Flora 221 (2016) 100–106

Contents lists available at ScienceDirect

Flora

journal homepage: www.elsevier.com/locate/flora

Nectary structure in four melliferous plant species native to Chile☆

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ARTICLE INFO

Article history:
Received 3 March 2015
Received in revised form 23 February 2016
Accepted 25 February 2016
Edited by Shahin Zarre
Available online 2 March 2016

Keywords:
Nectar
Honey
Floral visitors
Apis mellifera
Chilean flora

ABSTRACT

Floral nectary is specialized structure mostly locating in flowers secreting nectar, a sugar-rich liquid involved in the mutual interactions of pollination and the main resource used by honey bees, *Apis mellifera*, to produce honey. The objective of this study is to provide detailed examination of the floral nectary in four plant species native to Chile: *Quillaja saponaria*, *Eucryphia cordifolia*, *Escallonia pulverulenta* and *Gevuina avellana*, all visited by wide diversity of insects including honeybees. These plants are responsible for the main production of monofloral honey in Chile. The descriptions were based on direct and microscopic observation of several histological sections of the flowers. The nectary of the four studied species, have very different structures, forming differentiated tissues. Our observations indicated that *E. cordifolia* and *Q. saponaria* have the highest nectary volume. On the other hand, *E. pulverulenta* and *Q. saponaria* have thick cuticles and nectar stomata. The secretory tissue in nectary of *E. cordifolia* was rich in starch, while *E. pulverulenta*, *Q. saponaria* and *G. avellana* were rich in tanniferous cells. With the exception of *G. avellana*, vascular bundles were always present in the sub-nectary parenchyma. The four studied species have exposed nectary and their flowers exhibit similar morphological characteristics, such as colour, and petal coherence. The large number of floral visitors in our studied species, including *A. mellifera* might be associated with these nectary features and flower traits, among others. This research, contribute to the knowledge of floral biology in Chilean flora, which would be useful for studies in the field of apiculture and plant-pollinator interactions.

1. Introduction

Floral nectary is a structure composed of specialized tissues that secrete nectar, the sugar-rich liquid produced by the plant to attract and reward animals responsible for pollination. Nectary is widespread among angiosperms and show a great diversity in shape, structure and functions (e.g. Fahn, 1979; Elias, 1983; Smets, 1986; Freitas et al., 2001). Morphologically, the nectary may be recognizable as glands located in different parts of the flower (Fahn, 1979,1985; Bernadello, 2007), which usually differ histologically from their adjacent tissues and vary considerably among species in terms of position, anatomy, and secretion mechanisms.

The structure of the nectary is generally composed of an epidermis, a parenchyma that produces or stores substances that become dissolved in the nectar, and the vascular bundle, which conveys water or nutrients to the parenchyma (Fahn, 1979, 1985; Pacini et al., 2003; Pacini and Nicolson, 2007). These three anatomical components can vary greatly depending on the type of nectary (Pacini et al., 2003). In some species, the total volume of the nectary can be related to the amount of nectar produced (Gulyás et al., 1976; Dafni et al., 1988; Orosz-Kovács et al., 1996; Petanidou et al., 2000). The type of tissues that comprise the nectary might vary in many aspects, such as the presence and proportion of assimilator or storage tissues, the number and type of vascular bundles that feed the nectary and also influence nectar volume, secretion dynamics, and the chemical composition of the nectar (Fahn, 1985; Rathcke, 1992; Pacini et al., 2003; Weryszko-Chmielewska et al., 2003; Nepi, 2007).

Nectary location and structure, together with other floral attributes, might determine nectar accessibility which is related to the number and type of floral visitors (Harder and Cruzan, 1990; Pacini et al., 2003; Weryszko-Chmielewska et al., 2003; Bernadello, 2007; Nepi, 2007). Thus, the efficiency of the honeybee (*Apis*

☆ This article is part of a special issue entitled "FLO-RE-S network for contemporary studies in flower structure and biology".

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http://dx.doi.org/10.1016/j.flora.2016.02.013
0367-2530/

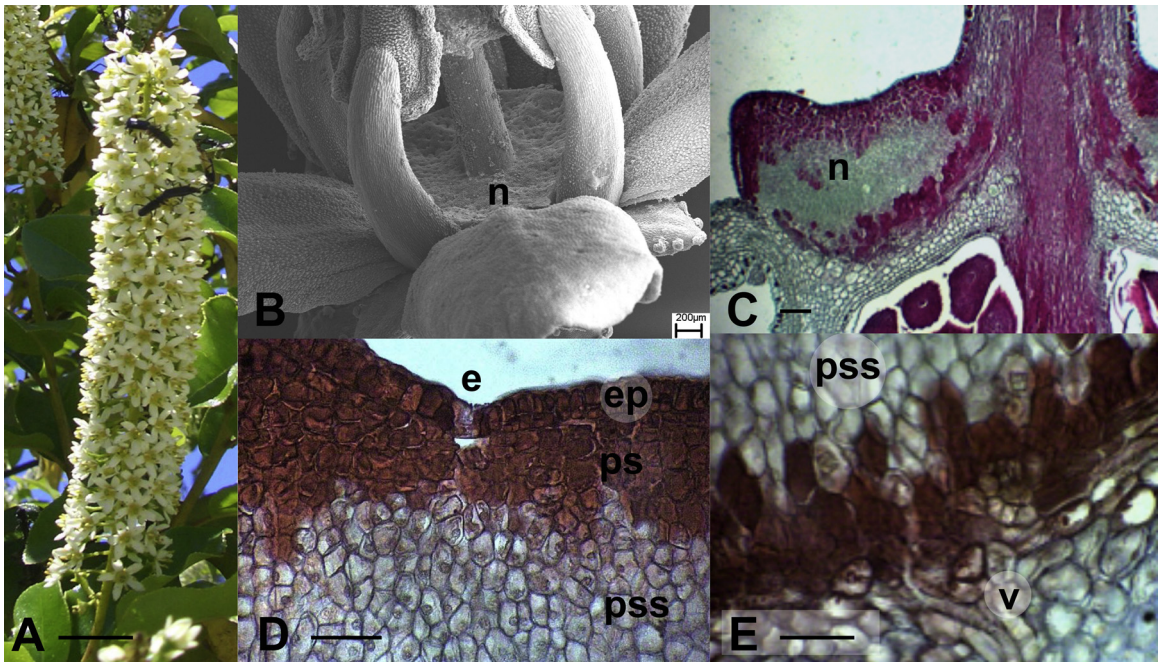

Fig. 1. A: Inflorescence of *Escallonia pulverulenta*. B: SEM of an isolated flower. C: Cross-section of the flower of *E. pulverulenta* showing the nectary. D: Cross-section of the nectary of the flower of *E. pulverulenta*, showing epidermis (ep), stoma (e), secretor parenchyma (ps) and sub-secretory parenchyma (pss). E: Cross-section showing the arrival of vascular bundle (v) to the sub-secretory parenchyma (pss) of the nectary of *E. pulverulenta*. Scale bar: A = 5 mm, B = 200 µm, C = 1 mm, D, E = 500 µm.

mellifera) to collect nectar is dependent on these traits (Proctor et al., 1996).

Floral nectar and nectary are involved in the mutualistic interactions of pollination, which are considered to be among the most important biological interactions responsible for the persistence of plant communities (Harper 1977; Rathcke, 1992; Willson et al., 1996). To a large degree, pollination is also responsible for agricultural production and is one of the most important ecosystem services for maintaining biodiversity (Garibaldi et al., 2013).

There is scarce information available regarding the characteristics of nectar secretion and the structure of nectary in native plants of continental Chile. In fact, there is only one study related to the nectary structure of a native species of Bignoniaceae (Belmonte et al., 1994), despite the high proportion of species with mutual pollination interactions (Aizen et al., 2002) and the importance of native flora for honey production in Chile (Montenegro et al., 2008).

The main native species from which high quality monofloral honey is produced are *Quillaja saponaria* Mol. (Quillajaceae), *Eucryphia cordifolia* Cav. (Eucryphiaceae), *Escallonia pulverulenta* (Ruiz and Pav.) Pers. (Escalloniaceae) and *Gevuina avellana* Mol. (Proteaceae) (Montenegro et al., 2008). Flowers of these four species are visited by a large number of insects.

E. cordifolia has a high rate of recorded floral visitors. Over ten years of research revealed 137 pollinator species (average of 44 species per year) including 67 dipterans, 32 coleopterans, 26 hymenopterans, 7 lepidopterans, and 5 infrequent visitors from other insect orders. The two numerically most common and constant pollinators visiting the flowers of *E. cordifolia* are the introduced honeybee *A. mellifera*, and the native larger bumblebee *Bombus dahlbomii* (Smith-Ramírez et al., 2014).

For *G. avellana*, after one study season, 29 flower visitors were recorded, belonging to eight families of the orders: Coleoptera, Diptera, and Hymenoptera (Tapia, 2000).

For *Q. saponaria*, after one study season, 42 flower visitors were recorded, representing 27 families belonging to the orders: Coleoptera, Diptera, Hymenoptera, Lepidoptera, and Hemiptera. The most frequent visitors were *Megachilidae* spp. (Hymenoptera; 50%), followed by *Chauliognathus militaris* (Coleoptera; 22.5%), and *A. mellifera*, with 7% of the total visits (Díaz-Forestier et al., 2009). Similar results and same orders were recorded for *E. pulverulenta*, with 34–24 families (Díaz-Forestier, 2007). There is no native member of the genus *Apis* in Chile.

In addition to their melliferous relevance, these four native species have other economic importance. For example, *Q. saponaria* is largely exploited to obtain saponin-rich extracts from its bark (San Martín and Briones, 1999), *G. avellana* seeds are edible, toasted, or as an oil or flour, and the leaves have ornamental uses, and the wood of *E. cordifolia* is highly valued for housing.

The goal of this study is to describe the nectary structure in these four Chilean melliferous species as well as its location, volume, and degree of exposure of the nectary, contributing to the knowledge of floral biology, which would be useful for studies in the field of apiculture and plant-pollinator interactions.

2. Materials and methods

Q. saponaria and *E. pulverulenta* are endemic trees from the sclerophyllous forests of central Chile (30°38′S–38°30′S). Their flowering periods extends from the end of November to the beginning of January. *G. avellana* and *E. cordifolia* (Eucryphiaceae) are endemic to the South American temperate rain forest of Chile and Argentina with flowering period between January and March (Rodríguez et al., 1983; Smith-Ramírez and Armesto, 1994).

The flowers of *E. pulverulenta* are arranged on terminal, dense, and spiciform, racemes 10–22 cm long (Fig. 1A). The flowers range from 5 to 7 mm in diam., are actinomorphic and have an inferior ovary. The calyx is turbinate, and the corolla is formed by five free white petals that alternate with five stamens (Fig. 1B).

Inflorescences of *Q. saponaria* are generally organized in dichasial (thyrsoid) cymes, with a terminal hermaphrodite flower flanked by 2–4 lateral usually male flowers. Flowers are flattened, 1–1.5 cm in diam., and actinomorphic. Five white petals that alternate with the sepals surround the superior ovary; the calyx is thick