

## SIZE AND TYPE OF POLLEN GRAINS OF SOME MELLIFEROUS PLANTS IN ROMANIA

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### Abstract

*In Romania there are about 1000 melliferous plant species, from these about 200 are considered important for beekeeping. Based on the descriptions found in the literature, a classification according to the type and size of the hydrated pollen grains of these melliferous plant species was attempted in the present study. The melliferous species that were analysed belong to 57 plant families, and more than half of them have medium size pollen grains. Several pollen types were noted: inaperturate; monoporate; triporate; tetraporate; pentaporate; periporate; tricolpate; hexacolpate; pericolpate; monosulcate; tricolpate; tetra-colpate; heteroaperturate (pseudocolpus); spiraperturate; syncolpate; bisaccate; pollen grains in groups (tetrad, polyad). From these, tricolpate pollen is the most frequent (about half of the species), followed by tricolpate pollen. These two morphological characters of the pollen grain of some melliferous species present in Romania were used to determine the species that show similar traits for identification purposes when using the light microscope technique. Pollen shapes, symmetry, wall thickness and surface patterns can further help group the plant species and narrow the search, when pollen identification is carried out.*

**Key words:** botanical identification; light microscope; melliferous plants; pollen morphology.

### INTRODUCTION

The knowledge of the melliferous plants that are available in a given area is very important for apiculture. The microscopic analysis of the pollen of various plants visited by honeybees for their nectar and/or pollen is an established method that helps to determine the source of honey and the botanical origin of bee pollen.

Pollen is the male gametophyte in higher plants, a very unusual vegetative cell that carries the male gametes or their progenitor cells (Sarkar et al., 2017). The structure of the pollen grains is very complex, in order to protect the male genetic material during the transport from the anther to the stigma.

Pollen grains have different morphological characteristics and colour, depending on the plant species, therefore they have great significance in taxonomic and phylogenetic studies. The light microscope images of the hydrated pollen grains can provide a description of pollen size, polar and equatorial shapes, symmetry, type and number of apertures, aperture size and position, wall thickness and surface patterns, that allow a botanical identification at family, genus or

species level.

Romania has a great diversity of melliferous plants (ICDA București & Asociația Crescătorilor de Albine din România, 2007; Ion, 2012; Ion et al., 2018) and has very good potential for commercial beekeeping (Isopescu et al., 2017). Comprehensive studies regarding the pollen spectrum of honey and bee pollen in Romania can be found in the literature, for example Dobre et al. (2013) provided a palynological evaluation of selected honeys from different regions of Romania, while other studies include the description of the palynological spectrum of bee pollen samples (Mărgăoan et al., 2010; Bobiș, 2014; Spulber et al., 2017; Stanciu et al., 2016).

The current study presents a preliminary analysis of the pollen of some melliferous species in Romania according to the size of the pollen grain and aperture type (number, shape and position of the aperture/s). In addition, the appearance of the pollen-unit was also used (monad, tetrad or polyad). Such data can be enlarged by adding distinctive differences and giving a key for plant taxons with similar pollen, also by providing tailored lists of the floral sources for specific areas.

## MATERIALS AND METHODS

In the present study 220 melliferous plant species that belong to 57 plant families were analysed (Table 1). The selection of the plant species was based on the descriptions of the melliferous flora of Romania by the ICDA

București & Asociația Crescătorilor de Albine din România (2007) and of Ion (2012), with only a few species added from other sources (Table 1). The morphological description of the pollen was also taken from different publications.

Table 1. Melliferous plants included in the present study and the references for the morphological descriptions of the pollen

Botanical family	Botanical name	Common name	References for the morphological descriptions of the pollen
Aceraceae	<i>Acer campestre</i>	Field maple	Hesse, Halbritter & Heigl (2020a)
	<i>Acer platanoides</i>	Norway maple	Sam, Auer & Halbritter (2020a)
	<i>Acer pseudoplatanus</i>	Sycamore	Sam, Auer & Halbritter (2020b)
Adoxaceae	<i>Acer tataricum</i>	Tatar maple	Halbritter & Heigl (2020a)
	<i>Sambucus nigra</i>	Elderberry	Halbritter, Diethart & Auer (2020)
	<i>Viburnum opulus</i>	Guelder rose	Halbritter & Heigl (2020ij)
Amaranthaceae	<i>Atriplex patula</i>	Spear saltbush	Sam & Heigl (2021)
	<i>Beta vulgaris</i>	Beet	Hecker (1988)
	<i>Beta vulgaris</i> var. <i>altissima</i> ( <i>B. vulgaris</i> saccharifera)	Sugar beet	Angelini et al. (2014)
Amaryllidaceae	<i>Allium cepa</i>	Onion	Halbritter & Heigl (2020b)
	<i>Allium ursinum</i>	Wild garlic	Halbritter, Aktuna & Heigl (2020)
	<i>Galanthus nivalis</i>	Snowdrop	Halbritter, Heigl & Schneider (2020a)
Apiaceae	<i>Angelica archangelica</i> (Mărza și Nicolaide, 1990)	Angelica	Halbritter (2016a)
	<i>Carum carvi</i>	Caraway	Heigl (2020b)
	<i>Coriandrum sativum</i>	Coriander	Auer (2020a)
	<i>Daucus carota</i>	Wild carrot	Halbritter & Heigl (2020k)
	<i>Eryngium campestre</i>	Field eryngo	Halbritter & Heigl (2020n)
	<i>Foeniculum vulgare</i>	Fennel	Heigl (2020e)
	<i>Oenanthe aquatica</i>	Fineleaf water dropwort	Auer (2020f)
	<i>Pastinaca sativa</i> (Mărza și Nicolaide, 1990)	Parsnip	Heigl (2020o)
	<i>Pimpinella anisum</i>	Anise	Stebler (2021w)
	<i>Pimpinella saxifrage</i>	Burnet-saxifrage	Heigl (2020q)
	<i>Sium latifolium</i>	Great water-parsnip	Serbănescu-Jitariu et al. (1994)
Apocynaceae	<i>Asclepias syriaca</i>	Milkweed	Tarnavschi et al. (1981)
	<i>Periploca greaca</i>	Periploca	Tarnavschi et al. (1981)
Araliaceae	<i>Hedera helix</i>	Ivy	Tarnavschi et al. (1981)
Asparagaceae	<i>Convallaria majalis</i>	Lily of the valley	Aktuna & Heigl (2020a)
	<i>Scilla bifolia</i>	Alpine squill	Aktuna & Heigl (2020b)
Asteraceae	<i>Bellis perennis</i>	Lawn daisy	Halbritter & Heigl (2020c)
	<i>Carduus acanthoides</i>	Plumeless thistle	Halbritter & Auer (2020a)
	<i>Carduus nutans</i>	Plumeless thistle	Halbritter & Heigl, 2020g
	<i>Carthamus tinctorius</i>	Safflower	Stebler (2021e)
	<i>Centaurea cyanus</i>	Cornflower	Halbritter & Bombosi (2016)
	<i>Chrysanthemum leucanthemum</i> ( <i>Leucanthemum vulgare</i> )	Dog daisy	Halbritter & Heigl (2021b)
	<i>Cichorium intybus</i>	Common chicory	Halbritter & Heigl (2020h)
	<i>Cirsium arvense</i>	Field thistle	Halbritter (2016b)
	<i>Cynara scolymus</i> ( <i>C. cardunculus</i> var. <i>scolymus</i> )	The globe artichoke	Heigl (2020d)
	<i>Echinops sphaerocephalus</i>	Great globe-thistle	Halbritter, Heigl & Svojtka (2020a)
	<i>Helianthus annuus</i>	Sunflower	Halbritter, Heigl & Svojtka (2020c)
	<i>Helianthus tuberosus</i>	Jerusalem artichoke	Halbritter, Heigl & Buchner (2020)
	<i>Leontodon autumnalis</i> ( <i>Scorzoneroides autumnalis</i> )	Fall dandelion	Heigl (2020y)
	<i>Senecio subalpinus</i> ( <i>Jacobaea subalpina</i> )	Mountain ragwort	Heigl (2021b)
	<i>Solidago virgaurea</i>	European goldenrod	Halbritter & Heigl (2020gg)
<i>Taraxacum officinale</i>	Dandelion	Bombosi & Heigl (2021)	
<i>Tragopogon pratensis</i>	Meadow salsify	Heigl (2020bb)	
<i>Tussilago farfara</i>	Coltsfoot	Halbritter, Heigl & Schneider (2020e)	
Berberidaceae	<i>Berberis vulgaris</i>	Barberry	Tarnavschi et al. (1981)
Betulaceae	<i>Alnus glutinosa</i>	Common alder	Tarnavschi et al. (1981); Halbritter, Sam, Weber & Auer (2020)
	<i>Betula alba</i> (Mărza și Nicolaide, 1990)	Silver birch	Stebler (2021c)
	<i>Corylus avellana</i>	Common hazel	Halbritter, Diethart & Heigl (2020a)
Boraginaceae	<i>Borago officinalis</i> ( <i>Echium amoenum</i> )	Starflower	Tarnavschi et al. (1981); Halbritter & Heigl (2020e)
	<i>Echium vulgare</i>	Blueweed	Tarnavschi et al. (1981)
	<i>Phacelia tanacetifolia</i>	Lacy phacelia	Halbritter & Kratschmer (2016a)

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	<i>Pulmonaria angustifolia</i>	Narrow-leaved lungwort	Halbritter & Heigl (2021d)
	<i>Pulmonaria officinalis</i>	Lungwort	Halbritter, Bombosi, Weber & Heigl (2020)
	<i>Symphytum officinale</i>	Comfrey	Bombosi, Halbritter & Heigl (2020)
Brassicaceae	<i>Brassica napus</i>	Rapeseed	Diethart & Heigl (2020b)
	<i>Brassica nigra</i>	Black mustard	Bombosi (2016a)
	<i>Brassica oleracea</i>	Cabbage	Heigl (2020a)
	<i>Brassica oleracea</i> var. <i>gongyloides</i>	Kohlrabi	Stebler (2021d)
	<i>Brassica rapa</i> ( <i>Brassica campestris</i> )	Oil seed rape	Tarnavschi et al. (1987)
	<i>Raphanus sativus</i> ( <i>R. raphanistrum</i> subsp. <i>sativus</i> )	Radish	Stebler (2021y)
	<i>Rorippa sylvestris</i>	Creeping yellowcress	Auer (2020h)
	<i>Sinapis alba</i> ( <i>Brassica alba</i> )		Bombosi & Heigl (2020c); Stebler (2021cc)
	<i>Sinapis arvensis</i>	Wild mustard	Heigl (2020z)
Campanulaceae	<i>Campanula carpatica</i>	Carpathian harebell	Tarnavschi et al. (1981)
	<i>Phyteuma orbiculare</i>	Round-headed rampion	Halbritter & Heigl (2020w)
Cannabaceae	<i>Humulus lupulus</i>		Halbritter & Heigl (2020q)
Cornaceae	<i>Cornus mas</i>	European cornel	Weber, Halbritter, Heigl & Schneider (2020); Stebler (2021g)
	<i>Cornus sanguinea</i> (Márza și Nicolaide, 1990)	Common dogwood	Halbritter & Heigl (2020i)
Cucurbitaceae	<i>Citrullus colocynthis</i> (Márza și Nicolaide, 1990)	Wild gourd	Stebler (2021f)
	<i>Citrullus lanatus</i>	Watermelon	Tarnavschi et al. (1987)
	<i>Cucumis melo</i> (Bura et al., 2005)	Melon	Halbritter (2016c)
	<i>Cucumis sativus</i> (Márza și Nicolaide, 1990)	Cucumber	Halbritter & Heigl (2020i)
	<i>Cucurbita maxima</i>	Squash	Tarnavschi et al. (1981)
	<i>Cucurbita pepo</i>	Summer squash	Halbritter & Hesse (2016)
Elaeagnaceae	<i>Elaeagnus angustifolia</i>	Wild olive	Halbritter & Heigl (2020l)
	<i>Hippophaë rhamnoides</i>	Sea-buckthorn	Halbritter, Heigl & Svojtka (2020b)
Ericaceae	<i>Calluna vulgaris</i>	Common heather	Halbritter & Heigl (2020f)
	<i>Vaccinium myrtillus</i> ( <i>V. oreophilum</i> , <i>Myrtillus niger</i> )	Bilberry	Halbritter & Heigl (2021e)
	<i>Vaccinium vitis-idaea</i>	Mountain cranberry	Halbritter, Heigl & Sonnleitner (2020)
Fabaceae	<i>Amorpha fruticosa</i>	False indigo-bush	Halbritter & Heigl (2021a); Stebler (2021b)
	<i>Coronilla varia</i> ( <i>Securigera varia</i> )	Crownvetch	Halbritter, Heigl & Vladović (2021); Stebler (2021h)
	<i>Galega officinalis</i>	Galega	Heigl (2020h)
	<i>Gleditsia triacanthos</i>	Honey locust	Heigl (2020j); Stebler (2021k)
	<i>Lotus corniculatus</i>	Common bird's-foot trefoil	Halbritter & Heigl (2020s); Stebler (2021r)
	<i>Medicago falcate</i>	Yellow lucerne	Halbritter, Heigl & Svojtka (2021)
	<i>Medicago lupulina</i>	Hop clover	Heigl (2020k)
	<i>Medicago sativa</i>	Alfalfa, lucerne	Heigl (2020l)
	<i>Melilotus albus</i>	Honey clover, white melilot	Heigl (2020m)
	<i>Melilotus officinalis</i>	Yellow melilot	Halbritter, Auer & Svojtka (2020b)
	<i>Onobrychis viciifolia</i> ( <i>O. sativa</i> )	Common sainfoin	Halbritter & Heigl (2020v)
	<i>Robinia pseudoacacia</i> ( <i>R. pseudoacacia</i> )	Black locust	Heigl (2020v); Stebler (2021aa)
	<i>Sophora japonica</i> ( <i>Styphnolobium japonicum</i> )		Heigl (2020aa)
	<i>Sophora jaubertii</i> ( <i>S. prodanii</i> )		Tarnavschi et al. (1990)
	<i>Trifolium arvense</i>	Hare's-foot clover	Tarnavschi et al. (1990)
	<i>Trifolium campestre</i>	Hop trefoil, field clover	Halbritter & Kratschmer (2016b)
	<i>Trifolium fragiferum</i>	The strawberry clover	Auer (2020i)
	<i>Trifolium hybridum</i>	Alsike clover	Heigl (2020cc)
	<i>Trifolium pratense</i>	Red clover	Halbritter & Auer (2020h); Stebler (2021ff)
	<i>Trifolium repens</i>	White clover	Halbritter, Heigl & Schneider (2020d)
	<i>Vicia panonica</i>	Hungarian vetch	Halbritter & Auer (2021)
	<i>Vicia sativa</i>	Common vetch	Auer (2020k)
Fagaceae	<i>Castanea sativa</i>	Sweet chestnut	Halbritter, Sam, Heigl & Buchner (2020)
	<i>Quercus robur</i> ( <i>Q. pedunculata</i> ) (Dobre et al., 2013)	Common oak	Diethart, Bouchal & Heigl (2020)
Gentianaceae	<i>Gentiana punctata</i>	The spotted gentian	Halbritter & Svojtka (2016)
Geraniaceae	<i>Geranium sanguineum</i> (Stanciu et al. 2016)	Bloody cranesbill	Heigl (2020i)
Grossulariaceae	<i>Ribes aureum</i>	Golden currant	Halbritter (2016f)
	<i>Ribes nigrum</i>	Blackcurrant	Heigl (2020t)
	<i>Ribes rubrum</i>	Redcurrant	Heigl (2020u)
	<i>Ribes uva-crispa</i> ( <i>R. grossularia</i> )	Gooseberry	Halbritter, Heigl & Schneider (2020c); Stebler (2021z)
Hypericaceae	<i>Hypericum perforatum</i>	St John's wort	Halbritter (2015)

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Iridaceae	<i>Crocus olivieri</i>		Uzundzhaliieva & Todorova (2012)
Lamiaceae	<i>Dracocephalum moldavica</i> ( <i>D. moldavicum</i> )	Moldavian dragonhead	Heigl (2021a)
	<i>Glechoma hederaceum</i>	Ground-ivy, creeping charlie	Halbritter & Auer (2020b)
	<i>Hyssopus officinalis</i>	Hyssop	Halbritter & Ulrich (2016); Stebler (2021m)
	<i>Lamium album</i>	White dead-nettle	Bombosi & Auer (2020a); Stebler (2021p)
	<i>Lamium purpureum</i>	Red dead-nettle	Halbritter & Auer (2020d); Stebler (2021q)
	<i>Lavandula angustifolia</i> ( <i>L. officinalis</i> )	Lavender	Halbritter, Weber & Heigl (2020a)
	<i>Leonurus cardiaca</i>	Motherwort	Auer (2020b)
	<i>Lycopus europaeus</i>	Bugleweed	Halbritter, Ulrich & Auer (2020a)
	<i>Marrubium vulgare</i>	Common horehound	Auer (2020d)
	<i>Melissa officinalis</i>	Lemon balm	Ulrich & Auer (2020)
	<i>Mentha aquatica</i> ( <i>M. hirsuta</i> )	Water mint	Ulrich (2016)
	<i>Mentha longifolia</i> ( <i>M. spicata</i> var. <i>longifolia</i> , <i>M. sylvestris</i> , <i>M. tomentosa</i> , <i>M. incana</i> )	Horse mint	Halbritter, Ulrich & Heigl (2020a)
	<i>Mentha pulegium</i>	Squaw mint	Auer (2020e)
	<i>Mentha</i> × <i>piperita</i>	Peppermint	Stebler (2021v)
	<i>Origanum marjorana</i> ( <i>Majorana hortensis</i> , <i>M. majorana</i> )	Marjoram	
	<i>Prunella vulgaris</i>		Halbritter & Heigl (2020bb)
	<i>Salvia nemorosa</i>	Wild sage	Ulrich, Heigl & Tweraser (2020a)
	<i>Salvia officinalis</i>	Sage	Halbritter & Heigl (2020ff)
	<i>Salvia pratensis</i> ( <i>S. virgata</i> )	Meadow sage	Tweraser, Loos & Heigl (2020)
	<i>Salvia verticillata</i>	Lilac sage	Ulrich, Heigl & Tweraser (2020b)
	<i>Satureja hortensis</i>	Summer savory	Heigl (2020x)
	<i>Scutellaria alpina</i>	Alpine skullcap	Halbritter & Weis (2016)
	<i>Stachys annua</i>	Annual yellow woundwort	Halbritter, Ulrich & Auer (2020b)
<i>Stachys officinalis</i> ( <i>Betonica officinalis</i> ) (Mărza și Nicolaide, 1990)	Common hedgenettle	Auer (2021b)	
<i>Stachys palustris</i>		Halbritter, Ulrich & Heigl (2020c)	
<i>Teucrium montanum</i>		Halbritter & Heigl (2020hh)	
<i>Thymus serpyllum</i>	Wild thyme	Stebler (2021ee)	
Liliaceae	<i>Erythronium dens-canis</i>	Dogtooth violet	Halbritter (2016d)
	<i>Gagea lutea</i>	Yellow star-of-Bethlehem	Halbritter & Heigl (2020p)
Linaceae	<i>Linum usitatissimum</i>	Common flax	Auer (2021a)
Loranthaceae	<i>Loranthus europaeus</i> (Dobre et al., 2013)	European yellow mistletoe	
Lythraceae	<i>Lythrum salicaria</i>	Purple loosestrife	Halbritter, Weber & Heigl (2020b)
Malvaceae	<i>Gossypium hirsutum</i>	Mexican cotton	Stebler (2021i)
	<i>Hibiscus trionum</i>	Bladder hibiscus	Halbritter & Auer (2020c)
	<i>Malva silvestris</i> (Mărza și Nicolaide, 1990)	Common mallow	Halbritter & Heigl (2021c)
Oleaceae	<i>Fraxinus excelsior</i>	Ash	Diethart & Heigl (2020c)
	<i>Fraxinus ornus</i>	Manna ash	Halbritter, Diethart & Heigl (2020b)
	<i>Ligustrum vulgare</i>	Common privet	Halbritter & Heigl (2020r)
Onagraceae	<i>Chamaerion angustifolium</i> ( <i>Chamaenerion angustifolium</i> , <i>Epilobium angustifolium</i> )	Fireweed	Halbritter & Heigl (2020m)
	<i>Epilobium parviflorum</i>	Smallflower hairy willowherb	Halbritter & Auer (2020g)
Papaveraceae	<i>Corydalis solida</i>		Heigl (2020c)
	<i>Papaver rhoeas</i>	Field poppy	Oberschneider & Heigl (2020c)
	<i>Papaver somniferum</i>	Breadseed poppy	Heigl (2020n)
Paulowniaceae	<i>Paulownia tomentosa</i>	Princess tree	Halbritter & Auer (2020c)
Phytolaccaceae	<i>Phytolacca americana</i> ( <i>P. decandra</i> )	Dragonberries	Heigl (2020p)
Pinaceae	<i>Abies alba</i> (Antonie, 2020)	Silver fir	Wrońska-Pilarek et al. (2020)
	<i>Picea abies</i> (Antonie, 2020)	European spruce	Halbritter & Heigl (2020x)
	<i>Pinus sylvestris</i> (Mărza și Nicolaide, 1990)	Pine	Halbritter & Heigl (2020y)
Plantaginaceae	<i>Plantago lanceolata</i>	Narrowleaf plantain	Halbritter, Ulrich & Heigl (2020b)
	<i>Veronica officinalis</i> (Mărza și Nicolaide, 1990)	Common speedwell	Auer (2020j)
Poaceae	<i>Sorghum bicolor</i>	Sorghum, great millet	Stebler (2021dd)
	<i>Zea mays</i>	Corn	Diethart & Heigl (2021)
Polemoniaceae	<i>Polemonium caeruleum</i>	Jacob's-ladder	Svojtka, Heigl & Halbritter (2020)
Polygonaceae	<i>Fagopyrum esculentum</i> ( <i>Polygonum fagopyrum</i> )	Common buckwheat	Halbritter, Heigl & Svojtka (2020d)
	<i>Rumex acetosa</i>	Common sorrel	Sam & Heigl (2020a)
Primulaceae	<i>Primula officinalis</i> ( <i>P. veris</i> )	Cowslip primrose	Halbritter & Heigl (2020aa)
Ranunculaceae	<i>Clematis vitalba</i>	Traveller's joy	Oberschneider & Heigl (2020a)
	<i>Delphinium consolida</i> ( <i>Consolida regalis</i> )	Field larkspur	Oberschneider & Heigl (2020b)
	<i>Ranunculus sceleratus</i>	Celery-leaved buttercup	Auer & Svojtka (2016)
Rhamnaceae	<i>Paliurus spina-christi</i>	Jerusalem thorn	Halbritter & Weber (2016)
	<i>Rhamnus frangula</i> ( <i>Frangula alnus</i> )	Alder buckthorn	Heigl (2020g)
Rosaceae	<i>Alchemilla vulgaris</i> ( <i>A. acutangula</i> , <i>Potentilla acutiloba</i> )	Lady's mantle	Șerbănescu-Jitariu et al. (1994); Reitsma (1966)
	<i>Amygdalus communis</i> ( <i>Prunus dulcis</i> , <i>P. amygdalus</i> )	Almond	Halbritter (2016e)

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	<i>Cotoneaster horizontalis</i>		Stebler (2021i)
	<i>Crataegus monogyna</i>	Common hawthorn	Bombosi & Heigl (2020a)
	<i>Cydonia oblonga</i>	Quince	Stebler (2021j)
	<i>Filipendula ulmaria</i>	Meadowsweet	Bombosi & Heigl (2020b)
	<i>Fragaria</i> × <i>ananas</i>	Garden strawberry	Heigl (2020f)
	<i>Fragaria moschata</i>	Musk strawberry	Halbritter & Heigl (2020o)
	<i>Malus domestica</i>	Apple tree	Auer (2020c); Stebler (2021s)
	<i>Malus sylvestris</i>	European crab apple	Halbritter & Heigl (2020t); Stebler (2021t)
	<i>Potentilla anserina</i> ( <i>Argentina anserina</i> )	Silverweed, silver cinquefoil	Auer (2020g); Stebler (2021x)
	<i>Potentilla reptans</i>	Creeping cinquefoil	Halbritter & Heigl (2020z)
	<i>Prunus armeniaca</i> ( <i>Armeniaca vulgaris</i> )	Apricot	Heigl (2020r)
	<i>Prunus avium</i>	Sweet cherry	Halbritter & Heigl (2020cc)
	<i>Prunus cerasus</i> ( <i>Cerasus vulgaris</i> )	Sour cherry	Șerbănescu-Jitariu et al. (1994)
	<i>Prunus domestica</i>	European plum	Halbritter & Heigl (2020dd)
	<i>Prunus persica</i>	The peach	Halbritter & Heigl (2020ee)
	<i>Prunus spinosa</i>	Blackthorn	Halbritter & Heigl (2020mm)
	<i>Pyrus communis</i>	Common pear	Heigl (2020s)
	<i>Rosa canina</i>	Dog rose	Bombosi & Auer (2020b)
	<i>Rubus caesius</i> ( <i>R. caeruleus</i> )	European dewberry	Halbritter & Auer (2020f)
	<i>Rubus hirtus</i> ( <i>R. fruticosus</i> )	An European blackberry species	Bombosi (2016b)
	<i>Rubus idaeus</i>	Raspberry	Heigl (2020w); Stebler (2021bb)
Salicaceae	<i>Populus alba</i>	Silver poplar	Diethart (2016)
	<i>Populus nigra</i> (Mărza și Nicolaide, 1990)	Black poplar	Halbritter, Sam & Heigl (2020)
	<i>Salix alba</i>	White willow	Diethart & Auer (2020)
	<i>Salix caprea</i>	Goat willow	Hesse, Halbritter & Heigl (2020b)
	<i>Salix cinerea</i>	Common sallow	Halbritter (2016g)
	<i>Salix viminalis</i>	Basket willow	Șerbănescu-Jitariu et al. (1994)
Santalaceae	<i>Viscum album</i>	Common mistletoe	Halbritter, Auer & Schneider (2020)
Sapindaceae	<i>Aesculus hippocastanum</i>	Horse chestnut	Stebler (2021a)
	<i>Koeleruteria paniculata</i>	Goldenrain tree	Stebler (2021o)
Scrophulariaceae	<i>Verbascum densiflorum</i>	Denseflower mullein	Halbritter (2016i)
Simaroubaceae	<i>Ailanthus altissima</i>	Ailanthus	Diethart & Heigl (2020a)
Solanaceae	<i>Lycium barbarum</i> ( <i>L. halimifolium</i> )	Chinese wolfberry	Halbritter, Auer & Svojtka (2020a)
	<i>Nicotiana tabacum</i>	Cultivated tobacco	Halbritter, Heigl & Schneider (2020b)
Tamaricaceae	<i>Tamarix gallica</i> (Mărza și Nicolaide, 1990)	French tamarisk	Halbritter (2016h)
	<i>Tamarix ramosissima</i> (Mărza și Nicolaide, 1990)	Saltcedar	Șerbănescu-Jitariu et al. (1994)
Tiliaceae	<i>Tilia cordata</i>	Small-leaved linden	Halbritter & Heigl (2020ii)
	<i>Tilia platyphyllos</i> ( <i>T. grandifolia</i> )	Large-leaved linden	Halbritter, Hesse & Heigl (2020)
	<i>Tilia tomentosa</i> ( <i>T. argentea</i> , <i>T. alba</i> ) (Vințan, 2015)	Silver linden	Sam & Heigl (2020b)
Ulmaceae	<i>Ulmus minor</i> ( <i>U. campestris</i> , <i>U. glabra</i> )	Field elm	Halbritter, Diethart & Heigl (2020c)
Verbenaceae	<i>Verbena officinalis</i>	Common verbena	Schneider & Halbritter (2016); Stebler (2021gg)
Violaceae	<i>Viola odorata</i>	Sweet violet	Halbritter & Heigl (2020kk)
Vitaceae	<i>Vitis silvestris</i> ( <i>V. sylvestris</i> )	Wild grape	Bucher & Kofler (2021)
	<i>Vitis vinifera</i>	Common grape vine	Halbritter & Heigl (2020ll)

## RESULTS AND DISCUSSIONS

The analysis of pollen types, showed that inaperturate pollen have only the two species of poplar, from the list of studied species (Table 1).

Monoporate pollen have only the Poaceae species, all of them have the same pollen type and although there are some size differences (large size pollen have some cultivated Poaceae) the microscopic pollen identification does not allow an analysis of the species or genus (therefore this pollen is referred to Poaceae-type). Anemophilous Poaceae pollen is widespread, especially in summer in temperate climates.

In the triporate category there are 6 species: *Betula alba*, *Corylus avellana*, *Humulus lupulus*, *Cucumis melo*, *Cucumis sativus* and *Chamaerion angustifolium*. In this group, several species have distinctive characteristics: the two Betulaceae species have small (*Betula*) and medium (*Corylus*) pollen grains with protruding pores (onci), also the Onagraceae species *Chamaerion angustifolium* has a distinctive characteristic, the presence of viscin threads. The Cucurbitaceae species have large size pollen grains. *Humulus lupulus* has triporate, small size pollen grain.

Tetraporate pollen have the two Campanulaceae species - *Campanula carpatica*

and *Phyteuma orbiculare*, both have medium size pollen.

Pentaporate pollen have *Alnus glutinosa* and *Ulmus minor*. Although they have similar size, alder has distinctive protruding pores (onci), similar to other Betulaceae species.

Fourteen plants have periporate pollen, they are from 6 families: Amaranthaceae - *Atriplex patula*, *Beta vulgaris*, *B. vulgaris saccharifera*; Cucurbitaceae - *Cucurbita maxima*, *C. pepo*; Grossulariaceae - *Ribes aureum*, *R. nigrum*, *R. rubrum*, *R. grossularia*; Malvaceae - *Gossypium hirsutum*, *Hibiscus trionum*, *Malva silvestris*; Plantaginaceae - *Plantago lanceolata* and Polemoniaceae - *Polemonium caeruleum*. All these species have pantoporate pollen grains. The three Malvaceae species have very large pollen grains. Large and very large pollen grains have also the two *Cucurbita* species, while the rest of species have small or medium size pollen grains.

In the tricolpate category there are 41 species, only one of them has large size pollen grains (*Linum usitatissimum*), 27 species have medium size pollen grains and 12 species have small size pollen grains (Table 2).

Table 2. Melliferous species with tricolpate, small and medium size pollen grains

Small size	Medium size
<i>Brassica oleracea</i> var. <i>gongyloides</i>	<i>Acer campestre</i> , <i>A. platanoides</i> , <i>A. pseudoplatanus</i>
<i>Clematis vitalba</i>	<i>Brassica napus</i> , <i>B. nigra</i> , <i>B. oleracea</i> , <i>B. rapa</i>
<i>Leonurus cardiaca</i>	<i>Delphinium consolida</i>
<i>Papaver rhoeas</i>	<i>Fraxinus excelsior</i>
<i>Raphanus sativus</i>	<i>Lamium album</i> , <i>L. purpureum</i>
<i>Rorippa sylvestris</i>	<i>Loranthus europaeus</i>
<i>Salix alba</i> , <i>S. viminalis</i>	<i>Marrubium vulgare</i>
<i>Scutellaria alpina</i>	<i>Onobrychis viciifolia</i>
<i>Sophora jaubertii</i>	<i>Papaver somniferum</i>
<i>Tamarix gallica</i> , <i>T. ramosissima</i>	<i>Phytolacca americana</i>
	<i>Quercus robur</i>
	<i>Ranunculus sceleratus</i>
	<i>Sinapis alba</i> , <i>S. arvensis</i>
	<i>Stachys annua</i> , <i>S. officinalis</i> , <i>S. palustris</i>
	<i>Teucrium montanum</i>
	<i>Tilia platyphyllos</i>
	<i>Veronica officinalis</i>
	<i>Viscum album</i>

In the hexacolpate category there are 19 species, 18 of them have medium size pollen grains (Table 3), and only one species, *Mentha pulegium*, has small size pollen grains.

Pericolpate (>6 apertures) pollen has only one species - *Primula officinalis* - whose pollen is stephanocolpate and of medium size.

Table 3. Melliferous species with hexacolpate, medium size pollen grains

Botanical name
<i>Corydalis solida</i>
<i>Dracocephalum moldavica</i>
<i>Glechoma hederaceum</i>
<i>Hyssopus officinalis</i>
<i>Lavandula angustifolia</i>
<i>Lycopus europaeus</i>
<i>Melissa officinalis</i>
<i>Mentha aquatic</i> , <i>M. longifolia</i> , <i>M. x piperita</i>
<i>Origanum marjorana</i>
<i>Prunella vulgaris</i>
<i>Salvia nemorosa</i> , <i>S. officinalis</i> , <i>S. pratensis</i> , <i>S. verticillata</i>
<i>Satureja hortensis</i>
<i>Thymus serpyllum</i>

Monosulcate pollen have some monocotyledonate plants from: Amaryllidaceae family - *Allium cepa*, *Allium ursinum*, *Galanthus nivalis*; Asparagaceae family - *Convallaria majalis*, *Scilla bifolia* and Liliaceae family - *Erythronium dens-canis*, *Gagea lutea*. These species have medium or large size pollen grains.

Based on the descriptions used in the current study, 108 species have tricolpate pollen grains of different size, ranging from very large - only one species - *Geranium sanguineum*, to small pollen grains (Table 4).

Tricolpate, heteroaperturate with pseudocolpus, pollen grains have *Phacelia tanacetifolia* and *Lythrum salicaria*. These two species have different pollen size: *Phacelia tanacetifolia* has small size pollen and *Lythrum salicaria* has medium size pollen grains.

Tetracolpate pollen grains of medium size have the two *Pulmonaria* species.

Two species have 8-10-colpate, stephanocolpate pollen grains that differ in size: *Borago officinalis* has medium size pollen grains and *Symphytum officinale* has small size pollen grain.

Spiraperturate pollen is found in only one species: *Berberis vulgaris* that has medium-large, spiraperturate pollen grain.

Similarly, only one species has syncolpate pollen. *Crocus olivieri* has large, syncolpate pollen.

Large or very large bisaccate pollen have the three Pinaceae species (*Abies alba*, *Picea abies*, *Pinus sylvestris*).

Although most pollen grains of the plants included in the present study occur as monad, pollen grains shed in tetrads are found in the three Ericaceae species (*Calluna vulgaris*, *Vaccinium myrtillus* and *Vaccinium vitis-idaea*)

and the Onagraceae specie *Epilobium parviflorum* (Table 5), while pollen grains shed in larger groups: polyads, with pollinarium made of two elongated pollinia have the two Apocynaceae species (*Asclepias syriaca* and *Periploca greaca*).

Table 5. Melliferous species with pollen grains shed in tetrads

Botanical name	Pollen sie and type
<i>Calluna vulgaris</i>	Medium size, triporate
<i>Epilobium parviflorum</i>	Large size, triporate
<i>Vaccinium myrtillus</i>	Medium size, tricolporate
<i>Vaccinium vitis-idaea</i>	Medium size, tricolporate

Table 4. Melliferous species with tricolporate pollen grains

Small size	Medium size	Large size
<i>Aesculus hippocastanum</i>	<i>Acer tataricum</i>	<i>Paliurus spina-christi</i>
<i>Amorpha fruticosa</i>	<i>Ailanthus altissima</i>	<i>Pastinaca sativa</i>
<i>Bellis perennis</i>	<i>Alchemilla vulgaris</i>	<i>Pimpinella anisum, P. saxifraga</i>
<i>Carum carvi</i>	<i>Amygdalus communis</i>	<i>Prunus armeniaca, P. avium, P. cerasus, P. domestica, P. persica, P. spinosa</i>
<i>Castanea sativa</i>	<i>Angelica archangelica</i>	<i>Pyrus communis</i>
<i>Cornus mas</i>	<i>Carduus acanthoides</i>	<i>Robinia pseudacacia</i>
<i>Coronilla varia</i>	<i>Centaurea cyanus</i>	<i>Rosa canina</i>
<i>Echium vulgare</i>	<i>Chrysanthemum leucanthemum</i>	<i>Rubus caesius, R. hirtus, R. idaeus</i>
<i>Filipendula ulmaria</i>	<i>Cichorium intybus</i>	<i>Sium latifolium</i>
<i>Fragaria × ananassa</i>	<i>Cirsium arvense</i>	<i>Tilia cordata, T. tomentosa</i>
<i>Fragaria moschata</i>	<i>Coriandrum sativum</i>	<i>Tragopogon pratensis</i>
<i>Fraxinus ornus</i>	<i>Cotoneaster horizontalis</i>	<i>Trifolium arvense, T. campestre, T. fragiferum, T. pratense, T. repens</i>
<i>Galega officinalis</i>	<i>Crataegus monogyna</i>	<i>Tussilago farfara</i>
<i>Hypericum perforatum</i>	<i>Cydonia oblonga</i>	<i>Verbascum densiflorum</i>
<i>Lotus corniculatus</i>	<i>Daucus carota</i>	<i>Verbena officinalis</i>
<i>Medicago lupulina</i>	<i>Elaeagnus angustifolia</i>	<i>Vicia pannonica</i>
<i>Melilotus albus</i>	<i>Eryngium campestre</i>	<i>Vicia sativa</i>
<i>Paulownia tomentosa</i>	<i>Fagopyrum esculentum</i>	<i>Viola odorata</i>
<i>Potentilla anserina</i>	<i>Foeniculum vulgare</i>	
<i>Potentilla reptans</i>	<i>Gentiana punctata</i>	
<i>Rhamnus frangula</i>	<i>Gleditsia triacanthos</i>	
<i>Rumex acetosa</i>	<i>Hedera helix</i>	
<i>Salix caprea</i>	<i>Helianthus annuus, H. tuberosus</i>	
<i>Salix cinerea</i>	<i>Hippophaë rhamnoides</i>	
<i>Sambucus nigra</i>	<i>Koeleruteria paniculata</i>	
<i>Senecio subalpinus</i>	<i>Leontodon autumnalis</i>	
<i>Solidago virgaurea</i>	<i>Ligustrum vulgare</i>	
<i>Sophora japonica</i>	<i>Lycium barbarum</i>	
<i>Taraxacum officinale</i>	<i>Malus domestica, M. sylvestris</i>	
<i>Trifolium hybridum</i>	<i>Medicago falcata, M. sativa</i>	
<i>Viburnum opulus</i>	<i>Melilotus officinalis</i>	
<i>Vitis silvestris</i>	<i>Nicotiana tabacum</i>	
<i>Vitis vinifera</i>	<i>Oenanthe aquatica</i>	

## CONCLUSIONS

The aim of this study was to use two morphological characters in the pollen grain of some melliferous species present in Romania, to determine the species that show similar traits for identification purposes when using the light microscope technique.

Of the 218 species that have data regarding their size (no data was used for *Asclepias syriaca* and *Periploca greaca* that have pollen grains in polyads), 7 species have very large size pollen grains, 18 species have large size pollen grains, 138 species have medium size pollen grains and 55 have small size pollen grains.

The studied pollen grains differ in aperture type and the appearance of the pollen-unit. Few species in the list that was analysed are having pollen of the following types (the plant family

they belong to is mentioned below in brackets): pericarpate (Primulaceae); spiraperturate (Berberidaceae); syncarpate (Iridaceae); inaperturate (Salicaceae); monoporate (Poaceae); tetraporate (Campanulaceae); pentaporate (Betulaceae, Ulmaceae); tricolporate – heteroaperturate (Boraginaceae; Lythraceae); tetracarpate (Boraginaceae); pericarpate (Boraginaceae); bisaccate (Pinaceae); triporate (Betulaceae, Cannabaceae, Cucurbitaceae, Onagraceae); monosulcate (Amaryllidaceae, Asparagaceae, Liliaceae). Also, few species in this list have pollen grains in groups (the plant family they belong to is mentioned in brackets): tetrads (Ericaceae, Onagraceae); polyads (Apocynaceae).

Fourteen/nineteen species have periporate (Fam. Amaranthaceae, Fam. Cucurbitaceae, Fam. Grossulariaceae, Fam. Malvaceae, Fam. Plantaginaceae, Fam. Polemoniaceae),

hexacolpate pollen, respectively (Fam. Lamiaceae, Fam. Papaveraceae).

The most common pollen types are the tricolpate pollen, found in species from numerous plant families (Aceraceae, Brassicaceae, Fabaceae, Fagaceae, Lamiaceae, Linaceae, Lorantheaceae, Oleaceae, Papaveraceae, Phytolaccaceae, Plantaginaceae, Ranunculaceae, Salicaceae, Santalaceae, Tamaricaceae, Tiliaceae) and the tricolporate pollen that is found in more than half of the species in this list, comprising a wide range of plant families (Aceraceae, Adoxaceae, Apiaceae, Araliaceae, Asteraceae, Boraginaceae, Cornaceae, Cucurbitaceae, Elaeagnaceae, Fabaceae, Fagaceae, Gentianaceae, Geraniaceae, Hypericaceae, Oleaceae, Paulowniaceae, Polygonaceae, Rhamnaceae, Rosaceae, Salicaceae, Sapindaceae, Scrophulariaceae, Simaroubaceae, Solanaceae, Tiliaceae, Verbenaceae, Violaceae, Vitaceae).

The development of a larger database that includes additional, distinctive morphological differences for the use of pollen analysis might prove useful as well as the knowledge of the distribution and ecology of the source plants.

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