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Development, structure and senescence of colleters in *Gardenia lucida* Roxb. (*Rubiaceae*)

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Abstract

Colleters are found on the adaxial basal part of the stipule and calyx of *Gardenia lucida*. They secrete a yellow transparent resinous substance commonly known as "Dikamali gum". They develop on both the stipule and calyx from a group of epidermal and hypodermal initials. A mature colleter consists of a central core of elongated parenchymatous cells surrounded by a palisade-like secretory epidermis. Druses type crystals of calcium oxalate are frequent in the colleters. At the time of senescence the central cells show lignification and the presence of tannin.

Key words: colleters, Gardenia lucida

INTRODUCTION

The term colleters coined by Hanstein (1848, vide Foster 1949) is derived from a Greek word „coll" meaning glue, referring to the sticky secretions of these structures. Such secretory structures have been reported in several angiosperm families like *Rhizophoraceae*, *Passifloraceae*, *Rubiaceae*, *Apocyanaceae* and *Asclepiadaceae*. However, various names have been assigned to them, such as "colleters" by Foster (1949), Esau (1953), "shaggy hairs" by Metcalfe and Chalk (1950), "squamellae" in *Apocyanaceae* and *Asclepiadaceae* by Ramayya and Bahadur (1968), "glandular trichomes" in *Apocyanaceae* by Williams et al. (1982) and "resin glands" in *Passifloraceae* by Durkee et al. (1984). In the family *Rubiaceae* itself these glandular structures have been variously called as "shaggy hairs" (Metcalfe and Chalk 1950),

"colleters" (Lersten 1974a, b, Miller et al. 1983) and "stipular glands" (Patel and Zaveri 1975). Here, these structures have also been described as colleters. The exudation from the shoot tip of *Gardenia lucida* is commonly known as "Dikamali gum", but the origin of this secretion is not mentioned anywhere. In *Rubiaceae* there is no previous report of the occurrence of colleters on the calyx. In the present paper we describe the development, structure and senescence of theses secretory structures occurring on the adaxial basal parts of stipule and calyx of *Gardenia lucida* Roxb.

MATERIALS AND METHODS

Apical buds and flowers of *Gardenia lucida* Roxb. at different growing phases were collected from the Sardar Patel University Botanical Garden and fixed in FAA. The fixed materials were transferred to 70% ethyl alcohol and dehydrated through T.B.A. series. Infiltration and embedding was done in tissue preparer (56.5°C). 8-10 μm sections were cut and stained with tannic acid ferric chloride and counter stained with safranine and fast green. The chemical nature of crystals was tested with cupric acetate and chloroglucinol was used to test the lignification (Johansen 1940). Photomicrographs are taken using a Carl-Zeiss tessovar and Carl-Zeiss photomiscroscope. The drawings were made using a projection microscope.

RESULTS

Gardenia lucida is a large glabrous shrub or small tree. The leaves are opposite and decussate. The stipules are intrapetiolar. Young shoots are greyish green, smooth and resinous. The apical bud is fully covered by an acute sheathing stipule. The exudation is found at the tip of both terminal and flower buds (Figs. 1, 2). This resinous substance is secreted by the colleters occurring at the adaxial basal part of the stipule and calyx (Fig. 3, 4). About 350-400 such secretory colleters were found to occur at the base of a single stipule or calyx. Fully grown stipules and calyxes measured 0.9-1.2 cm and 1.5-1.8 cm, respectively. The young leaves and corolla emerging out of these buds were covered with a yellow translucent resinous substance (Fig. 5). The colleters developed, matured and secreted before the stipule and calyx attained a length of 0.4 cm and 0.8 cm, respectively, when they were still in buds. These colleters were yellow, translucent at maturity owing to the colour of the secretion. Even if there was not much variation in the number and size of colleters on the stipule and calyx, there seemed to be more secretion from the stipular colleters. After secretion, the colleters showed signs of necrosis, which was evident morphologically by the change of the translucent yellow colour to brown. This colour change was completed when the emerged leaves attained a length of

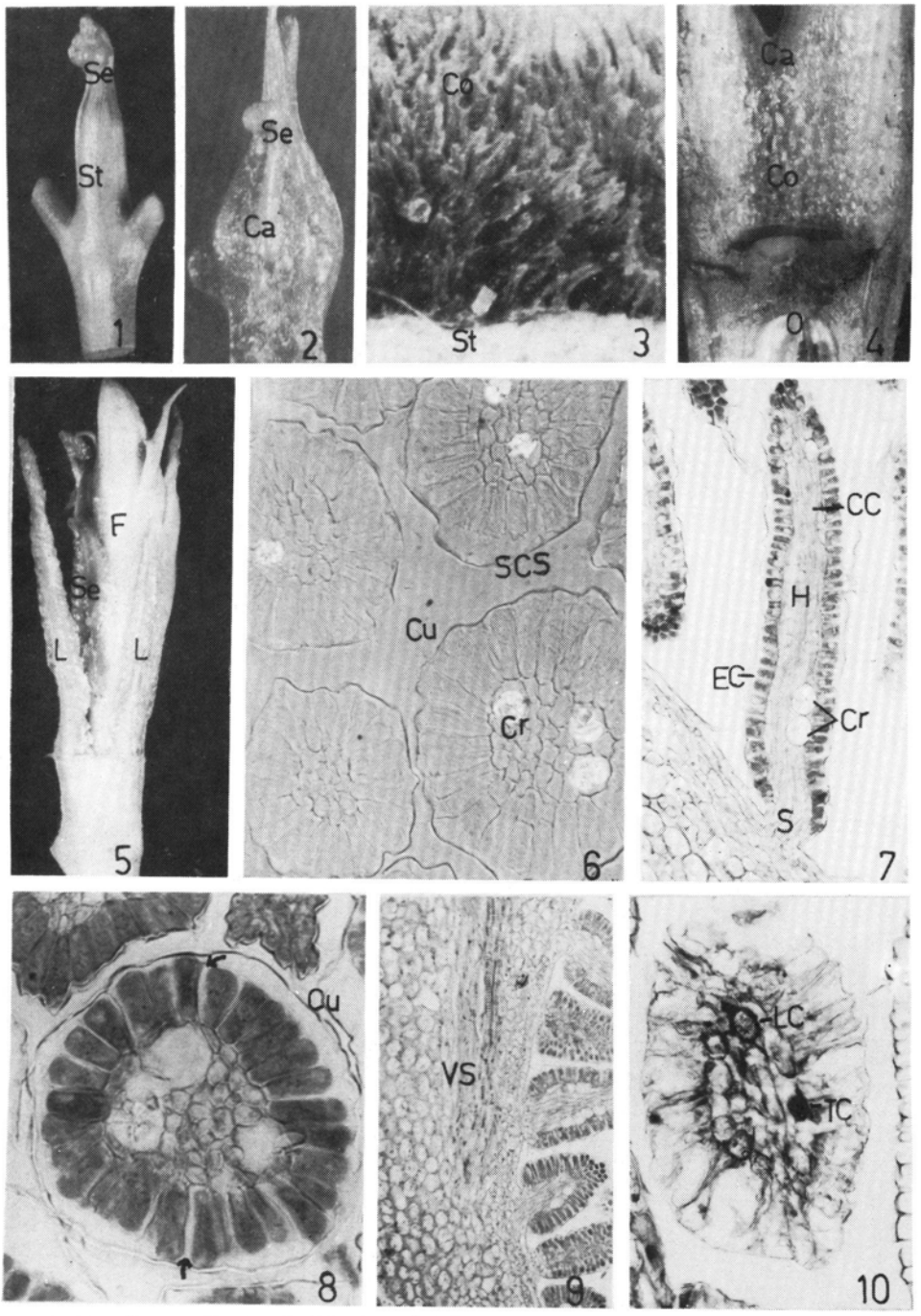
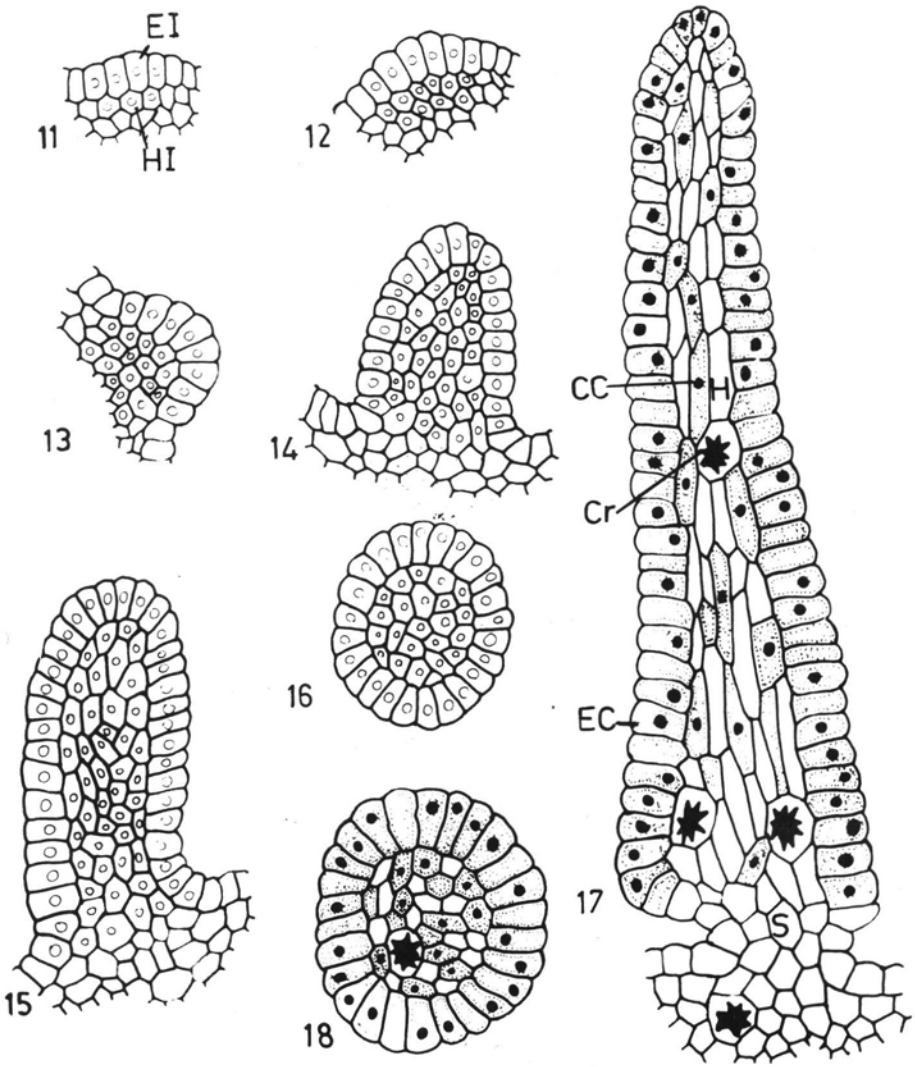


Fig. 1. Secretion on the terminal bud, × 3. Fig. 2. Secretion on the flower bud, × 2. Fig. 3. Colleters on stipule, × 10. Fig. 4. Colleters on calyx, × 5. Fig. 5. Young leaves and flower coated with secretion, × 4. Fig. 6. Transverse section of colleters with intact cuticle and crystals (Nomarsky interference photomicrograph), × 440. Fig. 7. Longitudinal section of colleter with detached and broken cuticle, × 140. Fig. 8. Transverse section of colleter with detached cuticle (arrows show the space formed by the withdrawal of cytoplasm along the radial walls), × 420. Fig. 9. Vascular strand of stipule passing close to the colleters, × 110. Fig. 10. Transverse section of colleter with lignified and tanniniferous central cells and empty broken epithelial cells at the time of senescence, × 240. Ca – calyx, CC – central cell, Co – colleter, Cr – crystal, Cu – cuticle, EC – epithelial cell, F – flower bud, H – head, L – leaf, LC – lignified cell, O – ovary, S – stalk, SCS – subcuticular space, Se – secret, St – stipule, TC – tannin cell, VS – vascular strand



Figs. 11-15. Developmental stages of colleter, × 480. Fig. 16. Transverse section of a developing colleter, × 480. Fig. 17. Longitudinal section of a mature colleter, × 340. Fig. 18. Transverse section of mature colleter, × 340. CC – central cell, Cr – crystal, EC – epithelial cell, EI – epidermal initial, H – head, HI – hypodermal initial, S – stalk

6-8 cm. The basal part of the stipule persisted at the base of very old leaves (13-14 cm) with the remnant of the colleters evidenced as dark brown spots.

The ontogeny of colleters on both stipule and calyx followed the same pattern. In the region of colleter initiation 3-4 epidermal cells and 2-3 proximal hypodermal cells were distinguished by their dense cytoplasm and prominent nuclei (Fig. 11). Divisions in these initials resulted in a small protuberance (Fig. 12). In epidermal initials, only anticlinal divisions were seen, but hypodermal initials divided both anticlinally and periclinally resulting in the formation of a mount (Fig. 13). This mount later elongated by frequent anticlinal and periclinal divisions in the hypodermal derivatives and simultaneous anticlinal divisions in the epidermal derivatives (Figs. 14-16). These frequent divisions and growth in both derivatives resulted in the formation of a finger-shaped structure with a long head and short stalk (Figs. 7, 17).

A fully grown colleter was about 500-600 μm in length and had a diameter of 80-90 μm through the centre. The basal and terminal parts had a diameter of 100 μm and 30 μm, respectively. It consisted of a central core of elongated parenchymatous cells enclosed by a palisade-like secretory epidermis (Figs. 7, 17). In transverse section, the central cells were polyhedral without intercellular spaces (Figs. 6, 8, 18). The fully mature and secreting colleters had very dense cytoplasm in the epithelial layers (Figs. 7, 8, 17, 18). This secretory epidermis had an intact cuticle before secretion (Fig. 6). When secretion started, the cuticle became separated in certain regions forming a subcuticular space and finally became fully detached due to the pressure of the secretion (Figs. 7, 8). Withdrawal of the cytoplasm along the radial walls of these epithelial cells and formation of a gap was also observed (Fig. 8). Thus, the secretion came out through the radial as well as the outer tangential walls. Druses type crystals of calcium oxalate were frequently seen in the central cells and their frequency was higher in the stipular colleters (Figs. 6, 7, 8, 17, 18). Even if vascular bundles of stipule and calyx were seen very close to the colleters, they never were found entering into these structures (Fig. 9).

During senescence, the central cells became lignified. Certain tannin filled cells were also seen along with these lignified cells. The epithelial cells became empty or vacuolated with degenerating walls (Fig. 10).

DISCUSSION

There are several reports of mucilaginous or resinous secretions in and around the bud of the *Rubiaceae* (Solereder 1908, Metcalfe and Chalk 1950, Horner and Lersten 1968, Lersten 1974a, b, Miller et al. 1983). Wherever the plant *Gardenia lucida* is mentioned, the shoot tip is described as smooth and resinous (Hooker 1882, Kirtikar and Basu 1933, Gamble

1957, Cooke 1958), but nothing is mentioned about the structures which secrete this resinous substance. It has become evident from the present study that the structures called colleters secrete this resin and are present not only on the stipule but also on the calyx. These colleters originate from a group of epidermal and hypodermal initials and develop into a standard type colleter described by Lersten (1974a, b).

The occurrence of different types of crystals in colleters and its taxonomic relations were first reported by Lersten (1974b) in different species of *Psychotria*. In *Gardenia*, only druses type crystals of calcium oxalate are present in the colleters. There is no vascular supply into these small colleters. The vasculature in a structure is directly proportional to its size and it is not necessarily related to any state of advancement (Carlquist 1969).

The formation of a gap along the radial walls by the withdrawal of the cytoplasm in the epithelial cells speeds up the process of secretion. Thus, the secretion which has come out of the cell through outer tangential wall and the two radial walls accumulates in the subcuticular space and by this increased pressure the cuticle becomes detached and breaks off. This secretion comes out of the large number of colleters accumulates in the space between the stipule and young leaves. Later it comes out of the bud in the form of small drops. Also in flower buds this resin accumulates in the calyx cup and later comes out of the bud. This is the reason why the shoot tip and flower bud appear resinous. As the young leaves are inrolled when in the bud this resinous substance coats the abaxial side more, which may reduce the rate of transpiration when these leaves emerge out of the bud.

The exudation of *Gardenia lucida* and that of *Gardenia gummifera*, commonly known as "Dikamali gum" is of economic importance. According to Kirtikar and Basu (1933) this resin has a hot sharp pungent taste, which stimulates the appetite, relieves constipation and the pains of bronchitis, and is commonly used in cutaneous diseases to keep off flies and worms. According to Thomas (1987) the "Dikamali gum" is a pure resin containing a volatile oil of 19 components which give it its characteristic smell.

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Rozwój, budowa i starzenie się gruczołów wydzielniczych u Gardenia lucida Roxb. (Rubiacae)

Streszczenie

Gruczoły wydzielnicze znaleziono na adaksialnej, bazalnej części przylistka i kielicha u *Gardenia lucida*. Wydzielają one żółtą, przejrzystą substancję żywiczą, popularnie zwaną "Dikamali gum". Gruczoły wydzielnicze rozwijają się zarówno na przylistku, jak i na koronie z epidermalnych i hipodermalnych zawiązków. Dojrzały gruczoł wydzielniczy składa się z centralnego rdzenia, zbudowanego z wydłużonych komórek parenchymatycznych, otoczonych epidermą wydzielniczą, podobną do palisady. W gruczołach wydzielniczych często występują, podobne do druz, kryształy wapnia. Podczas starzenia się komórki centralne drewnieją i wykazują obecność taniny.