

## ECOLOGICAL FEATURES OF FLOWERS INCLUDING NECTARY STRUCTURE OF CHOSEN SPECIES FROM *LAMIACEAE* FAMILY

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### S u m m a r y

Studies upon the following species were carried out in 1996: *Hyssopus officinalis* L. fl. *rosea*, *Mentha spicata* L. var. *crispata* (Benth.) Danert, *Nepeta foliosa* Moris, *Ocimum basilicum* L., and *Origanum vulgare* L. Dates of flowering, length and type of a corolla and morphological features of nectaries: size, shape and number of stomata were investigated. Corolla length for studied taxons lined up in a following decreasing sequence 17,05-3,66 mm - *Nepeta foliosa*, *Hyssopus officinalis*, *Ocimum basilicum*, *Origanum vulgare*, *Mentha spicata* - different from the decreasing sequence of nectary height 1300-350 µm: *Ocimum basilicum*, *Nepeta foliosa*, *Hyssopus officinalis*, *Mentha spicata*, *Origanum vulgare*. Dependence between the form of corolla and nectary shape was found. In the largest nectaries, a small number of secretional stomata (4-6) was observed. It varied in medium-sized and small nectaries (7-18). Stomata occurred usually on the thicker part of the nectary, asymmetrical disc facing the lower lip of the corolla.

**Keywords:** flowering, nectary morphology, *Nepeta*, *Hyssopus*, *Ocimum*, *Origanum*, *Mentha*

### INTRODUCTION

Flowers of *Lamiaceae* representatives are counted among those pollinated by bees (*Melittophilae*) in the morphological and ecological division system of entomogamic flowers (Kugler 1970). This is due to their numerous characteristic traits: symmetry, opportunity for insects landing on corolla elements, blue or purple colour, nectar production, pollination mechanism and characteristic flavour.

Plants of *Lamiaceae* family secrete large amounts of nectar (Demianowicz et al. 1960, Jabłoński 1989, 1994). Comparison of nectar production for many Mediterranean plant species (76) has led to conclusion that *Lamiaceae* plants produced nectar the most abundantly (Petanidou and Smets 1995). Those authors also found that flowers with corolla tubes longer than 4 mm secreted more nectar than flat ones.

Dafni et al. (1988) found positive correlation between nectary size and weight of the nectar secreted by flowers of several *Lamiaceae* species.

Present studies were undertaken in order to compare the dependence between corolla size for five *Lamiaceae* species and the size of their nectaries. Elements of nectary gland structure were also analysed.

## MATERIAL AND METHODS

Observations of flowering length for five *Lamiaceae* species were carried out in the Botanical Garden, UMCS, Lublin within the 1996 vegetation season.

Studies included the following taxons: *Nepeta foliosa* Moris, *Hyssopus officinalis* L. fl. Rosea, *Ocimum basilicum* L., *Origanum vulgare* L., and *Mentha spicata* L. var. *crispata* (Benth.) Danert.

Flowers were gathered on the day of flowering, being previously marked at the stage of swelled bud for corolla size and nectary morphology measurements. They included: length of corolla and its tube, area of tube longitudinal section as well as diameter of the lowest and the longest nectary. Corolla and nectary parameters were determined on the basis of 25-30 flowers of each species, but measurements of corolla tube section were done for 20 flowers.

The detailed observations of nectary morphology were performed using scanning electron microscope (SEM). Distribution and number of stomata taking part in nectar secretion was evaluated on the basis of 3 preparations (nectaries) for each species.

Nectaries with ovaries were pre-fixed in 4% glutaraldehyde in 0.1 M phosphate buffer, pH 7.2. Then, they were fixed in 1% osmium tetroxide and dehydrated in alcohol and 100% acetone. After drying at critical point in liquid CO<sub>2</sub>, they were coated with gold using CS 100 Sputter Coater. Observations were done using scanning electron microscope BS 300 Tesla.

## RESULTS

### Flowering period

Species of *Lamiaceae* family were characterised by extended flowering (Tab. 1). *Nepeta foliosa* and *Ocimum basilicum* flowered in June-September and the periods lasted 90 and 95 days, respectively. *Hyssopus officinalis* flowering period occurred in July-September (80 days), *Origanum vulgare* in July-October (100 days), and *Mentha spicata* in August-October (60 days).

### Morphological traits of flowers

Flowers of taxons studied were different with regard to corolla size (Tab. 2) and its colour (Tab. 3).

Table 1

Blooming calendar of five species from *Lamiaceae* family  
Kalendarz kwitnienia pięciu gatunków rodziny *Lamiaceae*

Species - Gatunek	VI	VII	VIII	IX	X
<i>Nepeta foliosa</i> Moris.	████████████████████				
<i>Ocimum basilicum</i> L.	████████████████			██████████	
<i>Origanum vulgare</i> L.		████████████████████			
<i>Hyssopus officinalis</i> L. <i>fl. rosea</i>		████████████████			
<i>Mentha spicata</i> L. var. <i>crispata</i> (Benth.) Danert.			██████████████		

Table 2

Morphological features of corolla and nectary for five species of *Lamiaceae* family - Cechy morfologiczne kwiatów i nektarników dla pięciu gatunków rodziny *Lamiaceae*

Species Gatunek	Petal length Długość płatków kor. (mm)	Corolla tube Rurka kwiatowa		Nectary traits Kształt nektarników			
		Length Długość (mm)	Section area Przekrój (mm <sup>2</sup> )	Diameter Średnica (μm)	Min. height wysokość (μm)	Max height wysokość (μm)	Number of stomata - Liczba aparatów szpar.
<i>Nepeta foliosa</i> Moris	17,05	11,75	9,82	1052	418	746	4-6
<i>Hyssopus officinalis</i> L. <i>fl. rosea</i>	11,86	7,14	5,72	802	348	626	17-18
<i>Ocimum basilicum</i> L.	9,62	5,18	7,90	1520	1300	1300	4-5
<i>Origanum vulgare</i> L.	6,19	4,13	3,98	545	350	350	15-18
<i>Mentha spicata</i> L. var. <i>crispata</i> (Benth.) Danert.	3,66	2,35	1,94	690	380	380	7-8

Table 3

Comparison of colours, and corolla and nectary symmetry for five species of *Lamiaceae* family - Porównanie koloru oraz symetrii kwiatów i nektarników dla pięciu gatunków rodziny *Lamiaceae*

Species - Gatunek	Corolla colour Kolor płatków korony	Corolla symmetry Symetria kwiatów	Nectary shape Kształt nektarników
<i>Nepeta foliosa</i> Moris	violet-blue	zygomorphic	asymmetric disc
<i>Hyssopus officinalis</i> L. <i>fl. rosea</i>	rosy	zygomorphic	asymertic disc
<i>Ocimum basilicum</i> L.	white	zygomorphic	irregular disc
<i>Origanum vulgare</i> L.	rosy-violet	slightly zygomorphic	regular disc
<i>Mentha spicata</i> L. var. <i>crispata</i> (Benth.) Danert.	white-violet	almost radial	regular disc

Taking into account the petal and corolla tube length as well as area of its longitudinal section, taxons can be lined up due to the following decreasing

sequence: *Nepeta foliosa*, *Hyssopus officinalis*, *Ocimum basilicum*, *Origanum vulgare* and *Mentha spicata*.

Plants of individual species also differed for their flower symmetry (Tab. 3). Three of the species with the largest flowers also showed evident zygomorphic symmetry; in *Origanum vulgare* slightly marked zygomorphy (slightly two-lip corolla) occurred; *Mentha spicata* flowers were characterised by almost radial symmetry with uniform petal length and little wider petal lobe of upper lip.

### Morphology of nectaries

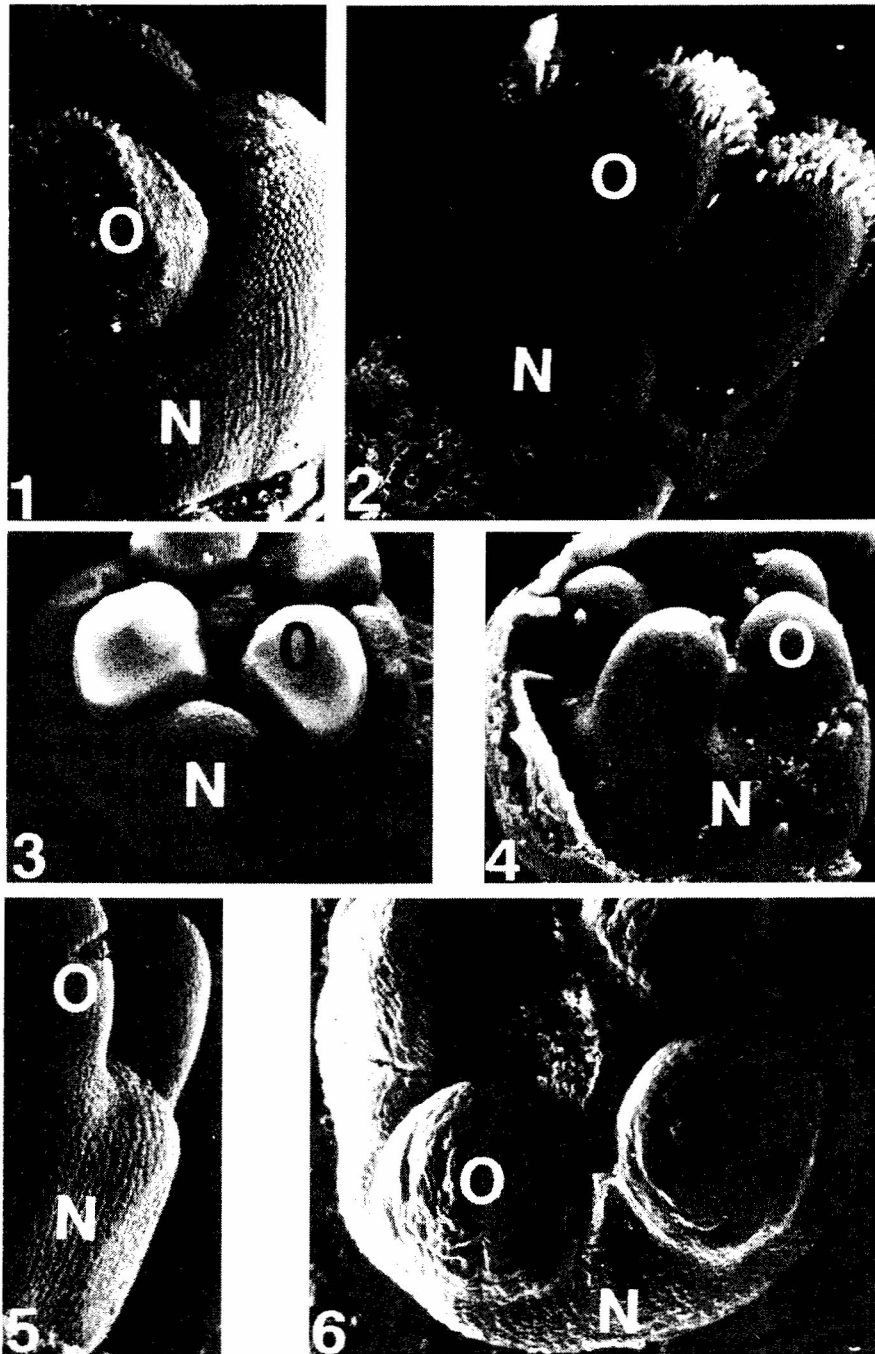
Nectaries of *Lamiaceae* family flowers have the shape of a disc that surrounds the basis of a four-segmented ovary (Phot. 2, 3, 4, 6). They were of different size in observed species (Tab. 2) and showed non-uniform development of their particular parts penetrating between ovary segments from outside (Phot. 2-4). All those above traits influenced the symmetry of nectaries.

Three types of nectaries were distinguished:

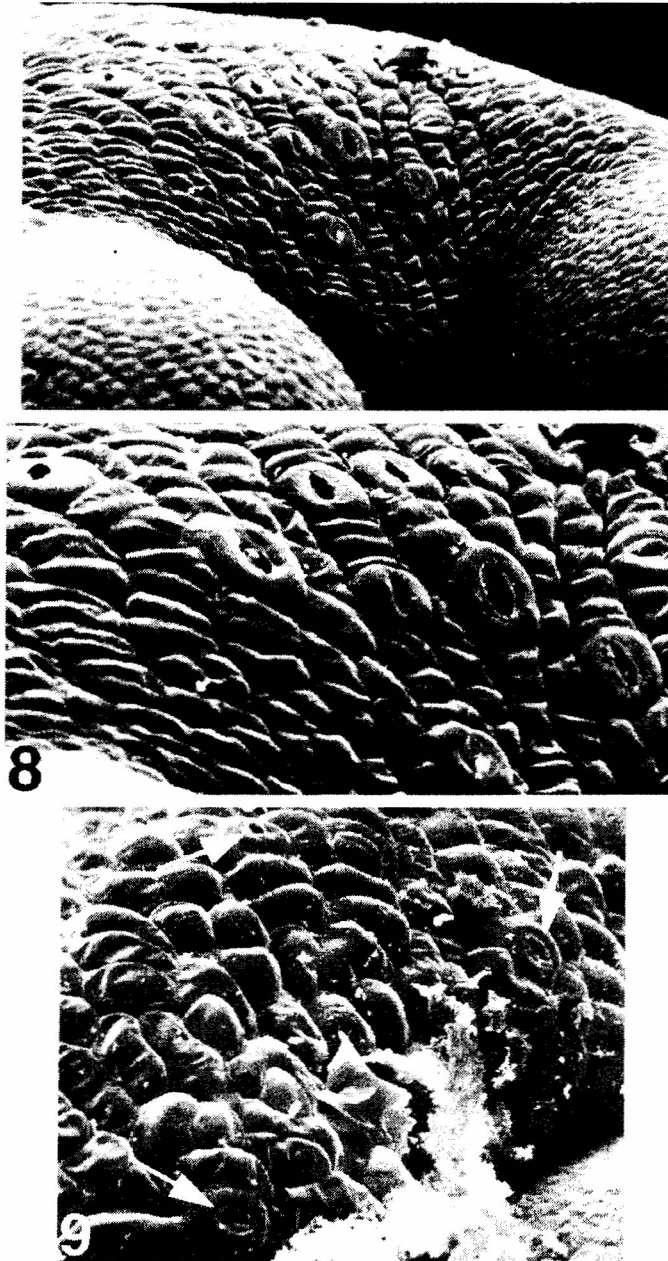
- irregular disc - three evident relieves interpetalous in relation to ovary segments occur in the nectary - *Ocimum basilicum* (Phot. 3);
- asymmetric disc - only one clear relief being at the same time the highest part of the gland occurs in nectary - *Nepeta foliosa*, *Hyssopus officinalis* (Phot. 1, 2);
- regular disc - nectary is symmetrical, its parts are uniformly developed - *Mentha spicata* (Phot. 4), or it forms small relief - *Origanum vulgare* (Phot. 4, 5).

Dependence between nectary shape and corolla form was observed. *Hyssopus officinalis* and *Nepeta foliosa* characterized with a distinct two-lip corolla had the nectary forming large relief on the lower lip side. *Ocimum basilicum* with atypical structure and large upper lip formed nectary possessing three evident relieves. Slightly zygomorphic flower of *Origanum vulgare* had its nectary with very tiny relief. Almost radial flower of *Mentha spicata* had the nectary of regular disc shape.

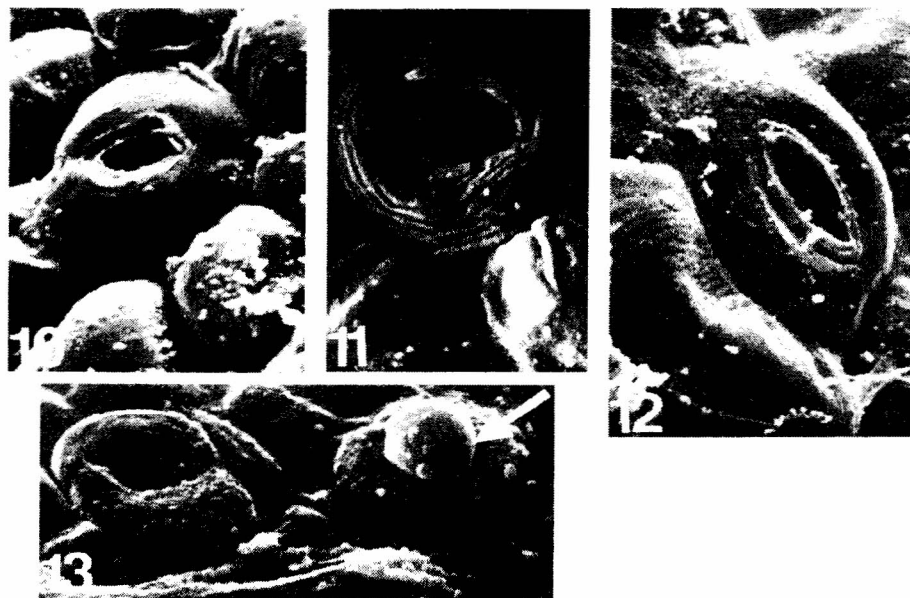
Nectary glands with the highest diameter and height were found in *Ocimum basilicum* and *Nepeta foliosa*, then in *Hyssopus officinalis*, *Mentha spicata* and *Origanum vulgare*. No positive dependence between corolla size and nectary dimensions was observed - flowers of *Nepeta foliosa* with corolla twice as large as in *Ocimum basilicum* formed much smaller nectaries (Tab. 2). A lack of clear correlation between corolla length and nectary dimensions was also present comparing flowers of *Origanum vulgare* with *Mentha spicata*.



Phot. 1-6. Fragments of lower parts of *Lamiaceae* flowers studied with visible nectary (N) surrounding basal part of four-segment ovary (O); scanning electron microscope SEM). - Fragmenty dolnych partii badanych kwiatów z rodziny *Lamiaceae* z widocznymi nektarnikami (N) otaczającymi czterokomorowe zalążnie (O)



Phot. 7-9. Nectary surface with visible stomata, SEM. 7 - Stomata spot in upper part of *Origanum vulgare* nectary; 8 - Numerous stomata larger than other epidermis cells, *Origanum vulgare*; 9 - Loosely distributed stomata (arrows) in nectary epidermis of *Ocimum basilicum* - Powierzchnia nektarnika z widocznymi aparatami szparkowymi, SEM. 7 - aparaty szparkowe w wyższej części nektarnika *Origanum vulgare*; 8 - liczne aparaty szparkowe większe niż komórki epidermalne *Origanum vulgare*; 9 - rzadko rozmieszczone aparaty szparkowe (strzałki) w epidermie nektarnika *Ocimum basilicum*



Phot. 10-13. Nectary stomata with visible holes through which nectar is secreted;  
 13 - visible drop of nectar in one stoma (arrow) - Aparaty szparkowe  
 nektarników z widocznymi szparkami, przez które wydzielany jest nektar.  
 13 - widoczna kropla nektaru na aparacie szparkowym (strzałka)

Nectar secretion in *Lamiaceae* is through modified stomata (Phot. 10-12). They are situated almost exclusively on relieves of nectary gland (Phot. 1, 7) facing the lower lip of corolla.

Stomata occur the most frequently close to each other in numerous groups forming stomatal spots (Phot. 7, 8, 9). The least number of stomata (4-6) was observed in nectaries with the largest size (*Ocimum basilicum*, *Nepeta foliosa*) (Tab. 2). A few stomata (7-8) were also found in nectary of *Mentha spicata*. Much more stomata were found in *Hyssopus officinalis* (17-18) and *Origanum vulgare* (15-18). In the latter, presence of two stomatal spots occurring on neighboring segments of nectary and consisting of various numbers of stomata (12 and 6, or 10 and 5) was found.

Stomata were placed on the same level as other epidermis cells in the most of species studied (Phot. 9-12). Only in the nectary of *Origanum vulgare*, stomata characterised by larger size and clearer cell relief were observed (Phot. 7, 8).

## DISCUSSION

The length of corolla tube in flowers from *Lamiaceae* family significantly varied (2.35-11.75mm). Dafni (1991) proved for 13 other species of the same family with corolla tube length between 4.3-21.3 mm that flowers with much larger corolla secreted more nectar which was characterised by higher energetical value (1.06-187.9 J).

Three types of nectary structure with different symmetry were distinguished in the taxons studied in the present paper. Other authors found that nectaries in *Lamiaceae* can be of various forms (Frei 1955, Kulijev 1959). Dąbni et al. (1988) observed 9 other representatives of *Lamiaceae* family and found that in one case the nectary was of symmetrical disc shape and others were of asymmetry associated with the presence of one relief.

No dependence between the size of individual nectary and length of corolla tube nor between nectary dimensions and number of stomata was observed in present study results.

Many authors confirm positive dependence between nectary size and abundance of nectar secreted in closely related plants characterised by similar anatomical type of nectary (Dąbni et al. 1988, Kertész 1996).

Teuber et al. (1980) found in several *Medicago sativa* varieties and clones that plants with medium and large number of stomata in nectary produced the most nectar. Davis and Gunning (1991) observed significant differences regarding the number of modified stomata in nectaries of flowers originating from *Vicia faba*. In a single variety the number varied from 19 to 29. Authors found positive correlation between number of modified stomata on the nectary top and amount of sugars in nectar.

No nectaring abundance of plants was studied in presented work, but from the literature data (Rawski 1948) it follows that flowers of *Lamiaceae* family secrete large (*Nepeta foliosa*, *Hyssopus officinalis*, *Mentha spicata*) or moderate amounts of nectar (*Ocimum basilicum*, *Origanum vulgare*). Comparison of secreted nectar weight estimated for some species studied by other authors suggests that it is associated with nectary size, because relatively large nectary glands in flowers of *Hyssopus officinalis* secrete more nectar (Demianowicz et al. 1960) than much smaller nectaries of *Origanum vulgare* (Jabłoński 1990). In papers published, no numerical data referring to the abundance of nectar secretion by *Ocimum basilicum* characterised by largest nectaries as well as *Mentha spicata* L. var. *crispata* and *Nepeta foliosa* were found.

## CONCLUSIONS

1. Nectary size is not correlated with corolla dimensions in *Lamiaceae* family species analyzed.
2. Taxons of *Lamiaceae* family form morphologically different nectaries, which is associated with the level of corolla zygomorphy.
3. Secretional stomata in *Lamiaceae* nectaries form stomatal spots occurring on gland relieves situated on the lower lip of corolla.



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**CECHY EKOLOGICZNE KWIATÓW Z UWZGLĘDNIENIEM  
BUDOWY NEKTARNIKÓW WYBRANYCH GATUNKÓW  
Z RODZINY WARGOWYCH (*LAMIACEAE*)**

**Weryszko-Chmielewska E.**

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

Przeprowadzono badania wielkości korony oraz morfologii nektarników pięciu gatunków z rodziny *Lamiaceae*: *Nepeta foliosa* Moris, *Hyssopus officinalis* L. fl. *rosea*, *Ocimum basilicum* L., *Origanum vulgare* L., *Mentha spicata* L. var. *crispata*. Długość rurki korony badanych gatunków zawarta była w przedziale 2,35 - 11,75 mm, natomiast maksymalna wysokość nektarnika wynosiła 350-1300  $\mu\text{m}$ . Długość korony badanych taksonów podana w szeregu malejącym: kocimiętka, hyzop, bazylia, lebiodka, mięta nie odpowiadała malejącym wielkościom nektarników: bazylia, kocimiętka, hyzop, mięta, lebiodka. Stwierdzono zależność między stopniem grzbiecistości korony a kształtem nektarnika. Szparki wydzielnicze (4-18) tworzyły skupienia na uwypukleniach nektarników, zwróconych ku wardze dolnej korony.

**Słowa kluczowe:** kwitnienie, morfologia nektarników, *Nepeta*, *Hyssopus*, *Ocimum*, *Mentha*.