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Hair styles in four local collections of Solanaceae: A morphological study

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Abstract
Hair styles hold significant position in plant taxonomy, physiology, ecology and stress response study. The family Solanaceae with large number of genera exhibited diverse types of hair or trichome or indumentum types. With an objective to study hair style pattern in Solanaceae, four locally available plants were selected and epidermal hair styles were investigated. Following proper methodology in cleaning, peeling and observation, both vegetative and reproductive parts were studied for hair pattern. Plant parts like leaves, stems and floral members such as sepals, petals, anther filaments, ovary, style and stigmatic surface were studied as much as possible. Fairly widespread diversity was observed between two different taxa and between parts of same plant. The hair styles ranged from glandular to non-glandular, unicellular, bicellular to multicellular, branched to un-branched, stellate, stinging, strigose, hirsute, hispid types etc. which were found to be stable in different replicates. The similarities and dissimilarities among taxa regarding hair styles can be used as a reference point for future systematic and biological studies in the family Solanaceae.

Keywords: Hair style, morphological study, plant parts, Solanaceae

Introduction

The Solanaceae Juss., is a large family consisting of 147 genera and 3000 species, mostly shrubs or herbs, rarely lianes distributed mainly in the tropical and temperate regions (Lawrence 1951; Judd *et al*. 2002) [15,9]. In India, this family is represented by 15 genera and 88 species. Most of the species are found in either wild or cultivated throughout India and a few are found in Himalayas, Southern and Eastern India. Species such as potato, tomato, chilies, egg plant, tobacco and *Datura* are cultivated throughout India. Many members of the family are also used as medicinal plants. Atropine from *Atropa belladona*, is used as sedative, stimulant and as an antidot in opium poisoning. Similarly, *Withania somnifera* or 'Aswagandha' is used as a stimulant, tonic and treatment of sleep disorder (Judd *et al*. 2002; Harisha and Jani 2013; Sampaio *et al*. 2014) [9, 7, 23].

Plant surfaces show spectacular variation in the shape, size, location, and origin of epidermal projections (Werker 2000) [27]. The most important and well studied among these are plant hairs and unicellular or multicellular appendages (hair-like structures), originating from epidermal cells of various plant parts including leaves, stems and flowers (Oksanen 2018) [20], and developing out wards (Werker 2000) [27]. Broadly, plant hairs can be classified into glandular (presence of glandular head) and non-glandular (absence of glandular head) (Werker 2000) [27]. Both glandular and non-glandular hairs are again distinguished into unicellular and multicellular types. Non-glandular unicellular hairs are five types and the multicellular non-glandular hair further classified into two-branched and unbranched. Non-glandular multicellular branched hairs are four types – stellate, peltate, Candelabra, T- shaped and non-glandular multicellular unbranched hairs are generally of three types-, uniseriate, biseriate, multiseriate (Mbagwu *et al*. 2007; Sumitha and Thankappan 2018) [17, 25].

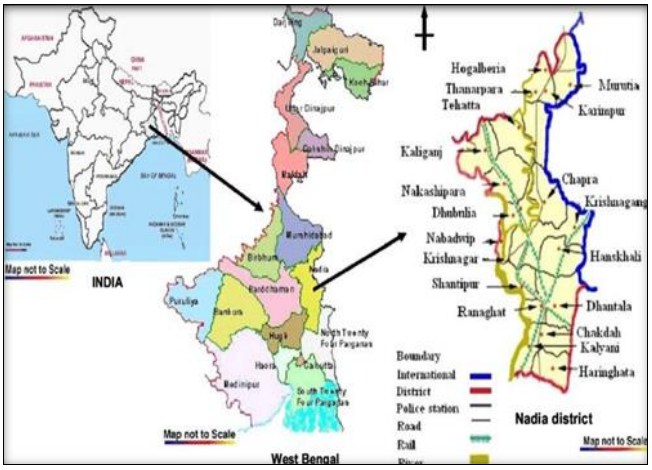
Plant hairs are distributed almost universally in the plant kingdom and exhibit dramatic variation in their morphology and density, both intra and interspecifically and also among and between related and distant plant families. The use of morphological and leaf epidermal features has been found to be of immense interest in plant taxonomy (Mbagwu and Edeoga 2006; Sumitha and Thankappan 2018) [16, 25]. Considering its importance, present endeavour has been made to describe the epidermal characters of different vegetative and reproductive parts of four members of Solanaceae. Definitely, it can provide a reference for future study on hair types and its use in determining systematic position of Solanaceous members in Angiosperm.

Materials and methods

The present study was carried out in four plants belonging to the family Solanaceae.

Study Area

The present study was conducted in the month of March-May 2023. Plants materials were collected from Phulia, Santipur, Nadia, West Bengal, India. The plants were the most abundant in the present study area (Fig. 1).



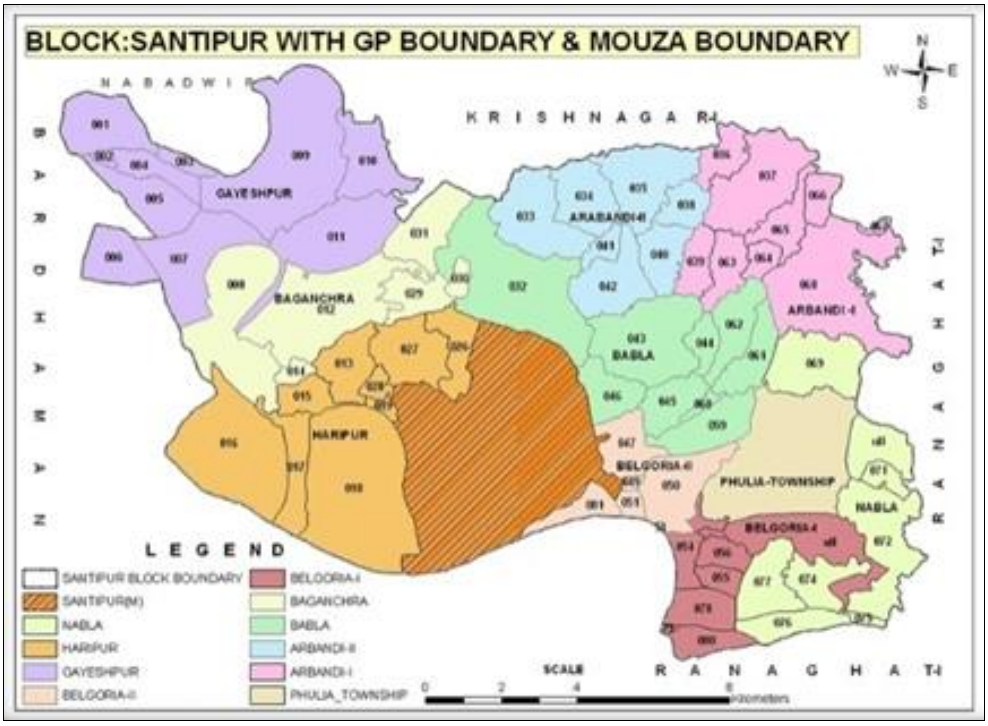


Fig 1: Study Area

Plant materials

A mixture of wild and domesticated species of genus Solanum (4 species in total) were included in the study. The plants selected are-

- *Solanum nigrum* L.
- *Solanum melongena* L.
- *Datura metel* L.
- *Cestrum diurnum* L.

Plants were identified with the help of available Herbarium at Department of Botany, Ranaghat College and author citation was done with www.ipni.org and the www.theplantlist.org.

Methodology

The collected plant samples were carefully cleaned (not with water, just dust free) and each part (stem, leaf, flower, and fruit) of every plant were observed under compound light microscope (10x, 40x). Adaxial (dorsal) and abaxial (ventral) side of fresh leaf samples (n =5 per side per sample) were used. For the microscopic observation the stems of collected plants were cut in transverse section (TS). Stems and leaf surfaces were peeled whenever necessary. The mechanical scratching method was followed for obtaining the peels. Epidermal peelings were taken from both the upper and lower surfaces of the fresh leaves, using a sharp razor blade. The peelings were then washed in distilled water and the peelings were then mounted in 50% glycerine, sealed using wax and observed under Microscope. Chemical pre-treatment was not done in any case and staining was avoided to prevent any damage or alteration of the hair types. Each part of the four taxa were studied in three different plants of same species. Photographs of each sample were taken in triplicate and suitable one was selected. Hair type identification was done following (Roe 1971) [22] and hand book of terminology of plant indumentum (Hewson 1988) [8].

Results

Epidermal characters of four members of Solanaceae were analysed in the present study. Both vegetative and reproductive organs were considered. Among the vegetative characters, hair styles of dorsal and ventral leaf surface and stem surface were studied. The reproductive parts included surface hairs of floral parts like sepals, petals, anther lobes, filaments, ovary and fruits. The nature of hair types is given in Table 1. The nature of epidermal hairs analysed in four members of Solanaceae are detailed below.

***Solanum nigrum* L.**

Upper epidermis of leaves showed multicellular finger hairs. The lower epidermis showed long stellate hairs. The hair style was also strigose to sericeous types. Similar hair styles were conspicuous in surface of stems and sepals. Among the floral reproductive members, hispid hairs were present on anther filament while in gynoecium, long hirsute and scabrous type of hair were observed on stigma and style, respectively (Fig. 2 a-d).

***Solanum melongena* L.**

Leaves: Large number of stellate hairs with 6-8 arms was found present on both sides. However, in another cultivar, the upper epidermis had multicellular finger hairs and the lower epidermis was covered by large number of stellate hairs. Similar types of hairs were present on sepals and petals. In later two cases, occurrence of stellate hair was higher in dorsal side than that in ventral side.

Stems: Modified Candelabrum-like branched, multicellular hair intermixed with finger-like unbranched, non-glandular trichome hair was observed. Among reproductive organs, non-glandular branched and unbranched hairs were present on stigma but short, unbranched glandular hairs were conspicuous on anther filament (Fig 2 & 3 e-j). Differences were observed in two varieties of *S. melongena*.

***Datura metel* L.**

Both upper and lower epidermis of leaves showed multicellular finger hairs with pointed tips. On dorsal side of leaves, hydathode-trichome like hair was also found intermixed with glandular hair. Stinging hairs were found on ventral side. In flower parts, sepals contained non-glandular, unbranched, densely congregated hairs, intermixed with one or two glandular hairs. Variation of hair types was much higher at ventral side than that in ventral side. In petals, lower number of hairs was observed than that on dorsal side. In ventral side of petals, finger –like long unbranched, non-glandular hair were found mixed with short unbranched Glandular hair. At dorsal side of petals, higher number of non-glandular and unbranched stinging hairs was found under light microscope (Fig 3 k-o).

***Cestrum diurnum* L.**

Hair features were not distinct on leaves and stem surface of the plant in present preparation. Small glandular hairs were seldom observed on the surface. Among floral members, petals exhibit short and stout hispid-type of hair whereas villous style in addition to hispid type was observed on ovary wall. The strigose style of hair was distinct on the anther filament (Fig 3p-r).

Table 1: Summary of Solanaceous hair types in the present study

Sl. no.	Name of the studied plants	Plant part/s	Major hair styles observed
1.	*Solanum nigrum* L.	Stems, leaves, floral parts	Multicellular finger, Stellate, Strigose to Sericeous, Hispid, Hirsute, Scabrous
2.	*Solanum melongena* L.	Stems, leaves, floral parts	Stellate, multicellular finger hair, candelabra
3.	*Datura metel* L.	Stems, leaves, floral parts	Multicellular finger, Hydathode trichrome, glandular hair, stinging, hispid, sericeous
4.	*Cestrum diurnum* L.	Stems, leaves, floral parts	Glandular hair, hispid, villous, strigose

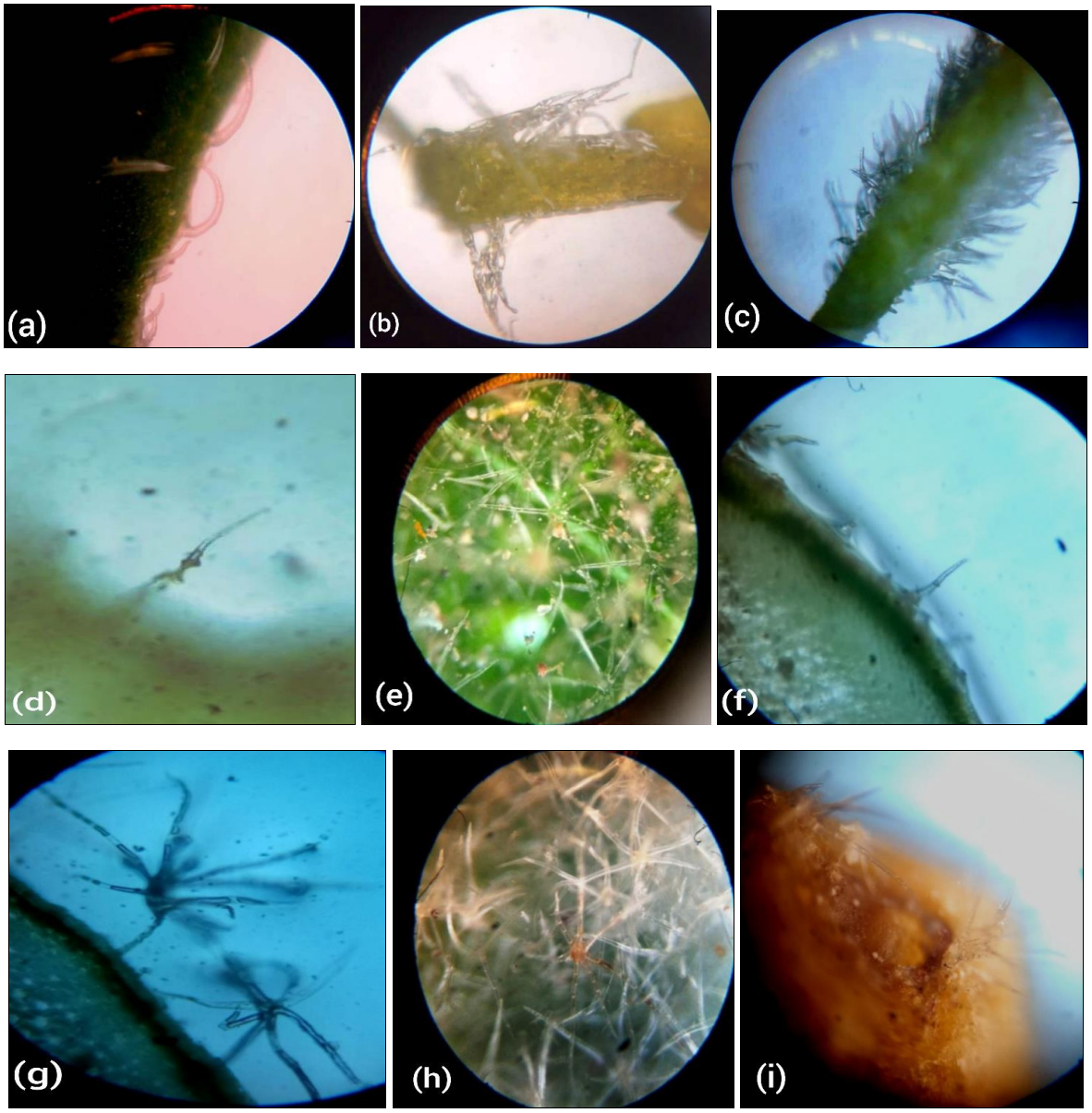


Fig 2: (a)-(d):*Solanum nigrum*: surface hair types; (a)Finger hairs on Stem, (b)Hispid hair on anther filament, (c) Hirsute Style, (d) Stinging hairs leaves; **(e)-(i) *Solanum melongena:*** e) stellate hairs on adaxial leaf surface, (f) Unbranched multicellular and (g) branched multicellular hairs on stem surface, (h) stellate hairs on sepals like patals (i) mixed hairs on ovary

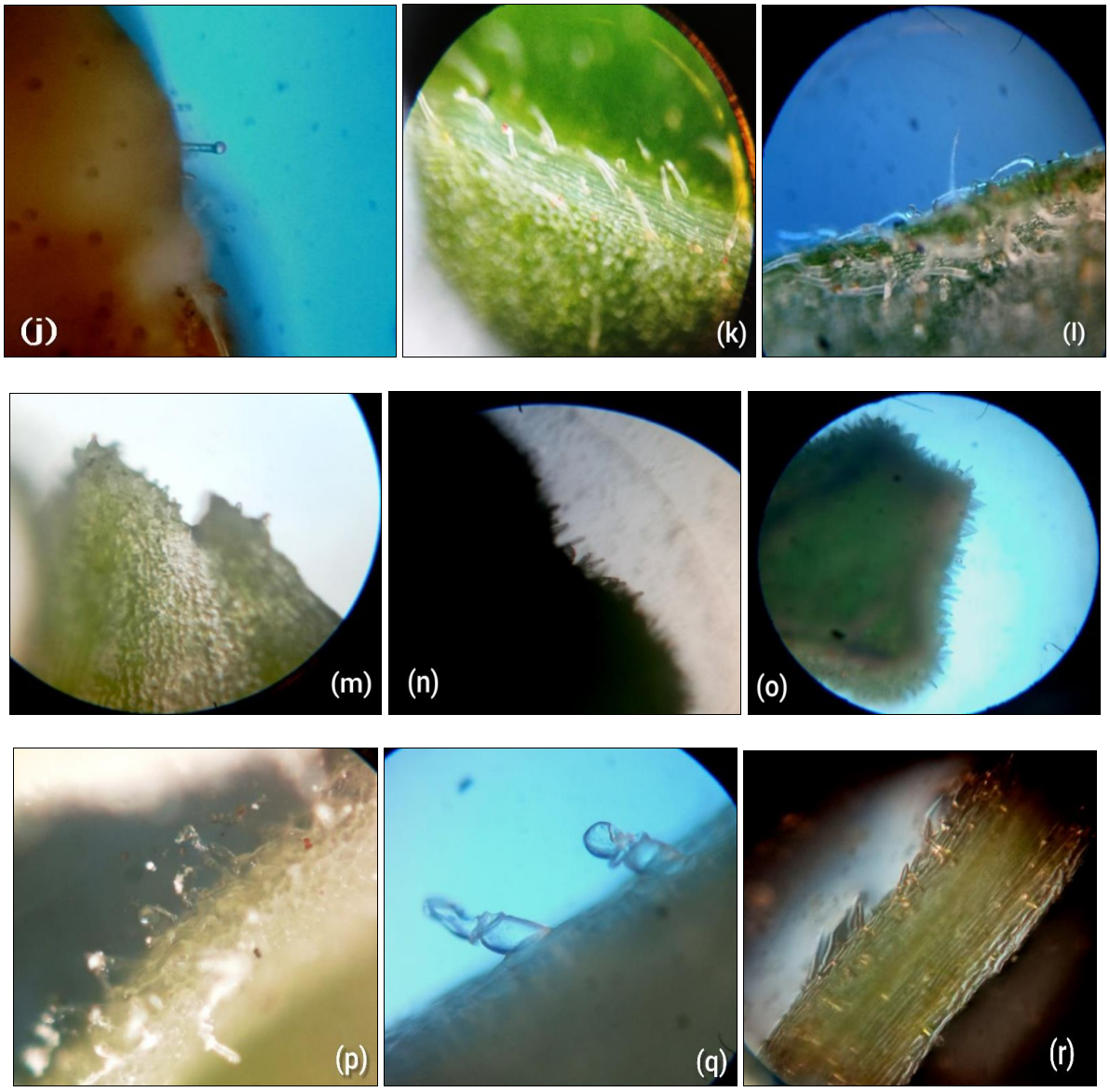


Fig 3: ***Solanum melongena:*** (j) small glandular hair on filament; **(k)-(o)** ***Datura metel:*** (k) glandular and non-glandular hispid hairs on leaf surface, (l) small glandular, hispid and sericeous hairs mixed on stems, (m) glandular multicellular hairs on filament,(n) unicellular hair on stigma (o) dense unicellular, glandular fruit spine hairs; **(p)-(r)** ***Cestrum diurnum:*** hairs on (p) petal surface, (q) stem surface, (r) anther filament wall.

Discussion

Utilization of epidermal hair styles or indumentation in plant taxonomy and systematics has become a growing trend to solve taxonomic problems. Being very distinctive, easily noticeable and variable, the hair styles can be correlated with other taxonomic features of the taxa under investigation (Cutler, 1969; Seithe and Sullivan, 1990) [3,24]. In the angiosperm family Solanaceae, hair styles have been considered as one of the most dependable genetic traits (Bukenya and Carasco, 1994; Adedeji *et al*., 2007; Harisha and Jani, 2013) [2,1,7]. In the present investigation, different hair styles were tracked under light microscope in four different taxa belonging to the family Solanaceae. Occurrences of stellate hairs were common in leaves and stems of *S. melongena* as also observed in previous studies (Adedeji *et al*., 2007; Sumitha and Thankappan, 2018) [1, 25]. Stellate hairs with 6-8 distinct arms are also common in leaves, stems and floral parts of *S. melongena*. Hair styles are diverse in these two species ranging from glandular to non-glandular to stellate with different morphology in plant parts, as partially covered in an earlier study on leaf surface of *S. melongena* (Watts and Kariyat, 2021) [26]. Kumar *et al*., 2017 [13] reported variation in number of arms in stellate hairs of *Solanum* spp. Stellate hairs with 7-8 arms were also reported in *S. asperum, S. maranguapense* and other species (Sampaio *et al*., 2014) [23]. Maximum number of radiating arms (up to 18) was reported in the pluricellular stellate trichomes of *S. mauritianum* (Kumar *et al*., 2017) [13]. The thick mat provided by stellate hairs in the present study may be correlated with ecological and protective adaptation of Solanaceous members. Sampaio *et al*., 2014 [23] observed great diversity of stellate trichomes, mainly porrect-stellate and multiangulate, and peltatetrichomes in *S. swartzianum* at Atlantic forest. Recently, Ragab *et al*., 2022 [21]studied foliar epidermal nature of 21 species from Solanoideae belonging to the family Solanaceae. Along with other leaf epidermal characters, the study showed diversity of trichomes exhibiting four types: glandular, nonglandular, stellate, and dendritic. Non-glandular trichomes were found absent in the leaves of *Hyoscyamus* species, as found in the

present *S. melongena*, *Datura metel* but the pattern and intermixing with other types of hairs on a particular plant parts are unique in the present study which assumes significance for the future work.

In *S. nigrum*, the floral reproductive members like anther filament, stigma and style exhibited different hair pattern from that of vegetative parts; while hispid hairs were present on anther filament, long hirsute and scabrous type of hair were noticeable on stigma and style, respectively. Besides the distinct stellate types, hairs in the present investigation also exhibited glandular types which were found in the sepals, anther filament, fruit surface and ventral side of petals of *Datura sp*, anther filament of *S. melongena* and very infrequently in leaves and stem surface of *Cestrum diurnum*. In *Datura*, hydathode-trichome like hair was found intermixed with glandular hair on dorsal side of leaves. Interestingly, the above said hairs are found intermixed with long stinging hairs in leaf ventral surface of *Datura metel*. In the later case, attenuated glandular hairs with minute tips as well as glandular hairs with globular head both were observed intermixed with non-glandular hair on leaf surfaces which supports the earlier observation (Watts and Kariyat, 2021) [26]. Recently, Kaur *et al*., (2023) [12] found significant intervarietal variation for trichome number as well as dimensions in tomato. Although intraspecific variation was not studied here, the differences of hair morphology between two varieties of *S. melongena* were observed (unpublished). This and earlier observations strongly indicated that trichome/hair studies should be extended beyond the basic classification into glandular and non-glandular, accommodating the sub-types and their dimensions (Kaur *et al*., 2023) [12]. The glandular hairs were multicellular in most of the cases and were considered characteristics features of *Solanum* sp (Kumar *et al*., 2017) [13]. Presence of stinging hairs (trichomes with stinging cells containing irritant fluids) in the present specimens has biological significance as it functions as hypodermal syringes and can cause various allergic reactions such as pain, itching, oedema and visible dermal reactions to mammalian herbivores, as reported earlier (Ensikat *et al*., 2021) [4]. Lower frequency of glandular hair compared to non-glandular unbranched as well as dendroid-stelliform hairs was reported earlier in *Physalis* spp of Solanaceae (Seithe and Sullivan, 1990) [24]. Four types of trichomes (glandular, non-glandular dendritic, non-glandular bicellular and non-glandular multicellular) was reportedly found in *Withania somnifera* (Munien *et al*., 2015) [18], which in accordance with the present study indicating occurrence of intraspecific variation in epidermal hair styles in Solanaceous taxa.

In *S. nigrum*, hairs are non-glandular and strigose type. On stem surfaces, multicellular, finger-like hairs with pointed tips are also found. Strigose type of hairs was also observed in *S. nigrum* and on anther filament of *C. diurnum.* Absence of glandular hairs/trichomes was also reported in leaves of Egyptian collection of *S. nigrum* (Ragab *et al*., 2022) [21]. In leaves of *C. nocturnum* L., glandular trichome with unicellular stalk and multicellular head, and glandular trichome with multicellular stalk and multicellular head was reported (Khin Lay New, Moe ZinZinThet. 2020) [19]. In the present study, a Candelabrum-like hair pattern was observed on stem surfaces of *S. melongena* with some modifications. Besides, non-glandular hispid, hirsute, and scabrous types of hairs were also screened in species of *Solanum* sp. A villous type of hair style intermixed with hirsute type were dominant in ovary wall of *C. diurnum*. Many non-glandular hair or trichome types exhibit xeromorphic nature and prevent apoplastic water leakage (Fahn, 1990) [5]. Recent studies also indicated that non-glandular hairs in the *Solanum* species prevent herbivory primarily by deterring herbivore movement, feeding and oviposition (Kaur and Kariyat, 2020) [11]. Quite contrastingly, glandular trichomes may not cause physical damage as it is pliable but can release toxic chemicals to intoxicate herbivores (Kariyat, 2019; Kaur and Kariyat, 2020) [10,11]. Glas *et al*. (2012) [6] reviewed the metabolic diversity found especially within glandular trichomes of the Solanaceae, and the genomic tools like targeted genetic engineering, available to manipulate their activities for increasing pest resistance in sustainable agriculture.

Conclusion & Future Prospects

Diversity of hairs or trichomes can be considered as a measure of evolutionary progress of the species. The hair style is a genetically-controlled morphology in plants. In the present study, diverse types of hair styles were revealed; unicellular, bicellular, multicellular, un-branched, branched, glandular, non-glandular, hirsute, hispid, villous, scabrous, candelabrum-like, sessile, stalked, strigose and stellate types with non-glandular types in higher frequency as compared to glandular one. Both glandular and non-glandular hairs were noticed in the four taxa and diversity of hair styles exists in number, distribution pattern, and structure of hairs. Seithe and Sullivan, (1990) [24]stressed the importance non-glandular stellate-dendritic hair in taxonomic assemblage and grouping of solanaceous members like *Physalis* sp. An evolutionary trend from unbranched to branched, glandular to non glandular, non stalked to stalked, and few to many branches has been proposed (Lavania, 1990) [14]. Among the hair styles, stellate, non-glandular types were found in the members who did not show huge glandular types and vice-versa, indicating distinct hair types in Solanaceae. The similarities and dissimilarities among four taxa regarding epidermal hair characters can be added as a reference of future taxonomic grouping of taxa in Solanaceae. Furthermore, being an important stressor, hairs in Solanaceae can also act as referral source for further studies regarding hair-related traits and their relationships with biotic and abiotic stresses.

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