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# LEAF EPIDERMAL ANATOMY OF *CYNODON DACTYLON* (L.) PERS. IN RELATION TO ECOTYPIC ADAPTATION

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*Keywords:* Anatomy; *Cynodon dactylon*; Leaf epidermis; Stomatal features.

**Abstract**

Qualitative and quantitative studies were done on leaf epidermal characteristics with special reference to stomatal features to find out the impact of environmental condition on twenty four accessions of *Cynodon dactylon* (L.) Pers. collected from different ecological habitats of Bangladesh. The foliar epidermal peels from both surfaces of mature leaves were observed under microscope. The leaves were found to be amphistomatic and stomata were paracytic type. The epidermal cells in this study were found to be sinuous. Silica bodies were found to be saddle and cross shaped. Prickles angular were pointed at the tip. Macro-hairs were present in all the accessions, but no micro-hair was found both adaxially or abaxially. Stomatal frequency and stomatal index were found to vary from accession to accession on both adaxial and abaxial surface of leaves, and the differences were statistically significant in most of the cases.

## Introduction

*Cynodon dactylon* (L.) Pers is a typical warm season turfgrass belongs to the family of Poaceae and this grass species is widely adapted to various environments of tropical and sub-tropical regions around the world. There are some ways for genetic diversity and population structure analysis of *C. dactylon* like interphase nuclear phenotype and chromosomal characterization that are very useful parameters in distinguishing the cytotypes, accessions and even germplasm of a plant species (Nitu *et al*., 2019 a&b).

The leaf epidermis is generally considered as an important aspect for the classification and delimitation of species and genera, and for sorting out the evolutionary and phylogenetic problems (Stace, 1984; Jones, 1986). Ahmed *et al*. (2011) stated that the leaf epidermal characters have significance in grass systematics and classification of ambiguous groups which are not properly adjusted within grasses, particularly at sub-family and tribe level. Therefore, it is imperative to make any attempt to study the epidermal characters of taxonomic importance. It is evidenced now that leaf epidermal features can help to elucidate many ecological parameters. In Poaceae leaf epidermal anatomy shows variations with a higher degree of specialization than that of any other family and provides extensive features of taxonomic importance. Leaf epidermal anatomical features like stomata and trichomes along with some other qualitative and quantitative characters are very much useful in perspective of morphological, ecological, physiological and taxonomical studies. The morphology and ontogenies of taxa are considered to be more important in case of intra-generic and intra-species systematics due to diversity of stomatal types. On the contrary, the most frequent stomata type is considered as taxonomic character.

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Plant anatomical traits are good indicators of habitat quality, since they manifest variability in relation to microclimatic conditions (Barber *et al*., 2004). Stomatal traits like stomatal density, stomatal apparatus and guard cell architecture respond to environmental and physiological cues (Nadeu and Sack, 2002; Gitz and Baker, 2009). The present study aims to identify the leaf epidermal features which may focus on stomatal characters because of their importance in many ecological aspects of grass species. *Cynodon dactylon* has paracytic type of stomata (Abid *et al*., 2007) and they are arranged in parallel rows in with silica bodies on the epidermal surface. Paracytic type is considered to be primitive and their arrangement reflects the developmental process. In *C. dactylon* stomata may be present on both side (adaxial and abaxial) of the expanded leaf, but in many grass species they are exclusively abaxial. Leaf epidermal traits i.e.; epidermal cells, stomata and micro-hairs have been proved valuable in identification and differentiation of different taxa (Stenglein *et al*., 2003). Macro-hairs are also found to vary in size, shape and wall thickness and these are of great value in grass systematic. The shape of silica bodies varies among different grass species from round or oblong to linear, crescent or dumbbell shaped, nodular, sinuous and shaddle or cross shaped (Chaudhary *et al*., 2001b; Ahmad *et al*., 2012; Chaudhari *et al*., 2014). Stomatal parameters like size, number and shape are of great ecological significance (Jian *et al*., 2012) and extremely important in stress tolerance (Xu and Zhou, 2008; Zheng *et al*., 2013). Stomatal size and shape regulate water use efficiency. In small stomata less turgour is required for their opening and closing (Tufail *et al*., 2017). Stomatal frequency improves the photosynthetic efficiency of plant species. The present study is focused on the qualitative and quantitative leaf epidermal characteristics with special reference to stomatal features to find out the impact of environmental conditions on *C. dactylon*.

**Materials and Methods**

A total of 24 accessions of *Cynodon dactylon* (L.) Pers. was collected from different ecological habitats in Bangladesh. Selections were based on environmental conditions of the collection site. All the accessions were planted in 1.5 m × 1.4 m plots of the research field of the Institute of Biological Sciences, University of Rajshahi, Bangladesh. The site has an annual average rainfall of 661.2 mm of which the majority falls during the rainy season (July-September 2019). No fertilizers were used in the experimentation field. The soil at the research field is loamy soil.

Both abaxial and adaxial surface of the leaves of *C. dactylon* were studied qualitative and quantitatively which have been mentioned in Tables 1-9. The foliar epidermal peels were stained with 1% safranin and observed under microscope (SWIFT- S.A No.760090) for detailed obtaining feature as it is done usually. The photomicrographs of the mounted materials were taken using a digital camera (Model: C-B5, Brand: Optica) fitted on the electrical light microscope (Model: XSZ-107T, Brand: Novel) with total magnification of 10X in Laboratory of Phycology and Limnology, University of Rajshahi, Bangladesh. These photomicrographs were useful for identification and differentiation based on the features of epidermal cells. In case of some quantitative characters ocular micrometer was used for measurement and the values were converted into micron (µ) with the help of stage micrometer.

Observations for number of stomata present in microscopic view field was made for recording and for calculating the stomatal frequency and thereafter, expressed in terms of stomata/mm$^2$. At a given magnification the total number of stomata was counted as visible by square grid scale under microscope. The square grid was composed of 100 identical small squares. The diameter of view field was calculated by ocular scale. The stomatal index (SI) was calculated using the formula SI = (S/S + E) × 100 where, S and E are the number of stomata per unit area and number of epidermal cells per unit area, respectively in microscopic view field and the values were expressed in percentage (%). Morphometric measurements for different cells (long cells, stomatal cells, epidermal cells) were taken under suitable magnification by using calibrated ocular micrometer.

*Statistical analysis*

A statistical comparison of means of different accessions and leaf epidermal quantitative characters was carried out by analysis of variance (ANOVA) followed by Duncun's Multiple Range Test (DMRT). Significance level was set at $p<0.05$. The data analysis was done using SPSS version 20.0 for Windows. Graphs were drawn by Microsoft Office Excel software.

**Results and Discussion**

*Qualitative leaf epidermal characters*

Under this sub-head the findings are described and discussed based on Table 1, Figs. 1A-C (a-x), and 2A-C (a-x). The leaves were found to be amphistomatic. The stomata were paracytic type, dumbbell shaped with two subsidiary cells placed parallel to the pore. Two guard cells were found with two subsidiary cells lateral to the guard cells. Subsidiary cells in *C. dactylon* were found to be dome shaped at both abaxial and adaxial surface of the leaves. Hepworth *et al*. (2018) reported, amphistomatic leaves with dumbbell-like, aligned stomata as usual in grass species. Like almost all grasses stomata in *C. dactylon* are paracytic type earlier proved by Abid *et al*. (2007). Due to disposition of the subsidiary cells, the stomata were markedly paracytic, which is also typical of Poaceae family (Rudall *et al*., 2017). Stomatal shape was more responsive to salt stress in the salt range population where elliptic stomatal complex transform to rhomboid and smaller ones under high salt stress (Hameed *et al.*, 2014), supports the present findings in case of the accessions collected from three coastal areas (Barguna, Cox's Bazar and St. Martin's Island) of Bangladesh.

The epidermal cells were elongated and arranged in vertical rows parallel to the long axis of the leaf. All epidermal cells in *C. dactylon* were found to be sinuous. Almost all epidermal cells in *C. dactylon* are found sinuous or wavy similar to the findings of Ahmed *et al*. (2010). *Cynodon dactylon* accessions had epidermal cells with sinuous cell walls, a common feature among species belonging to the Poaceae family (Khan *et al*., 2017) and which is related to the increase of the surface for higher light uptake (De Castro *et al*., 2009).

Length and width of long cells are significant parameters which help in identification and classification of grasses (Elahi and Ashraf, 2002). The long cell margins were found to show sinuous almost in all the accessions. But, in case of the accessions of Barguna, Cox's Bazar and St. Martin's Island, the long cell margins were found to be slightly sinuous. Silica bodies were saddle shaped and found in the materials collected from Rangpur, Lalmonirhat, Dinajpur, Thakurgaon, Panchagarh, Gaibandha, Rajshahi, Naogaon, Gazipur, Jhenaidah. Cross shaped silica bodies were found in materials of Pabna, Sherpur, Mymensingh, Khulna, Shariatpur, Khagrachari, Bandarban and Rangamati. Both saddle and cross shaped silica bodies were found in case of Narsingdi, Jessore and Faridpur. Horizontally elongated shaped silica bodies were found in case of samples collected from Barguna, Cox's Bazar and St. Martin's Island. Silica bodies are a type of phytolith in specialized epidermal cells of grass leaves. Various workers have considered silica bodies to be diagnostic for the family Poaceae (Twiss *et al*., 1969; Brown, 1984; Mulholland, 1989). Piperno and Pearsall (1998) studied the silica bodies of Tropical American grasses and discussed their taxonomic implications. Thomasson *et al.* (1986) noted that micro-morphological characters of the leaf provided information on the fossils phylogeny and taxonomic relationships. According to Metclafe (1960), Chaudhary *et al*. (2001a), and Ahmed (2009) silica bodies in *C. dactylon* are saddle shaped, which were again confirmed by the present research.

**Table 1. Qualitative leaf epidermal characteristics on both abaxial and adaxial surfaces of *Cynodon dactylon* (L.) Pers. collected from different habitats of Bangladesh.**

| Sl. No. | Habitats | Stomata type | Shape of subsidiary cells | Long cell margins | Types of silica bodies | Macro hair | Micro hair | Prickle angular | Hook |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Rangpur | Paracytic | Dome | Sinuous | Saddle | + | - | + | + |
| 2 | Lalmonirhat | Paracytic | Dome | Sinuous | Saddle | + | - | + | + |
| 3 | Dinajpur | Paracytic | Dome | Sinuous | Saddle | + | - | + | + |
| 4 | Thakurgaon | Paracytic | Dome | Sinuous | Saddle | + | - | + | + |
| 5 | Panchagarh | Paracytic | Dome | Sinuous | Saddle | + | - | + | + |
| 6 | Gaibandha | Paracytic | Dome | Sinuous | Saddle | + | - | + | + |
| 7 | Rajshahi | Paracytic | Dome | Sinuous | Saddle | + | - | + | + |
| 8 | Naogaon | Paracytic | Dome | Sinuous | Saddle | + | - | + | + |
| 9 | Pabna | Paracytic | Dome | Sinuous | Cross | + | - | + | + |
| 10 | Gazipur | Paracytic | Dome | Sinuous | Saddle | + | - | + | + |
| 11 | Narsingdi | Paracytic | Dome | Sinuous | Saddle, Cross | + | - | + | + |
| 12 | Sherpur | Paracytic | Dome | Sinuous | Cross | + | - | + | + |
| 13 | Mymensingh | Paracytic | Dome | Sinuous | Cross | + | - | + | + |
| 14 | Khulna | Paracytic | Dome | Sinuous | Cross | + | - | + | + |
| 15 | Jessore | Paracytic | Dome | Sinuous | Saddle, Cross | + | - | + | + |
| 16 | Jhenaidah | Paracytic | Dome | Sinuous | Saddle | + | - | + | + |
| 17 | Faridpur | Paracytic | Dome | Sinuous | Saddle, Cross | + | - | + | + |
| 18 | Shariatpur | Paracytic | Dome | Sinuous | Cross | + | - | + | + |
| 19 | Barguna | Paracytic | Dome | Slightly sinuous | Horizontally elongated | + | - | - | - |
| 20 | Khagrachari | Paracytic | Dome | Sinuous | Cross | + | - | + | + |
| 21 | Bandarban | Paracytic | Dome | Sinuous | Cross | + | - | + | + |
| 22 | Rangamati | Paracytic | Dome | Sinuous | Cross | + | - | + | + |
| 23 | Cox's Bazar | Paracytic | Dome | Slightly sinuous | Horizontally elongated | + | - | - | - |
| 24 | St. Martin’s Island | Paracytic | Dome | Slightly sinuous | Horizontally elongated | + | - | - | - |

+ = Present, - = Absent.

Prickles angular were pointed at the tip and they were present in almost all accessions except those from Barguna, Cox’s Bazar and St. Martin’s Island. Hooks were also present in almost all the accessions except from those materials of Barguna, Cox’s Bazar and St. Martin’s Island. Macro-hairs were present in all accessions. No micro-hair was found in adaxially or abaxially in this present study. Chaudhary *et al.* (2001b) found that in *C. dactylon,* stomata were with triangular subsidiary cells, silica bodies were saddle shaped, and micro-hairs with hemispherical distal cells, while macro-hairs were absent. Freire *et al.* (2005) observed the presence of micro hairs in *C. dactylon.* In the current study, an opposite result has been observes, macro hair was present but micro hair was absent. These features were similar to the results of Prat (1934, 1961), Metcalfe (1960), Ahmad (2009), and Khan *et al.* (2017). It may be due to environmental variations as *C. dactylon* is a wide spreading grass, which varies considerably in habit. Ishtiaq *et al.* (2018) also found that micro-hair was absent in *C. dactylon.* In the present investigation, *C. dactylon* showed dome shaped subsidiary cells at both abaxial and adaxial surface of the leaves.

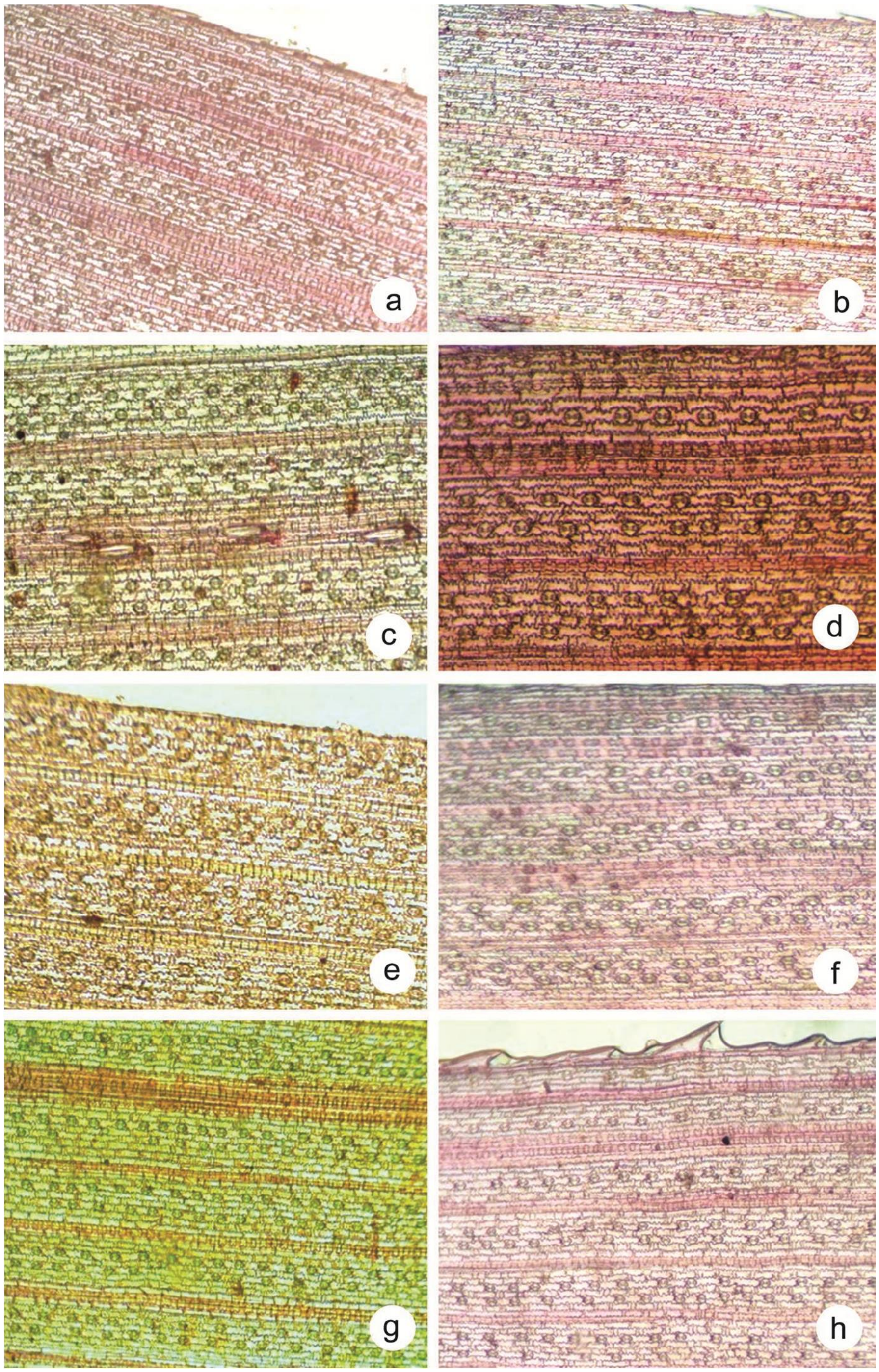


Fig. 1A (a-h): Foliar epidermal structure on abaxial surface of *C. dactylon* accessions collected from different habitats; a) Rangpur, b) Lalmonirhat, c) Dinajpur, d) Thakurgaon, e) Panchagarh, f) Gaibandha, g) Rajshahi, h) Naogaon.

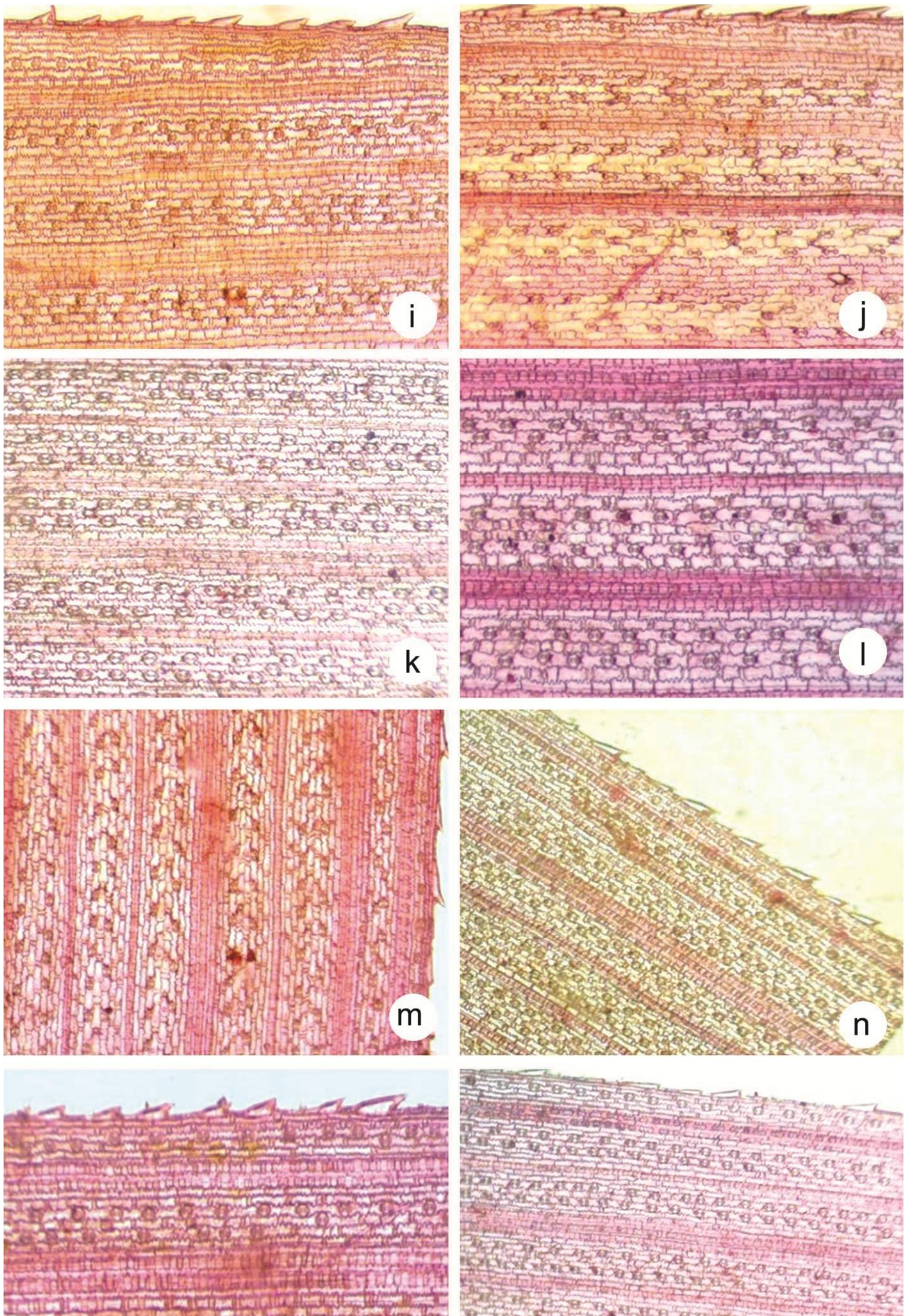


Fig. 1B (i-p): Foliar epidermal structure on abaxial surface of *C. dactylon* accessions collected from different habitats; i) Pabna, j) Gazipur, k) Narsingdi, l) Sherpur, m) Mymensingh, n) Khulna, o) Jessore, p) Jhenaidah.

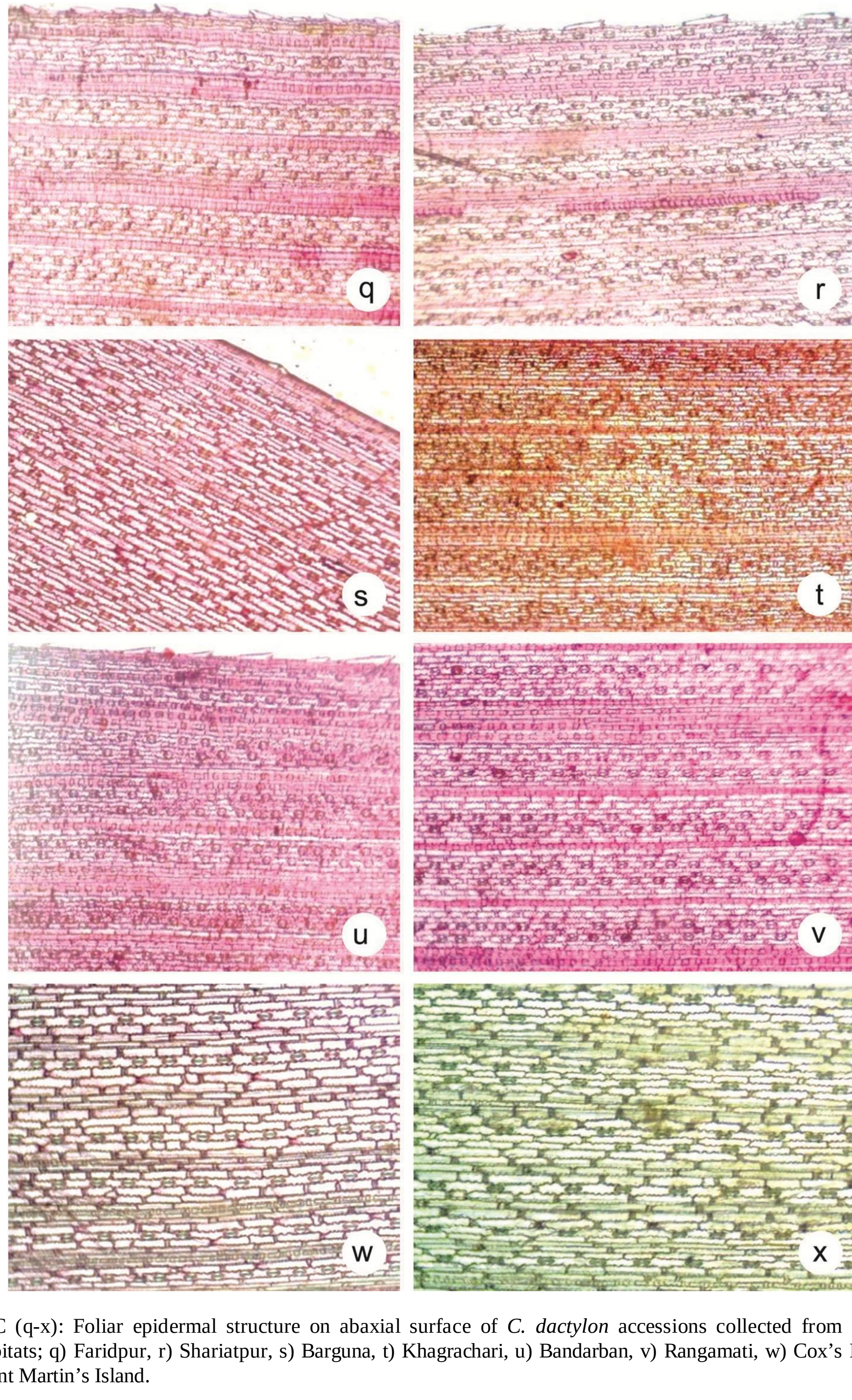


Fig. 1C (q-x): Foliar epidermal structure on abaxial surface of *C. dactylon* accessions collected from different habitats; q) Faridpur, r) Shariatpur, s) Barguna, t) Khagrachari, u) Bandarban, v) Rangamati, w) Cox's Bazar, x) Saint Martin's Island.

*Quantitative leaf epidermal characters*

Under this subhead the findings are described and discussed based on the Figs. 1A-C (a-x) and 2A-C (a-x) and the values are shown in Tables 2-9. For abaxial surface of the leaves, highest mean value for long cell numbers per $mm^2$ was found in sample collected from Khulna (7.72) and lowest value was found in case of St. Martin's Island (2.14) (Table 2). In adaxial surface of the leaves highest mean value for long cell numbers per $mm^2$ was found in sample collected from Shariatpur (9.65) and lowest value was found in Barguna (3.31) (Table 6). The mean value of long cell length was highest in case of samples collected from St. Martin's Island (110.26 µm) and lowest in case of Cox's Bazar (32.20 µm) in abaxial surface of the leaves (Table 2). Long cell length was highest in case of Barguna (90.76 µm) and lowest in case of Shariatpur (31.39 µm) in adaxial surface of the leaves (Table 6). The mean long cell width was found to be highest in sample of St. Martin's Island (8.82 µm) and lowest in sample of Cox's Bazar (4.03 µm) in abaxial surface the leaves (Table 2). Long cell width was highest in Cox's Bazar (12.33 µm) and lowest in Rangamati (3.40 µm) in adaxial surface of the leaves (Table 6). The variations regarding different parameters in case of long cells might be due to variations of environmental behavior such as water stress and changes in temperature.

Stomatal frequency was highest in sample of Gazipur (5.56 $mm^{-2}$) and lowest in sample of St. Martin's Island (1.78 $mm^{-2}$) in abaxial surfaces of the leaves (Table 3). Stomatal frequency was highest in case of Shariatpur (6.61 $mm^{-2}$) and lowest in case of Barguna (3.02 $mm^{-2}$) in adaxial surfaces of the leaves (Table 7). Leaf morphological characters like stomatal frequency, distribution, and epidermal features may affect gas exchange quite remarkably and their relationships with key environmental factors such as light, water status, and $CO_2$ levels have been found to respond to changing environmental variables of temperature, rainfall, irradiance and $CO_2$ (Beeling, 1995; Royer *et al*., 2001). Therefore, they mainly contribute to the ability of plants to control their water relations and to gain carbon (Hetherington and Woodward, 2003). It has been shown that environmental signals such as light intensity, carbon dioxide concentration and water availability may affect stomatal development by modifying their size and frequency (Knapp *et al.*, 1994; Dyki *et al*., 1998). Therefore, it is possible that variations in stomatal characteristics may influence plant growth and productivity (Kundu and Tigerstedt, 1998). Reduction in stomatal frequency and size might also be an efficient feature of checking under water loss via transpiration during limited water availability and under high salinities as reported by different researchers (Walsh, 1990; Bray and Reid, 2002). The salt range ecotype showed decreased stomatal area and frequency under saline conditions on the adaxial leaf surface, so due to this it can be regarded as the best adapted ecotype against highly saline environments.

Intrinsic variation is a factor that may obscure the potential use of stomatal frequency as a paleoclimatalogical tool (Wagner *et al.,* 2005). In terms of stomatal frequency intrinsic variation is the variability in stomatal distribution across a leaf surfaces (Poole and Kurshner, 1999) and has the potential to be large in angiosperms (Uhl and Kerp, 2005). The reality of reduced stomatal conductance as a response to increased $CO_2$ has been inferred from measurements of transpiration rates during $CO_2$ -doubling experiments with agricultural species as well as tree seedlings. An increasing $CO_2$ concentration often leads to a significant decrease in leaf conductance corresponding with an increase in water-use efficiency (Eamus, 1991). These parameters are helpful to differentiate the species. However, the stomatal features may prove to be a little taxonomic value unless the developments of different stomata types were studied. A greater number of information on taxa will be helpful to understand the taxonomic value of stomata type and distribution. Beerling (1995), and McElwain and Chaloner (1995) have provided evidence that stomata frequency decline in response to increasing $CO_2$ and may have occurred over geological

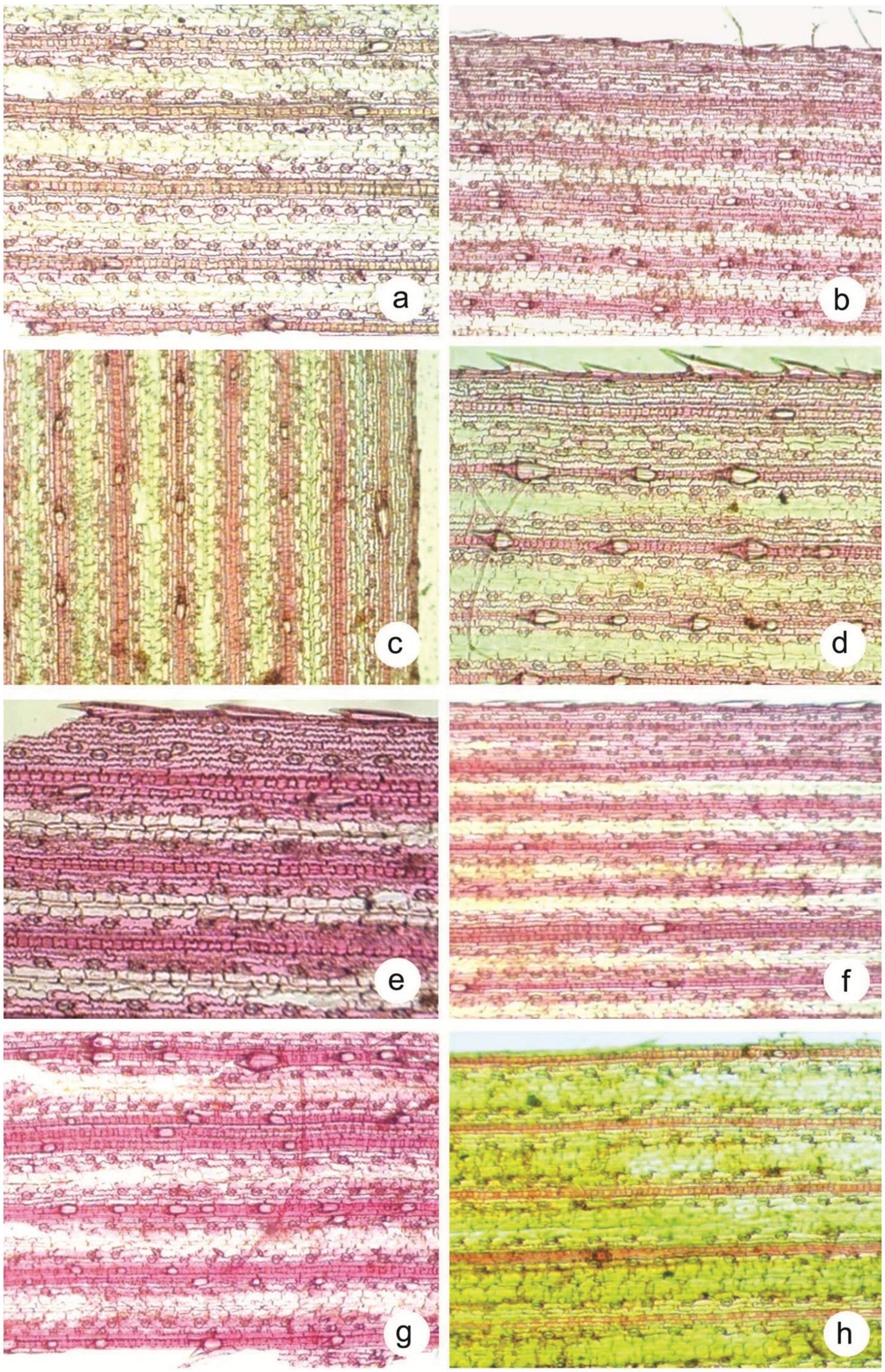


Fig. 2A (a-h): Foliar epidermal structure on adaxial surface of *C. dactylon* accessions collected from different habitats; a) Rangpur, b) Lalmonirhat, c) Dinajpur, d) Thakurgaon, e) Panchagarh, f) Gaibandha, g) Rajshahi, h) Naogaon.

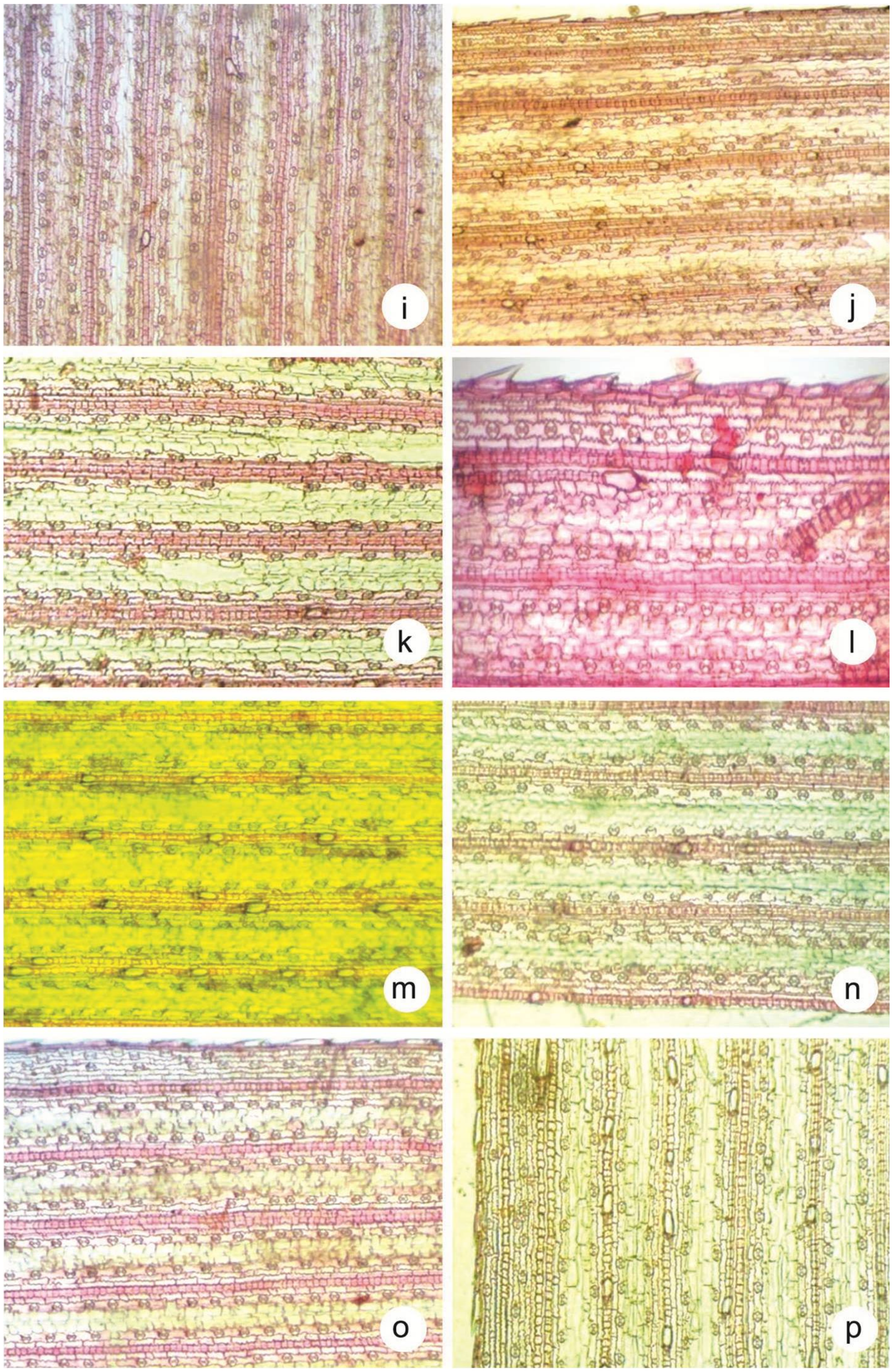


Fig. 2B (i-p): Foliar epidermal structure on adaxial surface of *C. dactylon* accessions collected from different habitats; i) Pabna, j) Gazipur, k) Narsingdi, l) Sherpur, m) Mymensingh, n) Khulna, o) Jessore, p) Jhenaidah.

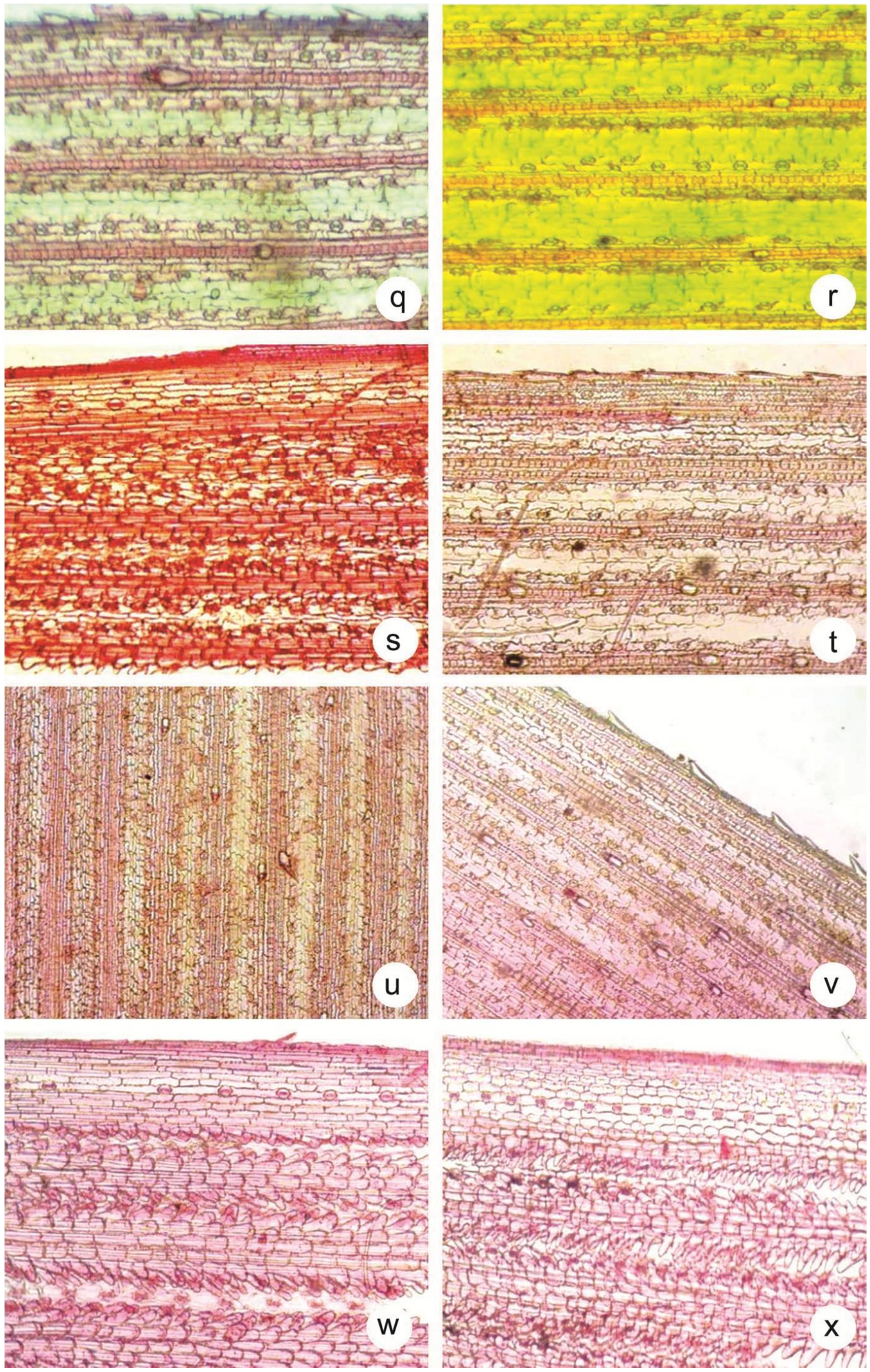


Fig. 2C (q-x): Foliar epidermal structure on adaxial surface of *C. dactylon* accessions collected from different habitats; q) Faridpur, r) Shariatpur, s) Barguna, t) Khagrachari, u) Bandarban, v) Rangamati, w) Cox's Bazar, x) Saint Martin's Island.

time. Stomatal frequency in present day can be estimated by growing them at different $CO_2$ concentration (Vesque, 1989).

Epidermal cell number per $mm^2$ was highest in case of Gaibandha (23.89) and lowest in case of St. Martin's Island (4.5) in abaxial surface of the leaves (Table 3). Epidermal cell number per $mm^2$ was highest in case of Shariatpur (19.99) and lowest in case of Barguna (9.28) in adaxial surface of the leaves (Table 7). Fernandez and Mujica (1973) determined that an increase in light intensity decreased the epidermal cell number and increased the stomatal number index and size. Schoch *et al.* (1984) reported that blue and far-red light reduced the stomatal index while red light increased this stomatal index. Kim *et al*. (2004) showed that blue and red light increased the stomata size and decreased the stomata number. Lee *et al*. (2007) found that white light increased the stomatal number and size, while blue light reduced the mentioned parameters.

**Table 2. Quantitative epidermal characteristics on abaxial surface of leaves of *Cynodon dactylon* collected from different habitats of Bangladesh.**

| Sl. No. | Habitats | Long cells/$mm^2$ | Long cell length (µm) | Long cell width (µm) |
|---|---|---|---|---|
| 1 | Rangpur | 7.66 ± 0.15cd | 33.91 ± 2.39hi | 6.43 ± 0.26abcd |
| 2 | Lalmonirhat | 5.69 ± 0.13hijk | 42.95 ± 2.39 efg | 6.42 ± 0.17abcd |
| 3 | Dinajpur | 5.76 ± 0.10ghij | 32.29 ± 2.26i | 8.02 ± 0.17ab |
| 4 | Thakurgaon | 4.75 ± 0.08m | 40.29 ± 2.30efgh | 8.02 ± 0.22a |
| 5 | Panchagarh | 5.17 ± 0.13jklm | 42.29 ± 2.26efg | 8.03 ± 0.26ab |
| 6 | Gaibandha | 6.19 ± 0.08efghi | 39.94 ± 1.61efgh | 8.02 ± 0.13abc |
| 7 | Rajshahi | 5.16 ± 0.10jklm | 39.86 ± 2.00efgh | 6.69 ± 0.13abcd |
| 8 | Naogaon | 7.07 ± 0.08bc | 40.20±1.56efgh | 6.42±0.17abcd |
| 9 | Pabna | 5.56±0.10ijkl | 38.88±1.65fghi | 8.03±0.26abcd |
| 10 | Gazipur | 7.09±0.13bc | 44.29±2.30def | 4.43±0.22cd |
| 11 | Narsingdi | 5.01±0.13lm | 40.23±1.78efgh | 8.02±0.17abc |
| 12 | Sherpur | 6.37±0.13defg | 40.37±1.61efgh | 7.02±0.13abcd |
| 13 | Mymensingh | 5.10±0.15klm | 32.95±2.21i | 7.70±0.13abcd |
| 14 | Khulna | 7.72±0.10a | 58.90±2.00c | 6.82±0.13abcd |
| 15 | Jessore | 6.09±0.13fghi | 49.63±2.30d | 7.22±0.13abcd |
| 16 | Jhenaidah | 6.61±0.13cdef | 37.64±2.34ghi | 4.83±0.22d |
| 17 | Faridpur | 5.04±0.10klm | 37.02±1.74ghi | 6.17±0.26abcd |
| 18 | Shariatpur | 6.01±0.13fghi | 45.87±2.08de | 8.03±0.26a |
| 19 | Barguna | 2.57±0.13n | 96.28±2.17b | 8.43±0.26ab |
| 20 | Khagrachari | 7.62±0.15ab | 33.59±2.00hi | 7.48±0.13abcd |
| 21 | Bandarban | 6.32±0.10efgh | 34.31±2.43hi | 6.68±0.13abcd |
| 22 | Rangamati | 6.81±0.13cde | 34.22±1.69hi | 6.70±0.26bcd |
| 23 | Cox's Bazar | 2.47±0.08n | 32.20±1.56i | 4.03±0.22cd |
| 24 | St. Martin's Island | 2.14±0.15n | 110.26±2.00a | 8.82±0.17a |

SE = Standard error, n = 24. In the column, mean values bearing similar letter(s) or without letter are identical and those having dissimilar letters are differed significantly as per Duncan's Multiple Range Test.

**Table 3. Quantitative epidermal characteristics on abaxial surface of leaves of *Cynodon dactylon* collected from different habitats of Bangladesh.**

| Sl. No. | Habitats | Stomatal frequency | Epidermal cell no. /mm$^2$ | Stomatal index |
|---|---|---|---|---|
| 1 | Rangpur | 4.52±0.10fghi | 11.92±0.95cdef | 26.36±0.49ab |
| 2 | Lalmonirhat | 4.59±0.08efgh | 13.28±0.91bcdef | 26.34±0.62ab |
| 3 | Dinajpur | 4.82±0.15cdef | 12.61±1.30cdef | 26.47±0.36ab |
| 4 | Thakurgaon | 3.71±0.08k | 10.81±1.30ef | 25.46±0.32ab |
| 5 | Panchagarh | 4.26±0.15hij | 9.60±1.21f | 28.00±0.91ab |
| 6 | Gaibandha | 4.29±0.13hij | 23.89±0.69a | 25.40±0.82ab |
| 7 | Rajshahi | 4.03±0.08jk | 12.37±1.30cdef | 25.61±0.88ab |
| 8 | Naogaon | 4.93±0.13cde | 12.59±1.48cdef | 26.40±0.61ab |
| 9 | Pabna | 4.82±0.15cdef | 13.78±0.78bcde | 25.78±0.52ab |
| 10 | Gazipur | 5.56±0.10a | 16.21±1.04b | 25.80±0.61ab |
| 11 | Narsingdi | 4.19±0.08ij | 11.33±1.35def | 26.25±0.30ab |
| 12 | Sherpur | 4.32±0.10ghij | 13.29±1.30bcdef | 25.67±0.96ab |
| 13 | Mymensingh | 4.77±0.13cdef | 10.61±1.04ef | 27.42±1.40ab |
| 14 | Khulna | 5.40±0.10ab | 15.53±1.04bc | 27.78±1.31ab |
| 15 | Jessore | 5.06±0.15bcd | 10.48±0.65ef | 28.43±1.55a |
| 16 | Jhenaidah | 4.83±0.08cdef | 13.63±1.17bcde | 25.36±0.30b |
| 17 | Faridpur | 4.68±0.10defg | 10.32±0.91ef | 27.64±1.51ab |
| 18 | Shariatpur | 4.69±0.13cdefg | 11.06±1.08ef | 27.36±1.78ab |
| 19 | Barguna | 2.13±0.13l | 5.54±1.39g | 26.26±0.43ab |
| 20 | Khagrachari | 4.56±0.10efghi | 12.3±0.78cdef | 25.98±0.29ab |
| 21 | Bandarban | 5.07±0.08bc | 14.86±1.08bcd | 26.13±0.71ab |
| 22 | Rangamati | 4.52±0.10fghi | 12.98±1.39bcdef | 26.17±0.56ab |
| 23 | Cox's Bazar | 2.13±0.13l | 5.56±1.56g | 26.31±0.30ab |
| 24 | St. Martin’s Island | 1.78±0.15m | 4.5±0.78g | 26.59±0.78ab |

SE = Standard error, n = 24. In the column, mean values bearing similar letter(s) or without letter are identical and those having dissimilar letters are differed significantly as per Duncan’s Multiple Range Test.

Stomatal index was highest in Jessore (28.43%) and lowest in Jhenaidah (25.36%) for abaxial surface of the leaves (Table 3). Stomatal index was highest in Khulna (28.76%) and lowest in Jhenaidah (24.97%) in adaxial surface of the leaves (Table 7). Stomatal length with guard cell was highest in sample of Cox’s Bazar (21.50 µm) and lowest in case of Mymensingh (11.50 µm) in abaxial surface of the leaves (Table 4). Stomatal length with guard cell was highest in case of St. Martin’s Island (17.59 µm) and lowest in case of Mymensingh (11.56 µm) in adaxial surface of the leaves (Table 8). Stomatal breadth with guard cell was highest in sample of St. Martin’s Island (13.71 µm) and lowest in Khulna (8.11 µm) in abaxial surface of the leaves (Table 4). Stomatal breadth with guard cell was highest in Barguna (15.62 µm) and lowest in Khulna (8.11 µm) in adaxial surface of the leaves (Table 8). Tufail *et al*. (2017) observed stomata with small dimensions in ecotype of *C. dactylon*, which could be related to a more efficient physiological regulation since less turgor is required for the opening and closing of the ostiole. It reinforces what had been previously reported in fossils of species belonging to several families, including Poaceae (Franks and Beerling, 2009) along with different plant species in which higher stomatal densities mediated by small sized stomata provide enhanced conductivity and higher photosynthesis rates (Franks *et al*. 2009; Drake *et al*. 2013; Vrablova *et al.*, 2017). Nevertheless, Hetherington and Woodward (2003) pointed out that when the environmental alterations are unfavorable the conductance of small stomata is quickly reduced. Carpenter and Smith (1975) had established such a relationship involving stomata size and growth habit. Xerophytic species have much smaller stomata than mesophytic species. It may be compensating for the presence of larger stomata and it may be associated with adaptive success of polyploids (Van De Peer *et al*., 2017), mainly regarding water stress and changes in temperature (Simonneau *et al*., 2017).

**Table 4. Quantitative epidermal characteristics on abaxial surface of leaves of *Cynodon dactylon* collected from different habitats of Bangladesh.**

| Sl. No. | Habitats | Stomata length with guard cell (µm) | Stomata breadth with guard cell (µm) | Epidermal cell length (µm) | Epidermal cell breadth (µm) |
|---|---|---|---|---|---|
| 1 | Rangpur | 12.82±0.66f | 9.11±0.87cd | 32.12±0.95h | 8.14±1.13cd |
| 2 | Lalmonirhat | 16.39±0.33cd | 9.48±1.13bcd | 35.06±0.95fg | 8.41±1.13cd |
| 3 | Dinajpur | 16.75±0.38c | 8.26±0.43d | 38.12±0.95de | 8.09±0.74cd |
| 4 | Thakurgaon | 15.75±0.28cde | 9.07±0.87cd | 32.13±1.00h | 8.10±0.78cd |
| 5 | Panchagarh | 16.12±0.59cde | 9.38±0.78bcd | 39.29±0.74d | 10.12±0.95c |
| 6 | Gaibandha | 15.60±0.51cde | 9.02±0.48cd | 36.10±0.78ef | 9.73±1.04cd |
| 7 | Rajshahi | 15.86±0.66e | 8.22±0.43d | 24.06±0.43k | 8.06±0.43cd |
| 8 | Naogaon | 16.05±0.64cde | 9.37±0.69bcd | 36.07±0.56ef | 8.10±0.78cd |
| 9 | Pabna | 15.95±0.38cde | 9.58±1.13bcd | 36.07±0.52ef | 8.07±0.56cd |
| 10 | Gazipur | 15.70±0.66e | 10.66±0.43bcd | 38.75±0.87d | 7.79±0.43cd |
| 11 | Narsingdi | 16.30±0.56cde | 11.81±0.61ab | 29.41±0.56i | 8.06±0.43cd |
| 12 | Sherpur | 12.57±0.53f | 8.61±1.00cd | 34.85±1.04fg | 8.23±0.52cd |
| 13 | Mymensingh | 11.50±0.46f | 10.40±1.04bcd | 33.32±0.95gh | 8.14±1.13cd |
| 14 | Khulna | 14.95±0.28e | 8.11±0.87d | 27.00±0.48j | 7.31±0.82d |
| 15 | Jessore | 12.23±0.28f | 8.14±1.08d | 36.11±0.82ef | 8.14±1.08cd |
| 16 | Jhenaidah | 15.35±0.59e | 10.21±1.04bcd | 29.40±0.48i | 7.73±1.04cd |
| 17 | Faridpur | 15.87±0.59de | 8.14±1.08d | 23.07±0.52k | 8.46±0.43cd |
| 18 | Shariatpur | 15.30±0.36de | 12.07±0.56ab | 28.12±0.91ij | 8.78±1.08cd |
| 19 | Barguna | 19.53±0.33b | 9.83±0.56bcd | 72.25±0.61b | 10.26±1.00c |
| 20 | Khagrachari | 16.2±0.51cde | 8.86±0.48cd | 40.08±0.61d | 8.07±0.52cd |
| 21 | Bandarban | 14.79±0.33e | 8.12±0.91d | 32.12±0.91h | 8.09±0.69cd |
| 22 | Rangamati | 15.74±0.36cde | 8.93±1.04cd | 26.07±0.52j | 8.67±1.04cd |
| 23 | Cox's Bazar | 21.5±0.36a | 11.29±0.74abc | 70.09±0.69c | 21.74±1.13a |
| 24 | St. Martin’s Island | 20.63±0.48ab | 13.71±0.87a | 80.06±0.43a | 16.25±0.91b |

SE = Standard error, n = 24. In the column, mean values bearing similar letter(s) or without letter are identical and those having dissimilar letters are differed significantly as per Duncan’s Multiple Range Test.

**Table 5. Quantitative epidermal characteristics on abaxial surface of leaves of *Cynodon dactylon* collected from different habitats of Bangladesh.**

| Sl. No. | Habitats | Silica bodies /mm$^2$ | Prickles angular /mm$^2$ | Hooks/mm$^2$ | Macro hair/mm$^2$ |
|---|---|---|---|---|---|
| 1 | Rangpur | 7.05±0.53cdefgh | 0.22±0.02bcd | 0.15±0.03fgh | 0.04±0.00fg |
| 2 | Lalmonirhat | 5.28±0.31gh | 0.23±0.03bcd | 0.26±0.02 de | 0.15±0.03bcd |
| 3 | Dinajpur | 7.61±0.33bc | 0.26±0.02abcd | 0.18±0.02fg | 0.14±0.02bcde |
| 4 | Thakurgaon | 5.79±0.38gh | 0.22±0.02bcd | 0.02±0.02jk | 0.09±0.01cdefg |
| 5 | Panchagarh | 5.01±0.33h | 0.29±0.01ab | 0.28±0.04cd | 0.07±0.03defg |
| 6 | Gaibandha | 6.66±0.46efgh | 0.32±0.04a | 0.04±0.00ijk | 0.14±0.02bcde |
| 7 | Rajshahi | 6.45±0.43fgh | 0.26±0.02abcd | 0.96±0.04a | 0.10±0.02bcdefg |
| 8 | Naogaon | 8.29±0.43bcd | 0.30±0.02ab | 0.43±0.03b | 0.12±0.04bcdef |
| 9 | Pabna | 7.24±0.61bcdefg | 0.22±0.02bcd | 0.29±0.01cd | 0.10±0.02bcdefg |
| 10 | Gazipur | 7.66±0.46bcde | 0.31±0.03a | 0.47±0.03b | 0.06±0.02efg |
| 11 | Narsingdi | 5.92±0.51gh | 0.26±0.02abcd | 0.31±0.03cd | 0.10±0.02cdefg |
| 12 | Sherpur | 7.01±0.64efgh | 0.23±0.03bcd | 0.02±0.02jk | 0.07±0.03defg |
| 13 | Mymensingh | 6.39±0.38cdefgh | 0.19±0.03d | 0.35±0.03c | 0.11±0.03bcdefg |
| 14 | Khulna | 8.46±0.46ab | 0.31±0.03a | 0.29±0.01cd | 0.14±0.02bcde |
| 15 | Jessore | 7.36±0.51bcdef | 0.23±0.03bcd | 0.16±0.00fg | 0.11±0.03bcdefg |
| 16 | Jhenaidah | 7.17±0.64defgh | 0.28±0.00abc | 0.30±0.02cd | 0.12±0.04bcdef |
| 17 | Faridpur | 5.16±0.41h | 0.23±0.03bcd | 0.11±0.03ghi | 0.09±0.01cdefg |
| 18 | Shariatpur | 8.10±0.56bcdef | 0.20±0.00cd | 0.18±0.02fg | 0.18±0.02b |
| 19 | Barguna | 2.57±0.64i | 0.00±0.00e | 0.03±0.03jk | 0.10±0.02cdefg |
| 20 | Khagrachari | 9.75±0.28a | 0.24±0.00abcd | 0.09±0.01hij | 0.02±0.02g |
| 21 | Bandarban | 10.26±0.66a | 0.27±0.03abc | 0.19±0.03ef | 0.07±0.03defg |
| 22 | Rangamati | 8.87±0.59ab | 0.20±0.00cd | 0.08±0.04hijk | 0.05±0.01fg |
| 23 | Cox's Bazar | 2.92±0.61i | 0.00±0.00e | 0.00±0.00k | 0.26±0.02a |
| 24 | St. Martin’s Island | 2.13±0.53i | 0.00±0.00e | 0.02±0.02jk | 0.16±0.04bc |

SE = Standard error, n = 24. In the column, mean values bearing similar letter(s) or without letter are identical and those having dissimilar letters are differed significantly as per Duncan’s Multiple Range Test.

Epidermal cell length was highest in St. Martin’s Island (80.06 µm) and lowest in Faridpur (23.07 µm) in abaxial surface of the leaves (Table 4). Epidermal cell length was highest in Barguna (72.06 µm) and lowest in Khulna (28.76 µm) in adaxial surface of the leaves (Table 8). Epidermal cell breadth was highest in case of Cox’s Bazar (21.74 µm) and lowest in case of Khulna (7.31 µm) in abaxial surface of the leaves (Table 4). Epidermal cell breadth was highest in case of Cox’s Bazar (12.20 µm) and lowest in case of Faridpur (7.10 µm) in adaxial surface of the leaves (Table 8). The epidermis consists of various types of functionally specialized cells play vital role in restricting water loss, regulate gaseous exchange, defense, attract pollinators, photosynthesis, transpiration, respiration, mechanical strength and flexibility. Palmer and Tucker (1981) also observed that foliar epidermal features were useful in the systematics and characterization within sub families and tribes. Many leaf epidermal characters such as length and shape of epidermal cells, stomata, stomatal type, papillae, prickle angular, macro and micro hair, hooks, margins and silica bodies are taxonomically informative and can be used as an important tool in the delimitation of grasses (Prat, 1932; Metcalfe, 1960; Ellis, 1979; Petronela and Nevana, 2010). Watson and Dallwitz (1992) reported detailed description of the leaf epidermis in numerous taxa, pointing out the significance of these characters in the systematics of the Poaceae.

**Table 6. Quantitative epidermal characteristics on adaxial surface of leaves of *Cynodon dactylon* collected from different habitats of Bangladesh.**

| Sl. No. | Habitats | Long cells/mm$^2$ | Long cell length (µm) | Long cell width (µm) |
|---|---|---|---|---|
| 1 | Rangpur | 5.88±0.50efghij | 37.72±0.82mn | 6.63±0.42cd |
| 2 | Lalmonirhat | 5.33±0.52hij | 50.12±0.70g | 7.73±0.24bc |
| 3 | Dinajpur | 5.15±0.20ij | 48.85±0.76g | 7.39±0.34bc |
| 4 | Thakurgaon | 9.20±0.44a | 72.69±0.61b | 7.68±0.44bc |
| 5 | Panchagarh | 9.01±0.30a | 41.98±0.87jk | 6.53±0.24cd |
| 6 | Gaibandha | 8.46±0.32ab | 41.16±0.67kl | 7.40±0.36bc |
| 7 | Rajshahi | 6.81±0.60cdef | 36.05±0.76n | 7.51±0.56bc |
| 8 | Naogaon | 7.50±0.40bc | 44.09±0.79hi | 6.95±0.56bc |
| 9 | Pabna | 7.43±0.42bc | 55.46±0.73ef | 6.72±0.58cd |
| 10 | Gazipur | 6.32±0.58cdefghi | 33.06±0.58o | 7.73±0.24bc |
| 11 | Narsingdi | 7.17±0.52bcde | 43.55±0.79hij | 6.61±0.38cd |
| 12 | Sherpur | 4.61±0.38j | 54.26±0.82f | 5.39±0.34de |
| 13 | Mymensingh | 5.75±0.20fghij | 49.95±0.84g | 7.10±0.54bc |
| 14 | Khulna | 6.75±0.34cdefg | 64.69±0.61c | 4.62±0.40ef |
| 15 | Jessore | 6.34±0.54cdefghi | 56.66±0.58e | 6.63±0.42cd |
| 16 | Jhenaidah | 6.60±0.28cdefgh | 59.53±0.79d | 6.94±0.26bc |
| 17 | Faridpur | 5.92±0.36defghij | 42.03±0.61ijk | 6.64±0.44cd |
| 18 | Shariatpur | 9.65±0.52a | 31.39±0.64p | 4.92±0.22e |
| 19 | Barguna | 3.31±0.20k | 90.76±0.67a | 8.28±0.50b |
| 20 | Khagrachari | 5.43±0.42ghij | 54.45±0.76f | 7.92±0.58bc |
| 21 | Bandarban | 6.92±0.36cdef | 44.98±0.87h | 7.02±0.40bc |
| 22 | Rangamati | 6.62±0.40cdefgh | 39.32±0.58lm | 3.40±0.36f |
| 23 | Cox's Bazar | 3.33±0.24k | 72.95±0.84b | 12.33±0.60a |
| 24 | St. Martin's Island | 7.28±0.44bcd | 58.98±0.87d | 7.85±0.60bc |

SE = Standard error, n = 24. In the column, mean values bearing similar letter(s) or without letter are identical and those having dissimilar letters are differed significantly as per Duncan's Multiple Range Test.

**Table 7. Quantitative epidermal characteristics on adaxial surface of leaves of *Cynodon dactylon* collected from different habitats of Bangladesh.**

| Sl. No. | Habitats | Stomatal frequency | Epidermal cell/mm$^2$ | Stomatal index |
|---|---|---|---|---|
| 1 | Rangpur | 5.21±0.24bcde | 16.06±0.73cdef | 25.77±0.59bc |
| 2 | Lalmonirhat | 4.59±0.42defg | 13.20±0.82hi | 26.67±0.36b |
| 3 | Dinajpur | 5.15±0.56bcde | 14.95±0.70efgh | 26.07±0.46bc |
| 4 | Thakurgaon | 6.29±0.38ab | 19.03±0.70ab | 25.43±0.33bc |
| 5 | Panchagarh | 5.44±0.22abcde | 16.05±0.79cdef | 26.81±0.64b |
| 6 | Gaibandha | 6.31±0.56ab | 18.85±0.76ab | 25.73±0.56bc |
| 7 | Rajshahi | 5.29±0.38bcde | 15.98±0.73cdef | 25.93±0.64bc |
| 8 | Naogaon | 5.76±0.28abcd | 17.69±0.79bcd | 25.60±0.46bc |
| 9 | Pabna | 4.61±0.38cdefg | 13.57±0.76ghi | 26.07±0.28bc |
| 10 | Gazipur | 3.85±0.24fghi | 11.85±0.61ij | 25.80±0.61bc |
| 11 | Narsingdi | 5.92±0.22abc | 17.92±0.82abc | 25.87±0.33bc |
| 12 | Sherpur | 4.36±0.22efgh | 13.04±0.64hi | 26.24±0.48bc |
| 13 | Mymensingh | 4.86±0.26cdefg | 14.89±0.79efgh | 25.78±0.43bc |
| 14 | Khulna | 5.23±0.20bcde | 13.89±0.76fghi | 28.76±0.43a |
| 15 | Jessore | 5.10±0.54bcdef | 14.76±0.82efgh | 26.55±0.61bc |
| 16 | Jhenaidah | 6.40±0.44ab | 19.57±0.61ab | 24.97±0.28c |
| 17 | Faridpur | 4.96±0.22cdef | 15.14±0.55efgh | 25.80±0.61bc |
| 18 | Shariatpur | 6.61±0.38a | 19.99±0.70a | 25.40±0.31bc |
| 19 | Barguna | 3.02±0.32i | 9.28±0.82k | 26.05±0.53bc |
| 20 | Khagrachari | 5.37±0.60abcde | 15.38±0.58defgh | 25.61±0.31bc |
| 21 | Bandarban | 5.58±0.32abcde | 16.49±0.61cde | 26.27±0.61bc |
| 22 | Rangamati | 5.57±0.60abcde | 15.66±0.55cdefg | 26.37±0.41bc |
| 23 | Cox's Bazar | 3.34±0.40hi | 9.72±0.67k | 26.26±0.33bc |
| 24 | St. Martin's Island | 3.70±0.32ghi | 10.48±0.64jk | 27.04±0.41b |

SE = Standard error, n = 24. In the column, mean values bearing similar letter(s) or without letter are identical and those having dissimilar letters are differed significantly as per Duncan's Multiple Range Test.

Number of silica bodies per mm$^2$ was highest in sample of Bandarban (10.26) and lowest in sample of St. Martin's Island (2.13) in abaxial surface of the leaves (Table 5). Number of silica bodies per mm$^2$ was highest in case of Naogaon (7.95) and lowest in case of Cox's Bazar (2.00) in adaxial surface of the leaves (Table 9). Prickles angular number per mm$^2$ was highest in case of Gaibandha (0.32) and lowest in case of Mymensingh (0.19) and no prickles angular was found in case of Barguna, Cox's Bazar and St. Martin's Island in abaxial surface of the leaves (Table 5). Prickles angular number per mm$^2$ was highest in case of Thakurgaon (0.42) and lowest in case of both Pabna and Rangamati (0.18) and no prickles angular was found in case of Barguna, Cox's Bazar and St. Martin's Island in adaxial surface of the leaves (Table 9). Number of hooks per mm$^2$ was highest in case of Rajshahi (0.96) and lowest in case of Thakurgaon (0.02), Sherpur (0.02)

**Table 8. Quantitative epidermal characteristics on adaxial surface of leaves of *Cynodon dactylon* collected from different habitats of Bangladesh.**

| Sl. No. | Habitats | Stomata length with guard cell (µm) | Stomata breadth with guard cell (µm) | Epidermal cell length (µm) | Epidermal cell breadth (µm) |
|---|---|---|---|---|---|
| 1 | Rangpur | 12.42±0.73ef | 8.77±0.30fgh | 38.79±0.70i | 8.33±0.60defgh |
| 2 | Lalmonirhat | 14.02±0.87cde | 10.73±0.24c | 34.16±0.73k | 8.43±0.42defgh |
| 3 | Dinajpur | 12.50±0.84ef | 9.81±0.38cdef | 38.22±0.79ij | 7.53±0.60gh |
| 4 | Thakurgaon | 13.69±0.55cdef | 9.35±0.52defgh | 42.69±0.61gh | 8.19±0.34efgh |
| 5 | Panchagarh | 15.41±0.76abcd | 9.77±0.60cdef | 47.29±0.55e | 8.17±0.30efgh |
| 6 | Gaibandha | 13.42±0.73def | 9.79±0.34cdef | 37.45±0.70ij | 8.11±0.56efgh |
| 7 | Rajshahi | 15.29±0.61abcd | 8.83±0.30efgh | 33.15±0.84k | 9.11±0.56bcdef |
| 8 | Naogaon | 15.66±0.58abcd | 12.19±0.34b | 37.72±0.82ij | 10.18±0.56bc |
| 9 | Pabna | 12.66±0.73ef | 9.83±0.42cdef | 29.52±0.64m | 8.33±0.60defgh |
| 10 | Gazipur | 14.09±0.67cde | 8.80±0.28fgh | 38.62±0.55i | 9.81±0.38bcd |
| 11 | Narsingdi | 14.29±0.61cde | 8.37±0.38gh | 33.85±0.76k | 8.38±0.20defgh |
| 12 | Sherpur | 15.57±0.61abcd | 9.38±0.32defgh | 40.85±0.76h | 8.74±0.46cdefg |
| 13 | Mymensingh | 11.56±0.67f | 8.78±0.32fgh | 51.79±0.70d | 7.99±0.34fgh |
| 14 | Khulna | 12.62±0.55ef | 8.11±0.20h | 28.76±0.67m | 8.11±0.20efgh |
| 15 | Jessore | 13.42±0.73def | 9.41±0.38defgh | 54.69±0.61c | 8.31±0.56defgh |
| 16 | Jhenaidah | 14.22±0.73cde | 8.70±0.30fgh | 44.95±0.84f | 8.59±0.58defgh |
| 17 | Faridpur | 15.96±0.82abc | 10.12±0.58cde | 36.36±0.67j | 7.10±0.40h |
| 18 | Shariatpur | 14.65±0.76bcde | 9.50±0.54cdefg | 30.72±0.64lm | 8.12±0.22efgh |
| 19 | Barguna | 16.72±0.64ab | 15.62±0.28a | 72.06±0.64A | 8.31±0.56defgh |
| 20 | Khagrachari | 15.34±0.55abcd | 9.50±0.30cdefg | 32.66±0.58kl | 9.60±0.36bcde |
| 21 | Bandarban | 12.57±0.79ef | 9.42±0.40defgh | 36.72±0.64ij | 8.61±0.52defgh |
| 22 | Rangamati | 12.86±0.58ef | 8.54±0.26fgh | 32.66±0.58kl | 8.20±0.36efgh |
| 23 | Cox's Bazar | 17.14±0.87a | 14.93±0.60a | 58.96±0.67B | 12.20±0.36a |
| 24 | St. Martin's Island | 17.59±0.70a | 10.40±0.36cd | 43.96±0.67fg | 10.39±0.42b |

SE = Standard error, n = 24. In the column, mean values bearing similar letter(s) or without letter are identical and those having dissimilar letters are differed significantly as per Duncan's Multiple Range Test.

and St. Martin's Island (0.02) in abaxial surface of the leaves (Table 5). Number of hooks per mm$^2$ was highest in case of Lalmonirhat (1.69) and lowest in case of Barguna (0.02) in adaxial surface of the leaves (Table 9). In case of Cox's Bazar, hook was absent both abaxial and adaxial surfaces of the leaves (Table 5 & 9). Macro hair number per mm$^2$ was highest in case of Cox's Bazar (0.26) and lowest in case of Khagrachari (0.02) in abaxial surface of the leaves (Table 5). Macro hair number per mm$^2$ was highest in case of Cox's Bazar (0.52) and lowest in in case of Gazipur (0.02) in adaxial surface of the leaves. No macro hair was found in the sample of Pabna (Table 9). However, all these characters were found to be highest and lowest both abaxially and adaxially, which indicates the taxonomic importance of the foliar characters. The foliar epidermis offers a

**Table 9. Quantitative epidermal characteristics on adaxial surface of leaves of *Cynodon dactylon* collected from different habitats of Bangladesh.**

| Sl. No. | Habitats | Silica bodies no./mm$^2$ | Prickles angular/mm$^2$ | Hooks no./mm$^2$ | Macro hair no./mm$^2$ |
|---|---|---|---|---|---|
| 1 | Rangpur | 5.69±0.30cd | 0.30±0.02cdef | 0.52±0.00f | 0.11±0.03de |
| 2 | Lalmonirhat | 4.89±0.52d | 0.39±0.03ab | 1.69±0.01a | 0.24±0.04bc |
| 3 | Dinajpur | 5.73±0.30cd | 0.22±0.02fg | 0.98±0.02d | 0.16±0.04cd |
| 4 | Thakurgaon | 6.77±0.60abc | 0.42±0.02a | 1.54±0.02b | 0.11±0.03de |
| 5 | Panchagarh | 5.09±0.52d | 0.24±0.04defg | 0.32±0.04j | 0.06±0.02efg |
| 6 | Gaibandha | 6.48±0.44bc | 0.28±0.04cdef | 0.48±0.04fgh | 0.04±0.00efg |
| 7 | Rajshahi | 5.69±0.38cd | 0.24±0.04defg | 1.62±0.02a | 0.25±0.01b |
| 8 | Naogaon | 7.95±0.20a | 0.30±0.02cde | 0.79±0.03e | 0.09±0.01defg |
| 9 | Pabna | 5.89±0.38cd | 0.18±0.02g | 0.42±0.02ghi | 0.00±0.00g |
| 10 | Gazipur | 5.86±0.46cd | 0.27±0.03cdef | 1.08±0.00c | 0.02±0.02fg |
| 11 | Narsingdi | 6.68±0.44abc | 0.26±0.02defg | 0.75±0.03e | 0.08±0.04defg |
| 12 | Sherpur | 4.83±0.34d | 0.32±0.00bcd | 0.36±0.04ij | 0.06±0.02efg |
| 13 | Mymensingh | 5.65±0.24cd | 0.30±0.02cdef | 1.11±0.03c | 0.11±0.03def |
| 14 | Khulna | 6.87±0.20abc | 0.22±0.02efg | 0.46±0.02fgh | 0.05±0.01efg |
| 15 | Jessore | 5.75±0.42cd | 0.35±0.03abc | 1.11±0.03c | 0.13±0.01de |
| 16 | Jhenaidah | 6.56±0.58bc | 0.39±0.03ab | 1.05±0.01cd | 0.10±0.02def |
| 17 | Faridpur | 5.79±0.34cd | 0.35±0.03abc | 0.42±0.02ghi | 0.12±0.00de |
| 18 | Shariatpur | 6.88±0.28abc | 0.26±0.02defg | 0.43±0.03ghi | 0.03±0.03efg |
| 19 | Barguna | 2.38±0.32e | 0.00±0.00h | 0.02±0.02k | 0.08±0.04defg |
| 20 | Khagrachari | 6.89±0.30abc | 0.41±0.01a | 1.52±0.04b | 0.16±0.04cd |
| 21 | Bandarban | 6.15±0.34cd | 0.26±0.02defg | 0.50±0.02fg | 0.07±0.03defg |
| 22 | Rangamati | 7.67±0.20ab | 0.18±0.02g | 0.40±0.04hi | 0.11±0.03de |
| 23 | Cox's Bazar | 2.00±0.58e | 0.00±0.00h | 0.00±0.00k | 0.52±0.04a |
| 24 | St. Martin’s Island | 2.55±0.56e | 0.00±0.00h | 0.04±0.04k | 0.24±0.04bc |

SE = Standard error, n = 24. In the column, mean values bearing similar letter(s) or without letter are identical and those having dissimilar letters are differed significantly as per Duncan’s Multiple Range Test.

Number of noteworthy taxonomic characters. The biosystematic and taxonomic studies of a number of families established the importance of leaf epidermis (Baranova, 1972; Raju, 1981; Stace, 1984). Although the taxonomists realized lately the importance of micromorphology of the epidermis and thus, the taxonomic monographs are now considered incomplete without it (Rejdali, 1991). The diversity and distributional pattern of the above mentioned characters can be viewed from different perspectives and used as a model system for investigations into developmental biology, ecology, physiology, morphology and evolution.

## Conclusion

Different parameters of leaf epidermal anatomy like long cells, silica bodies, prickles angular and hook might be helpful in identification of the accessions of *C. dactylon* particularly in case of the grasses collected from hilly regions of Bangladesh. This study mainly focused on qualitative and quantitative characters of twenty four habitats of *C. dactydon* and all of them were amphistomatus. Stomatal parameters like size and number were found to show great ecological importance especially in case of stress tolerance. The stomatal index and stomatal frequency were of vital value in the delimitation of close relation of accessions when their variations were found to be statistically significant in most of the cases. The present findings have indicated that attempts can be made in future using stomatal characters along with few other epidermal features as the aid in identification and classification of *Cynodon dactylon* at different ecological zones of Bangladesh.

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