THE STRUCTURE OF NECTARIES AND NECTAR SECRETION IN COMMON PEAR (*Pyrus communis* L.)

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Summary

The structure of nectaries of *Pyrus communis* was examined under light (LM) and scanning electron (SEM) microscopes. The nectar from pear blossom was collected with the pipettes methods and the sugar content in the nectar was determined refractometrically. Situated at the upper part of the floral receptacle, the nectaries of common pear were equally thick along their whole length. Small cells of the secretory tissue, with thick cytoplasm, made up a thick multi-layer which did not have any contact with the vascular tissue. Observations under SEM revealed that the cells of the above-nectary surface were covered with a thick cuticle with distinct lines, while the cuticle covering the nectary was relatively thin and smooth. The nectary epidermis cells were usually polygonal in shape. Numerous open stomata, throughout nectar is secreted, were situated on the bottom of hollows of considerable size. Around the stomata, dried nectar was observed of various shapes and forms. Nectar was secreted for three days. The average amount of the secreted nectar was 2.47 mg with the concentration of sugar of 12.8%. It seems that the location of nectaries in a flower and dilute, quickly drying nectar are the reasons for the low attractiveness of pear flowers to pollinators.

Keywords: *Pyrus communis*, nectary structure, nectar secretion.

INTRODUCTION

The common pear (*Pyrus communis* L.), *Rosaceae*, is one of the source species for many pear cultivars grown in orchards. It blossoms in early spring i.e. in April and May. Its white, fragrant flowers, 2.5-4 cm in diameter, are gathered in corymbs and unfold when the first leaves appear (Aas and Ridmiller 1994, Seneta and Dolatowski 2004).

A pear flower contains 20 to 30 stamens with red anthers. Initially bent inwards, the stamen filaments do not bend outwards until 2-4 days after the corolla have opened, thus giving access to nectar. In pear flowers, the stamens mature earlier than the anthers (protogyny). Some cultivars of pears do not produce pollen, in others anthers do not open (Maurizio and Grafl 1969). Pear trees provide insects with a rich pollen flow. One flower produces up to 1.2 mg of pollen. The pollen loads collected from pear flowers are green in colour, are large in size and average mass of 7.5 mg. One flower produces 60,800 pollen grains (Maurizio and Grafl 1969).

Previous studies have found that entomophilous pear flowers are much less frequently visited by insects than the flowers of an apple tree, which is its close relative. Despite the pollen they offer, they are not particularly attractive to bees, as they produce little nectar with a low concentration of sugars (Mc Gregor 1976, Lipiński 1982, Free 1993, Way 1995, Farkas et al. 2000). In Italy, *P. communis* is estimated as a nectar source of medium abundance for pollinators (Ferazzi and Priore 1987, Simonetti et al. 1989).

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In pear flowers nectar is secreted with the greatest intensity in the morning. The nectar which is produced at the time of day has the lowest concentration of sugars (Nyárády 1958, Simidchiev 1970). The dynamics of nectar secretion in pear flowers is difficult to examine as it evaporates quickly from the open surface of a nectary (Farkas et al. 2000). Cultivars derived from *P. communis* can be divided in terms of the dynamics of nectar secretion into three types: a) with continuous nectar secretion, b) those which produce nectar only in certain times of day, and c) not producing nectar at all or producing it only in some vegetation seasons (Farkas and Orosz-Kovács 2003).

It has been shown previously that in numerous plant species the amount of nectar secreted and the concentration of sugar in nectar are associated to the size and anatomy of nectaries (Durkee 1983, Orosz-Kovács et al. 1990). This study aimed at determining the internal structure and the size of nectary glands in the flowers of common pear as well as the amount of nectar produced and the sugar contents in it. The results provided grounds for an attempt at explaining the low attractiveness of the flowers of this species for pollinators.

MATERIAL AND METHODS

The flowers of a common pear (*Pyrus communis* L.) grown in the Botanic Garden of the Marie Curie University in Lublin were collected on day two after the petals of corolla had opened, at the beginning of pollen shedding. After the calyx and stamens were removed, the material was fixed in 70% ethanol. The cross-sections of the other parts of the flowers were made with a Vibratome 2000 (Technical Product International INC, USA). The 60 μm microsections were submerged in glycerol with gelatine and examined using a light microscope (LM).

The surface of nectary glands was observed under a scanning electron microscope (SEM) type BS-300 Tesla. Fragments of flowers were fixed in 2% glutaraldehyde with 2.5% paraformaldehyde in 0.75 M phosphate buffer at pH 6.8 for 12 hours at 4°C. The material was then dehydrated in alcohol and acetone series and dried at the critical point in liquid CO_2 and coated with gold using the CS 100 Sputter Coater.

The nectar secretion was examined by the pipette method, taking a portion of nectar from the whole flower life after pre-determining the length of secretion period (Jabłoński and Szklanowska 1979). Nectar samples were collected in the morning. Six samples were taken, with each sample containing nectar secreted by 10 to 18 flowers. The nectar was then weighed and the percentage of sugar was then measured refractometrically. Total sugar amount secreted in nectar by a single flower was then calculated. The nectar productivity of flowers was determined when the trees were in full blossom.

RESULTS

Automorphous nectary in the flowers of *Pyrus communis* is situated on the adaxial surface of a funnel-like floral receptacle, between the upper part of the pistil ovary and the stamens base, and its large part goes into a narrow hollow surrounding the style, which largely increases the nectary gland surface (Figs 1-3). The tissues of the floral receptacle also are part of the nectary, which situates it among receptacular nectaries.

An examination of longitudinal sections of pear flowers under a light microscope showed that the nectary glands of the species are of a similar thickness on the whole length (Figs 3, 4). Only the part of

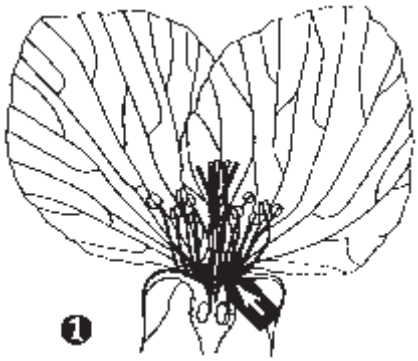


Fig. 1. Longitudinal section of a pear flower with a visible nectary (arrow), x 3.7

Fig. 3. Longitudinal section of a pear flower with a nectary (arrows), x 8

Fig. 5. Fragment of a nectary of *P. communis* with a visible glandular (asterisk) and subglandular (triangle) tissue, x 85

the nectary situated near the styles is a little thinner. The round or oval cells of the secretory tissue are small and their protoplasts are dark. They usually form a dense, 17-18 layer coat (Figs 5, 6). The vascular tissue does not reach the secretory

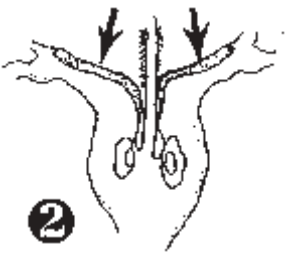


Fig. 2. A diagram showing a longitudinal section of a floral receptacle with a nectary (arrows), x 8

Fig. 4. Fragment of a longitudinal section of a floral receptacle with distinct glandular tissue of a nectary (arrow), x 30

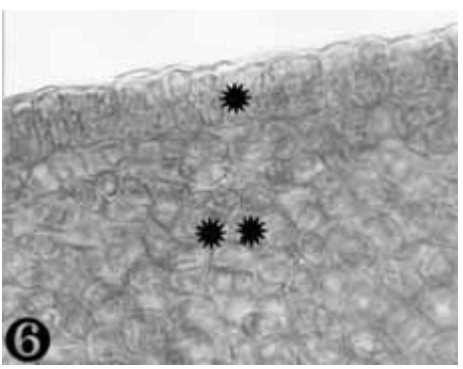


Fig. 6. Epidermis (asterisk) and upper layers of a nectary glandular tissue (double asterisk), x 365

cells, but is separated from them with several layers of subglandular parenchyma of larger cells (Fig. 5). Within the

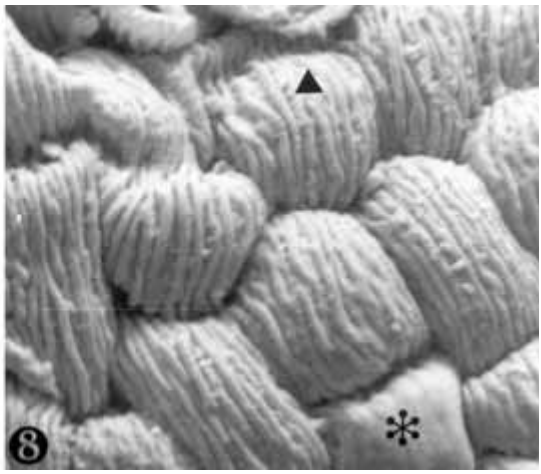


Fig. 7, 8. The surface of cells of the sub-nectary area with distinct cuticular lines (triangle) and smooth walls of outer cells of a nectary epidermis (asterisk), x 2600

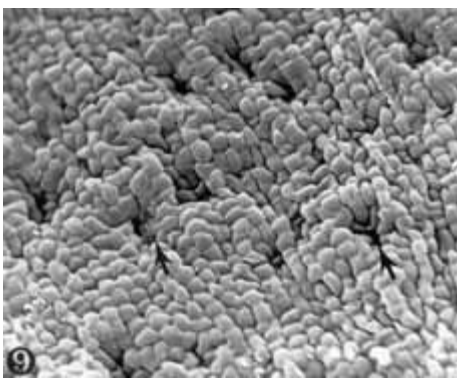


Fig. 9. The surface of cells of a pear nectary with epidermis cells with smooth cuticle and the stomata situated in the large hollows (arrows), x 460

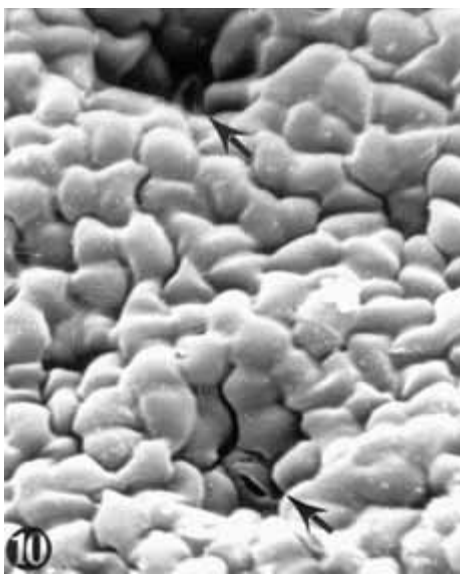
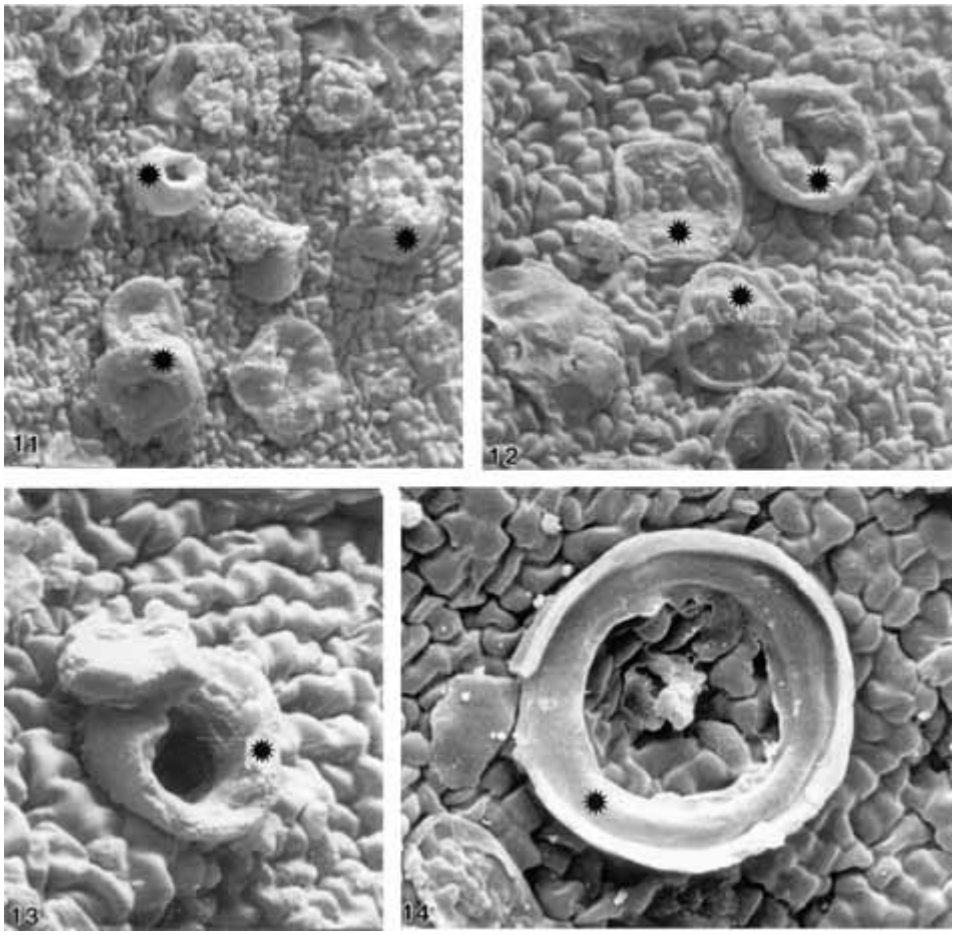


Fig. 10. Fragment of the surface of the epidermis of a nectary with visible open stomata (arrows) situated in large hollows, x 900

parenchyma there are cells of thickened, lignifying walls, similar to stone cells (sclereides). The cells which make up one layer of the epidermal cells are much elongated perpendicularly to the gland surface (Fig. 6).

Observation under SEM reveals that the upper part of the nectary gland is protected by a layer of epidermal cells with thickened cuticle with massive lines, which usually run in one direction (Figs 7, 8). However, the epidermal cells of the nectary glands usually have pentagonal or hexagonal shape, and their external walls are convex, which makes the gland surface a little crinkled. The cuticle which covers the nectary gland is relatively thin and smooth, without lines, unlike in the cells situated higher (Figs 7, 8). The open stomata, throughout nectar is secreted, are numerous (ca 270 per square millimetre of epidermis) and they are situated in hollows of considerable size, distributed evenly on the whole nectary gland surface (Figs 9,



Figs 11-14. Fragments of the surface of a nectary epidermis with dried nectar around the stomata (asterisks), 11- x 400, 12- x 570, 13, 14- x 850

10). In numerous sites of the epidermis, dried nectar was found around the stomata in various shapes, usually as discus-like forms or rings (Figs 11-14).

Nectar secretion in pear flowers was observed to start after the corolla have opened and finish when the anthers were empty. The average period of nectar secretion in a flower lasted 3 days. The nectar amount secreted during the whole life of a flower ranged from 1.3 to 3.92 mg (2.47 mg on average). The sugar contents in the nectar was low – 12.8% on average. The lowest sugar content in the nectar was merely 6.5%, and the highest was 25.5%. The nectar productivity of flowers is measured as the total mass of sugars secreted in the nectar. The average amount of sugars obtained from one flower of *P. communis* was 0.31 mg. While nectar was being collected from many flowers in various stages of development, traces of dried nectar were also observed on the nectary surface.

DISCUSSION

The nectaries of *Pyrus communis* and those of *Malus sylvestris* (which is closely related) are similarly situated and have a gland layer of similar thickness – a factor

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which affects the nectary gland production output (Weryszko-Chmielewska and Konarska 1995). However, earlier publications show that the flowers of pear cultivars secrete several times less nectar than the flowers of apple cultivars (Jabłoński 1986), although the nectary tissue of *Pyrus* has much greater surface than the corresponding tissue of *Malus* (Weryszko-Chmielewska and Konarska 1995). In this case, no positive correlation can be found between the nectary size and the amount of nectar produced; this relationship in various plants has been described by other researchers (Gulyás et al. 1976, Dafni et al. 1988, Orosz-Kovács et al. 1996, Weryszko-Chmielewska et al. 2004).

The observations conducted in this study show that a relatively large surface of a pear nectary consist not only of the ring of nectary gland tissue, which covers the funnel-like floral receptacle, but also of a strip which lines a narrow cleft in the vicinity of styles. This part of the nectary gland, situated deep inside and invisible with a naked eye, is practically inaccessible to pollinators, as they are unable to reach the part of the nectary situated so deep inside. Also, the smooth, ornamentless cuticle of the secretory epidermis of a pear and not protected by trichomes, can accelerate the flow of nectar down the cleft or cause it to dry, which also makes it impossible for pollinators to take this nectar. According to Orosz-Kovács et al. (1990, 1991), a thick, clearly ornamented cuticle keeps nectar on the nectary gland surface for longer periods and protects cells from excessive solar radiation (Juniper and Cox 1973). A similar role can be played by the trichomes situated on or near the glands, which was observed in *Prunus persica* by Radice and Galati (2003). The observed quick drying of nectar could be linked to a relatively low content of sucrose in nectar and the fact that simple sugars, particularly glucose, account for the majority of carbohydrates (Maurizio and Grafl 1969); a high concentration of glucose favours nectar crystallisation (Lipiński 1982). The current study shows that pear nectar is dilute, which is a result of a low sugar content; which has been reported earlier (Nyárády 1958, Mc Gregor 1976, Free 1993, Way 1995, Farkas et al. 2000). The daily nectar amount per flower in our samples ranged from 0.4 to 1.3 mg. These values are close to the results obtained by Sazykin (1955, quoted after: Free 1993), who found a single pear flower to secrete 0.84-0.85 mg nectar. According to Jabłoński (1986) the amount of nectar from one flower of various cultivars of pear ranges from 0.3 to 3.0 mg. Only Kulijev (1959) states that a single flower of *P. communis* secretes from 16 to 19 mg of nectar per day. The average total amount of sugars produced by one flower in this study was 0.3 mg, and their concentration was 12.8%. Literature suggests that nectar of such sugar concentration is not readily collected by pollinators (Lipiński 1982, Banaszak 1987). As a comparison, the nectar secreted by one *Malus sylvestris* flower contains 2.3-3 mg sugars (Bodnarčuk et al. 1993).

In this study, open nectary stomata were observed which, in a sense, prevents a plant from being able to control and adjust the nectar secretion. This fact may have additionally contributed to the intensity of nectar outflow and evaporation, and consequently, its relatively quick drying. Modified and constantly open stomata are also found in the nectary epidermis of many other plant species (Waddle and Lersten 1973, Teuber et al. 1980, Davis and Gunning 1992, Fahn 2000).

It seems obvious that insects, which have a choice between easily accessible nectar, rich in sugar (apple tree) on the one

hand, and dilute nectar, quickly drying and difficult to access on the other, will choose that which is more attractive to them.

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STRUKTURA NEKTARNIKÓW I NEKTAROWANIE GRUSZY POSPOLITEJ (*Pyrus communis* L.)

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Streszczenie

Strukturę nektarników kwiatowych *Pyrus communis* badano przy zastosowaniu mikroskopii świetlnej i skaningowej elektronowej (SEM). Obfitość nektarowania kwiatów gruszy oznaczono metodą pipetową, natomiast zawartość cukrów w nektarze oznaczono refraktometrycznie. Położone w górnej części dna kwiatowego gruczoły nektarnikowe gruszy pospolitej charakteryzowały się zbliżoną miąższością na całej ich długości. Drobne, zawierające gęstą cytoplazmę komórki tkanki sekrecyjnej budowały kilkunastowarstwowy pokład, nie wchodzący w kontakt z tkanką przewodzącą. Z obserwacji w SEM wynika, że powierzchnia komórek strefy ponadnektarnikowej pokryta była grubą warstwą kutykuli z wyraźnymi prążkami. Natomiast kutykula pokrywająca nektarnik była stosunkowo cienka i gładka. Komórki epidermalne gruczołu nektarnikowego miały najczęściej kształt wielokątów. Liczne, otwarte aparaty szparkowe, przez które odbywa się sekrecja nektaru leżały na dnie pokaźnych zagłębień. Wokół szparek często obserwowano zaschnięty nektar, tworzący różne formy. Sekrecja nektaru w kwiatach gruszy trwała 3 dni. Masa nektaru wydzielonego w ciągu całego życia kwiatu wynosiła średnio 2,47 mg, a koncentracja cukrów w nektarze średnio 12,8 %. Wydaje się, że opisana lokalizacja nektarnika w kwiecie oraz wodnisty i szybko wysychający nektar to główne powody małej atrakcyjności kwiatów gruszy dla owadów zapylających.

Słowa kluczowe: *Pyrus communis*, nektarnik, struktura, nektarowanie.