The flora of Kaliakra Nature Reserve with regard to its pollinators

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Abstract. The specific steppe flora of the Kaliakra Nature Reserve (08E1 Western-Pontic petrophytic steppes Natura 2000 habitat) is analyzed with regard to the pollination syndromes and breeding systems assessed respectively in terms of the functional morphology of blossoms and biological types of plants. The entomophilous pollination syndromes are classified. Plants with dish-bowl blossoms pollinated by small bees, flies and beetles are dominant. Next come the wind pollinated plants. A floristic analysis of the flora of Kaliakra Nature Reserve shows prevalence of Submediterranean geoelements over Euroasian, Euro-Mediterranean, Mediterranean, Pontian-Mediterranean, Euro-Siberian, Cosmopolitic, etc. in the area. This corresponds well to the dominance of the dish-bowl pollination syndrome. Also, the abundance of plants with wind pollination syndrome corresponds to the specific steppe flora and vegetation in the area. The analyses of functional blossom morphology only roughly predict pollinators. Each particular plant calls for detailed research. *Adonis vernalis* L., *Gypsophila trichotoma* Wend. *Crithmum maritimum* L. are presented as examples.

Key words: Bulgaria, Kaliakra Nature Reserve, North Black Sea Coast, pollination syndromes

Introduction

There is a specific steppe flora and vegetation in South Dobrudzha (Davidov 1914; Turrill 1929; Jordanov 1936; Stojanoff 1940; 1941a, b; 1950; Stefanoff 1943; Bondev 1991). The specific steppe communities are presently preserved mainly in the area along the Black Sea Coast, between the towns of Shabla and Balchik. The origin of this steppe flora is disputable: it either comes from the northern, or from the southern continental centers (Stefanoff 1943). The primary character of this steppe flora and vegetation has been proved by palaeoecological investigations (Bozilova 1982a, b; Bozilova & Tonkov 1985; Bozilova 1986; Filipova-Marinova 1986; Bozilova & Filipova 1989). The above-listed authors refer the South Dobrudzha steppe communities to Southwest Ukraine and North Dobrudzha on the basis of palynological data from lake Durankulak, with its characteristically high diversity of Asteraceae, Caryophyllaceae, Poaceae, and Fabaceae members.

Functional flower morphology (integrated with colour, odour, size, rewards, and phenology) is associated with some particular pollinator groups. They are known as floral or pollination syndromes (Faegri & van der Pijl 1979). The pollination syndrome concept implies that plants specialise in particular functional groups of pollinators exerting similar selective pressures on the floral traits (Fenster & al. 2004). The term "blossom" is suggested for comparative analysis and refers to both individual flowers and compact inflorescences, which function as a single unit of pollination (capitula of Asteraceae and Dipsacaceae, dense umbel, etc., Faegri & van der Pijl 1971). Different approaches have been used to qualify and quantify the floral characters (Leppik 1953, 1956, 1957;

Dafni 1992; Herrera 1996; Proctor & al. 1996, Dafni & Kevan 1996; Dafni & Neal 1997; Dafni & al. 1997; Neal & al. 1998; Giufra & al. 1999; Wolfe & Krstolic 1999; Endress 2001). Plant communities or floras of certain regions have been investigated with regard to their pollinators (Kevan 1972; Ostler & Harper 1978; Pleasants 1980; Diamantopolos & Margaris 1981; Arroyo & al. 1982; 1985; Douglas 1983; Bowers 1985a & b; McCann 1986; Hartmann 1988; Inouye & Pyke 1988; Herrera 1996; 1987; Menzel & Shmida 1993; Petanidou 1993; Dafni & O'Toole 1994; Kozuharova 1997; 2000; Lázaro & al. 2016 a & b; Lazarina & al. 2016: 2017). Pollinator guilds offer new means of assessing ecosystemic health, because the species diversity and abundance relationships are changed from the log-normal standard expected from ecological principles and niche theory (Kevan 1999; Steffan-Dewenter & al. 2002; Fontaine & al. 2005; Lázaro & al. 2016 b). The relative importance of pollinating honey bees, *Apis mellifera,* versus other species is debated for more than 20 years and the role of wild bees in the pollination process should not be neglected (Ollerton & al. 2012).

The aim of this study is to analyze the flora of Kaliakra Nature Reserve in the following aspects: 1) discussion of the breeding systems as compared to biological types 2) classification of the plant taxa according to their pollination syndromes; comparison of the result of floristic analysis and the pollination syndromes; 3) classification of the entomophylous plants according to the functional morphology of their blossoms and prediction of the pollinators, and 4) presentation of case reports on the pollination of *Adonis vernalis* L. (a steppe plant) *Gypsophila trichotoma* Wend. (a rare plant) and *Crithmum maritimum* L. (a typical plant for the coastal habitats)

Material and methods

Field investigations. The flora for this study was listed during field investigations conducted in 1996 (Bulgarian-Swiss Biodiversity Conservation Programme) and in the period 2011–2014. Study sites were in the area of Kaliakra Nature Reserve (N=10). Observations of pollinators of *Adonis vernalis*, *Gypsophila trichotoma* and *Crithmum maritimum* were conducted in 2007, 2008, 2009, and 2014, in the native habitat, in hot and sunny weather. A pollinator activity index was calculated as a quotient of the recorded number of pollinators and the minutes of observation multiplied by 60, following the standard protocol (Dafni 1992).

Data analysis. Identification of plants and floristic (florogenetical) analysis were carried out on the basis of phytochories after Jordanov (1963–1995), Tutin and co-workers (1964–1980), and Kozuharov (1992). The scheme of phytochories was accepted after Wulff (1941), with some modifications after Meusel (1965) and Glavac and co-authors (1972). The entomophilous plants were classified according to the functional morphology of their "blossoms", as suggested by Faegri and van der Pijl (1971). Data from field investigations were featured in excel tables. Descriptive statistics was used to analyze the obtained data.

Results and discussion

We have listed 417 species of terrestrial plants. A floristic analysis of the flora of Kaliakra Nature Reserve has shown that Submediterranean geoelements dominated in the area over Euroasian, Euro-Mediterranean, Mediterranean, Pontian-Mediterranean, Euro-Siberian, Cosmopolitic, etc. (Fig. 1).

Herbaceous plants dominated over arboreal (woody) plants and, within the herbaceous group, perennials dominated over annuals and biennials (Fig. 2). The results corresponded to the earlier published data (Kozuharov & al. 2001; Tzonev & al. 2004; 2006; Anastasiu & al. 2008; Făgăraş & al. 2008; 2010). Biological type indicates possible breeding systems – annuals are often capable for spontaneous self-pollination. Perennials are often cross-pollinated but they may also have additional compensatory reproductive mechanisms – facultative ability for spontaneous self-pollination or apomixis including vegetative propagation (Richards 1997).

Spore and gymnosperm plants were poorly presented in the flora of Kaliakra Nature Reserve (Fig. 3).

An analysis of the functional flower morphology has revealed that dish/bowl blossoms strongly dominated in the area (Fig. 3, Appendix 1). These dish/bowl blossoms provided more or less free access to the nectar and pollen. The symmetry of the

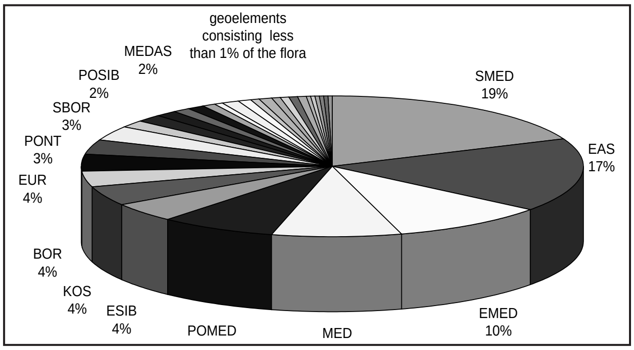

Fig. 1. Geoelements in the flora of Kaliakra Nature Reserve; Legend: Submediterranean – SMED, Euroasian – EAS, Euro-Mediterranean – EMED, MED, Pontian-Mediterranean – POMED, Euro-Siberian – ESIB, Cosmopolitic, KOS Boreal – BOR, European – EUR, Pontian – PONT, Sub-boreal – SBOR, Pontian-Siberian – POSIB, Mediterranean-Asiatic – MEDAS, Adventive – ADV, Sub-Pontian – SPONT, Balkan – BAL, Mediterranean-Central-Asiatic – MEDCAS, Asiatic – AS, Cultivated CULT, Pontian-Asiatic – POAS, Pontian-Central-Asiatic – POCAS, Submediterranean-Asiatic – SMEDAS, Endemic – END, European-Pontian – EPONT, European-Submediterranean – ESMED, North American NAM, Pontian-Balkan – POBAL, Balkan-Carpatian – BAL-CARP, Bulgarian – BUL, European-Irano-Turanian – EIT, Holarctic – HOL, Irano-Turanian – IT.

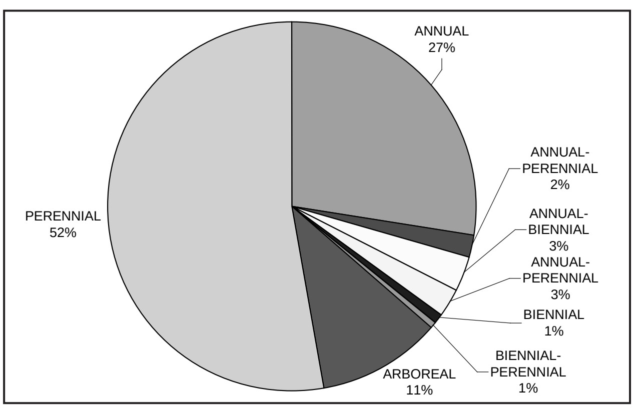

Fig. 2. Biological types in the flora of Kaliakra Nature Reserve.

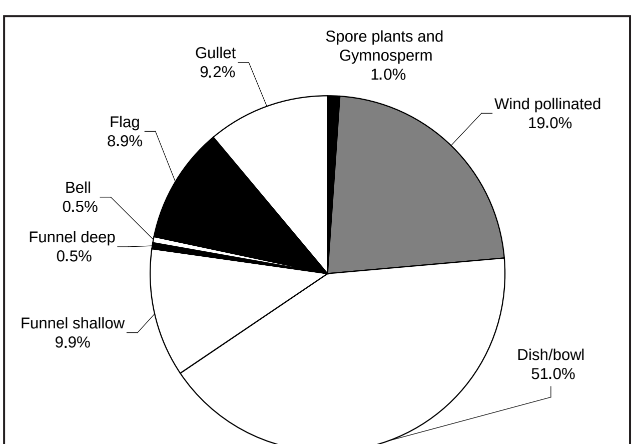

Fig. 3. Plant species of Kaliakra Nature Reserve classified according to the functional morphology of their "blossoms" (flower or compact inflorescence).

blossom was radial. Pollen vectors may comprise a wide range of insects, including short-tongued bees, wasps, antophilous flies, and even beetles. Some of the dish/bowl blossoms had an Asteraceae/Dipsaceae capitulim, with tube or funnel individual flowers. They may require pollinators with relevant proboscis to reach the nectar. Often the reward of the dish/bowl blossoms was pollen and, besides bees, flies and beetles were also attracted (Proctor & al. 1996). Pollination was orientated towards generalists. Many of these dish/bowl blossom plants were annuals and ephemerals and they self-pollinated spontaneously (Richards 1997).

Wind pollinated plants were the next most abundant plants in the area (Fig. 3, Appendix 1). The high percentage of wind pollinated plants fitted with the well described steppe character of the flora and vegetation (Davidov 1914; Turrill 1929; Jordanov 1936; Stojanoff 1940; 1941 a; b; 1950; Stefanoff 1943; Bondev 1991; Tzonev 2006).

Funnel blossoms had more or less hidden nectar. The depth of corolla tube restricted pollinators. In the area of Kaliakra Nature Reserve, the funnel shallow blossoms were well presented and much more numerous than the funnel deep blossoms (Fig. 3). Funnel shallow blossoms were characterised by hidden nectar, narrow but short corolla tube, radial symmetry to slight zygomorphy. Nectar was accessible to short-tongued insects: wild and honeybees and bee flies. Funnel deep blossoms were characterised by hidden nectar, narrow and deep corolla tube, radial symmetry to slight zygomorphy. Nectar was accessible to insects with long proboscis: butterflies and moths, long-tongued bees (some species of bumblebees).

Specialization in pollination was expressed in flag and gullet syndromes. These usually require large enough bees as pollen vectors, e.g. *Megachile* sp. div., *Andrena* sp. div., *Osmia* sp. div., bumblebees and honeybees, which are predominantly generalists and polylectic. These syndromes were equally well presented in the flora of Kaliakra Nature Reserve (Fig. 3, Appendix 1). A flag syndrome was characterized by zygomorphy (bilateral symmetry), with sexual organs in the lower part of the flower, and pollen deposited on the abdominal side of the insect, stemotribic pollination. A gullet syndrome was characterized by zygomorphy (bilateral symmetry), with sexual organs restricted to the functionally upper side of the flower, and pollen deposited on the dorsal side of the insect, more or less hidden nectar, nototribic pollination. Few of the plants with flag or gullet pollination syndromes were annuals adapted to self-pollination.

Bell blossom was characterized by more or less hidden nectar, wide corolla tube, radial symmetry to slight zygomorphy. Few plant species in the studied area have possessed this syndrome (Fig. 3, Appendix 1). These blossoms presented both food and shelter for their pollinators: small bees or flies.

Most plants in the area of Kaliakra Nature Reserve were generalists in their pollination. Few were specialists, like *Ficus carica* L. A long standing idea in biology maintained that ecological specialisation was an evolutionary "dead end" from which no species could ever emerge. In other words, if a species became too adapted to a particular ecological strategy (feeding or habitat requirements, or interaction with other species), then no amount of natural selection would make its descendants evolve different strategies and, thereby, diversify into new species. According to a traditional assumption, broader generalist strategies were highly unlikely to evolve from narrower specialised ones. A small number of case studies have shown that generalised pollination systems could evolve within some much more specialised clades (de Brito & al. 2017). Furthermore, specialization led to vulnerability of both components within the plant-pollinator system (Stefanaki & al. 2015).

The results of the pollination syndrome analysis complied with the earlier floristic analysis. Abundance of Submediterranean and Mediterranean geoelements implied a pollination system similar to those in the Mediterranean ecosystems. Solitary bees were the most important pollinators in the Mediterranean (Petanidou & Ellis 1993; Petanidou & Lamborn 2005; Potts & al. 2006; Lázaro & al. 2016 a; b; c; Lazarina & al. 2016; 2017).

For instance Solanum nigrum L. has a dish-bowl blossom and a syndrome of buzz-pollination but it is an annual and predominantly self-pollinated (Edmonds & Chweya 1997). In fact the breeding system is very complicated in this case, which reflects on its taxonomic appreciation (Venkateswarlu & Rao 1972). Taraxacum officinalis L. is an apomictic plant (Richards 1973; 1997; 2003). At the same time it is so attractive for bees (Fig. 4) and cross-pollination is performed. It has been well shown that the predictability of pollination syndromes is greater in pollinator-dependent species and in plants from tropical regions. Many plant species also have secondary pollinators that generally correspond to the ancestral pollinators documented in evolutionary studies (Rosas-Guerrero & al. 2014).

Our field observations on *Adonis vernalis* and *A. wolgensis* revealed active visitations by honeybees. Also, active flower visitors of this plant species were the beetles *Oxythyrea funesta* (Cetoniidae, Fig. 5). These phytofagous beetles were rather hairy and capable of transferring pollen. The average pollinator activity index was 9.4. For efficient pollination, pollen vectors were needed (Denisow & al. 2014). The authors reported that the proportion of pistils setting fruits after open pollination (41–82.1 %) was significantly higher, as compared to spontaneous self-pollination (only 5.5–12.3 %). The pollination requirements, along with the pollen/ovule ratio (P/O = 501) indicated a facultative xenogamous breeding system in *A. vernalis*. Therefore, considering the global lack of pollinators, improper pollination might weaken the population by a decrease in the proportion of recombinants and, in addition to other factors, might accelerate the extinction of small *A. vernalis* populations (Denisow & al. 2014).

Our case study of *Gypsophila trichotoma* revealed that the sampled flowers were basically hermaphrodite. There were morphs with short and long stamens, as well as few practically female flowers with short stamens and sterile anthers on a same genet. The flowers were self-compatible but did not self-pollinate spontaneously. The nectar drop at the base of the pistil was obvious with naked eye. The flowers had a pleasant hyacinth aroma. The plant was pollinated by small solitary or colonial bees (Halictidae and Coletidae) and hover flies. They were all polylectic generalists (Kozuharova & Gogala 2010). *Gypsophila trichotoma* was attractive to pollinators. (Fig. 6) The average pollinator activity index was 19.2.

Our field observations on *Crithmum maritimum* revealed that the pollinators were mainly various wasps and hover flies (Fig. 7). They are known as generalists (Proctor & al. 996). These insects were active visitors. The average pollinator activity index was 24.5.

Fig. 4. Honeybee foraging in the blossom of *Taraxacum officinalis.*

Fig. 5. pollinator of *Adonis vernalis – Oxythyrea funesta* (Cetoniidae).

Fig. 6. Pollinators of *Gypsophila trichotoma* – sweat bees (Halictidae) and hover flies.

Fig. 7. Pollinators of *Crithmum maritimum.*

Conclusion

Although a high percentage of the flora of Kaliakra Nature Reserve is wind pollinated, because of the specific steppe character, insect pollination is also significant. Many plant species have low level of pollination specialization. Pollinators must be generalists: wild bees, honeybees, as well as flies, beetles and butterflies. Reviews of plant–pollinator mutualistic networks have shown that generalization is a common pattern in this type of interaction (Bascompte & al. 2003). A recent concept of the mutualistic networks has practical conservation aspects. Survival of the mutualistic networks depends on the conservation of aggregation of all interacting taxa (Thébault & Fontaine 2010; Fortuna & al. 2010; Hegland & Totland 2012). In other words, in order to protect a particular endemic or rare plant species, is not sufficient to focus only on the plant object. It is necessary to develop a conservation strategy for the entire mutualistic network.

Neonicotinoids are often applied as systemic seed treatment to crops and have negatively affected the pollinators, when they appear in floral nectar and pollen. Neonicotinoids are one of the most dangerous threats. Experimentally, it was proven that neonicotinoids could increase losses in bee biodiversity (Wright & al. 2015; Stanley & al. 2015a; b; Goulson & al. 2015; Woodcock & al. 2016).

There is a great diversity of medicinal plants in the northern part of the Black Sea Coast floristic region: 593 species of vascular plants from 357 genera and 96 families are shown by a recent review of the studies (Zahariev & al. 2016). This accolunts for 80.2 % of all medicinal plants recognized by the Medicinal Plant Act (2000) in Bulgaria. When they are classified according to their blossom morphology, a pattern of pollination syndromes similar to the flora of Kaliakra is observed. Dish bowl blossoms dominate over the wind pollinated and funnel flowers, with the only difference in the recorded ratio of gullet/flag syndromes. Regarding the pollination syndromes, we can predict that at least 50–60 % of the medicinal plants in the area would need pollen vectors for their reproduction. These should be generalists – wild bees, honey bees, as well as flies, beetles and butterflies (Kozuharova 2018).

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Appendix 1. Plant species recorded in Kaliakra Nature Reserve, according to their functional blossom morphology.

Dish/bowl blossoms

Acer campestre L., *A. tataricum* L., *Adonis flammea* Jacq., *A. vernalis* L., *A. wolgensis* Stev., *Agrimonia eupatoria* L. *Achillea clypeolata* S.S., *Achillea millefolium* L., *Achillea leptophylla* Bieb., *Allium flavum* L., *A. rotundum* L., *Allium saxatile* Bieb., *Althaea cannabina* L., *Alyssum caliacrae* E.I.Nyar., *A. desertorum* Stapf., *A. murale* W. et K., *A. umbellatum* Desf., *Amygdalus communis* L. *A. nana* L. *Anagallis arvensis* L. *Anthemis arvensis* L., *A. tinctoria* L. *Arabidopsis thaliana* (L.) Heynh. *Anthriscus sylvestris* L. *Arabis sagittata* (Bertol.) DC. *Arenaria serpyllifolia* L., *Arctium lappa* L., *Aster amellus* L., *Aster oleifolius* (Lam.) Wagenitz, *Asparagus officinalis* L., *A. verticillatus* L. *Asphodeline lutea* (L.) Rchb. *Asyneuma limonifolium* (L.) Janch. *Bellevalia ciliata* (Cirillo) T. Nees, *Berteroa incana* (L.) DC. *Buglossoides arvensis* (L.) Johnst. *Bupleurum falcatum* L. *Calepina irregularis* (Asso) Thell. *Camelina sativa* (L.) Crantz. *Capsella bursa-pastoris* (L.) Medic. *Cardaria draba* Desf. *Caucalis platycarpos* L. *Cerastium bulgaricum* Uechtr. *Clematis vitalba* L., *Clypeola jonthlaspi* L., *Conium maculatum* L., *Cornus mas* L., *Cornus sanguinea* L., *Crataegus monogina* Jacq., *Crithmum maritimum* L., *Cuscuta campestris* Yunck., *Cynanchum acutum* L., *Carthamus lanatus* L., *Carduus pycnocephalus* Jacq., *Carlina vulgaris* L., *Centaurea calcitrapa* L., *Centaurea caliacrae* Prodan, *Centaurea cyannus* L., *Centaurea diffusa* Lam., *Centaurea marschalliana* Spreng., *Centaurea orientalis* L., *Centaurea solstitialis* L., *Centaurea thirkei* Schultz-Bip., *Cephalaria transsilvanica* Schrad., *Cephalaria uralensis* (Murr.) Roem. et Schult., *Chondrilla juncea* L., *Cichorium intybus* L., *Cirsium canum* (L.) All, *Cirsium ligulare* Boiss., *Cirsium vulgare* (Savi.) Ten., *Crepis sancta* (L.) Babck., *C. setosa* Hall. *Crupina vulgaris* Cass. *Daucus carota* L., *Descurainia sophia* (L.) Webb., *Diplotaxis muralis* (L.) DC., *Echinops microsephalus* S.S., *E. ritro* L., *E. sphaerocephalus* L., *Erodium cicutarium* (L.) L Her., *Eryngium campestre* L., *Erysimum cuspidatum* (Bieb.) DC., *E. diffusum* Ehrh., *E. hieracifolium* L., *Euphorbia amygdaloides* L., *E. helioscopia* L., *E. myrsinites* L., *E. nicaeensis* All., *Euonymus latifolia* Scop. *E. europaeus* L. *Falcaria vulgaris* Bernh. *Filago arvensis* L., *F. germanica* L., *F. vulgaris* Lam., *Filipendula ulmaria* (L.) Maxim. *F. vulgaris* Moench. *Fraxinus ornus* L., *Galium album* Mill., *G. aparine* L., *G. odoratum* L., *G. rubioides* L., *G. verum* L., *Geranium columbinum* L., *G. molle* L., *G. purpureum* Vill., *Gypsophila glomerata*, *G. muralis* L., *G. trichotoma* Wend., *Haplophyllum suaveolens* (DC.) G. Don. fil., *Hedera helix* L., *Helianthemum nummularium* (L.) Mill., *H. salicifolium*, *Heracleum ternatum* Vel., *Herniaria hirsuta* L., *Hornungia petraea* (L.) Rchb., *Hypericum elegans* Steph., *H. perforatum* L., *Inula oculus-christi* L., *Jurinea stoechadifolia* (Bied.) DC., *Knautia macedonica* L., *Lactuca saligna* L., *L. scariola* L. *Leontodon asper* (W.K.) Poir., *Lavathera thuringiaca* L., *Lepidium ruderale* L., *Linum tauricum* Willd., *L. angustifolium* Huds., *L. austriacum* L., *L. tenuifoliuum* L., *Malva neglecta* Wallr., *M. sylvestris* L., *Matricaria trichophylla* Boiss., *Minuartia glomerata* (M.B.) Deg., *M. viscosa* (Schreb.) Schinz. et Thell., *Matthiola odoratissima* (M. Bieb.) R., *Nigella arvensis* L., *Onopordon acanthium* L., *Paeonia peregrina* Mill., *P. tenuifolia* L. *Orlaja grandiflora* (L.) Hoffm. *Paliurus spina-christi* Mill. *Papaver rhoeas* L., *Pastinaca umbrosa* Stev. et DC., *Petasites albus* (L.) Gaertn. *Picris hieracioides* L., *Picris sprengeriana* (L.) Lam., *Petrorhagia illirica* P. W. Ball. et Heywood, *Peucedanum arenarium* W. et K., *Pimpinella tragium* subsp. *titanophila*, *Plantago lanceolata* L., *Plantago media* L., *Polygonum aviculare* L., *Potentilla argentea* L., *P. bornmuelleri* Borb., *P. recta* L., *Prunus mahaleb* L., *P. spinosa* L., *Pyrus sativa* Lam. et DC., *Rhagadiolus stellatus* D.C., *Reseda lutea* L., *R. luteola* L., *Rhamnus cathartica* L., *Rhodax canus* (L.) Fuss, *Rorippa lippicensis* (Wulf.) Rchb., *Rosa canina* L., *R. myriacantha* DC. ex Lam. et DC., *Ruscus aculeatus* L., *Ruta graveolens* L., *Scabiosa rotata* M. B. *Scabiosa ucranica* L., *Scolymus hispanicus* L., *Senecio vernalis* W.K. *Silibum marianum* (L.) Gartn. *Sonchus oleraceus* L., *Sambucus ebulus* L., *S. nigra* L., *Scandix australis, S. pecten-veneris* L., *Sedum acre* L., *Seseli tortuosum* L., *S. rigidum* W. et K., *Sinapis arvensis* L., *Sisymbrium altissimum* L., *S. orientale* L., *S. polyceratium* L., *Spergularia salina* G. et C. Presl, *Stellaria media* (L.) Vill., *Tanacetum achilleifolium* (Bieb.) Schultz-Bip. *T. corymbosum* (L.) Schultz-Bip. *T. millefolium* (L.) Tzvel., *Taraxacum bessarabicum* (Horn.) Hand.-Mazz, *T. officinale* Web., *Tragopogon dubius* Scop., *T. pratensis* L., *Thesium arvense* Horv., *Thlaspi alliaceum* L., *Thymelaea passerina* Coss. et Gern., *Tordylium apulum* L., *Torilis arvensis* (Huds.) Link., *T. nodosa* (L.) Gaerth., *Tribulus terrestris* L., *Valerianella locusta* (L.) Later., *V. pumila* (L.) DC., *Verbascum densiflorum* Bertol, *V. ovalifolium* J. Donn, *Vincetoxicum fuscatum* (Horn.) Rchb., *Solanum nigrum* L. *Xanthium spinosum* L., *X. strumarium* L., *Xeranthemum annuum* L., *X. cylindraceum* S.S.

Appendix 1. Continuation

Wind pollinated plants

Aegilops cylindrica Host., *A. geniculata* Roth, *A. ovata* L., *Agropyron brandzae* Pantu et Solakolu., *A. cristatum* Bess., *A. intermedium* (Host.) P. B., *Amaranthus albus* L., *A. retroflexus* L., *Artemisia austriaca* Jacq., *A. absinthium* L., *A. lerchiana* Weber., *A. pedemontana* Balbis., *A. vulgaris* L., *Atriplex hastata* L., *Avena eriantha* Durieu, *Beta trigyna* Waldst. et Kit., *Brachipodium silvaticum* (Huds.) P.B., *Camphorosma monspeliaca* L., *Bromus arvensis* L., *B. commutatus* Schrad., *B. inermis* Leyss., *B. moesiacus* Vel., *B. mollis* L., *B. riparius* Rehm., *B. sterilis* L., *B. tectorum* L., *Calamagrostis epigeios* (L.) Roth., *Canabis sativa* L., *Carex cuprina* Nendtv., *Carpinus orientalis* Mill. *Celtis australis* L. *Celtis caucasica* Willd., *Chenopodium album* L. *Cotinus coggygria* Scop. *Cynodon dactylon* Pers., *Dactylis glomerata* L., *Dichantium ischaemum* (L.) Roberty, *Elymus sabulosus* M.B., *Festuca pratensis* L., *F. heterophylla* Lam., *F. pseudovina* Hack. ex. Wiesd., *F. valesiaca*, *Haynaldia villosa* Schur., *Hordeum murinum* L., *Humulus lupulus* L., *Juglans regia* L., *Kochia prostrata* (L.) Schrad. *K. scoparia* (L.) Schrad., *Koeleria brevis* Stev., *K. macrantha* (Ledeb.) Shult., *Lolium perenne* L. *Melica ciliata* L., *Panicum crus-galli* L., *Parietaria diffusa* Mert. et Koch., *P. lusitanica* L., *Phleum graecum* Boiss. et Heldr., *P. tenue* Schrad., *Phragmites australis* (Kav.) Trin ex Steut, *Poa bulbosa* L., *P. compressa* L., *P. pratensis* L., *Rumex conglomeratus* L., *R. crispus* L., *Sanguisorba minor* Scop., *Sorghum halepensis* Pers., *Setaria viridis* P.B., *Scleropoa rigida* Grsb., *Stipa capillata* L., *S. lessingiana* Trin. et Rupr., *Taeniatherum caput-medusae* (L.) Nevski, *T. crinitum* Desf., *Thalictrum aquilegifolium* L., *T. minos* L., *Ulmus minor* Mill., *Urtica dioica* L., *Vulpia myuros* (L.) Gmel.

Funnel deep blossoms

Aristolochia clematitis L., *Datura stramonium* L., *Iris pumila* L.

Funnel shallow blossoms

Anchusa barrelieri (All.) Vitm., *Anchusa ochroleuca* Bieb., *Anchusa officinalis* L., *Anchusa tessala* Boiss. et Sprun., *Argusia sibirica* (L.) Dandy, *Asperula aristata* L., *A. arvensis* L., *A. cynanchica* L., *Buglossoides purpuro-caerulea* (L.) Johnston, *Calystegia sepium* (L.) R.Br., *Convolvulus arvensis* L., *C. cantabrica* L., *Dianthus giganteus* D Urv., *D. pseudarmeria* M.Bieb., *D. pallens* M. B., *Elaeagnus angustifolia* L., *Goniolimon besseranum* (Rchb.) Kusn., *G. collinum*, *Heliotropium europaeum* L., *Jasminum fruticans* L., *Lappula marginata* (Bieb.) Gurke., *Lappula myosotis* Moench., *Legousia speculum-veneris* (L.) Chaix, *Ligustrum vulgare* L., *Limonium gmelinii* (Wild.) O. Kuntze, *Limonium latifolium* (Sm.) O.Kuntze, *Lycopus europaeus* L., *Myosotis arvensis* (L.) Hill., *Nonea pulla* (L.) DC., *Onosma taurica* Pall. ex Willd., *O. visianii* G. C. Clem., *Petrorhagia prolifera* P.W. Ball. et Heywood, *Plumbago europaea* L., *Silene caliacre* D. Jord. et P. Pan., *S. conica* L., *S. dichotoma* Ehrh., *S. noctiflorum* L., *S. longiflora* Ehrh., *S. otites* (L.) Wib., *Syringa vulgaris* L.

Flag blossoms

Astragalus spruneri Boiss., *A. cicer* L., *A. glaucus* M. Beib., *A. hamosus* L., *A. onobrychis* L., *A. varius* S.G.Gmel., *A. vesicarius* L., *Chamaecytisus austriacus* (L.) Link., *C. jankae* (Velen.) Rothm., *Coronilla varia* L., *Lathyrus tuberosus* L., *Lotus corniculatus* L., *Medicago disciformis* DC., *M. falcata* L., *M. lupulina* L., *M. minima* (L.) Bartl., *M. orbicularis* (L.) Bartl., *M. rigidula* (L.) All., *Melilotus alba* Medic., *M. officinalis* Medic., *Onobrychis arenaria* (Kit.) DC., *Ononis arvensis* L., *O. spinosa* L., *Psoralea bituminosa* L., *Trifolium angustifolium* L., *T. hybridum* L., *T. scabrum* L., *Trigonela coerulea* Ser., *T. gladiata* Stev., *Vicia craca* L., *V. grandiflora* Scop., *V. lathyroides* L., *V. narbonensis* L., *V. peregrina* L., *V. tenuifolia* Roth., *Viola arvensis* Murr.

Gullet blossoms

Acinos suaveolens (Sm.) G. Don, *Ajuga chamaepitis* (L.) Schreb., *A. genevensis* L., *A. laxmannii* (L.) Benth., *Balota nigra* L., *Consolida regalis* S.F. Gay, *Digitalis ferruginea* L., *D. lanata* Ehrh., *Echium italicum* L., *E. vulgare* L., *Fumaria officinalis* L., *Linaria genistifolia* (L.) Mill., *Marrubium vulgare* L., *Mentha spicata* Huds., *Nepeta parviflora*, *Origanum vulgare* L., *Orobanche arenaria* Borkh., *O. lutea* Baumg., *Prunella vulgaris* L., *Salvia aethiopis* L., *S. argentea* L., *S. nemorosa* L., *S. nutans* L., *S. pratensis* L., *S. virgata* Ait., *Satureja coerulea* Janka, *Scutellaria orientalis* L., *Sideritis montana* L., *S. syriaca* L., *Stachys germanica* L., *S. recta* L., *Teucrium chamaedrys* L., *T. polium* L., *Thymus callieri* Birl. ex Vel., *T. zygioides*, *Verbena officinalis* L., *Ziphora capitata* L.

Bell blossoms

Campanula sibirica L., *Ecbalium elaterium* (L.) A. Rich.

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