

## Chapter 4: Results

Unless otherwise stated, the following account holds good for the five species of *Alternanthera*.

### 4.1 GROWTH HABIT AND PLANT MORPHOLOGY (Table 7)

Morphological characters of taxonomic importance for all species in the present study are shown in Table 7. In general, all the species of *Alternanthera* are herbs except *A. brasiliana*, which is a shrub. Although the species studied are perennial; under unfavourable conditions, they could be annual. *Alternanthera* species in the present study is either a common weed [*A. sessilis* ‘Green’, *A. paronychioides* & *A. ficoidea*]; medicinal plant [*A. sessilis* ‘Red’] or an ornamental plant (*A. brasiliana* & *A. betzickiana*).

As one of the common weeds, *A. sessilis* ‘Green’ could be found in various habitats exhibiting different types of growth habits. In terrestrial habitats such as hot and dry waste lands, it is decumbent or creeping. The plant branches extensively with robust roots and eventually forms a mat (Figure 1). In damp area such as shallow and wet ditches, *A. sessilis* ‘Green’ shows decumbent growth. In aquatic areas such as canals or lake margins, the growth habit is ascending and the plant partially submerged in water has numerous lateral branches (Figures 2A & B). The lower parts of the stem that are submerged in water are attached to the substrate by a group of long and stringy roots at the nodes (Figure 3). *Alternanthera sessilis* ‘Green’ is also found in shallow marshes; it exhibits ascending growth when the area is inundated by water. *Alternanthera sessilis* ‘Red’ is more commonly cultivated as a medicinal plant and thus, it is rarely found as a weed in the field. Similar to the green leaf form, the red leaf form

is decumbent, creeping or prostrate and often forms a mat on the ground (Figure 1). Occasionally, it is ascending.

*Alternanthera brasiliana* is commonly grown as an ornamental plant and could be found in both open and shady areas. *Alternanthera brasiliana* is decumbent at the base and then grows upwards, ascending and erect. The plant grows gregariously up to 1–1.5 m tall (Figure 4A). *Alternanthera paronychioides*, a less common weed, is found in either dry waste lands or along road sides but rarely in damp areas. It is prostrate and very often it forms a mat on the ground with numerous prostrate branches on the sandy loam soil (Figure 7). On a rare occasion, *A. paronychioides* is found growing ascending at the edge of a mangrove site in the Kuala Selangor Nature Park

*Alternanthera bettzickiana* is a bushy plant that shows erect or ascending habit (Figure 5). This is always used as a bedding plant. *Alternanthera ficoidea* shows a similar growth habit as *A. sessilis*, which is decumbent and ascending in waste lands or along ditches (Figure 6).

## Stems

The stems vary in colour and hair type. In both leaf forms of *A. sessilis*, the stem internodes are covered with very short, erect, stiff hairs concentrated mainly along the interpetiolar median, at the nodes and leaf axils as well as the longitudinal side of the stem; otherwise, the stem is glabrescent (Figure 8). In the other species, hairs densely cover the young stem internodes initially. In *A. paronychioides* and *A. ficoidea*, the hairs are flexuous long (Figures 9B & 10A), while those of *A. brasiliana* (Figure 4E) and *A. bettzickiana* (Figure 10A) are appressed straight to curved. As the stems grow older, it becomes glabrescent in *A. paronychioides* and *A. ficoidea* (Figures 9C & 10C) while the hair is moderately scattered in *A. brasiliana* (Figure 4B) and *A. bettzickiana*.

Stem colour is a good supplementary character to distinguish some species. The red and green leaf forms of *A. sessilis* could be easily distinguished by its red and green stem respectively. The stems of *A. ficoidea* is also green but only the internodes adjacent to the nodes of *A. ficoidea* and *A. sessilis* as well as *A. bettzickiana* are tinged with purple (Figures 8 & 10B). Another species, *A. paronychioides* could be easily recognized by its light brown stem (Figure 9A).

Two types of stem are recorded in *A. sessilis* 'Green'. The stem is fistular when the plant is growing in aquatic habitats (Figure 3D) and solid when the plant is growing in terrestrial habitats. The stems of *A. brasiliiana* are obtusangular while the other species are terete. Another conspicuous character that distinguishes *A. brasiliiana* from the other species is that the internodes adjacent to the nodes are thickened and articulate (Figure 4D).

## Leaves

The leaves of the species studied are opposite, simple and they differ in shape, size, type of hair distribution and colour. Leaves are variable in shape; from narrowly elliptic to elliptic, lanceolate, oblanceolate and ovate. The leaf shape of *A. bettzickiana* often has undulations, which is very different from the other species studied (Figures 16A & B).

The average length and width of the leaf ranges from  $19.41 \pm 2.72$  mm to  $96.41 \pm 11.18$  mm and  $6.25 \pm 0.53$  mm to  $45.35 \pm 5.68$  mm respectively. Of these, *A. brasiliiana* has the largest leaves whereas *A. sessilis* 'Green' has the smallest leaves. Both leaf forms of *A. sessilis* (from the terrestrial habitats) shows no significant difference in their length and width ( $p > 0.05$ ) (Appendix 4.1.2). *Alternanthera sessilis*

‘Green’ collected from the aquatic areas significantly longer than those from the terrestrial areas ( $p < 0.05$ ) (Appendix 4.1.4). However, *A. sessilis* ‘Green’ collected from the terrestrial areas significantly wider than those from the aquatic areas ( $p < 0.05$ ) (Appendix 4.1.4).

The leaf apex of the species studied could be categorized into three groups. In *A. sessilis*, *A. brasiliiana* and *A. paronychioides*, the apex is either acute, acuminate or obtuse without a mucro, while those of *A. ficoidea* is either acute or acuminate with a mucro (Figures 15A & B) and those of *A. bettzickiana* is either obtuse or round with a mucro (Figure 16F). *Alternanthera brasiliiana*, *A. paronychioides*, *A. ficoidea* and *A. bettzickiana* have long, narrow, attenuate leaf base which forms a distinctly demarcated petiole (Figures 13A & B, 14A & 16D). Although *A. sessilis* has attenuate base, it does not form a demarcated petiole. The petiole of most of the species is longer than 10 mm except in *A. sessilis*.

The leaf margin is either sparsely serrate as in *A. sessilis* and *A. ficoidea* (Figures 12D, 15C & D) or entire as in *A. brasiliiana* and *A. paronychioides* (Figures 13F, 14D & E). *A. ficoidea*, on the other hand, has a undulate margin (Figures 16D & E). The leaf margin of *A. sessilis* is occasionally finely fimbriate and could be a good supplementary character to distinguish *A. sessilis* from the other species studied (Figures 12E & F).

In *A. sessilis*, a few long hairs are observed on the midrib of the abaxial and adaxial surface. Minute barb-like hairs are occasionally scattered over the lamina, otherwise the lamina is glabrous (Figure 12). In *A. brasiliiana*, minute dentate hairs are scattered over the lamina especially on the midrib of the adaxial surface (Figures 13C–F). For the other three species, the young leaves are distinctive from the mature leaves. In the young leaves of *A. paronychioides*, appressed long hairs are moderately

and densely scattered all over the adaxial and abaxial surface respectively (Figure 14). In the young leaves of *A. ficoidea* and *A. bettzickiana*, the appressed long hairs are densely scattered on both surfaces (Figure 15A & B). However, as the leaves grow older, the adaxial and abaxial surfaces of *A. paronychioides*, *A. ficoidea* and *A. bettzickiana* become glabrescent.

The leaf colour varies according to species. For instance, *A. sessilis* ‘Red’ and ‘Green’ has red and green leaves respectively. The leaves are green in *A. paronychioides* and purple red in *A. brasiliana*. Finally, the leaves of *A. ficoidea* are green while *A. bettzickiana* are green or green variegated with white (Figure 16).

### **Inflorescences**

The spike inflorescences of *Alternanthera* are usually solitary and occasionally in a cluster of two. The inflorescences are axillary and sessile in all the species studied except in *A. brasiliana*. The inflorescence of *A. brasiliana* is terminal and supported by a long peduncle (Figure 18). Initially, the inflorescence is subglobose or hemispheric-ovoid and gradually become cylindrical when it grows older (Figures 18B, 19A, 20A & 21A). Hairy rachis is only found in *A. sessilis* (Figures 17B & C).

The bracts and bracteoles are 1-nerved, scarious, white and persist on the rachis even after fruit dispersion. *Alternanthera sessilis* and *A. paronychioides* have three bracts while *A. brasiliana*, *A. ficoidea* and *A. bettzickiana* have one single bract. The shape of the bract is deltoid in *A. sessilis*, convex-lanceolate in *A. paronychioides* (Figure 19B) and ovate in *A. brasiliana* (Figure 18B), *A. ficoidea* (Figure 20C) and *A. bettzickiana* (Figure 21B). The average length and width of the bract ranges from  $2.42 \pm 0.19$  mm to  $3.19 \pm 0.13$  mm and  $0.89 \pm 0.08$  mm to  $1.27 \pm 0.16$  mm respectively. The

apex is acute in *A. sessilis* while that in the other species is mucronate with a prominent midrib. Both the abaxial and adaxial surface of *A. sessilis* and *A. paronychioides* are glabrous. In the other species studied, the abaxial surface is usually hairy while the adaxial surface is glabrous. The long hairs are dense at the upper part of the bract in *A. brasiliiana* (Figure 18E) but sparsely scattered at the upper part of the bract in *A. ficoidea* (Figure 20C). In *A. bettzickiana*, on the other hand, the short hairs moderately covered the lower part (Figure 21B).

The bracteoles of *A. brasiliiana*, *A. ficoidea* and *A. bettzickiana* (Figure 21C) are lanceolate and folded at the midrib. The average length and width varies from  $3.27 \pm 0.24$  mm to  $3.90 \pm 0.24$  mm and  $1.08 \pm 0.14$  mm to  $2.79 \pm 0.23$  mm respectively. The entire apex is mucronate with a prominent midrib. In these species, the abaxial surface is usually hairy while the adaxial surface is glabrous. In *A. brasiliiana*, the abaxial surface is hairy at the upper part resulting in an irregular dentate crest (Figure 18D). In *A. ficoidea*, the bracteole is hairy along the midrib but the bracteole is hairy at the lower part in *A. bettzickiana* (Figure 21C). The hairs are long, straight and projecting slanting upwards. The adaxial surface of the bracteoles in *A. brasiliiana*, *A. ficoidea* and *A. bettzickiana* are glabrous.

## Flowers

The shape of the petals is lanceolate in most of the species studied but oblong-lanceolate in *A. brasiliiana*. The five petals are equal in *A. sessilis* and *A. brasiliiana* while they are subequal in *A. paronychioides* (Figure 19C), *A. ficoidea* and *A. bettzickiana*. The average length and width varies from  $1.73 \pm 0.23$  mm to  $5.18 \pm 0.1$  mm and  $0.69 \pm 0.14$  mm to  $1.22 \pm 0.11$  mm respectively. In the species with subequal petals, the outer three petals are generally bigger than the inner two. Often, the inner

two petals are folded at the midrib (Figures 20D & 21E). In *A. sessilis*, both leaf forms do not differ significantly in the petal length and width ( $p > 0.05$ ) (Appendix 4.1.3).

The apex of the petal varies from acute or shortly acuminate to mucronate. *A. ficoidea* and *A. bettzickiana* differ distinctly from the other species in having a prominent midrib with a sharp mucronate apex (Figures 20E & 21E). The margin is sparsely denticulate at the upper part in *A. sessilis* (Figure 17D) and it is entire in the other species.

Among the five species studied, only the petals of *A. sessilis* are 1-nerved. In *A. brasiliiana*, three prominent nerves are clearly seen from the base to the upper part of the petals (Figure 18C). In the outer petals of *A. paronychioides* (Figure 19D), *A. ficoidea* and *A. bettzickiana*, three prominent nerves are seen up to the middle part of the petals.

The abaxial surface of the petal is glabrous in *A. sessilis* but hairy in the other species. In *A. brasiliiana*, the abaxial surface is covered entirely by appressed straight hairs (Figure 18C). Hair distribution on the outer petal varies according to species. In *A. paronychioides*, the long straight hairs are moderately distributed at the lower part (Figure 19D). In *A. ficoidea*, the long straight hairs projecting slanting upwards along the petal (Figure 20E). *A. bettzickiana*, on the other hand, the long straight hairs are distributed only up to the middle part of the petal (Figure 21D). In all the species studied, the adaxial surface is usually glabrous and rarely, slightly hairy with a few minute hairs as in *A. sessilis*. For the inner petal of *A. bettzickiana*, *A. paronychioides* and *A. ficoidea*, the abaxial and adaxial surface is hairy and glabrous respectively (Figure 20D).

The petal is white or white only at the upper part while the colour varies at the lower part. For instance, the lower part is pink in *A. sessilis* 'Red' or green in *A.*

*paronychioides*, *A. brasiliana* and *A. sessilis* 'Green'; while the entire petal of *A. ficoidea* and *A. bettzickiana* is white.

The number of stamens that make up the androecium is three in *A. sessilis* and five in the other species. Four stamens, one of which is degenerated or not well developed, have occasionally been found *A. sessilis* 'Red'. The shortest stamen is recorded in *A. sessilis* (red) (average:  $0.71 \pm 0.09$  mm) and the longest is recorded in *A. ficoidea* (average:  $2.45 \pm 0.13$  mm). In *A. sessilis*, both leaf forms do not differ significantly in the length of stamen ( $p > 0.05$ ) (Appendix 4.1.2). In all the species studied, five filaments fuse at the base forming a short cup except *A. brasiliana* in which the filaments fuse for most of their length forming a cylindrical tube.

Generally, the anthers are oblong and yellow. Nevertheless, the anthers of *A. brasiliana* are membranous; light brown and devoid of pollen grains. One to two anthers of *A. bettzickiana* are shrunken and brown indicating abnormality. The anthers are alternated with scarious pseudostaminodes. The pseudostaminodes in *A. sessilis* are either shorter than or as long as the stamens, while those of *A. paronychioides* are half as long as the stamens (Figure 22A). The pseudostaminodes in *A. brasiliana* (Figure 22B), *A. ficoidea* (Figures 22D) and *A. bettzickiana* are slightly longer than or as long as the anthers. Three types of apex are recorded in the species studied. The apex of the pseudostaminodes is narrowly to broadly triangular with entire-subentire margin in *A. sessilis*; broadly short-dentate in *A. paronychioides*; narrowly triangular and irregularly dentate or laciniate in *A. brasiliana*, *A. bettzickiana* and *A. ficoidea* (Figures 22E & F). The colour of pseudostaminodes is generally white with yellow at the apex during blooming. However, the pseudostaminodes of *A. sessilis* are white throughout flower anthesis while they are completely light green in *A. paronychioides* (Figure 22A).



The pistil is made up of a single basal ovary with a capitate stigma. The species studied could be divided into three groups based on the shape of the ovary, which are: obcordate (*A. sessilis* and *A. paronychioides*) (Figure 23A); obovoid (*A. brasiliiana*) (Figure 23B) and subconical (*A. bettzickiana* and *A. ficoidea*) (Figures 23C & D). The style is shorter in *A. sessilis*, *A. paronychioides* and *A. ficoidea* (average length < 0.2 mm) when compared to that of *A. brasiliiana* and *A. bettzickiana* (average length > 0.2mm). The colour of the ovary is light green in all the species except in *A. sessilis* 'Red', which is red.