

**The Moravian Gate as route of migration of thermophilous bee species to Poland: fact or myth? A case study in the “Góra Gipsowa” steppe reserve and other habitats near Kietrz**

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**ABSTRACT.** This study complements earlier research on wild bees (Apiformes) in the “Góra Gipsowa” steppe reserve and other habitats near the town of Kietrz (SW Poland), close to the Czech border. It also attempts to reassess the opinion of some researchers about the Moravian Gate as a migration route of southern species to Poland. 109 bee species were recorded at the study sites, including 10 red-listed ones; southern species accounted for 16.5% of this number. The hypothetical route of migration of thermophilous bees through the Moravian Gate to Poland was analysed and the species composition of southern species at either side of the Moravian Gate compared. The results of this study indicate that at present the Moravian Gate plays no part in the migration of southern bee species to Poland.

**KEY WORDS:** Hymenoptera, Apoidea, Apiformes, SW Poland, xerothermic habitats, “Góra Gipsowa” nature reserve, Moravian Gate.

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INTRODUCTION

This study complements earlier research on the species composition of wild bees (Apiformes) in the “Góra Gipsowa” steppe reserve (BANASZAK et. al. 2013c, TWERD

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& BANASZAK 2013) and its vicinity in the Opole region of SW Poland. Using wild bees as an example, we also attempted to reassess earlier opinions about the Moravian Gate as a migration route of southern species to Poland.

The Moravian Gate is a natural pass, about 65 km long and 15 km wide (MAIER 2015), between the eastern Sudetens and the western Carpathians near the headwaters of the Rivers Oder and Vistula (PENN 2001). According to many botanists, southern xerothermic plant species migrated to the Poland through the Moravian Gate (SZAFER 1926, MEDWECKA-KORNAŚ & KORNAŚ 1977, PAWŁOWSKA 1977, SENDEK & BABCZYŃSKA-SENDEK 1990). One of the species that presumably migrated northwards through the Moravian Gate is *Quercus pubescens* WILLD., a species native to the Mediterranean region. In Poland, this species is present in only one locality, the nature reserve “Bielinek” (Pomeranian Lakeland), far to the north of the northern limit of its continuous range. Other plant species that have probably migrated northwards from southern Europe in the same way include *Anthericum liliago* L., *Lithospermum purpurocaeruleum* L., *Dorycnium herbaceum* VILL., *D. germanicum* (GREMLI) RIKLI and *Orchis tridentata* SCOP. (WODZICZKO et al. 1948). However, molecular analyses (CIEŚLAK 2015) have not confirmed the migration of xerothermic plant species from south to north through the Moravian Gate.

The presence of xerothermic vegetation indicates that animals with similar requirements can be expected there. For example, the European ground squirrel *Spermophilus citellus* (LINNAEUS, 1766) most probably migrated to Silesia through the Moravian Gate (SURDACKI 1965). Among invertebrates, the weevil *Helianthemapion velatum* (GERSTAECKER, 1854) (Coleoptera: Apionidae) is a particularly noteworthy migrant (MAZUR & PAWŁOWSKI 1993, WANAT & CELADYN 2015). Other examples of species that have arrived in our country via this depression between the Carpathians and the Sudetens are *Aphis vitalbae* FERRARI, 1872 (Hemiptera, Sternorrhyncha: Aphididae) (HAŁAJ & OSIADACZ 2015), *Cymatia rogenhoferi* (FIEBER, 1864) (Hemiptera, Heteroptera: Corixidae) (KARG 1966), *Pinthaeus sanguinipes* (FABRICIUS, 1781) (Hemiptera, Heteroptera: Pentatomidae) (CHŁOND & GORCZYCA 2009) and probably also *Eucharis adscendens* (FABRICIUS, 1787) (Hymenoptera, Apocrita: Eucharitidae) (SZAFRAŃSKI 2011), *Bittacus hageni* BRAUER, 1860 (Mecoptera: Bittacidae) (PRZYBYŁOWICZ 2006) and *Mantis religiosa religiosa* (LINNAEUS, 1758) (Mantodea) (KRÓLIK 2010). BUSZKO (1990) describes two possible migration routes of xerothermophilous species of mining lepidopterans in Poland: from the west along the River Noteć to the Lower Vistula, and from the south through the Moravian Gate to the upper Vistula and Oder. Nevertheless, results of 40 years of observations on weevils (Coleoptera: Rhynchitidae, Apionidae, Nanophyidae and Curculionidae) (KUŚKA (2001) emphasize the minor part played by the Moravian Gate in the spread of xerothermophilous species to Poland, and show that the

migration of species from the south was possible only after the initiation of agriculture. LIANA (1976), who attempted to assess the role of the Moravian Gate in the migration of xerothermophilous orthopterans to the Małopolska Upland, was of a similar opinion.

In relation to bees, a number of publications relating to southern Poland, i.e. Lower and Upper Silesia, the Małopolska Upland and the Kraków-Częstochowa Upland, have turned out to be very useful (DITTRICH 1903, ŁOZIŃSKI 1920, NOSKIEWICZ 1924, 1950, 1959, MACKO & NOSKIEWICZ 1954, 1959, CELARY 1988, 1995, 1999, 2000, CELARY & WIŚNIEWSKI 2001, 2003, 2007, 2011), as well as others concerning the Czech Republic (PŘIDAL & VESELÝ 2011, STRAKA et al. 2007, PŘIDAL 2014) or Slovakia (LUKÁŠ 1983, 1987, STRAKA et al. 2007, PŘIDAL 2014). We have attempted to assess the possibility of bee migration to Poland through the Moravian Gate on the basis of these papers.

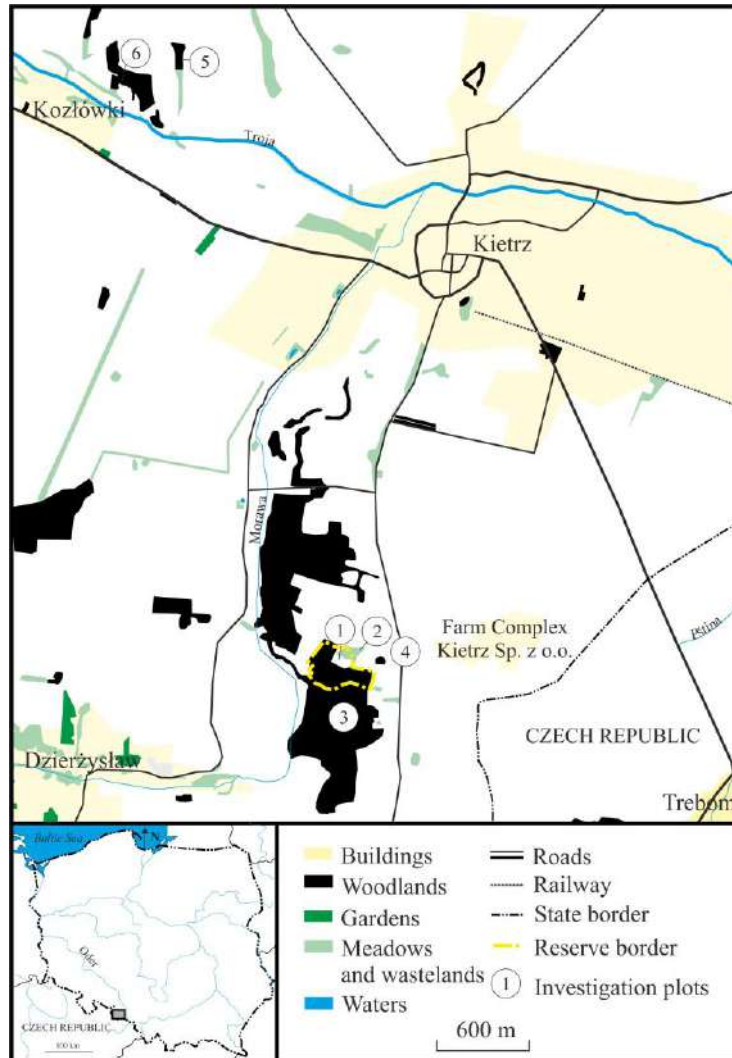
## MATERIAL AND METHODS

### Study area

With respect to the physical geographical division of Poland (KONDRACKI 2002), the study area lies at the exit of the Moravian Gate (Moravia, Czech Republic), within the Silesian Lowland macroregion (Nizina Śląska) and the Głubczyce Plateau mesoregion (Płaskowyż Głubczycki). According to the latest geobotanical regionalization (MATUSZKIEWICZ 2008), the area is situated in the Brandenburg-Wielkopolska Division, Lower Silesian Land, Głubczyce Plateau District and Głubczyce-Racibórz Subdistrict. Climatically, it is in the Southern Lower Silesia region (XXV). The area has few days with ground frost, very cold weather and overcast sky, and likewise few days with ground frost, very cold weather and precipitation (WOŚ 1993).

We specified the location of the six study sites in the eastern Sudetens (RAFALSKI 1960) on the UTM grid (10 km × 10 km) and of the zoogeographic region using the <http://gis.biomap.pl> application. They are briefly described below and their location is shown on a map (Fig. 1).

**1. “Góra Gipsowa” steppe reserve** (UTM: YR14). This nature reserve is situated close to the town of Kietrz, on the southern slopes of the Góra Gipsowa (altitude 285 m), which are composed of clayey gravels overlying Miocene gypsum deposits (KUŚKA 2001). This habitat is an island among intensive farmland. The specific geological structure and former



**Fig. 1.** Location of study sites: 1 = “Góra Gipsowa” steppe reserve; 2 = wooded patch; 3 = disused gypsum mine “Dzierżysław”; 4 = roadside; 5 = gully between fields; 6 = forest glade.

use of this site as pastureland enabled xerothermic grasslands of the class *Festuco-Brometea* to develop. The most stable plant community there is flowery steppe *Thalictro-Salvietum pratensis* (SENDEK & BABCZYŃSKA-SENDEK 1990), in which many plant species typical of steppe and shrub communities are found, e.g. *Achillea setacea* WALDST. & KIT., *Anthericum ramosum* L., *Bupleurum falcatum* L., *Campanula bononiensis* L., *Cirsium*

*pannonicum* (L.F.) LINK, *Dactylorhiza sambucina* (L.) SOÓ, *Elymus hispidus* (OPIZ) MELDERIS, *Festuca valesiaca* SCHLEICH. ex GAUDIN, *Inula hirta* L., *Ornithogalum collinum* GUSS., *Potentilla alba* L., *Prunella grandiflora* (L.) SCHOLLER., *Tanacetum corymbosum* (L.) SCH. BIP., *Thesium linophyllum* L. and *Verbascum phoeniceum* L. The reserve was enlarged in 2016, so now it covers an area of 8.65 ha (ORDINANCE... 2016).

**2. Wooded patch** (UTM: YR14) bordering the northern edge of the “Góra Gipsowa” reserve. In spring, herbaceous bee forage plants are represented there by *Chelidonium majus* L., *Lamium album* L. and *L. purpureum* L.

**3. The “Dzierżysław” gypsum mine**, at the foot of the Góra Gipsowa (UTM: YR14). This disused mine is situated several kilometres south of Kietrz, very close to the Czech border. The site is largely overgrown by trees and shrubs. The main bee forage plant in spring is *Chelidonium majus*.

**4. Roadside**, along the road from Kietrz to the “Góra Gipsowa” reserve (UTM: YR14). Field research was conducted in a plot about 200 m long, where bee forage plants were represented in spring primarily by *Alliaria petiolata* (M. BIEB.) CAVARA & GRANDE, *Chelidonium majus*, *Lamium album* and *Taraxacum officinale* F.H. WIGG.

**5. Gully between fields** near Kietrz (UTM: YR15). The gully is about 575 m long with slopes about 3.5 m in height. It runs nearly perpendicular to the valley of the submontane River Troja, close to the farmsteads in the village of Kozłówki. The substrate of the gully slopes shows it to be the result of erosion of loess soils and to some extent of older geological structures. The slopes are partly covered by trees – *Acer pseudoplatanus* L., *Betula pendula* ROTH, *Crataegus monogyna* JACQ., *Salix* sp. and *Quercus* sp. – and shrubs – *Sarothamnus scoparius* (L.) W.D.J. KOCH, *Prunus* sp., *Rosa canina* L. and *Sambucus nigra* L. The ground layer of vegetation is dominated by grasses and other herbaceous plants, e.g. *Alliaria petiolata*, *Anthriscus* sp., *Euphorbia* sp., *Galium* sp. and *Viola* sp. In the depression at the northern end of the gully, the major bee forage plants are *Chelidonium majus* and *Lamium purpureum*. *Ranunculus illyricus* L., a species typical of xerothermic grasslands and currently critically endangered in Poland, used to be recorded at this site (WODZICZKO et al. 1948, KUŚKA 2001).

**6. Forest glade** near Kozłówki (UTM: YR15) with a patch of *Lamium purpureum* flowering abundantly in spring. It is surrounded by deciduous forest. The tree layer is dominated mainly by *Fraxinus excelsior* L. (about 60-80 years old).

#### Earlier research carried out in the “Góra Gipsowa” reserve and near Kietrz

Only four groups of insects have been relatively well studied in the “Góra Gipsowa” steppe reserve: Coleoptera (SZYMCZAKOWSKI 1965, KUŚKA 1977, 1981, 2001, 2006, 2007, MELKE & GRZYWOCZ 2002, GREŃ et al. 2015), Heteroptera (HEBDA 2002, 2004), Orthoptera (LIANA 1976) and recently wild bees Apiformes (BANASZAK et. al. 2013c,

TWERD & BANASZAK 2013). TWERD & BANASZAK (2013) perceived a probable threat to the “Góra Gipsowa” reserve: because it lies among intensively farmed arable fields, it is exposed to the agrochemicals, not always properly applied, that the owners of that land spray their crops with. The dramatic decline in the number of wild bee species and individuals in 2010 compared with 2008 was most probably due to the inappropriate use of such agrochemicals.

Among the insects of the gully between fields near Kietrz, only the coleopteran fauna has so far been explored (KUŚKA 2007). Additionally, during research on the wild bee fauna of the gully, a single specimen of an interesting heteropteran, *Tritomegas sexmaculatus* (RAMBUR, 1839), was found (SOBIERAJ-BETLIŃSKA in press). Until recently, this had been regarded as a typical xerothermophilous species, but it is being come across more and more frequently in urban areas (mainly ruderal habitats and gardens) (LIS et al. 2012).

### Methods

Earlier research in the “Góra Gipsowa” steppe reserve was carried out in the summer of 2008 (11-13 July) and 2010 (13-15 July). Wild bees were caught with an entomological net by searching on flowers and at the bees’ favourite nesting sites. In 2015, supplementary field research was done in spring using the same methods at six sites: the “Góra Gipsowa” nature reserve (5 and 7 May), the wooded patch north of the reserve (5 and 7 May), the roadside along the road from Kietrz to the “Góra Gipsowa” reserve (5 and 7 May), the gully between fields near Kietrz (8 May), the forest glade near Kozłówek (6 and 8 May) and the disused “Dzierżysław” gypsum mine (7 May). The samples were collected on dry, sunny days, with very little or no wind, between 10:00 and 17:00 hrs. Quantitative methods were not applied. The Nature Conservation Officer and Regional Director of Environmental Conservation in Opole granted the necessary permission for collecting insects in the reserve during this study. The specimens collected were preserved, labelled and identified. They are deposited in the collection of the Department of Ecology, Institute of Environmental Biology, Kazimierz Wielki University, Bydgoszcz.

The dominance of species is expressed as the percentages of a given species in the bee community. Five dominance classes are distinguished to describe various levels of the dominance index (D): eudominants ( $D_5$ ), i.e. species accounting for > 10.0% of the total catch; dominants ( $D_4$ ) 5.1–10.0%; subdominants ( $D_3$ ) 2.1–5.0%; recedents ( $D_2$ ) 1.1–2.0%; and subrecedents ( $D_1$ ) < 1.1% (KASPRZAK & NIEDBAŁA 1981).

The scientific nomenclature of the bee species is taken from OSYTSHNJUK (1977), DATHE (1980), BANASZAK (2004), MICHENER (2007) and DUBITZKY et al. (2010), while the systematic classification of families follows MICHENER (2007). Within families, the lower taxa (genera and species) are listed alphabetically. The categories of threat to bee species

are adopted after BANASZAK (2004). The legal status is based on the Regulation of the Minister of Environmental Conservation of 16 December 2016 relating to the conservation of animal species.

The zoogeographical status of the bees was determined on the basis of monographs or publications relating to particular bee families (CELARY 1990, 1995, DYLEWSKA 2000, BANASZAK et al. 2001, PESENKO et al. 2000, 2002, PAWLIKOWSKI & CELARY 2003), and also on assessments of the first author.

The nomenclature of plant species is according to MIREK et al. (2002).

## RESULTS

### **Species diversity and dominance structure of wild bees (Apiformes) in the “Góra Gipsowa” reserve and other habitats near Kietrz**

During field research in 2008, 2010, and 2015, a total of 1622 wild bee specimens were collected, representing 109 species (Table 1). Accounting for 23% of native Apiformes (BANASZAK 2004, BANASZAK et al. 2013a, WENDZONKA 2014, MOTYKA & BYSTROWSKI 2016, MOTYKA et al. 2016, PAWLIKOWSKI et al. 2016), they belong to 6 families and 32 genera.

The percentages of bee families in the total number of bee species in the study area were as follows: Colletidae (11.9%), Andrenidae (19.3%), Halictidae (18.3%), Melittidae (2.8%), Megachilidae (20.2%) and Apidae (27.5%).

The eudominants in the wild bee communities were *Anthophora plumipes* (13.9%) and *Andrena flavipes* (11.7%), while *Bombus terrestris* (7.5%) and *Nomada succincta* (5.3%) were dominants. The other taxa, classified as subdominants, recedents and subrecedents, together made up 61.7%. The percentage contributions of individual species to the total catch (excluding *Apis mellifera*) varied from 0.1 to 13.9%.

With regard to qualitative structure, the cleptoparasitic bee *Nomada succincta* and its host *Andrena nigroaenea* were dominant in the gully between fields. The partly bare, steep sides of the gully provide favourable nesting conditions for many bees. In contrast, the roadside and wooded patch in Kietrz and the forest glade near Kozłówki proved to be excellent habitats for the spring species *Anthophora plumipes*, which was abundant on flowers of *Lamium album* and *L. purpureum*. This bee species was represented by two subspecies – *A. plumipes squalens* DOURS, 1869 (light-coloured form) and *A. plumipes nigra* (FRIESE, 1896) (black form).

**Table 1.** Number of species and individuals of Apiformes in the reserve “Góra Gipsowa” and other localities near Kietrz<sup>1</sup>. Percentage of families in a community. Study plots: 1 = “Góra Gipsowa” steppe reserve, 2 = Wooded patch, 3 = “Dzierżysław” gypsum mine, 4 = Roadside, 5 = Gully between fields, 6 = Forest glade. N = total number of specimens, D = dominance [%].

No.	Species	Study plots and period of investigation						N	D	
		2008		2010		2015				
		1	2	3	4	5	6			
<b>Colletidae (11.9%)<sup>1</sup></b>										
1.	<i>Colletes cunicularius</i> (LINNAEUS, 1761)	-	-	-	-	-	-	1	1	0.1
2.	<i>Colletes fodiens</i> (FOURCROY, 1785)	14	-	-	-	-	-	-	14	0.9
3.	<i>Colletes similis</i> SCHENCK, 1853	4	-	-	-	-	-	-	4	0.2
4.	<i>Hylaeus communis</i> NYLANDER, 1852	1	-	-	-	-	-	-	1	0.1
5.	<i>Hylaeus confusus</i> NYLANDER, 1852	4	1	-	-	-	-	-	5	0.3
6.	<i>Hylaeus difformis</i> (EVERSMANN, 1852)	1	2	-	-	-	-	-	3	0.2
7.	<i>Hylaeus dilatatus</i> (KIRBY, 1802)	4	-	-	-	-	-	-	4	0.2
8.	<i>Hylaeus gibbus</i> SAUNDERS, 1850	8	3	-	-	-	-	-	11	0.7
9.	<i>Hylaeus hyalinatus</i> SMITH, 1842	7	-	-	-	-	-	-	7	0.4
10.	<i>Hylaeus leptcephalus</i> (MORAWITZ, 1871) = <i>H. bisinuatus</i> FÖRSTER, 1871	1	-	-	-	-	-	-	1	0.1
11.	<i>Hylaeus paulus</i> BRIDWELL, 1919	10	-	-	-	-	-	-	10	0.6
12.	<i>Hylaeus pectoralis</i> FÖRSTER, 1871	-	2	-	-	-	-	-	2	0.1
13.	<i>Hylaeus punctatus</i> (BRULLÉ, 1832)	1	-	-	-	-	-	-	1	0.1
<b>Andrenidae (19.3%)</b>										
14.	<i>Andrena bicolor</i> FABRICIUS, 1775	2	-	-	-	-	-	-	3	0.2
15.	<i>Andrena carantonica</i> PÉREZ, 1902 = <i>A. jakobi</i> PERKINS, 1921	-	-	-	-	-	-	2	3	0.2
16.	<i>Andrena dorsata</i> (KIRBY, 1802)	29	-	-	-	-	-	-	29	1.8
17.	<i>Andrena flavipes</i> PANZER, 1799	182	-	-	-	-	-	6	189	11.7



Table 1. Continued.

No.	Species	Study plots and period of investigation												N	D		
		2008		2010		2015		2015									
		1	2	3	4	5	6	1	2	3	4	5	6				
18.	<i>Andrena floricola</i> EVERSMAAN, 1852	4	-	-	-	-	-	-	-	-	-	-	-	-	-	4	0.2
19.	<i>Andrena fuba</i> (MÜLLER, 1766)	-	-	-	-	2	-	-	1	3	-	-	-	-	-	6	0.4
20.	<i>Andrena gravida</i> IMHOFF, 1832	-	-	9	4	-	-	-	-	6	-	-	-	-	-	19	1.2
21.	<i>Andrena haemorrhoa</i> (FABRICIUS, 1781)	4	-	2	-	-	-	-	1	6	-	-	-	-	-	13	0.8
22.	<i>Andrena helvola</i> (LINNAEUS, 1758)	-	-	-	-	-	-	1	-	5	2	-	-	-	-	8	0.5
23.	<i>Andrena minutula</i> (KIRBY, 1802)	6	-	-	-	-	-	-	-	-	-	-	-	-	6	0.4	
24.	<i>Andrena minutuloides</i> PERKINS, 1914	24	-	-	-	-	-	-	-	-	-	-	-	-	24	1.5	
25.	<i>Andrena nigroaenea</i> (KIRBY, 1802)	-	-	2	-	-	-	-	3	63	3	-	-	-	77	4.7	
26.	<i>Andrena nitida</i> (MÜLLER, 1776)	-	-	2	-	-	-	-	2	-	2	-	-	-	7	0.4	
27.	<i>Andrena propinqua</i> SCHENCK, 1853	1	-	-	-	-	-	-	-	-	-	-	-	-	1	0.1	
28.	<i>Andrena semilaevis</i> PÉREZ, 1903	3	-	-	-	-	-	-	-	-	-	-	-	-	3	0.2	
29.	<i>Andrena subopaca</i> NYLANDER, 1848	2	-	2	-	-	-	-	1	3	-	-	-	-	8	0.5	
30.	<i>Andrena vaga</i> PANZER, 1799	-	-	1	1	-	-	-	1	-	-	-	-	-	3	0.2	
31.	<i>Andrena ventralis</i> IMHOFF, 1832	-	-	-	-	-	-	-	-	1	-	-	-	-	1	0.1	
32.	<i>Andrena</i> sp. 1	-	-	-	-	-	-	-	-	1	-	-	-	-	1	0.1	
33.	<i>Andrena</i> sp. 2	-	-	-	-	-	-	-	-	1	-	-	-	-	1	0.1	
34.	<i>Panurgus calcaratus</i> (SCOPOLI, 1763)	14	-	-	-	-	-	-	-	-	-	-	-	-	14	0.9	
<b>Halictidae (18.3%)</b>																	
35.	<i>Halictus maculatus</i> SMITH, 1848	1	-	-	-	-	-	-	-	-	-	-	-	-	1	0.1	
36.	<i>Halictus rubicundus</i> (CHRIST, 1791)	2	-	-	-	-	-	-	-	-	-	-	-	-	2	0.1	
37.	<i>Halictus sexcinctus</i> (FABRICIUS, 1775)	-	1	-	-	-	-	-	-	-	-	-	-	-	1	0.1	
38.	<i>Halictus subauratus</i> (ROSSI, 1792)	10	-	-	-	-	-	-	-	-	-	-	-	-	10	0.6	
39.	<i>Halictus tumulorum</i> (LINNAEUS, 1758)	38	2	-	-	-	-	-	-	-	-	-	-	-	40	2.5	

Table 1. Continued.

No.	Species	Study plots and period of investigation										N	D
		2008		2010		2015		2015					
		1	2	3	4	5	6	7	8	9	10		
40.	<i>Lasioglossum calceatum</i> (SCOPOLI, 1763)	11	4	-	-	-	-	-	-	3	-	18	1.1
41.	<i>Lasioglossum laiceps</i> (SCHENCK, 1869)	-	-	-	-	-	-	-	-	4	-	4	0.2
42.	<i>Lasioglossum morio</i> (FABRICIUS, 1793)	1	-	-	-	-	-	-	-	-	-	1	0.1
43.	<i>Lasioglossum nigripes</i> (LEPELETIER, 1841)	1	-	-	-	-	-	-	-	-	-	1	0.1
44.	<i>Lasioglossum pauxillum</i> (SCHENCK, 1853)	77	2	1	-	-	-	-	-	-	1	81	5.0
45.	<i>Lasioglossum quadrimotatum</i> (KIRBY, 1802)	2	-	-	-	-	-	-	-	-	-	2	0.1
46.	<i>Lasioglossum sexnotatum</i> (KIRBY, 1802)	2	-	-	-	-	-	-	-	-	-	2	0.1
47.	<i>Lasioglossum xanthopus</i> (KIRBY, 1802)	4	-	-	-	-	-	-	-	-	-	4	0.2
48.	<i>Lasioglossum zonulum</i> (SMITH, 1848)	2	-	-	-	-	-	-	-	-	-	2	0.1
49.	<i>Rhopitoides canus</i> (EVERSMANN, 1852)	5	2	-	-	-	-	-	-	-	-	7	0.4
50.	<i>Rophites quinquespinosus</i> SPINOLA, 1808	19	1	-	-	-	-	-	-	-	-	20	1.2
51.	<i>Sphécodes albilabris</i> (FABRICIUS, 1793)	1	-	-	-	-	-	-	-	-	-	1	0.1
52.	<i>Sphécodes ferruginatus</i> HAGENS, 1882	-	-	-	-	-	-	-	-	1	-	1	0.1
53.	<i>Sphécodes monilicornis</i> (KIRBY, 1802)	1	-	-	-	-	-	-	-	-	-	1	0.1
54.	<i>Systropha curvicornis</i> (SCOPOLI, 1770)	6	-	-	-	-	-	-	-	-	-	6	0.4
<b>Melittidae (2.8%)</b>													
55.	<i>Dasygaster hirtipes</i> (FABRICIUS, 1793)	30	-	-	-	-	-	-	-	-	-	30	1.8
56.	<i>Macropis europaea</i> WARNCKE, 1973	52	-	-	-	-	-	-	-	-	-	52	3.2
57.	<i>Melitta leporina</i> (PANZER, 1799)	7	-	-	-	-	-	-	-	-	-	7	0.4
<b>Megachilidae (20.2%)</b>													
58.	<i>Anthidium strigatum</i> (PANZER, 1805)	21	8	-	-	-	-	-	-	-	-	29	1.8
59.	<i>Anthidium manicatum</i> (LINNAEUS, 1758)	8	1	-	-	-	-	-	-	-	-	9	0.6
60.	<i>Anthidium punctatum</i> LATREILLE, 1809	2	-	-	-	-	-	-	-	-	-	2	0.1

Table 1. Continued.

No.	Species	Study plots and period of investigation						N	D
		2008		2010		2015			
		1	2	3	4	5	6		
61.	<i>Chelostoma florissome</i> (LINNAEUS, 1758)	-	-	-	-	-	1	0.1	
62.	<i>Coelioxys alata</i> FÖRSTER, 1853	1	-	-	-	-	-	0.1	
63.	<i>Coelioxys elongata</i> LEPELETIER, 1841	1	-	-	-	-	-	0.1	
64.	<i>Coelioxys internis</i> (KIRBY, 1802)	1	-	-	-	-	-	0.1	
65.	<i>Coelioxys quadridentata</i> (LINNAEUS, 1758)	3	-	-	-	-	3	0.2	
66.	<i>Coelioxys rufescens</i> LEPELETIER & SERVILLE, 1825	2	-	-	-	-	2	0.1	
67.	<i>Heriades rrunconum</i> (LINNAEUS, 1758)	1	-	-	-	-	-	0.1	
68.	<i>Hoplitis anthocopoides</i> (SCHENCK, 1853)	1	-	-	-	-	-	0.1	
69.	<i>Hoplitis claviventris</i> (THOMSON, 1872)	1	-	-	-	-	-	0.1	
70.	<i>Hoplitis leucomelana</i> (KIRBY, 1802)	3	5	-	-	-	8	0.5	
71.	<i>Hoplosmia spinulosa</i> (KIRBY, 1802)	4	-	-	-	-	4	0.2	
72.	<i>Megachile alpicola</i> ALFKEN, 1924	1	-	-	-	-	-	0.1	
73.	<i>Megachile centuncularis</i> (LINNAEUS, 1758)	3	-	-	-	-	3	0.2	
74.	<i>Megachile ericetorum</i> (LEPELETIER, 1841)	1	-	-	-	-	-	0.1	
75.	<i>Megachile rotundata</i> (FABRICIUS, 1784)	1	-	-	-	-	1	0.1	
76.	<i>Megachile versicolor</i> SMITH, 1844	12	2	-	-	-	14	0.9	
77.	<i>Megachile willughbiella</i> (KIRBY, 1802)	1	-	-	-	-	-	0.1	
78.	<i>Osmia bicornis</i> (LINNAEUS, 1758) = <i>O. rufa</i> (LINNAEUS, 1758)	-	-	1	-	-	2	0.2	
79.	<i>Osmia caerulescens</i> (LINNAEUS, 1758)	2	-	-	-	-	-	0.1	
<b>Apidae (27.5%)</b>									
80.	<i>Ammobates punctatus</i> (FABRICIUS, 1804)	1	-	-	-	-	-	1	0.1
81.	<i>Anthophora bimaculata</i> (PANZER, 1798)	7	-	-	-	-	-	7	0.4

Table 1. Continued.

No.	Species	Study plots and period of investigation												N	D			
		2008		2010		2015		2015										
		1	2	3	4	5	6	1	2	3	4	5	6					
82.	<i>Anthophora plumipes squalens</i> DOURS, 1869	-	-	16	47	2	88	10	56	226	13.9							
	<i>Anthophora plumipes nigra</i> (FRIESE, 1896)	-	-	-	1	-	6	-	-	7								
83.	<i>Bombus bohemicus</i> (SEIDL, 1837)	1	-	-	-	-	1	1	-	3	0.2							
84.	<i>Bombus cryptarum</i> FABRICIUS, 1775	7	-	-	-	-	-	-	-	7	0.4							
85.	<i>Bombus hortorum</i> (LINNAEUS, 1761)	3	4	5	7	-	5	-	23	47	2.9							
86.	<i>Bombus humilis</i> ILLIGER, 1806	1	-	-	-	-	-	-	-	1	0.1							
87.	<i>Bombus hypnorum</i> (LINNAEUS, 1758)	7	-	-	-	-	-	-	-	7	0.4							
88.	<i>Bombus lapidarius</i> (LINNAEUS, 1758)	2	-	3	3	1	10	-	-	19	1.2							
89.	<i>Bombus lucorum</i> (LINNAEUS, 1761)	37	18	-	-	-	-	-	-	55	3.4							
90.	<i>Bombus muscorum</i> (LINNAEUS, 1758)	7	-	-	-	-	-	-	-	7	0.4							
91.	<i>Bombus pascuorum</i> (SCOPOLI, 1763)	25	12	5	8	-	3	1	12	66	4.1							
92.	<i>Bombus pratorum</i> (LINNAEUS, 1761)	5	1	1	8	2	2	4	2	25	1.5							
93.	<i>Bombus ruderarius</i> (MÜLLER, 1776)	1	-	2	4	-	2	-	1	10	0.6							
94.	<i>Bombus sylvorum</i> (LINNAEUS, 1761)	10	1	1	1	-	1	-	-	14	0.9							
95.	<i>Bombus terrestris</i> (LINNAEUS, 1758)	54	22	5	5	-	33	2	-	121	7.5							
96.	<i>Bombus vestalis</i> (GEOFFROY in FOURCROY, 1785)	-	1	-	-	-	-	-	-	1	0.1							
97.	<i>Ceratina cyanea</i> (KIRBY, 1802)	8	-	-	-	-	-	-	-	8	0.5							
98.	<i>Epeolus variegatus</i> (LINNAEUS, 1758)	10	-	-	-	-	-	-	-	10	0.6							
99.	<i>Nomada bifasciata</i> OLIVIER, 1811	-	-	-	-	-	1	3	-	4	0.2							
100.	<i>Nomada flava</i> PANZER, 1798	-	-	2	-	-	-	3	1	6	0.4							
101.	<i>Nomada flavoguttata</i> (KIRBY, 1802)	1	-	-	-	-	-	-	-	1	0.1							
102.	<i>Nomada flavopicta</i> (KIRBY, 1802)	1	-	-	-	-	-	-	-	1	0.1							
103.	<i>Nomada fucata</i> PANZER, 1798	1	-	-	-	-	-	-	-	1	0.1							

Table 1. Continued.

No.	Species	Study plots and period of investigation											N	D			
		2008		2010		2015		2015									
		1	2	3	4	5	6	1	2	3	4	5			6		
104.	<i>Nomada marshamella</i> (KIRBY, 1802)	-	-	-	-	-	-	-	-	-	-	-	-	8	-	8	0.5
105.	<i>Nomada ruficornis</i> (LINNAEUS, 1758)	-	-	-	1	-	-	-	1	4	-	-	-	6	-	6	0.4
106.	<i>Nomada signata</i> JURINE, 1807	-	-	-	-	1	1	1	-	-	-	-	-	2	-	2	0.1
107.	<i>Nomada succincta</i> PANZER, 1798	-	-	-	1	-	-	1	1	82	1	1	1	96	1	96	5.3
108.	<i>Nomada strigata</i> FABRICIUS, 1793	-	-	-	-	-	-	1	-	1	1	-	3	3	3	3	0.2
109.	<i>Nomada zonata</i> PANZER, 1798	-	-	-	-	-	-	-	-	1	-	-	1	1	1	1	0.1
110.	<i>Apis mellifera</i> LINNAEUS, 1758	+	+	+	+	+	+	-	-	-	-	+	+	+	+	+	+
<b>Number of individuals</b>		<b>857</b>	<b>96</b>	<b>62</b>	<b>62</b>	<b>95</b>	<b>9</b>	<b>163</b>	<b>231</b>	<b>109</b>	<b>109</b>	<b>163</b>	<b>231</b>	<b>109</b>	<b>1622</b>	<b>100.0</b>	
<b>Number of species (without <i>Apis mellifera</i>)</b>		<b>80</b>	<b>21</b>	<b>19</b>	<b>19</b>	<b>15</b>	<b>7</b>	<b>18</b>	<b>26</b>	<b>15</b>	<b>15</b>	<b>7</b>	<b>18</b>	<b>26</b>	<b>15</b>	<b>-</b>	<b>-</b>

Ten of the 109 bee species recorded in the “Góra Gipsowa” reserve and other habitats near Kietrz are threatened (BANASZAK 2004); another twelve are partly protected by law in Poland (Regulation 2016). *Andrena semilaevis* and *Hylaeus punctatus* are vulnerable species (VU), while eight species – *Ammobates punctatus*, *Coelioxys alata*, *Lasioglossum nigripes*, *Hylaeus leptocephalus*, *H. paulus*, *H. pectoralis*, *Nomada bifasciata* and *Systropha curvicornis* – are classified as data deficient (DD) (BANASZAK 2004). In the study area, we recorded several species that are rare or very rare in Poland; they are briefly discussed below.

For a long time *Hylaeus paulus* was misidentified as *H. gracilicornis*. The former represents the Euro-Siberian element and has been reported from Austria, Germany, Poland, Switzerland, Mongolia, Siberia, the Russian Far East and Japan (CELARY 1999). In Poland it has been recorded in several localities: Rogaczewo near Kościanin Wielkopolska Province (BANASZAK 2000); Bolesław and Trzebnów in the Kraków-Częstochowa Upland (CELARY 1999); Osicze and Miotelka in the Ojców National Park (Kraków-Częstochowa Upland) (CELARY & WIŚNIEWSKI 2001); Bydgoszcz (leg. J. BANASZAK 2002), the vicinity of Szubin-Folusz (BANASZAK 2004) in the Wielkopolska-Kujawy Lowland; and Wejsuny on Lake Warnoły in Mazuria (BANASZAK 2010).

*Ammobates punctatus* is a very rare cleptoparasitic bee with a range in North Africa (Algeria) and in southern and central Europe. Females of this species lay their eggs in nests of *Anthophora bimaculata* (CELARY 1990). It has been recorded in various parts of Poland.

*Systropha curvicornis*, classified as a Western Palaearctic species (PESENKO et al. 2000), has been recorded in several localities in Poland in the last 24 years (KOWALCZYK 1997, KOWALCZYK et al. 2009ab, WIŚNIEWSKI & PIOTROWSKI 2013).

#### **Comparison of lists of southern species on either side of the Moravian Gate**

Southern species accounted for 16.5% (18 species) of the total number of species collected in the “Góra Gipsowa” reserve and the other habitats near Kietrz. This group includes *Hylaeus difformis*, *H. leptocephalus*, *H. paulus*, *H. punctatus*, *Andrena flavipes*, *A. floricola*, *A. propinqua*, *Rhophitoides canus*, *Rophites quinquespinosus*, *Halictus sexcinctus*, *Lasioglossum nigripes*, *L. pauxillum*, *L. quadrinotatum*, *Sphcodes ferruginatus*, *Anthidiellum strigatum*, *Megachile rotundata*, *Nomada bifasciata* and *N. zonata*.

Among the southern species found in the “Góra Gipsowa” reserve and the other habitats near Kietrz, *Hylaeus punctatus* could have used the Moravian Gate as a migration route to Poland. *H. punctatus* is a sub-Ponto-Mediterranean species that has reached Central Europe. Present in all parts of Poland, it has been observed primarily at sunny sites. It may also have migrated to Poland from the west.

*Lasioglossum nigripes* is a Ponto-Mediterranean species. Infrequent in Poland, it has been reported from Wrocław (DITTRICH 1903), Sandomierz and Kazimierz Dolny (DYLEWSKA & NOSKIEWICZ 1963), Góry Pieprzowe (NOSKIEWICZ 1959, DYLEWSKA & NOSKIEWICZ 1963) and the “Zbocza Płutowskie” reserve (BANASZAK 1980). The species used to be common in the Podolia region (KUNTZE & NOSKIEWICZ 1938), so it will have migrated to Poland from there, but the localities in Wrocław and the “Góra Gipsowa” reserve support the hypothesis about the independent expansion of this species from Thuringia and Saxony. As this species lives in Bohemia, Moravia and Slovakia (STRAKA et al. 2007), it could also have migrated to Poland from the south through the Moravian Gate.

*Sphecodes cristatus* has not been recorded in the “Góra Gipsowa” reserve or in the other habitats near Kietrz, but its migration to Poland from the south through the Moravian Gate is probable. The range of *S. cristatus* lies in the southern temperate zone of the Western Palearctic. A very rare species, it is known in most countries from just a few records (BOGUSCH & STRAKA 2012). In Poland it has so far been recorded in the Mazovian Lowland (Dziewanów Polski, Łowicz), the Małopolska Upland (“Góry Pieprzowe”), Lower Silesia (Wrocław) (PESENKO et al. 2002) and the Kraków-Częstochowa Upland (Klucze, Olsztyn) (CELARY 2000). It has also been reported from Moravia and Slovakia (STRAKA et al. 2007) and recently even from Bohemia (STRAKA et al. 2015).

No bee species has been recorded in Lower Silesia in recent times which could provide incontrovertible evidence that southern bee species currently use the Moravian Gate as a migration route.

**Table 2.** Numbers and percentage of southern species in bee communities (Apiformes) of selected xerothermic habitats. 1 = LUKÁŠ 1987 (“Trenčianska Skalka”, W Slovakia); 2 = LUKÁŠ 1983 (“Turecko” reserve, W Slovakia); 3 = PŘIDAL & VESELÝ 2011 (“Mohelno Serpentine Steppe” national nature reserve, Czech Republic: SW Moravia); 4 = this study.

Index	Location			
	1	2	3	4
Total number of species	213	146	175	109
Number of southern species	79	36	34	18
Percentage of southern species	37.1	24.7	19.4	16.5

A comparison of the percentages of southern species to the bee communities (Apiformes) in the “Góra Gipsowa” reserve and the nearby habitats with patches of xerothermic vegetation in the Czech Republic and Slovakia shows that they were conspicuously smaller in our study (Table 2). The species diversity of thermophilous bees

was the highest in five selected biotopes in the “Trenčianska Skalka” conurbation around the city of Trenčín (W Slovakia) (79 species, LUKÁŠ 1987) and in the “Turecko” nature reserve (about 19 km SW of Trenčín) (36 species, LUKÁŠ 1983). 34 thermophilous species were found in the “Mohelno Serpentine Steppe” national nature reserve (Czech Republic: SW Moravia) (PŘIDAL & VESELÝ 2011).

## DISCUSSION

This study complements our earlier research on wild bees in the xerothermic vegetation of the “Góra Gipsowa” reserve and other habitats near Kietrz. Some of our earlier results have already been published (BANASZAK et al. 2013c, TWERD & BANASZAK 2013). The aim of this paper was to assess the role of the Moravian Gate as a migration route of southern species to Poland. 109 wild bee species of 6 families were collected in the study area, accounting for about 23% of the total number of bee species in Poland. This is a relatively large number, considering the small size of the study sites.

Compared with the bee fauna of Poland as a whole (BANASZAK 2004, BANASZAK et al. 2013a, WENDZONKA 2014, MOTYKA & BYSTROWSKI 2016, MOTYKA et al. 2016, PAWLIKOWSKI et al. 2016), the percentages of species from 4 bee families (Apidae, Colletidae, Megachilidae, Melittidae) were higher in this study. The Megachilidae are a very specialized group, and the high number of species from this family indicates that the nature reserve and its vicinity, despite the strong human impact they are subjected to, have preserved their natural value.

The “Góra Gipsowa” reserve and the other habitats near Kietrz are situated very close to the southern border of Poland, about 50 km from Hranice in the Czech Republic, in the narrowest part of the Moravian Gate, which appears to allow insects to use this migration route. There are limestone outcrops in Hranice and at Štramberk, several kilometres north of the town (KUŠKA 2001, 2006). The geographical location of study area offers an opportunity for the dispersal of thermophilous bee species from south to north, i.e. to Poland. However, in view of the lack of earlier data on the bee fauna of the “Góra Gipsowa” reserve and the other habitats near Kietrz, it is difficult to assess the scale of changes in the bee communities of the study area. One can only assume that such changes are basically associated with habitat transformations (MAZUR & KUBISZ 2000, BANASZAK et al. 2010). The succession of plants in thermophilous vegetation reserves has always led to conspicuous changes in the species composition of wild bees (BANASZAK et al. 1998, 2003, CIERZNIAK et al. 2005). The successive degradation of the “Góra Gipsowa” reserve has certainly wrought changes in the composition of its insect fauna. We would expect a smaller number of species of highly specialized bees, with a narrow ecological tolerance,



and of species that are incapable of long migrations (BANASZAK et al. 2013c). Following research on coleopterans, KUŚKA (2006, 2007) stated that 8 taxa had probably disappeared, confirming the substantial impoverishment of the habitat.

The species diversity of wild bees in the “Góra Gipsowa” reserve (94 species in an area of 1.72 ha) can be compared with those of habitat islands surrounded by meadows: the proposed “Folusz” nature reserve near Szubin (88 species on about 3 ha) (BANASZAK et al. 2004), the “Ostrów Małe Rudy” near Bydgoszcz (107 species in an area of about 6 ha) (BANASZAK et al. 2013b), and arable fields near Poznań and Turew (14-51 species in plots covering 0.23 to 0.5 ha) (BANASZAK & CIERZNIAK 2002). It is evident that island size increases bee species diversity to a small extent. Habitat islands in the agricultural landscape near Turew and Poznań have far fewer species than islands in semi-natural habitats. In spite of its small size and location very close to intensively farmed fields, the “Góra Gipsowa” reserve has been shown to support a similar number of bee species to the proposed “Folusz” reserve.

The Kietrz region, along with the “Góra Gipsowa” reserve, is colonized by a relatively small number of species with southerly distribution ranges. Of course, this may be due to the low intensity of research there. Analysis of their distribution in Poland indicates that some of them (*Hylaeus punctatus*, *Lasioglossum nigripes*) have migrated to the study area from other directions, i.e. from the east and west. The attempt in this study to assess the role of the Moravian Gate as a migration route of southern species to Poland from the Danube catchment area suggests that it plays a relatively small role. This is consistent with the results of earlier research on orthopterans (LIANA 1976), heteropterans (HEBDA 2002) and beetles (KUŚKA 1977, 1981, 2001, 2006, 2007).

Another issue is the condition of the fauna of the reserve and its vicinity before intensive farming was started in this region and before livestock grazing was banned in the reserve. German researchers (KEILHOLZ 1927) reported large proportions of southern species, and some zoologists may have been inspired by the logical association of the areas on either side of the Carpathians and Sudetens. A different and interesting opinion was cited by KOZŁOWSKA (1936), who suggested that in comparison to the neighbouring Moravia, the fauna of the Cieszyn Foothills contained only species and whole communities associated with a more or less humid climate. In spite of the favourable substrate, we did not record in the study area any typical steppe species of Apiformes, genetically linked with south-eastern Europe and central Asia. The steppe communities in the southern part of the Moravian Gate remain separate. The line of contact between the Carpathians and the Sudetens between Cieszyn and Brno is the barrier that prevented the northward migration of steppe plants. As KUŚKA (2001) emphasized, there are no xerothermic habitats along the humid valley of the Oder from the river head in the Oderské Vrchy Mountains to the frontier with Poland. This contrasts with the striking richness in southern species on the

south sides of the Carpathians and Sudetens (LUKÁŠ 1983, 1987, PŘIDAL & VESELÝ 2011). The “Trenčianska Skalka”, the “Turecko” nature reserve and the “Mohelno Serpentine Steppe” national nature reserve all lie farther south than Lower Silesia. Some of the species mentioned here have thermal limits. Thermophilous species recorded in the “Mohelno Serpentine Steppe” probably have a considerable migration capability because this habitat lies at an elevation of 400 m.

The results of this study appear to indicate that at present the Moravian Gate does not play any part in the migration of southern bee species to Poland. To confirm these remarks, however, further research is needed in the “Góra Gipsowa” reserve and other the habitats near Kietrz.

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