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RESEARCH ARTICLE

FOLIAR FEATURES OF *ALTERNANTHERA* (FORSSK.) SPECIES OF SOUTHERN WESTERN GHATS OF KERALA.

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Abstract

Seven species of the genus *Alternanthera* of Amaranthaceae family were analyzed through foliar characteristics. The leaf shapes, stomatal index, type of stomata and foliar trichomes have been studied. Four species viz. *A. philoxeroides*, *A. tenella* var. *tenella*, *A. paronychioides* and *A. brasiliana* were observed to have trichomes which were elongated and multicellular. The typical stomatal pattern was diacytic though there occur other types like anisocytic in fewer densities. The stomatal index was highest for *A. paronychioides* and least for *A.pungens*. The study gives an insight into the applicability of foliar traits in the systematic studies of *Alternanthera* genus.

Introduction:-

The cosmopolitan family Amaranthaceae is having 64 genera and ca. 800 species, abundantly distributed in the tropical regions of Africa, America and India. There is obvious dominance of ubiquitous weedy species in the family (Alwadie, 2005). The neotropical genus *Alternanthera*, an important representative of the family Amaranthaceae was established by Forsskal in 1775. This genus has 80-200 species with South America as its main centre of diversity (Sa´nchez-del Pino et al. 2012). The threatened ecosystems like wetlands and water bodies are mainly colonized by these taxa (Liendo et al., 2013). The genus exhibits high phenotypic variability that leads to nomenclatural problems as well as incorrect application of names (Pederson, 2000). The monophyly of *Alternanthera* was recently established within GomphrenoideaeKostel. (Sa´nchez-del Pino et al. 2012). In India, the genus is represented by 12 species (Hooker and Jakson, 1965). A few species of the taxa are reported to have antimicrobial activities against fungal and bacterial strains (Sivakumar and Sunmathi, 2016). The genus is having medicinal potential and reported to contain volatile constituents, flavonoids, essential amino acids, steroids as well as glycosides (The Wealth of India, 2004). Some species also find application in snake bites and a few others are consumed as vegetables (Swapna et al., 2011).

Foliar features can provide valuable data on systematics as well as ecological adaptation of a species (Anil Kumar et al., 2017). The morphological and anatomical characterization of *Alternanthera* species of Kerala has been attempted in the present study. The morpho anatomical investigation of alligator weed, *Alternanthera philoxeroides* has been attempted (Jana et al., 2013). However, a detailed foliar characterization of species seen in Kerala is still lacking and hence the study was undertaken.

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Materials and Methods:-

The various species are collected from different geographical zones of the state. The gross morphology, floral biology and other salient features are taken into account for the systematic categorization.

Alternanthera bettzickiana(Regel) G, Nicholson:-
Leaves are simple, opposite, 1-3- 14 x 0.5- 2cm, elliptic to oblanceolate or rhomboid – ovate, acute or acuminate at the apex, long attenuate at base. Leaves are petiolate ~0.96 cm in length. Adaxial surface of leaves is glabrous in nature, abaxial surface is pubescent. Leaf margin is entire and leaf colour is greenish purple.

Alternanthera brasiliana (L.) Kuntze:-
Leaves simple and entire with decussate phyllotaxy, oval-lanceolate shape, cuneate base, acute-acuminate apex and slightly wavy margin, measuring about 10 cm long and 4 cm wide. The foliar surface is membranous, moderately hairy and purple green on the adaxial side and shiny purple on abaxial surface. Leaves are petiolate ~ 1.26 cm in length.

Alternanthera paronychioides A.St.-Hil:-
Leaves are simple, opposite, 3 x 0.7 cm, leaf lamina is oblanceolate to spathulate in shape, leaf apex is acute and leaf base is attenuate in nature, leaf surface is glabrous. Leaves having petiole

Alternanthera philoxeroides (Mart.) Grisb:-
Leaves are simple, opposite, 5-10 x 0.5-2.5 cm; leaf blade is elliptic to obovate-lanceolate with acute base, with prominent midrib on the lower surface. Leaf margin is entire and slightly pubescent, leaves are succulent in nature. Leaves are sessile

Alternanthera pungensKunth:-
Leaves are simple 1.5 x 1 cm, deltoid to obovate, apex obtuse, base narrowed, short. Glabrous leaf surface, Petiolate leaves ~0.54cm in length.

Alternanthera sessilis (L.) DC:-
Leaves are simple, opposite, 3-4 x 1 cm, elliptic-oblong to oblanceolate, leaf apex obtuse, base attenuate, leaf margin entire. Petiole absent, leaf surface glabrous.

Alternanthera tenella Colla.var.tenella:-
Leaves are simple, opposite 3-4.5 x 2 cm, elliptic-oblong, leaf apex is sub-acute, subsessile, ovoid, leaf base is attenuate in nature. Leaf surface is covered with hairs. Leaf margin is entire. Petiolate leaves having ~0.82cm petiole length.

Study of foliar trichomes:-
Fresh leaf peels were taken and mounted in glycerine. They were observed under microscope. The density and nature of tricomes were analyzed.

Stomatal studies:-
Fresh leaf peels were taken and mounted in glycerine. The number of stomata were counted in ten random fields and average taken as stomatal index by using the formula
Stomatal index = S X 100/E+S
S - No of Stomata
E - No of Epidermal cells

Results and Discussion:-

The foliar epidermis is one of the most noteworthy taxonomic characters from biosystematic point of view. For example, studies have been conducted in many families on the basis of the leaf epidermis to delineate taxa (Albert and Sharma, 2013; Aworinde et. al., 2014). Micromorphological parameters of different plant parts have been used as aids in the taxonomical recognition of species (Kathiresan et. al., 2011).

Trichomes provide protection to living cells against the damages induced by UV-radiation (Skaltsa et al. 1994) and stress induced by low temperatures (Agrawal et al. 2004). The formation of trichomes is often triggered by abiotic stresses like drought and UV radiation (Hoglund and Larsson, 2005). It is a known fact that habitat has a strong influence on the appearance of foliar trichomes. In the genus *Acinos* of Lamiaceae, frequency and kinds of dominant trichomes displayed variation among populations in accordance with habitats (Talebi and Shayestehfar, 2014). Few earlier attempts have been made to study the foliar trichomes in some *Alternanthera* species especially that of *A .brasiliana* (Duarte and Debur 2004). In the present study, trichomes have been observed in *A.brasiliana*, *A. paronychioides*, *A.philoxeroides*, *A. pungens* and *A. tenella* var. *tenella* (Fig.1, **A, B, C, D, E**). Both glandular and nonglandular trichomes are absent in *A. sessilis* and *A. betzickiana*. On the other hand, species like *A.brasiliana*, *A. paronychioides* and *A. tenella* var. *tenella* are having nonglandular trichomes only (Fig.1, **A, B, E**). These nonglandular trichomes are having pointed apices (Fig.1, **A, B, E**). *A. pungens* exclusively possesses small multicellular glandular trichomes (Fig.1.**D**). Meanwhile *A. philoxeroides* possesses both glandular and nonglandular trichomes in lesser frequencies (Fig.1**, C**). The taxonomic relationships among the three species of *Stachytarpheta* has been elucidated through trichome analysis (Iroka et al., 2015). In *Solanum* also, the trichome morphology and distribution has been employed for taxonomic discrimination (Anilkumar et al., 2017).

The foliar stomatal index also shows variation in the taxa analyzed (Table.1). The highest stomatal index is exhibited by *A. paronychioides* (24.3%) followed by *A. tenella* var. *tenella* (23.7%) and *A. bettzickiana* (22.8%). These indices are much higher than that reported for *Gomphrena* species (Carvalho et al., 2010).The least index is shown by *A. pungens* (10.6%). The species with higher stomatal indices were observed to prefer moist habitats and hence the higher index may not pose any physiological stress due to transpirational loss. However, *A. pungens* grows in comparatively drier areas – along coastal belts and dry zones. The lower stomatal index can be considered as an adaptation to check the water loss. Further, wide variation in the stomatal indices of *Solanum* taxa has been reported (Anil kumar et al., 2017). The stomatal index is often treated as a species specific trait having taxonomic relevance.Stomatal index on leaf surfaces varies greatly among various species of plants.

The nature of stomata also shows marked variations (Table.2). More than one type of stomata is seen all the species analyzed except in *A.philoxeroides*, in which there is predominance of diacytic stomata (Fig.2). While in the rest of the species, eventhough diacytic stomata is predominant, there occur other stomatal types like anomocytic and paracytic in lesser frequencies (Fig.2). *A. bettzickiana* possesses two stomatal types like diacytic and paracytic (Fig.2.**A)**. While in *A. brasiliana*, diacytic and anomocytic stomata are seen (Fig.2.**B**) which supports the previous reports (Duarte and Debur, 2004). In *A. paronychioides*, the leaf surface has anomocytic and diacytic stomata but the frequency of anomocytic stomata is less (Fig.2.**C**). *A. pungens*, *A. sessilis* and *A. tenella* var. *tenella* possess three stomatal types in which diacytic is predominant while paracytic and anomocytic types are in lesser frequencies (Fig.2. **E, F, G**). *A. bettzickiana*, *A. brasiliana, A. paronychioides, A. philoxeroides, A. sessilis*, and *A. tenella* are showing sharing of subisidiary cells in lesser frequencies. (Fig.2, **A, B, C, D, F, G**).There is no subsidiary cell sharing in *A. pungens* (Fig.2**, E**). Foliar stomatal characteristics have been considered as valuable taxonomic tools in *Solanum* species of Southern Western Ghats of Kerala (Anil Kumar &Murugan, 2015). The study also explains the occurrence of more than one type of stomata in *Solanum* species. Daniel and Atumeyi (2011) analyzed stomatal complex type found in four *Dioscorea* species from anomocytic type to other variations in all the analysed species. Al-Edany and Al-Saadi (2012) studied five cultivated species belong to five genera of Myrtaceae such as *Callistemon viminalis, Eucalyptus camaldu- lensis, Myrtus communis, Psidiumguajava* and *Syzygium aromaticum*. It was clear that certain stomatal structural characteristics were of significant importance in separation of these taxa, However, Pyakurel and Wang (2014) suggested that stomatal and mesophyll features, being highly variable and susceptible to environmental variations serve little in species delimitation.

The leaf shape is also found to be characteristic (Table.3). Acute or acuminate apex is characteristic of, *A. bettzickiana*,*A. brasiliana* and *A. paronychioides* (Fig.3**.A, B, C**). The apex is obtuse in *A. pungens* and *A. sessilis* while in *A. tenella* var. *tenella*, the leaf apex is subacute (Fig.3, **E, F, G**). The leaves are succulent and sessile in *A.philoxeroides* and subsessile in *A. tenella* var. *tenella* (Fig.3**, D, G**). The leaves show pubescens in *A. pungens* and *A. tenella* var. *tenella* (Fig.3.**E, G**). The highest petiole length is displayed by *A. brasiliana* (1.26 cm) (Fig.3.**B**).

Table 1:-Stomatal index of *Alternanthera* spp.

SL NO	PLANT SPECIES	STOMATAL INDEX
1	*Alternanthera bettzickiana*	22.8%
2	*Alternanthera brasiliana*	14.6%
3	*Alternanthera paronychioides*	24.3%
4	*Alternanthera philoxeroides*	13.9%
5	*Alternanthera pungens*	10.6%
6	*Alternanthera sessilis*	14.8%
7	*Alternanthera tenella*	23.7%

Table 2:-Stomatal nature in*Alternanthera* spp.

Sl no	Plant species	Nature of stomata
1	*Alternanthera bettzickiana*	Diacytic
		Paracytic
2	*Alternanthera brasiliana*	Diacytic
		Anomocytic
3	*Alternanthera paronychioides*	Diacytic
		Anomocytic
4	*Alternanthera philoxeroides*	Diacytic
5	*Alternanthera pungens*	Diacytic
		Anomocytic
		Paracytic
6	*Alternanthera sessilis*	Diacytic
		Anomocytic
		Paracytic
7	*Alternanthera tenella*	Diacytic
		Anomocytic
		Paracytic

Table 3:- Leaf shape of *Alternanthera* spp.

Plant species	*A. bettzickiana*	*A. brasiliana*	*A. paronychioides*	*A. philoxeroides*	*A. pungens*	*A. sessilis*	*A. tenella*
Leaf nature	Normal	Normal	Normal	Succulent	Normal	Normal	Normal
Leaf apex	Acute or acuminate	Acute or acuminate	Acute or acuminate	Obovate-lanceolate	Obtuse	Obtuse	Subacute
Leaf base	Attenuate	Cuneate	Attenuate	Acute	Narrow	Attenuate	Attenuate
Leaf surface	Glabrous	Glabrous	Glabrous	Pubescent	Glabrous	Pubescent	Pubescent
Leaf margin	Entire	Entire	Entire	Entire	Entire	Entire	Entire
Leaf colour	Purple	Purple	Green	Green	Green	Green	Green

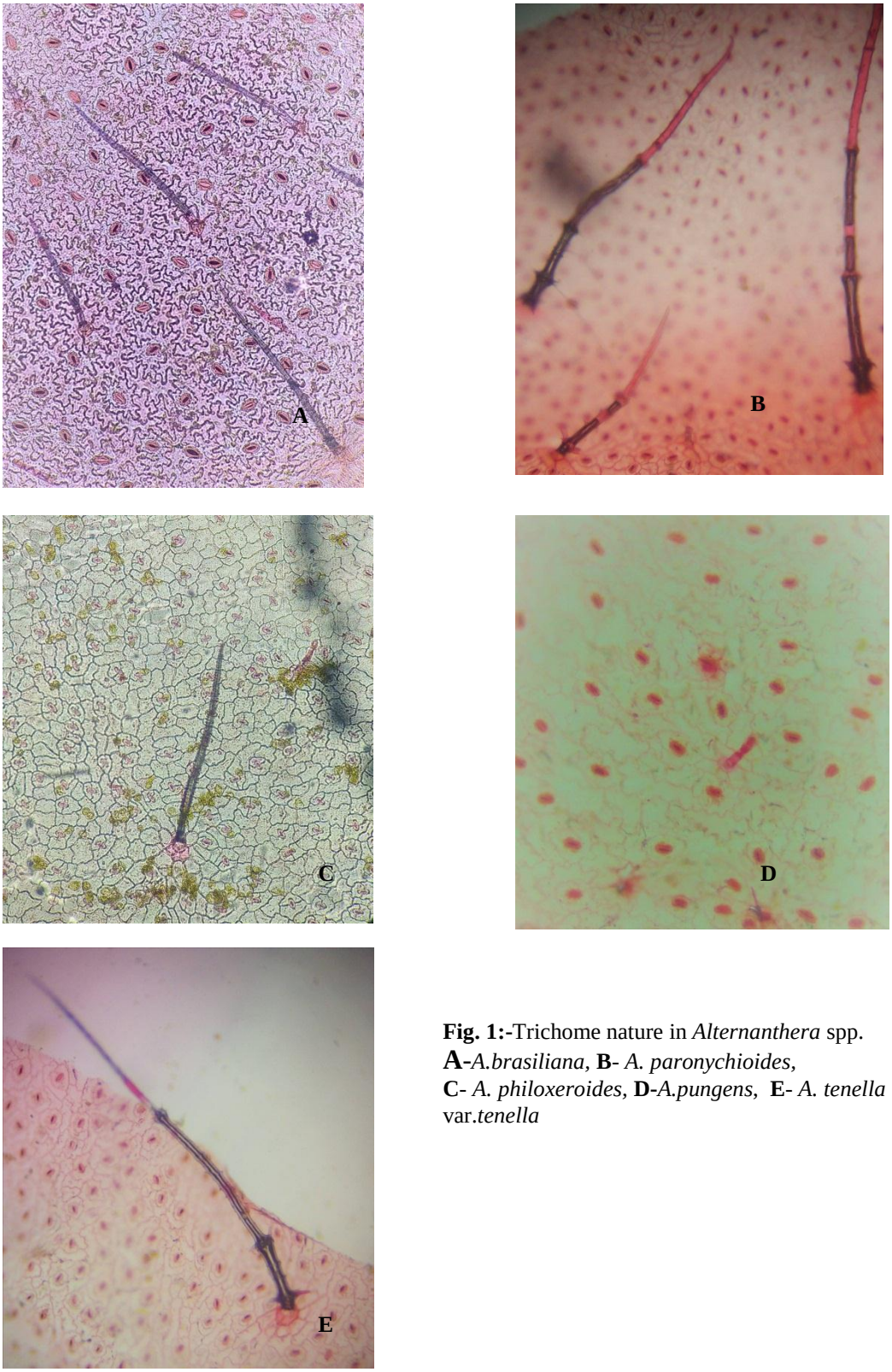

Fig. 1:-Trichome nature in *Alternanthera* spp. **A-***A.brasiliana*, **B**- *A. paronychioides*, **C**- *A. philoxeroides*, **D**-*A.pungens*, **E**- *A. tenella* var.*tenella*

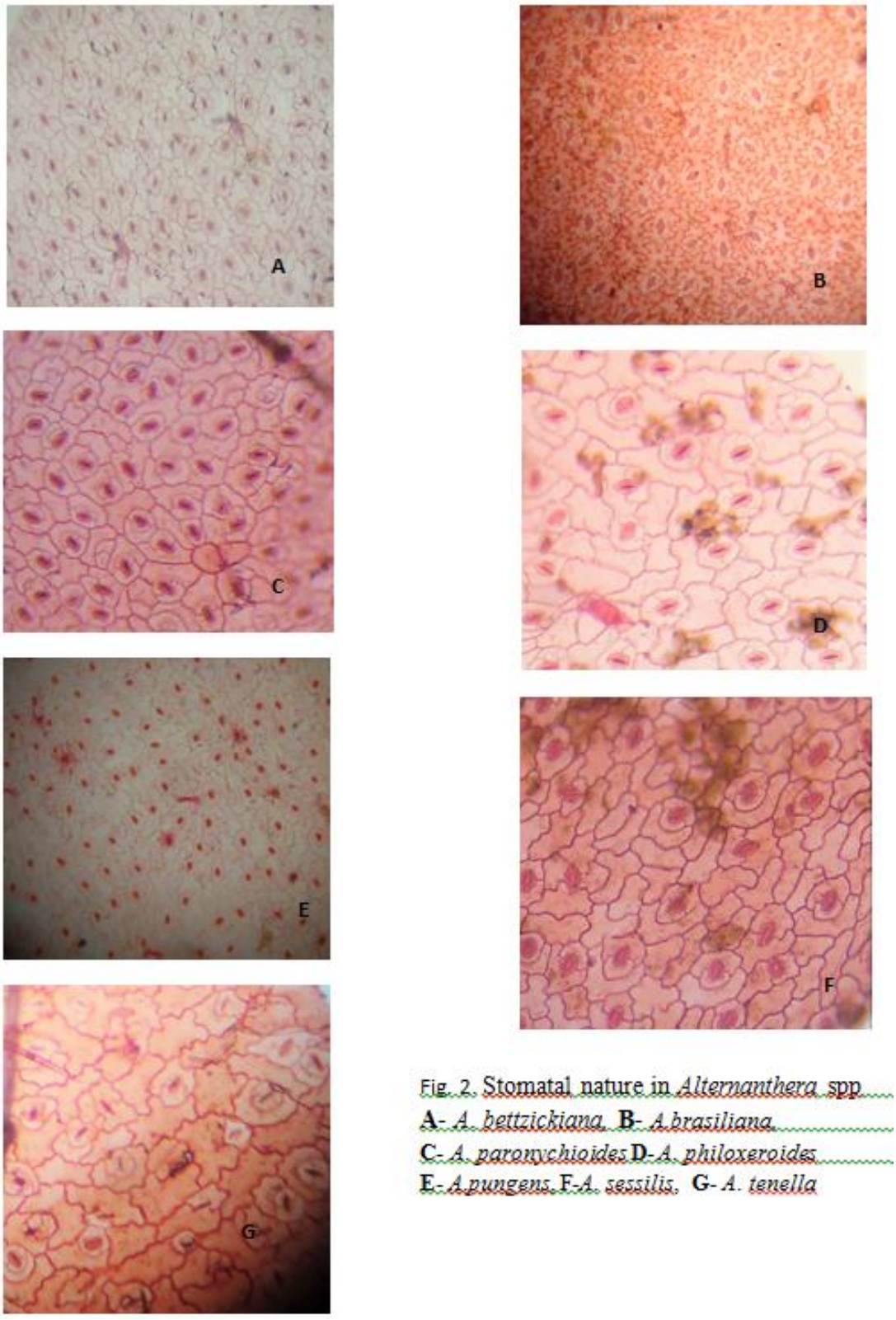

Fig. 2. Stomatal nature in *Alternanthera* spp.
A- *A. bettzickiana*, **B**- *A.brasiliana*,
C- *A. paronychioides* **D**- *A. philoxeroides*
E- *A.pungens*, **F**-*A. sessilis*, **G**- *A. tenella*

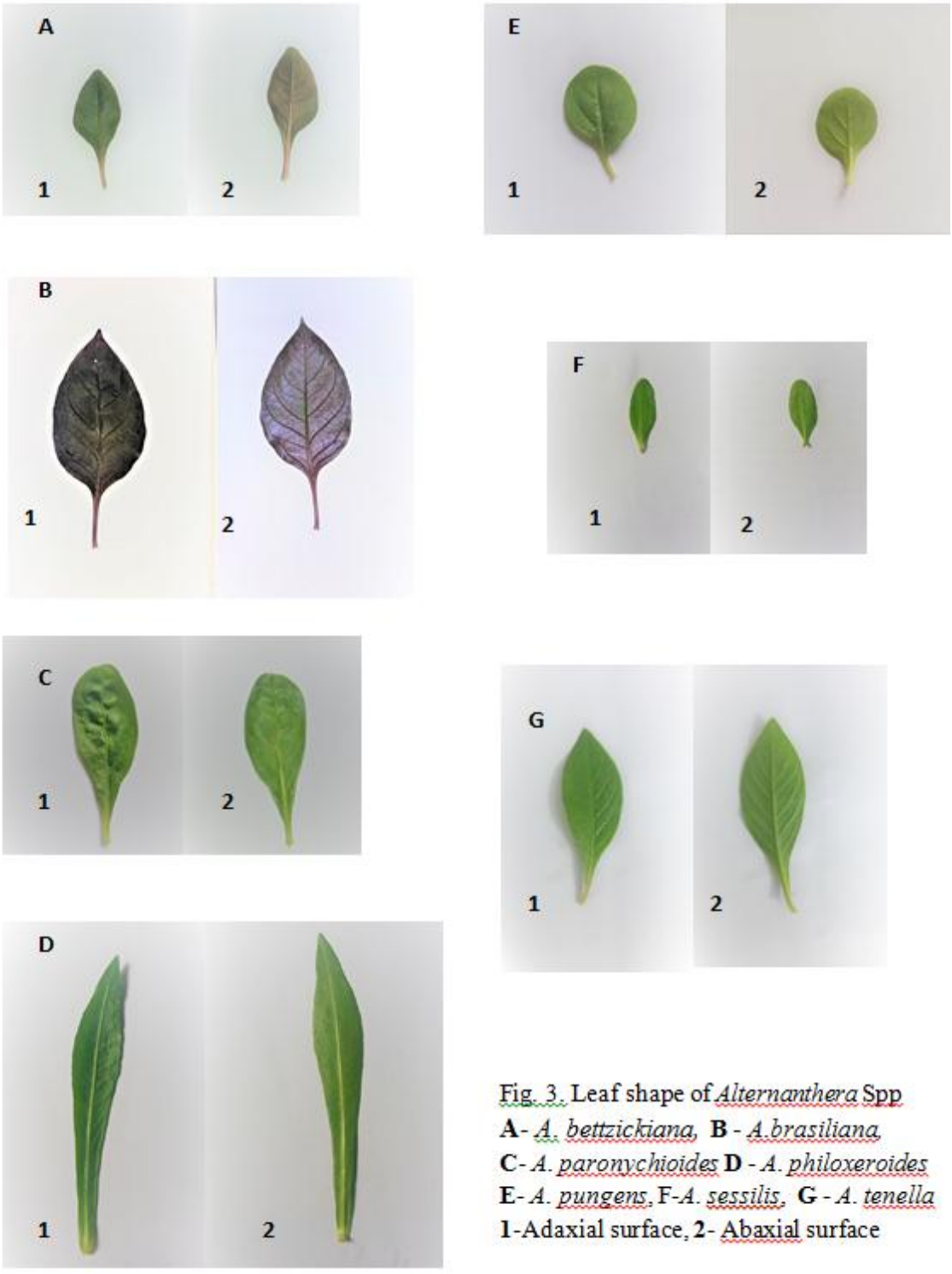

Fig. 3. Leaf shape of *Alternanthera* Spp
A- *A. bettzickiana*, **B** - *A.brasiliana*,
C- *A. paronychioides* **D** - *A. philoxeroides*
E- *A. pungens*, F-*A. sessilis*, **G** - *A. tenella*
1-Adaxial surface, **2**- Abaxial surface

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