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REVIEW ARTICLE

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Xylocopa valga Gerst. (Hymenoptera: Apidae) in Poland

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Abstract. In this article, we review the distribution and new data on the occurrence of *Xylocopa valga* Gerst. (Hymenoptera: Apidae) in Poland. This is also the first report of *X. valga* occurring in the Białowieża Forest, where it was captured visiting flowers of *Lychnis flos-cuculi* L. in a sandy grassland adjacent to the forest in the vicinity of Grudki, a small village near Białowieża. All 15 known records of this species in Poland are compiled into a detailed list, and the location of each sighting is presented on the map. In two cases, the known distributional data have been corrected and were brought up to date. The first case is a forgotten record of the species (Popov 1947) that was reconstructed based on museum specimens collected in the 1870s at Karolath, Silesia (formerly Germany, currently Poland: locality now named Siedlisko), and this record was added to the list. However, the second case concerns a record from Tuchla near Jarosław (Banaszak 1989), which was excluded from the list because it had been published as a result of misinterpretation of the label on the old museum specimens. Information on the species' biology, especially on the preferred habitats and nesting in dead wood, are also presented. *X. valga* is regarded as a saproxylic species occurring in forests, but its ability to inhabit the steppe zone is also discussed in this article. Furthermore, a list of flowering plants (95 species representing 30 families) visited by this bee species has been prepared based on the data from the literature as well as our own observations. The new record of *X. valga* in the Białowieża Forest in combination with the recent data from Western Europe suggests that this subpontic-mediterranean species is expanding its natural range probably due to climate change. We are thus also discussing its potential to spread further north.

Keywords: *Xylocopa valga*, Apidae, Białowieża Forest, Poland, geographical distribution, biology

1. Introduction

In Poland's fauna, the genus *Xylocopa* Latreille, 1802, of the family Apidae is represented by two rarely observed southern species: the common carpenter bee *Xylocopa valga* Gerstaecker, 1872, and the violet carpenter bee *Xylocopa violacea* (Linnaeus, 1758). Both species resemble the commonly known bumblebees (*Bombus*) in terms of the external appearance and body size (20–28 mm in length). However, the carpenter bees are less hairy and much darker – their entire body is black and shiny, and the wings are dark-brown with violaceous gloss. Carpenter bee males are easy to distinguish under field conditions: in *X. violacea*, antenna segments 11 and 12 are orange and the segment 13 (apical) is black and characteristically curved, whereas *X. valga* males have black straight antennae. A stereoscopic microscope is needed to study females of both carpenter bee species. Their antennae differ with regard to the length of the base segment (shorter in *X. valga*) as well as the number and distribution of sharp minute denticles on the exterior surface of hind tibia (more numerous in *X. valga*).

The northern limits of ranges of the two carpenter bee species run through Poland. In eastern and central parts of Europe, including Poland, *X. valga* is more often recorded than *X. violacea*, and its localities are extended further north. Information on the distribution of carpenter bees in Poland is sparse and mostly dates back more than a few decades. The aim of the present study was to update, verify and organise data on distribution and biology of *X. valga* in Poland as well as to discuss the questions on the northern range limit of this species in Europe.

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2. *Xylocopa valga* in the Białowieża Primeval Forest

In Poland's part of the Białowieża Primeval Forest, 181 species of bees (Apoidea) that represent all the bee families occurring in the country, such as Andrenidae, Apidae, Colletidae, Halictidae, Megachilidae and Melittidae, have been so far found (Banaszak, Jaroszewicz 2009). The genus *Xylocopa* has not yet been recorded in the Białowieża region. Not long ago, there was signalled *X. valga* incidence in the Belarusian part of the Białowieża Forest (Prišepčik 2006); however, this information requires confirmation as the published data was very poorly documented.

An individual *X. valga* male was captured on 13 June 2015, nearby the village Grudki (situated in the vicinity of the well-known village Białowieża) (FD84; 52˚41'04.7"N; 23˚47'58.3"E), on Ragged Robin (*Lychnis flos-cuculi* L.) inflorescence, growing on an arenaceous grassland along an inactive railway line. The grassland is situated north of the trackway and forms approximately 30-m-wide stripe, located latitudinal next to a Scots pine–Norway spruce forest stand, with oak and birch as admixtures (Fig. 1). Alongside the grassland, there runs a power line. On the south side, not far from railway track embankments, there extends a forest stand with dominant Norway spruce in the species composition and alone Scots pine and birch trees. The grassland was not studied using phytosociological methods. Plant species composition was determined based on the quantitative evaluations of the shares of individual plant species. The grassland was evaluated as floristically poor. There dominate grasses such as common bent (*Agrostis capillaris* L.), red fescue (*Festuca rubra* L.) and common windgrass (*Apera spica-venti* (L.) P. Beauv.), and the less frequent are Timothy-grass (*Phleum pratense* L.), cat grass (*Dactylis glomerata* L.), couch grass (*Agropyron repens* (L.) P. Beauv.) and bushgrass (*Calamagrostis epigejos* (L.) Roth.). Other plant families are represented by dominants such as silver cinquefoil (*Potentilla argentea* L.), field wormwood (*Artemisia campestris* L.), common yarrow (*Achillea millefolium* L.) and mountain-parsley (*Peucedanum oreoselinum* (L.) Moench.). Less frequently there occur red clover (*Trifolium pratense* L.), bird vetch (*Vicia cracca* L.), purple crown vetch (*Coronilla varia* L.), St John's wort (*Hypericum perforatum* L.), common sorrel (*Rumex acetosa* L.), hairy sedge (*Carex hirta* L.), bird's-foot trefoil (*Lotus corniculatus* L.), white campion (*Melandrium album* (Mill.) Garcke), hoary alyssum (*Berteroa incana* (L.) Dc.), common starwort (*Stellaria graminea* L.), catsear (*Hypochoeris radicata* L.) and the above-mentioned Ragged Robin. On the railway track embankment and around, there grow bloody geranium (*Geranium sanguineum* L.), woodland strawberry (*Fragaria vesca* L.), goldmoss stonecrop (*Sedum acre* L.), wild thyme (*Thymus serpyllum* L. em. Fr.), maiden pink (*Dianthus deltoides* L.), dropwort (*Filipendula vulgaris* Moench), maidenstears (*Silene vulgaris* (Moench) Garcke), yellow bedstraw (*Galium verum* L.), hedge bedstraw (*Galium mollugo* L.), field scabious (*Knautia arvensis* (L.) J. M. Coult.) and sticklewort (*Agrimonia eupatoria* L.) and also several young self-sown trees, such as pedunculate oak (*Quercus robur* L.), Norway spruce (*Picea abies* (L.) H. Karst.), Scots pine (*Pinus sylvestris* L.), common aspen (*Populus tremula* L.) and wild pear (*Pyrus pyraster* Burgsd.).

The evidence carpenter bee specimen is deposited in the collection of the Museum and Institute of Zoology of the Polish Academy of Sciences in Warsaw.

Photo 1. Place of discovery of *Xylocopa valga* in the Białowieża Forest (vicinity of the village of Grudki) (photo by J.M. Gutowski)

3. Species distribution in Europe and Poland

Xylocopa valga is a subpontic and Mediterranean species with a wide range – from the Iberian Peninsula and Morocco in the west to the central parts of Mongolia and China in the east and from the south-eastern coast of the Baltic Sea in the north to the Persian Gulf in the south. Its northern range limit that was scrupulously described by Popov (1947) has been recently revised because of the discovery of several new sites inhabited by this species in the western parts of Europe. As a result, species range limit expanded towards the north. New *X. valga* localities were found in France – in Alsace (Treiber 2015) and Picardy stretching north of the Paris Basin (Terzo et al. 2007) – and also in Germany – in Baden-Württemberg (Schmid-Egger, Doczkal 2012; Treiber 2015). Additionally, one specimen (a smashed female) was found in Brussels, yet, the latter is regarded as human-induced extension from the south (introduction with imported timber) (Terzo et al. 2007). There remains undecided the origin of one severely damaged *X. valga* female, which was found nearby the road in south-eastern Saxony (Germany), close to the border between Czech Republic and Poland. This specimen does not confirm the existence of a local *X. valga* population because it could be introduced from its relatively close sites located in Moravia or northern Austria (Franke 2006; Schmid-Egger, Doczkal 2012).

The current *X. valga* range limit shifted to the south in Europe's eastern parts, where in the 1920s and 1930s, there were recorded numerous localities of this species – situated along the Baltic Sea coast, that is, from Vilnius in Lithuania through Jelgava in Latvia to St. Petersburg and Lake Ladoga banks in Russia. The species has not been recorded in Lithuania and Latvia for years. In Belarus, it is observed only in the southern regions, despite the fact that only a few decades ago, it used to be found all over the country (Prišepčik 2006). In the collection of the Museum and Institute of Zoology of the Polish Academy of Sciences in Warsaw, one male specimen from that period of time has been preserved. It was captured in the cemetery in Szczuczyn (near Grodno, Belarus) by R. Bielawski in 1945. Prišepčik (2006) reports that in Belarus, for the past 20 years, *X. valga* has been found only twice: in 'Pripjatskij' National Park and Belarusian part of the Białowieża Primeval Forest. Alas, no detailed information has been provided by the author.

In Poland, *X. valga* is regarded as a very rare species, known thus far only from several localities. It is under strict protection and placed on the Polish Red List of Animals as a critically endangered species (CR).

Distribution of *X. valga* in Poland was studied and described by Banaszak (1979, 2004). The author published a list of localities of this species, which was prepared based on the data in faunistic publications as well as, for the first time, on the information from labels of specimens captured a long time ago and preserved in various museum collections. Nonetheless, the published list is not complete and thus requires revision and needs to be supplemented.

To begin with, the list of *X. valga* localities in Poland should be expanded by a disregarded sighting within the present-day territory of Poland, which was referred to by Popov (1947). The author described wide-ranging expansion of *X. valga* and informed that in the second half of the 1800s, this species also occurred in south-eastern Germany, which is evidenced by two female specimens preserved in the collection of the Zoological Museum of the Soviet Union Academy of Sciences in Leningrad (now the Zoology Institute of Russian Academy of Sciences in St. Petersburg). The two specimens collected by A. Müller in the village Karolath in Silesia (now south-western Poland) were bought by this Museum in 1873 in a well-known entomological company owned by Otto Staudinger. Now, the name of the village is Siedlisko, and it is the seat of the administrative district (gmina) in the Nowa Sól County, Lubuskie Province (western Poland). In the classification of the zoogeographic regions in the 'Catalogue of Polish Fauna', this area is placed in Wielkopolska-Kujawy Lowland, and not in Lower Silesia. It should be noted that the aforesaid *X. valga* isolated locality was not known to German entomologists who worked in Silesia at the end of the 1800s and the beginning of the 1900s. In the wide list of Silesian bee species prepared by Dittrich (1903), *X. valga* was reported from just one locality, that is, the village Odra (Odrau), situated in the Czech lands. This information was originally provided by a local entomologist Adolf Ducke, who observed *X. valga* in home gardens, on common laburnum (*Laburnum anagyroides* Medik. =*Cytisus laburnum*), in the years 1892 and 1898 (Ducke 1898, 1900). Such reports are worth recalling in view of the fact that they contain forgotten historical data on *X. valga* visiting common laburnum flowers.

At the same time, there should be corrected information on the locality of *X. valga* specimens found in the collection of Edward Lubicz-Niezabitowski, deposited at the Department of Agricultural and Forest Biology, Polish Academy of Sciences, Poznań (Banaszak 1979, 1989). There is preserved a couple of carpenter bee specimens from the village Tuchla. The specimens are briefly labelled, and no data is available on when and by whom they were captured. The female's label provides information on the site, and male's label says: 25 May, but no year is provided. According to Banaszak (1979), the specimens were captured most probably at the end of the 1800s or at the beginning of the 1900s. The name 'Tuchla' was interpreted by this author as the village Tuchla situated by the city Jarosław (south-eastern Poland) (Banaszak 1989), earlier incorrectly reported as 'Tuhla' by Jarosław (Banaszak 1979). In our view, the period of capturing does not raise any doubts; however, the interpretation of the locality name is mistaken: *X. valga* specimens from the Niezabitowski's collection were certainly found

in the village Tuchla situated in the east parts of the Beskid Mts. (now Ukraine), which were often visited by entomologists from Kraków (Rybiński, Lgocki), in the 1800s/1900s and not from entomologically unknown Tuchla in the former Radymno County (now Jarosław County). Most probably, carpenter bee specimens were captured accidentally by Michał Rybiński, a coleopterist and the curator of the Museum of the Physiographic Commission of the Kraków Scientific Society. In his publication on Galicia (Eastern Europe) beetles (Rybiński 1903), the author reported staying, amongst others, in the village Tuchla by the river Opór during his three expeditions to Chornohora in 1897–1903, undertaken as instructed by the Physiographic Commission. In this very publication, the date '25.V.' (without the year) is placed several times by beetle specimens found in the village Tuchla – the same type of information as that on the label attached to *X. valga* male from the Niezabitowski's collection. Hence, the village Tuchla by Jarosław should be removed from the list of *X. valga* localities in Poland. Likewise, the city Jarosław reported by Ruszkowski et al. (1997) should also be removed, because the latter only represents the generalised description of the locality: 'Tuchla next to Jarosław'.

The list of statements concerning *X. valga* localities within Poland's territory is as follows (chronological order; Fig. 2):

1. Siedlisko (Carolath/Karolath) [UTM grid square: WT53], 2♀, about 1870, leg. (collected by) A. Müller (Popov 1947).

2. Warszawa [EC08], 1♀, no date of collection (Popov 1947). Most probably, the specimen was captured at the beginning of the 1900s. Newer, but not detailed information on the finding of the carpenter bee by M. Lipiński in the Warsaw Botanical Garden (in the 1960s or the 1970s) as reported by Ruszkowski et al. (1997) cannot be treated as confirmation of *X. valga* occurrence in Warsaw, because the report specifies no carpenter bee species.

3. Krasnobród, vicinity [FB50], no information about specimens and the date of capturing, leg. Fudakowski (Kuntze, Noskiewicz 1938). In the article on Chrysidoidea, Fudakowski (1920) provides information that in the years 1915 and 1919, he collected materials in Krasnobród (south-eastern Poland), and undoubtedly, then there was observed *X. valga*. This locality (the only in Poland's part of Roztocze) was indisputably taken as a basis to regard *X. valga* as the species characteristic for the region, arriving here from Podole and Wołyń (Stravinskij 1958).

4. Kielce [DB73], 20 VII 1924, 1♀, coll. J. Isaak (Banaszak 1979).

5. Końskowola [EB79], 1♀, 1926, coll. J. Noskiewicz (Banaszak 1979).

6. Zawiercie [CA89], 18 V 1929, 1♀, coll. J. Isaak (Banaszak 1979).

7. Opole Lubelskie [EB66], 1♀, VII 1930, leg. Nieniewski (Banaszak 2004). This specimen is preserved in the Museum and Institute of Zoology and comes from the collection of a lepidopterist E. Świderski.

8. Przemyśl, Zasanie [FA21], 1 specimen, V 1950 (Krysiński 1957).

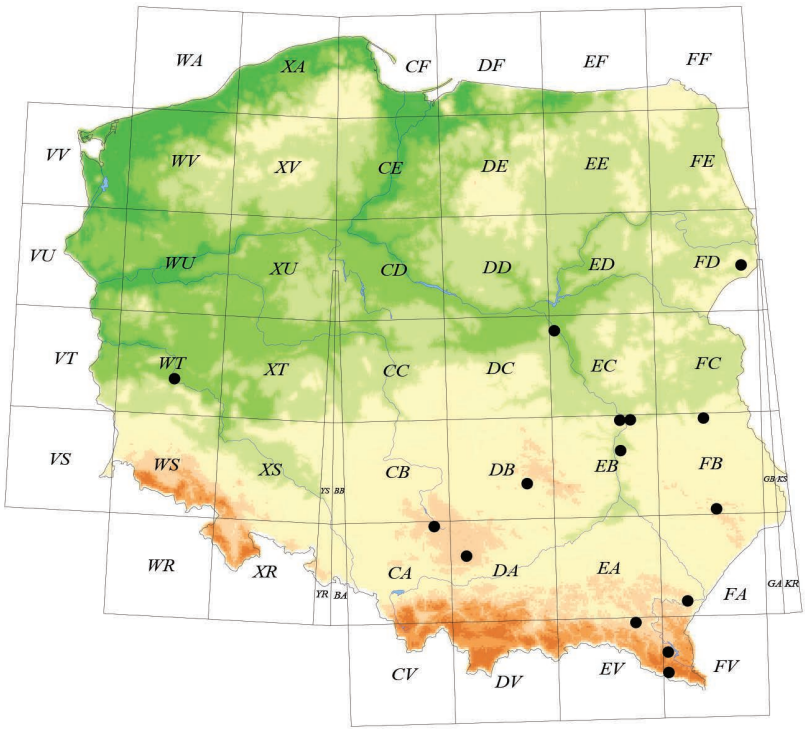

Figure 2. Localities of *Xylocopa valga* in Poland presented on the UTM map

9. Puławy [EB69], 1♀, 27 VI 1973, leg. M. Jazurek (Ruszkowski et al. 1997).

10. Posada Zarszyńska close to Sanok [EV79], observation of one flying specimen, V 1996 (Celary et al. 1998).

11. Wetlina [FV04], 1♂, dead, 1998 (Celary et al. 1998).

12. Polesie National Park [FB49], 1♀, 23 VI 2002, on sedge meadow next to forest, leg. G. Pawłowska (Banaszak, Piotrowski 2005).

13. Ojców National Park: Sąspowska Valley [DA16], 1♂ and observations of several flying specimens, 17 VI 2003 (Banaszak, Sołtyk 2005).

14. Polańczyk [FV06], 1♀, 12 VI 2007, a meadow adjacent to bushes, leg. K. Mikołajczak (Banaszak et al. 2009).

15. Grudki [FD84], the Białowieża Primeval Forest, 1♂, 13 VI 2015, leg. J.M. Gutowski and T. Huflejt.

In addition, Kuntze and Noskiewicz (1938) vaguely report that *X. valga* occurs in the Subcarpathian region and the Carpathian Mts.; nevertheless, this data probably concern the areas beyond present Poland's borders, that is, Ukraine.

4. Biology of *Xylocopa valga*

Xylocopa valga inhabits the edges of old forests, with abundance of lying or standing dead trees, and also – the steep slope hills overgrown with bushes as well as loess ravines. This species prefers warm, dry sites or those moderately humid. This is a thermophilic species; hence, it avoids dense and shaded forests, whereas in undulating areas, it stays around the slopes with southern or south-western exposures. In the past, in some regions, it was often observed around human settlements with houses made of wood and in the areas with old tree plantings (e.g. orchards or parks). In such environments, *X. valga* finds adequate conditions for establishing nests. The nest is usually built in wood – thick trunks and branches of dead trees – as well as in various wooden constructions (beams, posts, hedges) and even in uncovered roots of trees growing along forest roads (Ivanov et al. 2005). In undulating areas, it can nest in rock fissures and on loess slopes – directly in soil. In Crimea, *X. valga* inhabited reed tubes used as elements supporting little hives for breeding wild bees (Ivanov et al. 2005), and this evidences that under specific circumstances, even thin material can be useful for *X. valga* to build a nest. An interesting example of this species flexibility in terms of the selection of a nesting site comes from Lower Austria, where a fully operational nest in a polystyrene insulating board fixed to a foundation wall in a building with a basement was found (Dietrich, Prem 2004). Nesting in dry wood, where females excavate galleries, is regarded as typical for *X. valga*, and other nesting behaviours are interpreted as adaptations to changing conditions, which have a great importance in broadening the area of occurrence of this species (Amolin 2014; Dietrich, Prem 2004).

In Polish subject literature, incorrect statements about the biotope inhabited by *X. valga* can be found. These declare that above all, *X. valga* inhabits steppe areas and that tree and bush succession in steppe plant associations poses a threat to endurance of this species (Celary et al. 1998; Banaszak 2004). This needs to be clarified. The steppe – understood as a flat and forestless area, overgrown by herbaceous vegetation and with no rivers or lakes – is not an adequate environment for *X. valga* because of the lack of appropriate sites for nest establishment. Psarev et al. (2015) plainly state that the landscape of wide-ranging steppe areas, devoid of tree vegetation, actually impedes *X. valga* distribution. According to Popov (1947), the incidence of this species in forestless areas was understood when there was discovered that it can build nests also in the soil on steep slopes. Ivanov et al. (2005), who regard *X. valga* as a typical forest species, give explanation that the occurrence of this carpenter bee in steppe environments is due to its ability to inhabit wooden poles supporting electric power lines. In the past, some authors, and especially German entomologists, regarded *X. valga* as a steppe species; however, such classification should not be associated with inhabited environment but – with the general area of species occurrence and its requirements as to climate conditions. For example, Popov (1947) notes that the steppe climate is optimal for *X. valga*, because the consistent range of this species (especially in the eastern part of the area of its occurrence) apparently overlaps with the steppe climate region. This clarification can be supported by the opinion of Kuntze and Noskiewicz (1938), who point out that the term 'steppe species' can have different meanings and often refers to the concept of a pontic element or else to generalisation of the term 'eastern form'. Unquestionably, *X. valga* can be considered as the eastern form, as when compared to other areas of its wide-ranging distribution, it occurs most commonly in the areas nearby the Black Sea. Localities in western Europe indicate that *X. valga* prefers regions under the continental climate and can be often met in mountainous areas, whereas it avoids the Atlantic coast with high air humidity, where it is reinstated by another carpenter bee species – *X. violacea* (Terzo et al. 2007). Even though *X. valga* is not a typical representative of the steppe fauna, it is often classified as the steppe species. This is due to the fact that it usually forages in the regions characteristic of plenty mosaic environments, where steppe vegetation patches are small and neighbour with woody areas (Dugina 2009). The presence of old decaying trees is indispensable for the reproduction and development processes of *X. valga*, and thus, this species should not be characterised as the steppe species but as the forest saproxylic species, which uses dead trees for nesting and overwintering. *X. valga* finds the optimal conditions for the development within east European forest steppes.

Detailed studies on the biology of *X. valga* were carried out by Malyshev (1931). The results of this author's study show that it nests in dry wood that is not economically utilisable even if it goes through the first stages of decaying. According to many authors, in the process of nesting site selection, either tree species or its position relative to the horizon is of no importance for *X. valga*. Nests of this species have been observed on trunks of goat willow (*Salix caprea* L.), pedunculate oak (*Q. robur* L.), birch (*Betula* sp.), lime (*Tilia* sp.), European wild pear (*P. pyraster*) and European crab apple (*Malus sylvestris* Mill.). Also, it probably builds nests in field maple (*Acer campestre* L.) and Scots pine (*P. sylvestris* L.) (Malyshev 1931; Amolin 2014). The results of the analysis of nest location of carpenter bee on standing trees (Amolin 2014) showed that the nests were established only in insulated wood at the height of 1.7–3.5 m above the ground and in the sites where the tree diameter was 13–60 cm. Dead or dying trees or totally withered lateral ramifications in trees with alive crowns were used. Under anthropogenic conditions (Malyshev 1931), *X. valga* nests were established in wooden beams stored in the attic, in the darkest spots.

Over several subsequent years, the same site is usually used for nesting. During 3-year-long observations on *X. valga* nesting on a dead pear tree, Amolin (2014) noted that females gradually enlarged nest entrance holes up to 4×7 cm in size, although the standard entrance hole diameter is approximately 1.2–1.3 cm. According to the author, the described behaviour was to protect the nest against the damage caused by the woodpecker: irregular broadening of the entrance holes suggested woodpecker earlier feeding activities and mimicked nest damage, which was supposed to confuse woodpeckers and disinterest these birds in the nest as a potential food source.

The descriptions of the development of *X. valga* show some discrepancies, which can – at least to some extent – indicate factual differences in biology of this species in various regions of its occurrence. The greater part of literature sources says that the species has one generation annually. After overwintering, adults emerge in early spring (from mid-April). Following mating, fertilised females start creating nests, usually in wood of dead tree. The female makes a tunnel with a series of 10–12 brood cells, which are separated by partitions built using scraped wood shavings. Each cell is filled with pollen, and then one egg is laid on pollen. After laying eggs, the female stays inside and safeguards the nest. Emergence of young adults takes place from the end of July to the beginning of September. They do not leave wood and overwinter in the cells. The mother usually dies after offspring emergence; however, sometimes she overwinters and builds a nest again in next spring. Some sources say that the overwintering stage is a pre-pupa in cocoon. Malyshev (1931) observed that young *X. valga* specimens leave the nest in the fall and overwinter in the soil. Prîsepčik (2006) reports from Belarus that young bees that emerged in August, fly out and mate, then males soon die and fertilised females enter wood and overwinter. However, this information has not been confirmed by species phenology reported from neighbouring countries: in museum materials from Ukraine and other regions next to Belarus, numerous males that must have come from overwintering populations were found, because they were captured under field conditions in the spring and early summer – from mid-April to the end of July (Sheshurak 2012). Also, the specimen captured by the authors of the present study in the Białowieża Forest was undoubtedly a representative of the generation that developed in the previous year and overwintered.

X. valga is a polylectic species, meaning that it shows no specialisation as far as food acquisition is concerned and it visits flowers of numerous plants not related with each other so as to feed on pollen and nectar. A full list of visited flowering plants has not been published yet, and relevant information on such plants is scattered in numerous publications, most often – faunistic. Polish authors (Ruszkowski et al. 1997; Banaszak 2004) report that *X. valga* flies to and pollinates 30 species of flowering plants from 13 families; however, this data is much fragmentary. More detailed information on *X. valga* host plants was provided by Popov (1947). According to this author, *X. valga* was recorded on 60 plant species from 22 families, and most often, it was observed on woody species or introduced and cultivated alien plants, for example, sweet peas (*Lathyrus odoratus* L.) or black locust (*Robinia pseudoacacia* L.). Terzo et al. (2007) inform that *X. valga* most frequently visits legumes (Fabaceae) and flowers from the mint family (Lamiaceae); however, it shows no preferences for any specific plant species. Ivanov et al. (2005) highlight that *X. valga* is an important pollinator of many economically important plant species, such as lucerne (*Medicago sativa* L.), red clover (*T. pratense* L.) and sage (*Salvia* spp.).

The list of flowering plants visited by *X. valga* presented in this study is based on literature data and the authors' own studies (Ragged-Robin *L. flos-cuculi*). It comprises 95 species from 30 families (Table 1). The literature data comes from the lists prepared by other authors (Popov 1947; Ruszkowski et al. 1997) as well as from some original publications. In three cases, some discrepancies were found between the information in the published list and that provided in the original source. These cases need reconsideration; therefore, in Table 1, the names of 'uncertain' plants are marked with a question mark (?).

5. Concluding remarks

Discovery of the presence of *X. valga* in the Polish part of the Białowieża Primeval Forest and an earlier record of this species in the Belarusian part of the Forest (Prîsepčik 2006) show that the range of this species has been more and more shifting to the north, towards the Baltic coastal zone, previo-

Table 1. Flowering plant species visited by *Xylocopa valga* (? – data needed confirmation)

Plant family and plant species	Reference
Apiaceae – celery family	
Eryngium coeruleum MB. – eryngo	Popov (1947)
Apocynaceae – dogbane family	
?*Vinca major* L. – blue periwinkle	Popov (1947) to quote Malyshev
Vinca minor L. – dwarf periwinkle	Malyshev (1931)
Asclepiadaceae – milkweed family	
Asclepias syriaca L. – common milkweed	Popov (1947) to quote Rucki
Asparagaceae – asparagus family	
Ornithogalum sp. – Star-of-Bethlehem	Schedl (2007) to quote Schletterer
Asphodelaceae – asphodel family	
Asphodelus ramosus L. – branched asphodel	Terzo et al. (2007)
Asteraceae – aster family	
Carduus sp. – plumeless thistle	Malyshev (1931)
Centaurea sp. – starthistle	Terzo et al. (2007)
Cirsium monspessulanum (L.) Hill – thistle	Terzo et al. (2007)
Cirsium turkestanicum (Regel) Petr. – Afghan thistle	Ruszkowski et al. (1997) to quote Popov
Helianthus annuus L. – common sunflower	Popov (1947)
Onopordum acanthium L. – Scotch thistle	Popov (1947) to quote Bramson
Rhaponticum repens (L.) Hidalgo – Russian knapweed	Popov (1947), as *Acroptilon Picris* Pall.
Taraxacum officinale F.H. Wigg. agg. – dandelion	Malyshev (1931), as *Taraxacum officinalis* Web.
Boraginaceae – forget-me-not family	
Anchusa italica L. – Italian bugloss	Popov (1947) to quote Friese
Echium altissimum Jacq. – bugloss	Popov (1947)
Echium vulgare L. – common bugloss	Terzo et al. (2007)
Lindelofia anchusoides (Lindl.) Lehm.	Popov (1947)
Pulmonaria sp. – lungwort	Popov (1947) to quote Frey-Gessener et al.
Cactaceae – cactus family	
Opuntia sp. – opuntia	Malyshev (1931) to quote Friese
Caprifoliaceae – honeysuckle family	
Lonicera arborea Boiss. v. *persica* (Jaub. et Spach)	Popov (1947)
Lonicera tatarica L. – Tartarian honeysuckle	Malyshev (1931)
Caryophyllaceae – carnation family	
Lychnis flos-cuculi L. – Ragged-Robin	own observation
Saponaria officinalis L. – common soapwort	Malyshev (1931)
Convolvulaceae – morning glory family	
Cuscuta lehmanniana Bunge – dodder	Ruszkowski et al. (1997) to quote Popov
Dipsacaceae – teasel family	
Dipsacus laciniatus L. – cutleaf teasel	Popov (1947)
Euphorbiaceae – spurge family	
Euphorbia sp. – spurge	Popov (1947) to quote Frey-Gessener
Fabaceae – leguje family	
Alhagi klighizorum Schr.	Popov (1947)
Caragana arborescens Lam. – Siberian peashrub	Popov (1947) to quote Arnold
Cercis siliquastrum L. – Judas tree	Popov (1947), as *Cercis ciliquastrum* L.
Colutea arborescens L. – bladder-senna	Treiber (2015)
Cytisophyllum sessilifolium (L.) O. Lang – Sessile-leaved cytisus	Terzo et al. (2007), as *Cytisus sessilifolius* L.
Halimodendron argenteum Jacq. – caragana argentea	Popov (1947)
Hippocrepis emerus (L.) Lassen – scorpion senna	Malyshev (1931) to quote Friese, as *Coronilla emerus* L.
Indigofera gerardiana (Wall.) Baker – Himalayan indigo	Popov (1947), as *Indigofera garardiana* Wall.
Laburnum anagyroides Med. – common laburnum	Ducke (1898), as *Cytisus laburnum* L.

Plant family and plant species	Reference
Lathyrus latifolius L. – perennial peavine	Treiber (2015)
Lathyrus odoratus L. – sweet pea	Popov (1947) to quote Arnold
Lotus sp. – bird's-foot trefoils	Popov (1947) to quote Frey-Gessener
Medicago sativa L. – lucerne	Popov (1947)
Phaseolus vulgaris L. – common bean	Popov (1947) to quote Zubarev, as *Phaseolus yulgaris* L.
Robinia pseudoacacia L. – black locust	Malyshev (1931)
?*Securigera varia* (L.) Lassen – purple crown vetch	Banaszak (2004) to quote Ruszkowski et al., as *Coronilla varia*
Sophora alopecuroides L. – pea-flowered tree	Popov (1947)
Spartium junceum L. – weaver's broom	Popov (1947)
Trifolium pratense L. – red clover	Malyshev (1931)
Vicia cracca L. – bird vetch	Malyshev (1931)
Vicia melanops Sibth. & Sm. – vetch	Terzo et al. (2007)
Vicia villosa Roth – hairy vetch	Malyshev (1931), as *Vica villosa* Roth.
Wisteria sinensis (Sims) Sweet – Chinese wisteria	Popov (1947) to quote Friese, as *Glycine chinensis* Curt.
Fumariaceae – bleeding-heart family	
Corydalis sp. – corydalis	Popov (1947) to quote Frey-Gessener
Grossulariaceae – gooseberry family	
Ribes sp. – redcurrant	Popov (1947) to quote Lebedev
Iridaceae – iris family	
Iris sp. – iris	Popov (1947)
Lamiaceae – mint family	
Ajuga genevensis L. – Geneva bugleweed	Treiber (2015)
Ballota nigra L. – black horehound	Malyshev (1931)
Dracocephalum moldavicum L. – Moldavian dragonhead	Malyshev (1931), as *Dracocephalum moldavicus* L.
Dracocephalum ruyschiana L. – dragonhead	Psarev et al. (2015)
Hyssopus officinalis L. – hyssop	Popov (1947)
Lamium album L. – white dead-nettle	Ruszkowski et al. (1997) to quote Adolph
Lamium maculatum L. – spotted dead-nettle	Malyshev (1931)
Lamium purpureum L. – purple dead-nettle	Treiber (2015)
Lavandula x intermedia Emeric ex Loisel. – lavender	Terzo et al. (2007)
Mentha longifolia (L.) L. – horse mint	Popov (1947), as *Mentha silvestris* L.
Ocimum bosilicum L. – St. Joseph's wort	Popov (1947)
Salvia officinalis L. – common sage	Popov (1947) to quote Friese
Salvia pratensis L. – meadow sage	Malyshev (1931)
Salvia sclarea L. – clary sage	Ruszkowski et al. (1997) to quote Popov
Stachys recta L. – stiff hedgenettle	Treiber (2015)
Vitex agnus-castus L. – vitex	Popov (1947)
Lythraceae – loosestrife family	
Lythrum salicaria L. – purple loosestrife	Terzo et al. (2007)
Malvaceae – mallow family	
Althaea nudiflora Lindl. – marshmallow plant	Ruszkowski et al. (1997) to quote Popov
Lavatera thuringiaca L. – garden tree-mallow	Ruszkowski et al. (1997) to quote Popov
Moraceae – fig family	
Maclura pomifera (Raf.) Schneid. – osage orange	Popov (1947), as *Maclura aurantiaca* Nutt.
Morinaceae – whorlflower family	
Morina persica L. – whorlflower	Popov (1947) to quote Fahringer
Nitrariaceae – rue family	
Peganum harmala L. – Syrian rue	Popov (1947)
Papaveraceae – poppy family	
Papaver sp. – poppy	Popov (1947)
Paulowniaceae – empress-tree family	
Paulownia tomentosa Steud. – empress tree	Ruszkowski et al. (1997) to quote Popov

Plant family and plant species	Reference
Ranunculaceae – buttercup family	
Clematis orientalis L. – Chinese clematis	Ruszkowski et al. (1997) to quote Popov
Ficaria verna Huds. – lesser celandine	Malyshev (1931), as *Ficaria ranunculoides* Rhot.
Rosaceae – rose family	
Malus sp. – crab apple	Popov (1947) to quote Muzyčenko
Potentilla sp. – cinquefoil	Popov (1947) to quote Frey-Gessener
Prunus avium (L.) L. – sweet cherry	Popov (1947) to quote Malyshev, as *Cerasus avium*
?*Prunus cerasus* L. – sour cherry	Banaszak (2004) to quote Ruszkowski et al., as *Cerasus vulgaris*
Prunus domestica L. – plum	Treiber (2015), as *Prunus domesticus*
Prunus persica (L.) Batsch – peach	Popov (1947) to quote Muzyčenko, as *Persica vulgaris* L.
Prunus spinosa L. – blackthorn	Malyshev (1931)
Rosa canina L. – dog-rose	Malyshev (1931)
Salicaceae – willow family	
Salix caprea L. – goat willow	Treiber (2015)
Sapindaceae – soapberry family	
Koelreuteria paniculata Laxm. – goldenrain tree	Popov (1947)
Scrophulariaceae – figwort family	
Antirrhinum majus L. – common snapdragon	Malyshev (1931)
Digitalis purpurea L. – foxglove	Popov (1947)
Dodartia orientalis L.	Popov (1947)
Rhinanthus sp. – rattle	Terzo et al. (2007)
Verbascum songoricum Schrenck. – mullein	Popov (1947)
Veronica spicata L. – spiked speedwell	Popov (1947) to quote Gerstäcker and Schletterer

usly inhabited by this species. In the 1920s–1930s, numerous *X. valga* localities were observed in this region, which was attributed by Popov (1947) to warming up climate at that time. On the other hand, the same author admits that changing climate cannot give explanation for all the northern localities of this bee species, as several records concerned the time when the climate was not warming. It seems that earlier occurrence of *X. valga* in the northern parts of eastern Europe can be associated with burning groundcover, removing litter and cattle grazing in forests, which were common practices in this region until the mid-1900s. These activities made forest more insulated (instead of Norway spruce, there dominated Scots pine), opened and warm, which created favourable conditions for thermophilic species such as *X. valga*. At the same time, east European forests still remained less managed than those in the western parts of the continent; hence, there was available deadwood abundance for larvae development and adult overwintering. On the other hand, the lack of sufficient amounts of deadwood was probably the main factor limiting *X. valga* range in the west of Europe. In the mid-1900s, east European forests (including those in Poland) started became more shaded (banned grazing and reduction of fires) and the conditions of the forest landscape were less favourable for *X. valga*. This could cause the withdrawal of the species from the most northerly locations in Poland, Lithuania and Latvia. Now, *X. valga* range shifts back to the north, which might be associated with the ongoing climate change. In turn, in forests of the continent's western parts, the amount of deadwood has been gradually increasing, which supports the development of saproxylic insects, including *X. valga*. In view of the general European trend of shifting *X. valga* range towards the north, the sighting of this species in the Białowieża Forest does not support the forecast of changes in Poland's *X. valga* population presented by Banaszak (2004), who anticipates a possibility of extinction of this Aculeata representative within the territory of Poland.

The Białowieża Primeval Forest comprises a large forest complex, with deadwood abundance, which is famous for species richness of saproxylic insects, including those rare (Gutowski et al. 2004). The presence of *X. valga* adds to the register of these animals. The answer to the question whether this carpenter bee will be treated as a constant element of the local fauna depends on the results of the necessary research. Taking into account that *X. valga* migrates, just one male captured does not prove that the Białowieża Forest is inhabited by the species. Records of females during the reproduction season or the detection of nesting sites would be more useful to state decidedly that the species lives in the Białowieża Forest. Afterward, it would be possible to carry out detailed observations on the biology and the development of *X. valga* under local conditions as well as to evaluate its population numbers.

It is likely that the environment of the Białowieża Primeval Forest is adequate for *X. valga*. There are abundant sufficient nesting sites and satisfactory availability of food offered by species of rich forest vegetation as well as crop and ornamental plants cultivated in home gardens in neighbouring villages and forest settlements. It seems that nearly natural local forest, especially that in Białowieża National Park, should assure maintenance of *X. valga* reproduction base in space and time. The Białowieża Forest might be a valuable refuge of this species, even though the thermal conditions within the region are sub-optimal. Furthermore, from this point, *X. valga* would be able to expand further to the north-eastern regions where it used to occur.

If the colonisation of the Białowieża Forest by *X. valga* is confirmed, there shall be recommended a certain degree of human attention paid to this species. Detection of nesting sites could provide information for guidelines on the protection activities to take on. No doubt, there would be needed specific activities on raising awareness of the local community and visitors to the Białowieża Forest.

Conflict of interest

The Authors declare no conflict of interest.

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Authors' contribution

T.H., J.M.G – collection of materials, study conception, discussion and manuscript edition; T.H. – manuscript writing, preparation of the table and figure; J.M.G – photography.