

Trichomes of mericarpian species of the genus *Galium* (Rubiaceae) in Asian Russia

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Abstract. The surface structure of mericarp of 16 species from 9 sections of the genus *Galium*, growing in Asian Russia, has been studied by scanning electron microscopy. Clothing trichomes were found on the surface of the fruit. It was noted that the clothing trichomes are distributed over the mericarp or concentrated in separate parts of it. Based on the results obtained, two morphological types and six subtypes of clothing trichomes were identified, which have taxonomic significance.

Introduction

Trichomes (hairs) are outgrowths of plant epidermal cells of various shapes and structures. They perform protective (clothing trichomes) and excretory (glandular trichomes) functions [1]. The botanical literature describes the structure, origin, development of clothing and glandular trichomes in detail in many groups of plants, compiled morphological descriptions and developed classifications of various types of trichomes [2-4]. Researchers have shown the diagnostic role of trichome traits in the taxonomy of individual families [4, 5] and genus [6, 7].

Signs of trichomes of vegetative and generative organs are widely used in the taxonomy of the genus *Galium* L. (Rubiaceae). Researchers were paid attention to the these structures and use it in taxonomy of the genus *Galium* [8-10], but trichomes were not studied in detail. L.E. Muravnik and O.V. Kostina [11, 12] have identified that stipules of the species *G. aparine* L. and *G. album* Mill. pubescent with glandular hairs, which differ in size and location. In addition, the authors proved that in the process of ontogenesis, glandular hairs perform various functions and the metabolic direction of cells changes from the synthesis of polysaccharide mucus to the formation of secondary metabolites. Z.M. Al-Dabagh and I.K. Nasrullah [13] have studied the pubescence of stems, leaves, and fruits in five species *G. aparine*, *G. ceratopodum* Boiss, *G. setaceum* Lam., *G. spurium* L., *G. tricornutum* Dandy. They showed that trichomes are represented by simple unbranched hairs of two types, acumenated and hooked. The mericarps of *G. aparine* have peculiar hooked trichomes that contain polysaccharides and are involved in the expansion of the species [14].

The diversity of clothing trichomes of the species of the genus *Galium* growing in Asian Russia has not yet been studied enough: there are no data on the morphology and classification of hairs. This necessitated to identify of the types of trichomes, to describe of

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their morphology, as well as to determine of the possibility of using the types of trichomes in the taxonomy of the genus *Galium*.

Materials and Methods

Material for the study was ripe dry fruits stored in the herbaria of the V.L. Komarov Botanical Institute RAS (LE), N.V. Tsytsin Main Botanical Garden RAS (MHA), Faculty of Biology of Lomonosov Moscow State University (MW), Central Siberian Botanical Garden SB RAS (NS, NSK), South Siberian Botanical Garden of Altai State University (ALTB), Tomsk State University (TK). Investigation of the surface of fruits was carried out under a scanning electron microscope (Carl Zeiss EVO MA 10) in the Central Siberian Botanical Garden, the Siberian Branch of the Russian Academy of Sciences. The fruits were attached to the microscope stage with an adhesive tape, then gold was sputtered by means of a Mini SC 7620 device, followed by scanning.

The morphological description of the trichomes types was carried out using the terminology developed by T.A. Ostroumova, M.G. Pimenov and U.A. Ukrainskaya [4].

Results and discussion

The whole variety of fruit trichomes (mericarp) in species of the genus *Galium* growing in Asian Russia belongs to the group of non-glandular simple (unicellular) hairs, among which two types were identified: single sessile and single ones with a multi-row base (Table 1).

Table 1. Morphological classification of mericarp trichomes in species of the genus *Galium* of Asian Russia

Group	Type	Subtype	Species
Non-glandular hairs	Single sessile	Straight	<i>G. amurense</i> , <i>G. ruthenicum</i> , <i>G. densiflorum</i>
		Hook-shaped	<i>G. mugodsharicum</i> , <i>G. boreale</i>
		Sickle-shaped	<i>G. coriaceum</i> , <i>G. amblyophyllum</i> , <i>G. lacteum</i>
	Single ones with a multi-row base	Rounded	<i>G. songaricum</i>
		Flattened	<i>G. aparine</i> , <i>G. vaillantii</i>
		Ribbon-shaped	<i>G. odoratum</i> , <i>G. paradoxum</i> <i>G. kamtschaticum</i> , <i>G. triflorum</i> , <i>G. pseudoasprellum</i>

The first type is characterized by the presence of one polygonal cell at the base of the trichomes. The hairs of different lengths have a conical shape with a sharp tip; they are marked: straight, hook-shaped and sickle-shaped.

Trichomes of the second type characterise by a certain number of polygonal cells (6–10) presented at the base. The cells raise the hair above the surface of the fetus. All hairs with a multi-row base have a conical or cylindrical shape with a sharp hook-shaped apex, which are divided into three subtypes: rounded, flattened, and ribbon-shaped.

There are single sessile straight hairs of a conical elongated shape with a sharp straight apex and a wide base, slightly compressed laterally. Trichomes of this subtype are found in the species *G. amurense* Pobed. (section *Platygalium* W.D.J. Koch), *G. densiflorum* Ledeb., *G. ruthenicum* Willd. (section *Galium*). In the species *G. amurense*, the hairs are 380–580 µm long., directed upward or slightly at an angle, densely located throughout the fruit.

Trichomes of the species *G. densiflorum* and *G. ruthenicum* are 78–190 μm long, directed straight up or at an angle, sometimes appressed, fill the entire mericarp (Fig. 1).

Single sessile hook-shaped hairs are hairs of a conical shape with a sharp hook-shaped apex, with a wide base, rounded, slightly compressed laterally. They are observed for the species *G. boreale* L. and *G. mugodsharicum* Pobed. from the *Platygalium* section. *G. mugodsharicum* hairs are 100–160 μm long., sticking up, concentrated in the dorsal part of the mericarp. *G. boreale* has trichomes, 207–400 μm long, evenly distributed over the fruit, sticking out, located at an angle to the surface (Fig. 1).

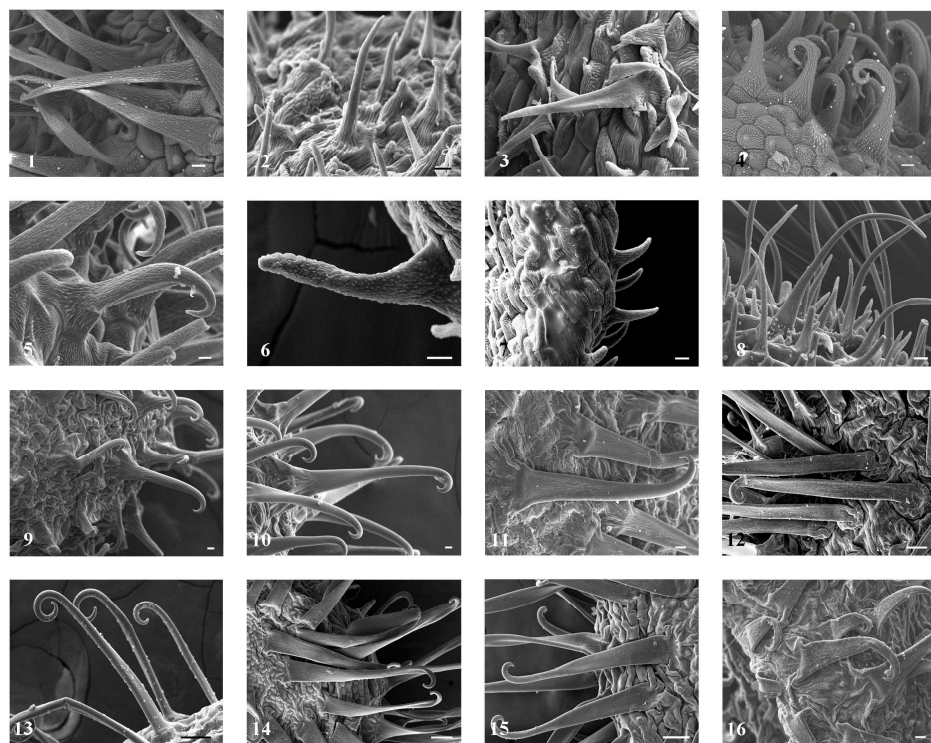


Fig. 1. Trichomes of mericarp species of the genus *Galium*: 1 – *G. amurense*; 2 – *G. ruthenicum*; 3 – *G. densiflorum*; 4 – *G. mugodsharicum*; 5 – *G. boreale*; 6 – *G. coriaceum*; 7 – *G. amblyophyllum*; 8 – *G. lacteum*; 9 – *G. songaricum*; 10 – *G. aparine*; 11 – *G. vaillantii*; 12 – *G. odoratum*; 13 – *G. paradoxum*; 14 – *G. kamtschaticum*; 15 – *G. triflorum*; 16 – *G. pseudoasprellum*. Scale bars: 20 μm (2, 3, 5, 6, 7, 8, 9, 10); 30 μm (11, 16); 100 μm (12, 13, 14, 15); 200 μm (1, 4).

Single sessile crescent hairs of a conical shape with a sharp apex, slightly widened at the base, laterally compressed, are found in the species *G. coriaceum* Bunge (section *Coriacea* A. Jelen., Kuranova et Pjatunina), *G. amblyophyllum* Pobed. (section *Platygalium*) and *G. lacteum* (Maxim.) Pobed. (section *Galium*). Trichomes of the species *G. coriaceum* are rare, 30–50 μm long., appressed or slightly protruding, combined in the basal-dorsal part of the mericarp, absent at the apex. *G. amblyophyllum* has hairs, 11–15 μm long., appressed, very rare, dispersed, concentrated in the basal part of the fetus. Hairs of the species *G. lacteum* are described as 140–218 μm in long, directed upward at a right angle, densely distributed throughout the mericarp. There are trichomes of the species *G. lacteum* that are slightly depressed into the bases cell, the edges of the cell form a ridge (Fig. 1).

There are single, multi-row, rounded hairs of a cylindrical shape, rounded in cross section, slightly widened at the base, with a hook-shaped apex, evenly occupy the mericarp. This type of trichomes is found only in the species *G. songaricum* Schrenk. (section

Depauperata Pobed.). The hairs of *G. songaricum* are 205–361 μm in long, sparse, protruding, directed upward, in the basal part there are 8 (10) large, dome-shaped cells that raise the hair above the fetal surface (Fig. 1).

Single, multi-row, flattened hairs of a conical shape, laterally compressed, oval in cross section, wide at the base, with a hook-shaped apex, are found in annual species *G. aparine* L., *G. vaillantii* DC. from the *Aparine* Lange section. Hairs are 250–480 μm long., spaced, localized throughout the fetus, sticking out, 10 (12) large, convex hair-lifting cells are at the base of the hair of the species *G. aparine*, or 8 (10) large, flat cells characterises of the species *G. vaillantii* (Fig. 1).

Single, multi-row, ribbon-shaped hairs are cone-shaped strongly compressed laterally, thin, widened at the base, hooked, characteristic of the species *G. paradoxum* Maxim., *G. kamtschaticum* Stell. ex Schult et Schult fil. (section *Cymogalia* Pobed.), *G. odoratum* (L.) Scop. (section *Hylaeae* (Griseb.) Ehrend.), *G. triflorum* Michx. (section *Senifolia* (Pobed.) A. Jelen., Kuranova et Pjatunina) and *G. pseudoasprellum* Makino (section *Trachygalium* K. Schum.). For the species of the *Cymogalia* section, dispersed, protruding hairs are characteristic, which are located completely along the mericarp, 440–730 μm long, at the base (6) of 8 large concave (*G. kamtschaticum*) or slightly convex (*G. paradoxum*) cells. On fruits of *G. odoratum* are observed protruding, densely located hairs throughout the fruit, 628–936 μm long., at the base with (6) 8 concave cells, which sometimes have the form of a cylinder. *G. triflorum* hairs are 260–350 μm long, upright, single occupy the entire surface of the mericarp, at the base of 6 (8) large, concave cells. Trichomes of the species *G. pseudoasprellum* are 295–370 μm long, upright, rarely appressed, concentrated in the dorsal part of the mericarp, at the base of 8 large, convex cells (Fig. 1).

Thus, in species of the genus *Galium* in Asiatic Russia, clothing trichomes on mericarps are represented by simple unicellular hairs. Dense and sparse pubescence is found on the fruits. It was revealed that trichomes are distributed evenly throughout the fruit (*G. amurense*, *G. boreale*, *G. densiflorum*, *G. ruthenicum*, *G. lacteum*, *G. songaricum*, *G. aparine*, *G. vaillantii*, *G. paradoxum*, *G. kamtschaticum*, *G. odoratum*, *G. triflorum*), sometimes concentrated in the dorsal (*G. mugodsharicum*), basal (*G. amblyophyllum*) or basal-dorsal (*G. coriaceum*) parts of the mericarp. The variety of trichomes on fruits is classified into two types - single sessile and single ones with a multi-row base. The hairs of the first type (single sessile) are straight, hook-shaped and sickle-shaped in the shape of the apex. The second type (single with a multi-row base) is characterized by the shape of the section of trichomes and is represented by rounded, flattened and ribbon-like hairs.

The species of the type section *Galium* are characterized by fruits with single sessile, straight or crescent hairs. For the species of the section *Platygalium*, fruits with single sessile straight, hooked, or sickle-shaped hairs were noted. In the *Coriaceae* section, fruits with single sessile sickle-shaped trichomes are observed. In the species of the sections *Cymogalia*, *Senifolia*, *Hylaeae*, and *Trachygalium*, single multi-row, ribbon-like hairs were found on fruits. Mericarps of the species of the *Depauperata* section are characterized by single multi-row, rounded hairs, and in the *Aparine* section, single multi-row flattened hairs are present on fruits.

The morphological types of the clothing trichomes we have noted have taxonomic significance and can be diagnostic at the species level.

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References

1. M. S. Gilyarov, Biological encyclopedic dictionary (Moscow, Soviet Encyclopedia, 1986)
2. Hanbuch der Pflanzenanatomie **4**, 5 (Berlin; Stuttgart : Borntraeger,1962)
3. E. V. Baikova, Buletin of Mosow society of Naturalists, **106**, 4 (2001)
4. T. A. Ostroumova, M. G. Pimenov, U. A. Ukrainskaya, Bot. J., **95**, 9 (2010)
5. E. V. Boyko, Turczaninowia, **14**, 2 (2011)
6. Yu. K. Vinogradova, A. S. Ryabchenko, S. R. Mayorov, Bot. J., **9**, 1 (2013)
7. E. V. Baikova, T. D. Fershalova, E. A. Karpova, Plant life of Asian Russia, **2**, 34 (2019)
8. A. P. de Candolle, *Galium* in Prodrumus systematis naturalis regni vegetabilis, 4 (Parisiis, 1830)
9. E. G. Pobedimova, *Galium* in Flora URSS, 23 (Moscow; Leningrad, 1958)
10. F. Ehrendorfer, F. Krendl, *Galium* in Flora Europea, 4 (Cambridge, 1976)
11. L. E. Muravnik, O. V. Kostina, Bot. J., **95**, 7 (2010)
12. L. E. Muravnik, O. V. Kostina, Bot. J., **96**, 8 (2011)
13. Z. M. Al-Dabagh, I. K. Nasrullah, Plant Archives. **19**, 1 (2019)
14. A. J. Bowling, H. B. Maxwell, K. C. Vaughn, Protoplasma **233** (2008)