing, leaf color, leaf shape, leaf margin, marginal sheath spacing, order of margin sheath, sinus shape, leaf tip, leaf trichome, lob tip gland and leaf pubescence, which distinguished the different taxa of the genus Passiflora at the inter and intra specific levels.

UPGMA dendrogram based on morphological differentiation of the accessions (Fig 3) revealed two principal clusters at an Euclidian distance 1.40. The first principal cluster consisted of P.coccinia, P.vitifolia, P.trifaciata and P.subpelata along with two accessions of P.edulis var. edulis (acc4 & acc5), whereas the second cluster possessed two sub clusters. All the varieties of P.foetida were grouped together in the second sub cluster along with the species, P.apoda and P.quadrangularis. However close relationship among the accessions of P.foetida var.foetida (acc 7, acc 8, acc 9, acc 12, acc 13 and acc14) was evident even though the accessions 10 and 11 differed
extensively from the others. It was observed that the accession *P. foetida* var. *gossipifolia* was a connecting link between *P. foetida* var. *foetida* and *P. foetida* var. *hispida*. The two hybrid varieties of *Passiflora* (*P. 'manapany' and *P. 'canelle'*), were clustered together with the varieties of *P.edulis* var. *flavicarpa* and *P.edulis* var. *panamared*, but the accessions of *P.edulis* var. *edulis* (acc 4 and acc 5) were seen grouped in the sub cluster of the second principal cluster.

A taxonomic key constructed based on the foliar features and the trichome characteristics distinguished the taxa at the inter and intra specific levels.

**Table 1:** Accessions of *Passiflora* and the places of collection.

| Subgenera   | Sectio n | Series  | Species     | Variety  | No.Acce ssion | Place of collection | Altitud e (ft) |
|-------------|-----------|---------|-------------|----------|---------------|---------------------|---------------|
| Plectostema | Cieca     |         | *P.apoda*   |          | 1             | TVM                 | 112           |
| Decal oba   | Miserae   |         | *P.trifaciata* |          | 1             | TVM                 | 112           |
| Distephna   |           |         | *P.coccinea* |          | 1             | TVM, TVM            | 112           |
|             |           |         | *P.vitifolia* |          | 1             | TVM, TVM            | 112           |
|             | Quadrangularae |         | *P.quadrangularis* |          | 1             | KKD                 | 75            |
|             | Lobatae   |         | *P.subpeltata* |          | 1             | KTM                 | 59            |
| Granadilla (Passiflora) |           |         | *P.edulis* | *edulis* | 3             | KVTM, KLM, MUNR     | 112 2956      |
| Incarnatae  |           |         | *P.edulis* | *flaviocarpa* | 2   | MUNR EKI         | 2956 2565     |
|             |           |         | *P.edulis* | *panamared* | 1  | TVM               | 112           |
| Dysosmia    |           |         | *P.foetida* | *foetida* | 8             | MTPLY M CHTA MDRI, TSSR, KULPZA, PTTA, V M | 171 181 175 29 106 70 112 |
|             |           |         | *P.foetida* | *hispida* | 4             | KLM, TSSR, KULPZA, KVTM | 35 29 106 112 |
|             |           |         | *P.foetida* | *gossipifolia* | 1  | TVM               | 112           |

*TVM Trivandrum, KVTM Kariyavattom, KLM Kollam, KKD Kozhikkodu, EDKI Edukki, MTPLYM Mettuppalayam, CHTA Chenkotta, TSSR Thrissur, KULPZA Kulathupuzha, ,MUNR Munnar, PTTA Pathanamthitta, MDRI Madhurai*
Table 2: List of qualitative and quantitative characters analysed with their character states Qualitative character.

| No | character                          | Description                                                                 |
|----|------------------------------------|-----------------------------------------------------------------------------|
| 1  | Leaf attachment                    | ‘0’ petiolate; ‘1’ sessile; ‘2’ stipulate; ‘3’ perfoliate                   |
| 2  | Stipule                            | ‘0’ filiform; ‘1’ fringed; ‘2’ connate                                     |
| 3  | Leaf arrangement                    | ‘0’ opposite; ‘1’ alternate; ‘2’ whorled                                    |
| 4  | Petiole nature                      | ‘0’ with gland; ‘1’ without gland                                           |
| 5  | Petiole grove                       | ‘0’ present; ‘1’ absent                                                     |
| 6  | Leaf texture                        | ‘0’ glabrous; ‘1’ pubescent; ‘2’ fleshy                                    |
| 7  | Leaf colour                         | ‘0’ green; ‘1’ light green; ‘2’ dark green; ‘3’ reddish green; ‘4’ purple   |
| 8  | Leaf size                           | ‘0’ large; ‘1’ medium; ‘2’ small                                           |
| 9  | Leaf shape                          | ‘0’ ovate; ‘1’ hastate; ‘2’ pinnately trilobed; ‘3’ palmately trilobed     |
| 10 | Leaf margin                         | ‘0’ serrate with gland; ‘1’ serrate without gland; ‘2’ entire with gland; ‘3’ entire without gland; ‘4’ crenate with gland; ‘5’ crenate without gland; ‘6’ ciliate; ‘7’ wavy serrate with gland; ‘8’ wavy serrate without gland |
| 11 | Marginal teeth order                | ‘0’ 1st order; ‘1’ 2nd order; ‘2’ 3rd order                                |
| 12 | Marginal teeth spacing              | ‘0’ regular; ‘1’ irregular                                                 |
| 13 | Teeth shape                         | ‘0’ convex; ‘1’ straight; ‘2’ concave; ‘3’ flexuous; ‘4’ retroflexed        |
| 14 | Teeth apex                          | ‘0’ simple; ‘1’ non specific glandular; ‘2’ mucronate; ‘3’ setaceous; ‘4’ papillate; ‘5’ spinous; ‘6’ spherolate |
| 15 | Sinus shape                         | ‘0’ angular; ‘1’ rounded                                                  |
| 16 | Leaf tip                            | ‘0’ acute; ‘1’ acuminate; ‘2’ cuspidate; ‘3’ mucronate; ‘4’ obtuse          |
| 17 | Leaf base                           | ‘0’ attenuate; ‘1’ shortly attenuate; ‘2’ cordate; ‘3’ subcordate; ‘4’ hastate |
| 18 | Nature of hair                      | ‘0’ hispid; ‘1’ puberlose; ‘2’ hirsute; ‘3’ peltate; ‘4’ stellate; ‘5’ glandular |
| 19 | Venation                            | ‘0’ pinnately reticulate; ‘1’ palmately reticulate                          |
| 20 | Oil gland                           | ‘0’ present; ‘1’ absent                                                    |
| 21 | Umbellical gland                    | ‘0’ present; ‘1’ absent                                                    |
| 22 | Umbellical gland position           | ‘0’ near to the laminar junction; ‘1’ away from the laminar junction; ‘2’ throughout the petiole |
| 23 | Lobe tip gland                      | ‘0’ absent; ‘1’ present                                                   |
| 24 | Smell                               | ‘0’ absent; ‘1’ pleasant; ‘2’ punchent                                    |
| 25 | Pubescent                           | ‘0’ absent; ‘1’ sparse; ‘2’ dense                                          |
| 26 | Leaf polymorphism                   | ‘0’ absent; ‘1’ present                                                   |
| 27 | Trichome                            | ‘0’ unicellular; ‘1’ multicellular; ‘2’ branched; ‘3’ glandular; ‘4’ none of these; ‘5’ all of the above |
| 28 | Stomata                             | ‘0’ anisocytic; ‘1’ anomocytic; ‘2’ monocytic                              |

Quantitative characters

| No | Character                        | Description |
|----|----------------------------------|-------------|
| 1  | Laminar length (cm)              | LML         |
| 2  | Laminar width area (cm)          | LMW         |
| 3  | Length of guard cell (µm)        | LGD         |
| 4  | Width of guard cell (µm)         | WGD         |
| 5  | Length of stomatal complex (µm)  | LSC         |
| 6  | Width of stomatal complex (µm)   | WSC         |
| 7  | Length of stomata (µm)           | LSto        |
| 8  | Width of stomata (µm)            | WSto        |
| 9  | Lower stomatal density (mm)      | LSD         |
| 10 | Upper stomatal density (mm)      | USD         |
| Accession | Leaf lobing | Stipule | Leaf Arrangement | Petiole Nature | Petiole Grove | Leaf texture | Leaf color | Leaf size | Leaf shape | Leaf margin | Marginal teeth | Marginal teeth spacing | Teeth shape | Teeth apex |
|-----------|------------|---------|-----------------|----------------|--------------|--------------|------------|-----------|------------|-------------|---------------|------------------------|-------------|-----------|
| P. edulis var. flavicarpa | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 3 | 0 | 0 | 1 | 0 | 1 |
| P. edulis var. flavicarpa | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 3 | 0 | 0 | 1 | 0 | 1 |
| P. edulis var. flavicarpa | 0 | 0 | 1 | 0 | 0 | 0 | 2 | 0 | 3 | 2 | 0 | 1 | 0 | 1 |
| P. edulis var. edulis | 0 | 0 | 1 | 0 | 0 | 0 | 2 | 0 | 3 | 2 | 0 | 1 | 0 | 1 |
| P. edulis panamared | 0 | 0 | 1 | 0 | 0 | 0 | 2 | 0 | 3 | 2 | 0 | 1 | 0 | 0 |
| P. foetida var. foetida | 0 | 1 | 1 | 0 | 0 | 1 | 0 | 1 | 3 | 6 | 0 | 1 | 2 | 4 |
| P. foetida var. foetida | 0 | 1 | 1 | 0 | 0 | 1 | 0 | 1 | 3 | 6 | 0 | 1 | 2 | 4 |
| P. foetida var. foetida | 0 | 1 | 1 | 0 | 0 | 1 | 0 | 1 | 3 | 6 | 0 | 1 | 2 | 4 |
| P. foetida var. foetida | 0 | 1 | 1 | 0 | 0 | 1 | 0 | 1 | 3 | 6 | 0 | 1 | 2 | 4 |
| P. foetida var. foetida | 0 | 1 | 1 | 0 | 0 | 1 | 0 | 1 | 3 | 6 | 0 | 1 | 2 | 4 |
| P. foetida var. foetida | 0 | 1 | 1 | 0 | 0 | 1 | 0 | 1 | 3 | 6 | 0 | 1 | 2 | 4 |
| P. foetida var. foetida | 0 | 1 | 1 | 0 | 0 | 1 | 0 | 1 | 3 | 6 | 0 | 1 | 2 | 4 |
| P. foetida var. foetida | 0 | 1 | 1 | 0 | 0 | 1 | 0 | 1 | 3 | 6 | 0 | 1 | 2 | 4 |
| P. foetida var. foetida | 0 | 1 | 1 | 0 | 0 | 1 | 0 | 1 | 3 | 6 | 0 | 1 | 2 | 4 |
| P. foetida var. foetida | 0 | 1 | 1 | 0 | 0 | 1 | 0 | 1 | 3 | 6 | 0 | 1 | 2 | 4 |
| P. foetida var. foetida | 0 | 1 | 1 | 0 | 0 | 1 | 0 | 1 | 3 | 6 | 0 | 1 | 2 | 4 |
| P. foetida var. foetida | 0 | 1 | 1 | 0 | 0 | 1 | 0 | 1 | 3 | 6 | 0 | 1 | 2 | 4 |
| P. coccinia | 1 | 2 | 1 | 0 | 0 | 1 | 4 | 0 | 0 | 7 | 0 | 1 | 0 | 0 |
| P. trifaciata | 0 | 2 | 1 | 0 | 1 | 0 | 2 | 1 | 2 | 3 | 0 | 1 | 0 | 0 |
| P. apoda | 0 | 2 | 1 | 0 | 0 | 1 | 1 | 1 | 2 | 3 | 0 | 1 | 0 | 0 |
| P. quadrangularis | 0 | 2 | 1 | 0 | 0 | 1 | 0 | 0 | 3 | 0 | 1 | 0 | 0 | 0 |
| P. subpeltat | 0 | 2 | 1 | 0 | 0 | 1 | 1 | 2 | 3 | 0 | 1 | 0 | 0 | 0 |
continued…

| Accession                      | Sinus shape | Leaf tip | Leaf base | Nature of hair | Veneration | Oil gland | Umbricinal gland position | Lobetip gland | Smell | Pubescent | Leaf polymorphism | Trichome | Stomata |
|-------------------------------|-------------|----------|-----------|----------------|------------|-----------|-----------------------------|---------------|-------|------------|-------------------|----------|---------|
| *P. edulis var. flavicarpa*   | 0           | 0        | 2         | 0              | 1          | 1         | 0                           | 1             | 1     | 0          | 1                 | 0        | 1       |
| *P. edulis var. flavicarpa*   | 0           | 0        | 2         | 0              | 1          | 1         | 0                           | 1             | 1     | 0          | 1                 | 0        | 1       |
| *P. edulis var. flavicarpa*   | 0           | 0        | 2         | 0              | 1          | 1         | 0                           | 1             | 1     | 0          | 1                 | 0        | 1       |
| *P. edulis var. edulis*       | 0           | 0        | 2         | 0              | 1          | 1         | 0                           | 1             | 1     | 0          | 1                 | 0        | 1       |
| *P. edulis var. edulis*       | 0           | 0        | 2         | 0              | 1          | 1         | 0                           | 1             | 1     | 0          | 1                 | 0        | 1       |
| *P. edulis panamaredad*       | 0           | 0        | 2         | 0              | 1          | 1         | 0                           | 1             | 1     | 0          | 1                 | 0        | 1       |
| *P. foeitida var. foeitida*  | 1           | 0        | 2         | 5              | 1          | 0         | 0                           | 2             | 1     | 2          | 9                 | 1        | 9       |
| *P. foeitida var. foeitida*  | 1           | 0        | 2         | 5              | 1          | 0         | 0                           | 2             | 1     | 2          | 9                 | 1        | 9       |
| *P. foeitida var. foeitida*  | 1           | 0        | 2         | 5              | 1          | 0         | 0                           | 2             | 1     | 2          | 9                 | 1        | 9       |
| *P. foeitida var. foeitida*  | 1           | 0        | 2         | 5              | 1          | 0         | 0                           | 2             | 1     | 2          | 9                 | 1        | 9       |
| *P. foeitida var. foeitida*  | 1           | 0        | 2         | 5              | 1          | 0         | 0                           | 2             | 1     | 2          | 8                 | 1        | 8       |
| *P. foeitida var. foeitida*  | 1           | 0        | 2         | 5              | 1          | 0         | 0                           | 2             | 1     | 2          | 8                 | 1        | 8       |
| *P. foeitida var. foeitida*  | 1           | 0        | 2         | 5              | 1          | 0         | 0                           | 2             | 1     | 2          | 8                 | 1        | 8       |
| *P. foeitida var. foeitida*  | 1           | 0        | 2         | 5              | 1          | 0         | 0                           | 2             | 1     | 2          | 8                 | 1        | 8       |
| *P. foeitida*                | 1           | 0        | 2         | 2              | 1          | 0         | 0                           | 2             | 1     | 2          | 8                 | 1        | 8       |
Table 4: Mean, standard deviation, range, coefficient of variation and F values of the quantitative traits.

| Character | Mean  | SD   | Range       | CV (%)  | F value  |
|-----------|-------|------|-------------|---------|----------|
| PTL       | 15.945| 1.467| 6.03-6.63   | 19.195  | 86.51**  |
| LML       | 65.041| 1.88 | 4.88-5.38   | 30.2507 | 93.056** |
| LMW       | **41.825** | **24.42** | **2.23-2.88** | **38.333** | **155.574**** |
| LGD       | 1.57  | 1.122| 1.40-7.70   | 18.2055 | 26.835** |
| WGD       | **0.12** | **1.51** | **33.76-36.44** | **16.1221** | **14.773**** |
| LSC       | 32.44 | 7.87 | 14.2-17.6   | 20.7707 | 50.305** |
| WSC       | 98.063| 1.43 | 2.0-10      | 29.2374 | 28.096** |
| LSto      | 0.142 | 0.6147| 2.0-5.10    | 18.5206 | 47.951** |
| W Sto     | 1.4266| .2768| .80-2.60    | 19.4028 | 21.272** |
| LSD       | 1.8769| 0.4066| .90-3.90    | 21.6634 | 37.825** |
| USD       | 2.22 | 0.8164| 1.6-7.0     | 36.7748 | 47.47** |

Table 5: Principal component analysis in 27 taxa of Passiflora species accounted by the first three principal components.

| Variables        | PC1     | PC2     | PC3     |
|------------------|---------|---------|---------|
| Leaf lobing      | **0.332** | -0.504 | **0.850** |
| Stipule          | 0.092   | -0.191  | -0.025  |
| Leaf arrangement | -0.291  | **0.312** | -0.081  |
| Petiole nature   | 0.092   | -0.191  | -0.060  |
| petiole grove    | -0.358  | 0.383   | -0.015  |
| leaf texture     | -0.488  | -0.293  | 0.072   |
| leaf color       | -0.933  | 0.34    | **0.288** |
| leaf size        | -**0.842** | -0.689 | -0.127  |
Discussions:-

The analysis of variance on the quantitative data revealed significant differences among the taxa at P<0.05 level. The highest coefficient of variation (Table 3.) estimated for laminar width (38.3cm), upper stomatal density (36.7), laminar length (30.25cm), and width of stomatal complex (29.23) suggests high degree of variability with regard to these characters. Of those, characters like laminar width and upper and lower stomatal density were found to be useful for distinguishing the taxa at inter specific level. Passiflora foetida var. gossippifolia was characterized by the presence of stomata on the adaxial surface, whereas in P.foetida var. foetida and P.foetida var. hispida they were amphistomatic. The lowest coefficient of variation was observed in characters like leaf length and width of stomata and guard cells in varieties of P.foetida indicating that they had only a minimal role in delimiting the taxa at the intra specific level. The significance of stomata and trichomes in the delimitation of the varieties of P.edulis was reported earlier by Chrochemore et al. [3].

Principal component analysis using qualitative morphological data exhibited significant differences at the inter and intra specific levels among the wild and cultivated species of Passiflora (Table 4). Anlaysis of data revealed that characters like leaf lobing (0.850), leaf trichome(4.637), sinus shape (1.021), and leaf margin (0.850) were highly significant in differentiating the wild and cultivated taxa of Passiflora at the inter and intra specific levels. This may be the reason for the variation observed among the varieties of P.foetida. Researches like Viscosi and Cardini [14], Al-shammary and Gornall [15] and Ogundipe [10] emphasized the significance of foliar characters like lobing, leaf trichome, leaf margin and sinus shape in distinguishing the intra specific variations in legumes, members of Saxifragaceae and in Alternanthera respectively.

UPGMA dendrogram (Fig.2) revealed the close relationships between the two species, P. vitifolia and P.coccinea. This may be due to presence of multicellular trichomes with characteristic leaf lobing, leaf base, leaf color, and leaf shape and teeth apex. The presence of the two accessions of the P. edulis var. edulis (ace 5 and ace 4) in the first cluster and P. edulis var.flavicarpa and var. panamared in the second cluster suggest the significance of foliar morphology in the delimitation of the taxa at the varietal level. The three varieties were clearly demarcated by the color of the leaves and the nature of leaf margin. Even though inter varietal differentiation was noticed in the varieties of P. foetida, the foliar characters did not support the delimitation of varieties at the intra varietal level. However, separation of the accessions (acc10 and acc 11) of P.foetida var.foetida, from the rest of accessions may be due to the presence of anisocytic stomata and dense pubescent leaves. The clustering of the accessions of P.foetida var.hispida, into two different groups may be due to variations in the number and length of trichomes. The interlinking of P.foetida var.gossippifolia and the varieties P.foetida var.hispida and P.foetida var.foetida may be due to the foliar characters (absence of leaf polymorphism, trilobed leaves, lob tip gland and entire leaf margin with glands) shared by them.
The variations in the foliar morphological characters at the inter specific levels were also noticed in the present investigation. Similarity in the entire leaf margin and the lack of trichomes and hairs in *P. subpeltata* and *P. faciata* pointed out the interspecific relationship. The presence of dense pubescence and multicellular trichomes in *P. vitifolia* and *P. coccinea* revealed their close relationships. Simple leaves with entire margin in *P. apoda* and *P. quadrangularis* can be the distinguishing character to delimit the species. Occurrence of the two hybrid varieties *P. 'Manapany' and P. 'Cananelle' together in the second subcluster may be due to the characters like leaf arrangement, leaf size, marginal sheath spacing and teeth apex shared by them, but the former was distinct by the presence of trichomes. According to Tangarife et al. [9] clustering of the seven species of *Passiflora* L. together in a single cluster based on the unique nature of the leaf arrangement and leaf margin.

The data suggest that the inter and intra specific variations in *Passiflora* may be primarily due to the foliar variations. The study emphasizes the significance of foliar characters in the delimitation of taxa at the inter and intra specific levels. The taxonomic key prepared, based on foliar features supports the findings.

**PC values indicated in boldface are significant**

**Fig 1:** Foliar morphological variation.

**Fig 2:** PCA scatter plot exhibiting foliar variations in species of *Passiflora*.
Fig 3:- Dendrogram based on UPGMA analysis generated from Euclidean distance of Leaf morphological characters.

**Taxonomic Key**

Leaves simple
1. Glabrous with entire margin……..*P.quadrangularis*
2. Pubescent with serrate margin…………..*P.coccinea*

Leaves lobed
1. Partially lobed, entire margin
2. Gland absent at the leaf tip
3. Leaves purple colored ..........*P.triaxiiata*
4. Leaves green colored..........*P.subpeltata*

Gland present at the leaf tip
1. Trichomes are non glandular and multicellular ….*P.apoda*
2. Trichomes are both glandular and non glandular
3. Unicellular non glandular, dense hispid trichomes
...P.foetida var. hispida
1. Unicellular non glandular, dense, pubescent trichomes

..........P.foetida var. foetida
1. Unicellular non glandular, sparsely pubescent trichome.
Petiole with pink color.........

P.foetida var.gossippifolia
1. Deeply lobed, serrate margin
2. Glabrous leaves
3. Marginal gland present
4. Wavy serrate margin
5. Pale green color...............P.edulis var. edulis
6. Linear serrate margin
7. Dark green color
8. Green color petiole.....P.edulis var .flavicarpa
9. Red color petiole.........P.edulis 'panamared '
10. Marginal gland absent
11. Linear serrate margin dark green color........P. 'Cannelle'
12. Leaves pubescent
13. Serrate margin, absent marginal gland, light green color........P. 'Manapany'

Acknowledgements:-
The authors are grateful to Dr.Suhara beevy S, Head, Department of Botany, University of Kerala for providing the facilities.

Reference:-
1. Killip, E.P. (1938). The American species of Passifloraceae.- Field Museum of Natural History, Botanical Series - 19: 1–613.
2. Vanderplank, J. (1996). Passion flowers. MIT Press, United Kingdom.
3. Feuillet, C.Y., Mcdougal, J. (2003). A new infrageneric classification of Passiflora.- Passiflora 14(1), 1-4.
4. Crochemore, M.L., Molinari, H.B., Vieira, L.G.E. (2003). Genetic diversity in passion fruit (Passiflora spp.) evaluated by RAPD markers, Braz. Arch. Biol. Technol. 46, 521-527.
5. dos Santos, L.F., de Oliveira, E.J., dos Santos , de Carvalho, A.F.M., Costa, J.L., Padua, J.G. (2011). ISSR markers as a tool for the assessment of genetic diversity in Passiflora, Biochen genet. 49(7), 540-544.
6. Souza, M.M., Pereira, T.N.S., Vieira, M.L.C. (2008). Cytogenetic studies in some species of Passiflora L. (Passifloraceae): A review emphasizing Brazilian species, Braz.arch. boil. Technol. 51 247-258.
7. Viana, A.J.C., Souza, M.M., Araújo, I.S., Corrêa, R.X., Ahnert D. (2010). Genetic diversity in Passiflora species determined by morphological and molecular characteristics, Biologia Plantarum. 54 (3), 535-538.
8. Krosnick, S.E., Freadenstein, J.V. (2005). Monophyly and floral character homology of old world Passiflora (subgenus Decaloba:super section Disemma). Systematic botany 30(1), 139-152
9. Tangarife, M.M.M., Caetano, C.M., Tique, C.A.P. (2009).Morphological Characterization of colombian Passiflora species, ACTA Agromonica. 58 (3).
10. Ogundipe, O.T. (1996) Taxonomic significance of Leaf epidermis in Alternanthera Frpsk.(Amaranthaceae), Bol.Soc.Brot.Ser. 2 ,231-244.
11. Petchsri, S., Boonkerd, T. (2003).Numerical taxonomy of Cassia sensu lato in Thailand. In BRT research reports 2003, Chuan printing press Ltd. Part., Bangkok
12. Soladoye, M.O., Onakoya, M.A, Chukwuma, E.C., Sonibare, M.A (2010). Morphometric study of the genus Senna Mill.In South-western Nigeria, Afr. J. Plant Sci. 4, 044-052.
13. Saheed, S.A., Illoh, H.C. (2011). Important morphological characters in several species of Cassiinae (Leguminosae) in south-western Nigeria, Not. Sci. Biol. 3, 47-56
14. Viscosi, V., Cardini, A. (2011). Leaf Morphology, Taxonomy and Geometric Morphometrics: A Simplified Protocol for Beginners. PLoS ONE 6(10)
15. Al-shammary, K.I.A., Gornall, R.J. (1994). Trichome Anatomy of Saxifragaceae s.l. from the Southern Hemisphere, Botanical Journal of the Linnean Society.114, 99-131.