

# ANATOMICAL TRAITS OF NECTARIES AND NECTAR SECRETION BY THE FLOWERS of *Cotoneaster lucidus* Schlecht. and *C. nanshan* Mottet.

Elżbieta Weryszko-Chmielewska,  
Mirosława Chwil, Agata Konarska

Department of Botany, Agricultural University, Lublin ul. Akademicka 13

Received 01 June 2004; accepted 02 July 2004

## S u m m a r y

In the years 2002 and 2003 a study was conducted on the structure of nectaries and on nectar secretion in two *Cotoneaster* species: Hedge *Cotoneaster lucidus* Schlecht. and Creeping *Cotoneaster nanshan* Mottet. Flower diameter at the upper surface of the nectary, radial length of nectary glands, thickness of the nectar-secreting layer and stomatal number were determined by means of light microscopy. The surface of nectaries was observed using scanning electron microscopy. Nectar weight per 10 flowers and sugar percentage of nectar were determined. The studied species differed for their nectary measurements but were similar with regard to epidermal structure. Stomatal number was an exception as it was higher by nearly 30% when compared to that in Creeping *Cotoneaster*. A higher stomatal number in Hedge *Cotoneaster* was accompanied by a higher weight of nectar secreted but of lower sugar concentration of nectar than in Creeping *Cotoneaster*. The weight of sugars secreted by 10 flowers in Hedge *Cotoneaster* was lower by more than 40% than that in Creeping *Cotoneaster*.

**Keywords:** *Pomoideae*, *Cotoneaster*, nectary, structure, nectar secretion.

## INTRODUCTION

The genus *Cononeaster* Med. (Rosaceae) comprises ca. 60 species. They occur in Eurasia and north-western Africa. The majority of species of that genus are native to China (Szweykowscy 1993).

The flowers of *Cotoneaster* are small, white-pink, pink or red clustered in small inflorescences – cincinnus or sub-umbels. Apple-like fruits are red or black in colour. Some *Cotoneaster* species are very similar to one another, especially with regard to flower morphology. In Poland, there are three *Cotoneaster* species. Many others are grown as ornamentals (Seneta 1991, Szweykowscy 1993).

Hedge *Cotoneaster lucidus* Schlecht. originates from eastern Siberia (Szweykowscy 1993). The plant reaches 3 m in height. Under Poland's conditions blooming occurs in May and June

(Rutkowski 1998). The flowers are light-pink with a creamy margin. Dark-green glossy leaves are very decorative also in the autumn since as they turn they become many shades of yellow and red. The fruits are black. Due to high frost resistance the plants are very often planted for trimmed hedges (Seneta 1991).

Creeping *Cotoneaster nanshan* Mottet (*C. adpressus* var. *praecox* Bois and Berth.) is native to mountainous regions of China. It is a low-growing, creeping shrub reaching 50 cm in height (Seneta 1991). The plants bloom in May (Rutkowski 1998). The flowers have red corolla petals with a lighter margin. The leaves are dark-green, tiny, with a strongly undulated leaf margin. The fruits are ball-shaped, showy red.

The flowers of different *Cotoneaster* species while growing to small size

produce substantial amounts of nectar of a fairly high sugar content of 15-40% (Szklanowska 1978, Jabłoński and Szklanowska 1979, Jabłoński and Kołtowski 1996, Weryszko-Chmielewska et al. 1996, Weryszko-Chmielewska et al. 2003a).

The objective of the study was to compare nectary morphology in two *Cotoneaster* species and to determine the abundance of nectar secretion in those taxa.

## MATERIAL AND METHODS

In May and in June of 2002 and 2003 investigations were carried out into the nectary morphology and nectar secretion in two species: Hedge *Cotoneaster Cotoneaster lucidus* Schlecht. and Creeping *Cotoneaster Cotoneaster nanshan* Mottet. The plants grew in the Botanical Garden area in Lublin. Before nectar collection the age of the flower was determined. The trial branches were bagged to prevent the access of insects. The entire nectar secreted by the flowers was collected with glass micropipettes.

Twice during the bloom period around 11:00 a.m. three nectar samples were collected from 4 – 8 flowers each. Immediately upon weighing the nectar, sugar concentration therein was determined by means of Abbe refractometer. The weight of sugars secreted by 10 flowers of each species was calculated based on amount of nectar and percent sugar content.

In order to compare nectary morphology the flowers of Hedge *Cotoneaster* and Creeping *Cotoneaster* were collected on the second day after the petals were opened. Upon the removal of the perianthum and the stamens the flowers were fixed in 70% ethanol. The longitudinal sections of flowers with the pistil and the nectary were made using the vibratome (Vibratome 2000) manufactured by

Technical Product International, INC., USA. The cut sections were embedded in glycerogelatin. Some of the preparations were stained with 1% toluidine blue. The following anatomical traits were studied under the light microscope:

- 1) flower diameter at the upper surface of the nectary,
- 2) radial length of nectary glands,
- 3) thickness of nectar-secreting layer.

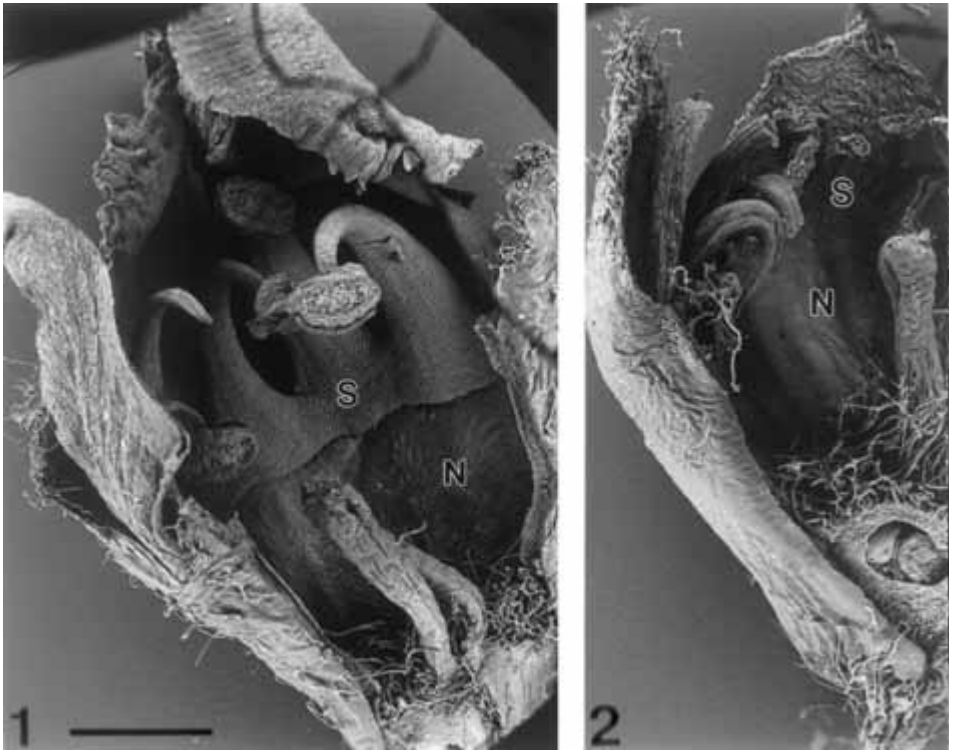
The surface of nectary glands was observed using scanning electron microscope (SEM) after the flower fragments were fixed in 4% glutar aldehyde in 0.1 M phosphate buffer at pH 7.2. The cut sections were subsequently dehydrated in acetone series then critical point dried in liquid CO<sub>2</sub> followed by coating with gold using CS 100 Sputter Coater. The observations were made using the scanning electron microscope LEO, type 1430VP.

## RESULTS

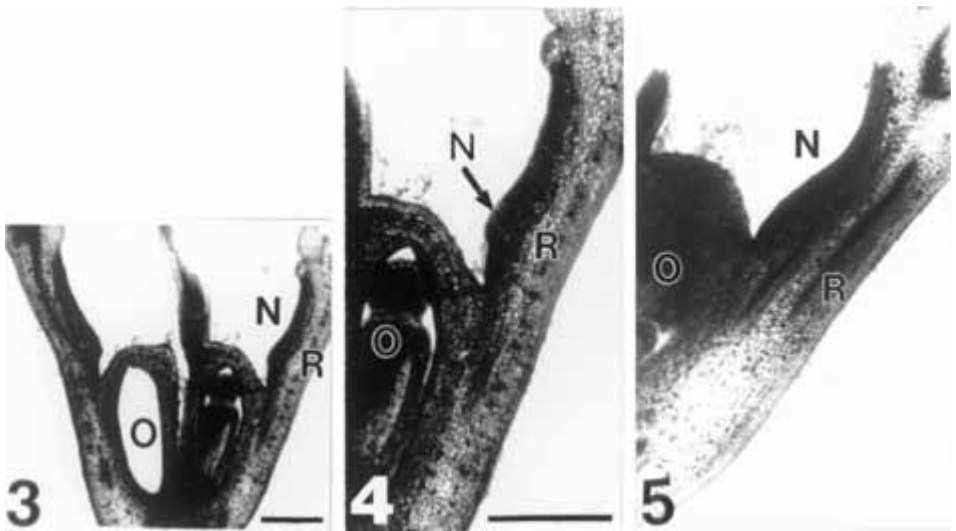
The nectary gland in *Cotoneaster* flowers forms a fleshy layer of cells that occupies the adaxial surface of the funnel-shaped flower bottom between the ovary and filament bases (Phot. 1 – 3). A slightly concave nectary surface forms a sui generis nectar container situated below the stamens, the ovary being the bottom of the container (Phot. 3).

The flower diameter at the upper surface of the nectary is ca. 4 mm in *Cotoneaster lucidus* and ca. 3 mm in *C. nanshan*. The height of nectary glands in both species is fairly similar – 2.2 mm in *Cotoneaster lucidus* and 1.8 mm in *C. nanshan*. The thickness of the nectar-secreting layer varied along the nectary, with the greatest thickness around the basal part (Phot. 4 and 5). The average values of that parameter were 190 µm for *C. lucidus* i 225 µm for *C. nanshan*.

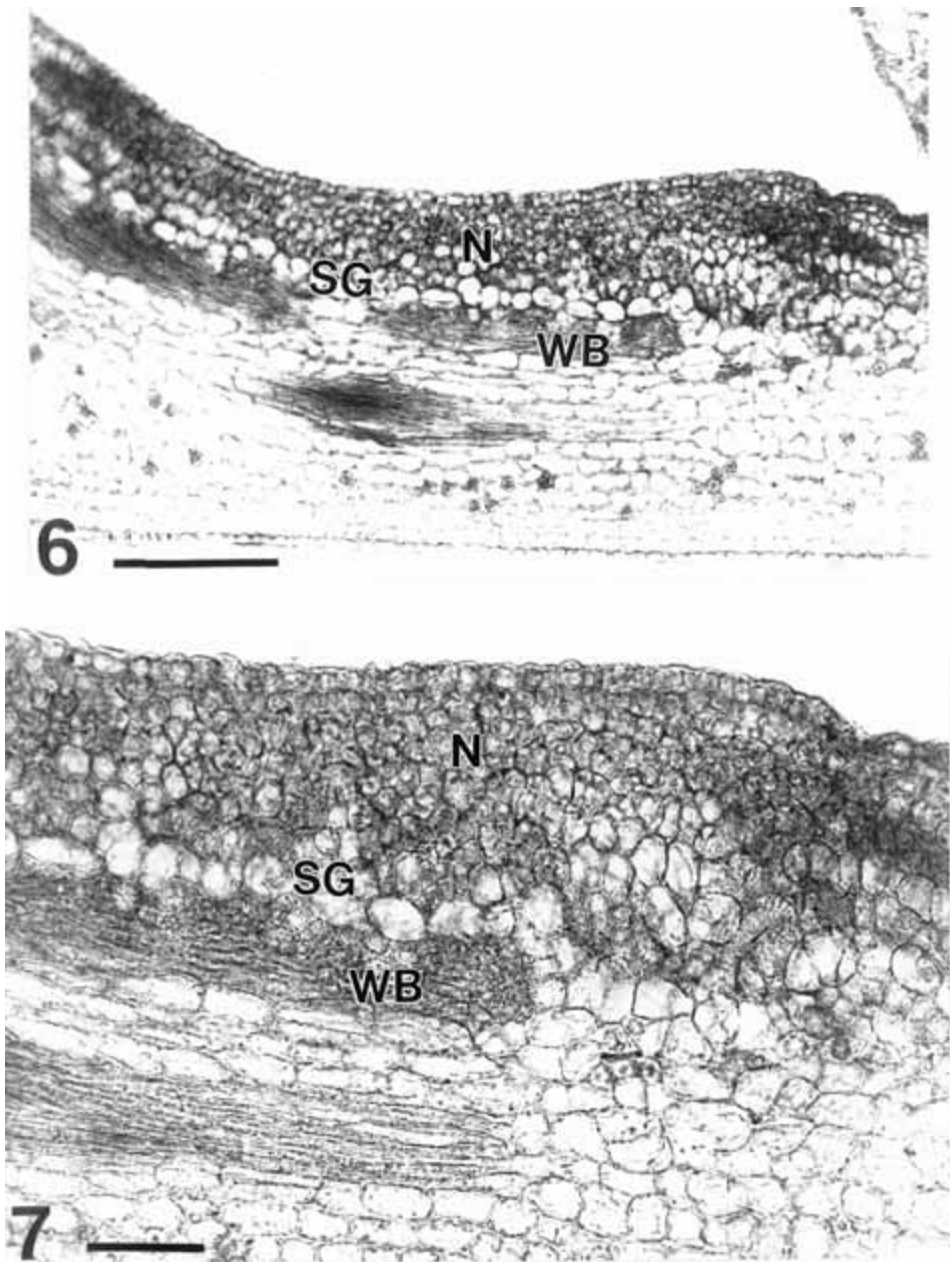
In the longitudinal section of the flower as viewed under the light microscope the



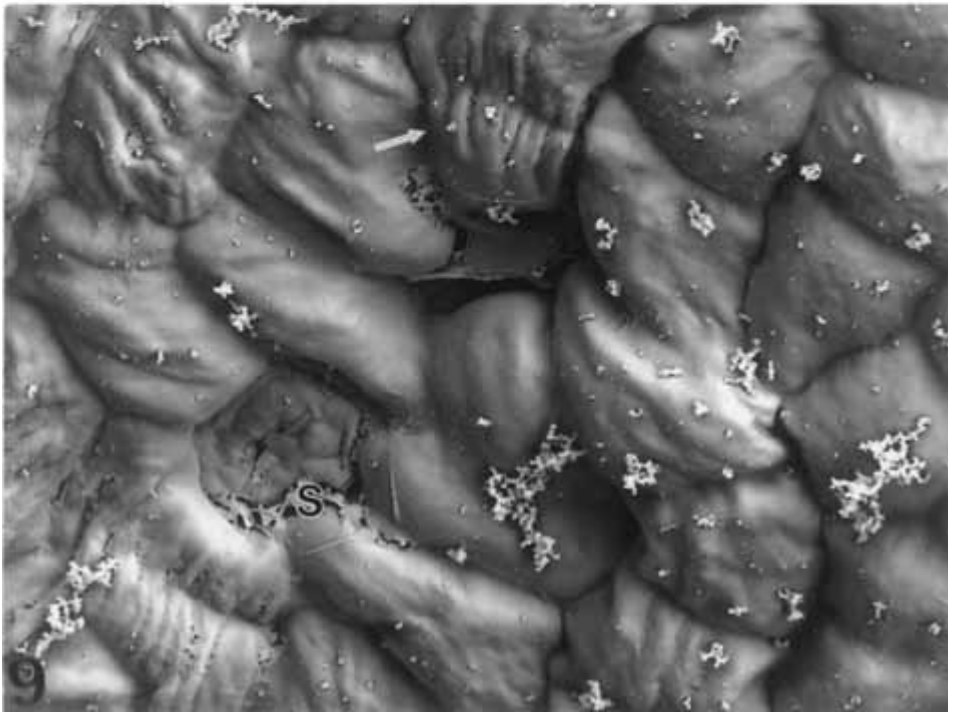
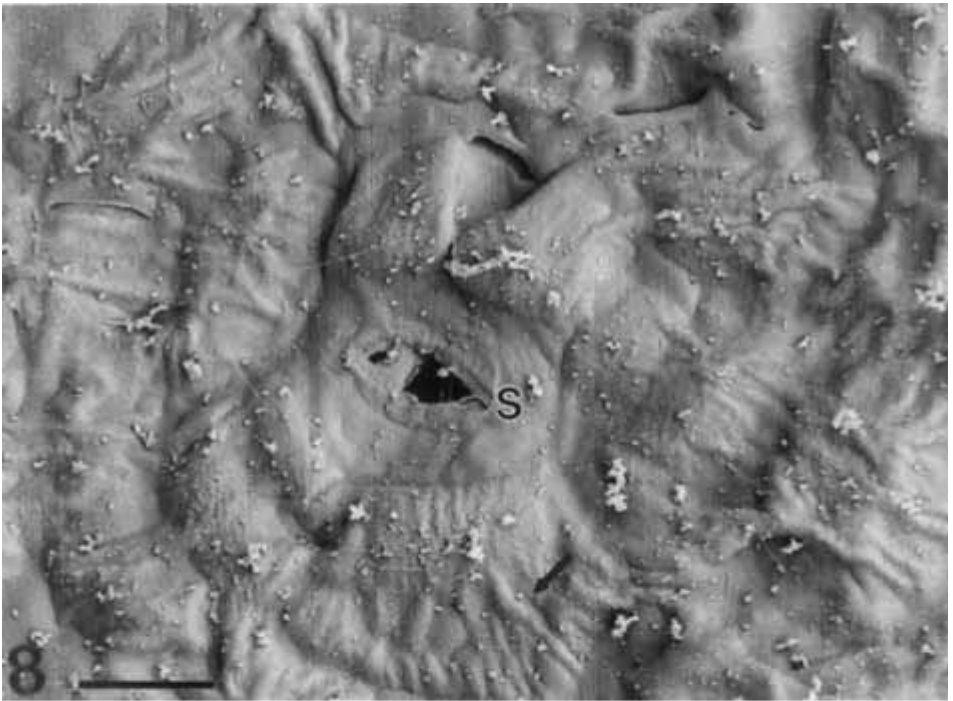
Phot. 1, 2. Longitudinal sections of flowers with a visible nectary (N) below the base of stamen filament (S) (SEM): 1 – *Cotoneaster nanshan*, 2 – *C. lucidus*, (bar = 1 mm).



Phot. 3 - 5. Fragments of longitudinal sections of flowers with a visible ovary (O), receptacle (R) and a nectary (N), 3, 4 – *Cotoneaster nanshan*, 5 – *C. lucidus*. 3 – bar = 500 µm, 4, 5 – bar = 500 µm.



**Phot. 6, 7.** Fragments of longitudinal sections of the receptacle of *C. lucidus* with a nectary (N), subglandular tissue (SG) and fibrovascular bundles (WB) 6 – bar = 100 μm, 7 – bar = 25 μm



**Phot. 8, 9.** Surface of the epidermal cells of the nectaries of *Cotoneaster*: 8 – *C. lucidus*, 9 – *C. nanshan*. Visible are the stomata (S) and banded cuticula (arrows) Bar = 10  $\mu$ m.

Table 1.

Number of stomata in the nectary epidermis and nectar secretion rate in two species of the genus *Cotoneaster* (averaged over the years 2002-2003)

Species	Flower longevity (days)	Number of stomata per unit area mm <sup>2</sup>	Nectar weight per 10 flowers (mg)	Sugar concentration of nectar (%)		Sugar weight per 10 flowers (mg)
				min - max	×	
<i>Cotoneaster lucidus</i>	3 - 4	110	132.50	10.5 - 16.5	13.0	17.23
<i>Cotoneaster nanshan</i>	3 - 4	80	99.05	23.0 - 31.5	29.6	29.36

epidermal cells of the nectary were of similar size in both species (Phot. 7). The slightly convex outer wall of those cells showed at some places banding of the cuticle. The small cells of the glandular parenchyma with dark protoplasts were separated from the fibrovascular bundles running to the stamens with larger cells of the subglandular parenchyma (Phot. 6, 7). The ramifications of the fibrovascular bundles that supplied the nectary reached the sub-surface layers of the nectariferous tissue.

The observation of the epidermis under the scanning electron microscope confirmed the occurrence of a distinct banding on the surface of some epidermal cells. Usually more distinct, cuticular bands were localized in both species at the stomata (Phot. 8, 9). The banding pattern did not show any regularity as the bands were oriented in different directions. In *C. lucidus*, the nectar-secreting stomata were located at the level of other epidermal cells (Phot. 8) whereas in *C. nanshan* they were in small cavities (Phot. 9). The pores of the stomata were open (Phot. 8) or covered with the remnants of the cuticula in younger nectaries (Phot. 9). The number of stomata in the secreting epidermis differed between the species under study. It was 110 per 1 mm<sup>2</sup> in Hedge *Cotoneaster* and 80 per 1 mm<sup>2</sup> in Creeping *Cotoneaster*.

The longevity of flowers in both taxa was 3 – 4 days. When comparing the nectar secretion in both *Cotoneaster* species it was found that *C. lucidus* secreted more nectar with the output being higher by 30% than that of the flowers of *C. nanshan* (Table 1) but the sugar concentration being much lower (13% against 29.6%). The higher sugar content of the nectar of *C. nanshan* resulted in a sugar output by 10 flowers higher by 70 % than that in *C. lucidus*.

## DISCUSSION

Due to abundant nectar secretion and high sugar concentration by the flowers of the *Cotoneaster* taxa under study they can be classed among shrubs of good nectar output along with other taxa of the sub-family *Pomoidae* e.g. *Aronia*, *Chaenomeles*, *Crataegus*, *Malus* and *Sorbus* (Jabłoński and Szklanowska 1979, Weryszko-Chmielewska et al. 1996, Weryszko-Chmielewska et al. 2003a, b).

The study showed that the weight of nectar secreted by the glandular tissue of the species under study was positively correlated with the number of stomata in the nectary epidermis. Such a relationship was also found in species of the genus *Medicago* (Teuber et al. 1980), *Vicia* (Davis and Gunning 1991) and in

several species of the family *Pomoideae* *Aronia*, *Chaenomeles* and *Cydonia* (Weryszko-Chmielewska et al. 1997).

A positive correlation was also found between nectary size and nectar weight. The nectary of *Cotoneaster lucidus* noted for its larger size secreted more nectar than the nectary of *C. nanshan*.

Conversely, the weight of nectar of those species, as reported in an earlier study (Weryszko-Chmielewska et al. 1996) was much lower (*C. lucidus* about 48%, *C. nanshan* about 77%) which was probably related to different weather conditions in the years of study since a higher nectar weight was accompanied by a lower sugar concentration.

Modified stomata of the nectaries in the species under study and in other species of that family described earlier were characterized by occupying different positions as related to the other epidermal cells (Weryszko-Chmielewska and Konarska 1996, Weryszko-Chmielewska et al. 1997, Weryszko-Chmielewska et al. 2003a, b). The stomata in *Cotoneaster hjelmqvistii*, *Cotoneaster lucidus*, *Aronia melanocarpa* and *Sorbus aucuparia* were situated at epidermis level; in *Cotoneaster nanshan* they were in small cavities and in *Crataegus crus-galli* and *Crataegus coccinea* they were much below the epidermis surface. In the species of the first group a more abundant nectar secretion was observed.

In earlier studies it was demonstrated that the size of nectary glands in the species of the genera *Cotoneaster*, *Sorbus* and *Crataegus* does not affect the abundance of nectar secretion (Weryszko-Chmielewska et al. 1996). The nectaries in three species of the genus *Cotoneaster*, although half the size in terms of the cross section area, were characterized by the nectar output higher by 37% and sugar concentration of nectar higher by 83% than the nectary glands of

three species of the genus *Crataegus*.

The results allow the conclusion that the *Cotoneaster* species under study, because of their blooming date and because of the amount of secreted nectar, may provide an important source of food for bees in May and in June.

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**CECHY ANATOMICZNE NEKTARNIKÓW  
ORAZ NEKTAROWANIE KWIATÓW  
*Cotoneaster lucidus* Schlecht. i *C. nanshan* Mottet.**

**W e r y s z k o - C h m i e l e w s k a E . , C h w i l M . ,  
K o n a r s k a A .**

S t r e s z c z e n i e

W latach 2002 i 2003 przeprowadzono badania dotyczące budowy nektarników i sekrecji nektaru dwu gatunków irgi: błyszczącej *Cotoneaster lucidus* Schlecht. i wczesnej *Cotoneaster nanshan* Mottet. W mikroskopie świetlnym określono średnicę kwiatów przy górnej powierzchni nektarnika, długość promieniową gruczołów nektarnikowych, grubość warstwy nektarującej oraz liczbę aparatów szparkowych na powierzchni mm<sup>2</sup> nektarnika. W skaningowym mikroskopie elektronowym obserwowano powierzchnię nektarników. Określono masę nektaru z 10 kwiatów oraz procentową zawartość w nim cukrów. Badane gatunki różniły się wynikami pomiarów cech anatomicznych nektarnika, natomiast wykazywały podobieństwa w strukturze epidermy. Wyjątek stanowiła liczba szparek, która była większa u irgi błyszczącej o prawie 30% w porównaniu do irgi wczesnej. Wyższej liczbie szparek w nektarniku irgi błyszczącej towarzyszyła większa masa wydzielonego nektaru, jednakże o niższej koncentracji cukrów niż u irgi wczesnej. Masa cukrów wydzielanych przez 10 kwiatów irgi błyszczącej była o ponad 40% mniejsza w porównaniu z masą cukrów wytwarzanych przez kwiaty irgi wczesnej.

**Słowa kluczowe:** *Pomoideae*, *Cotoneaster*, nektarnik, struktura, nektarowanie.