

# Oak and others, new to Poland, hosts of mistletoe *Viscum album* subsp. *album* in the city of Toruń and its immediate vicinity

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**Abstract.** The paper presents the distribution of localities of seven tree taxa, identified as new hosts of mistletoe in Poland, in the city of Toruń. Particular attention was paid to the description of a site with mistletoe on an oak identified as *Quercus x rosacea*. The reason for this is that native oaks are rare hosts of mistletoe in Central and Eastern Europe and this is the first finding of such a host–parasite association in Poland. The occurrence of all eight host species at 14 sites was compared with the distribution and description of localities and morphological characteristics of both host–mistletoe association components presented in the botanical, ecological and forestry literature.

**Keywords:** European mistletoe, hosts of *Viscum album*, *Quercus x rosacea*, host dendrometry, urban green areas, suburban forests, spatial distribution, northern Poland.

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## 1. Introduction

The European mistletoe *Viscum album* L. (*Santalaceae*) is an evergreen, epiphytic, hemi-parasitic shrub, widespread in Europe (Zuber, 2004). It shows clear preferences for host species and is therefore divided into four subspecies, the most abundant of which is *V. album* subsp. *album*, found on numerous species of deciduous trees and shrubs. Populations of *V. album* subsp. *austriacum* (Wiesb.) Vollm. (= subsp. *laxum* Boiss.), subsp. *abietis* (Wiesb.) Janch. and subsp. *creticum* N. Böhling, which parasitise conifers, are smaller (Zuber, 2004). According to Barney et al. (1998), 384 taxa of mistletoe hosts have been identified in Europe. In Poland, *V. album* was observed on 194 taxa (Stypiński, 1997), of which *Tilia cordata*, *Betula pendula*, *Acer platanoides*, *Sorbus aucuparia*, *Populus x canadensis*, *P. nigra* and *Salix alba* were the most frequently

parasitised. On the other hand, one of the least parasitised genera is *Quercus*. Although the infection of a tree by *V. album* can be considered a mutualistic relationship (there are indications that the host can take up secondary metabolites from mistletoe, which have insecticidal and fungicidal properties; after Kołodziejek et al., 2013), the negative aspects associated with the presence of the hemi-parasite outweigh the positive ones. *V. album* infection reduces the growth rate of the host, its viability and causes premature death. Trees parasitised by mistletoe are more susceptible to other pathogens (insects and fungi). The most serious threat from *V. album* is its capacity to increase water stress in the host, as mistletoe does not close its stomata during periods of water shortage (Zuber, 2004). *V. album* prefers a maritime climate, with temperatures above 15°C in summer and no lower than –7°C in winter (Zuber, 2004; Walas et al., 2022).

As a result of the observed climate change, the range and size of *V. album* subsp. *album* populations in Europe (Walas et al., 2022) can be expected to increase, and consequently its negative impact on trees and forest ecosystems will increase as well. For this reason, monitoring of *V. album* populations and observation of how they tend to parasitise new host species is an important element of the current and future management of mistletoe expansion.

The objectives of this study were: 1 – to collate the localities and describe the sites of mistletoe hosts new to Poland occurring in Toruń and adjacent areas, especially mistletoe sites on *Quercus x rosacea*, and 2 – to find an answer to the ecological question: How many new hosts of mistletoe and at how many sites they have been observed in the last few years in the city of Toruń under the conditions of urbanization and environmental changes?

## 2. Material and methods

A search for new, previously not recorded taxa of trees parasitised by *V. album* was conducted within the administrative limits of Toruń and its immediate vicinity. Fieldwork was carried out in 2021–2022 with intensification

in autumn and early spring, due to the greater possibility of spotting mistletoe individuals. When mistletoe is found in the canopy of a tree or shrub, the latter is identified taxonomically to the species level and, in the case of landscaped greenery, also to the variety/cultivar level, the location and individual characteristics of the host, the number of mistletoe individuals, their sex wherever possible and their location within the canopy are recorded.

The location of all sites is presented in decimal expansion of the ATPOL system of 1 x 1 km grid squares (Zajac A. & Zajac M., 2001). The nomenclature of taxa and their family affinity are given according to Rutkowski (1998) and Seneta et al. (2021).

## 3. Results

During the current stage of the research, *Viscum album* subsp. *album* was found on seven taxa that have not yet been reported as hosts of common mistletoe (widespread in Poland; Table 1).

The eight taxa of trees that are new to Poland as mistletoe hosts belong to four families. Five species represent the family of Rosaceae (*Crataegus nigra*, *Prunus persica*,

**Table 1.** List of *Viscum album* subsp. *album* host species new to Poland in the city of Toruń with the location and characteristics of the sites

| No.  | Taxon   | Location in ATPOL quadrats | Remarks  |
|------|---|----------------------------|--|
| I.   | <i>Crataegus nigra</i> Waldst. & Kit.   | DC3061                     | NCU campus, by the university sports hall, close to the tram line stop at Gagarina Street, on the southern boundary of the campus. A black hawthorn ( <i>Crataegus nigra</i> Waldst. & Kit.) hedge, planted in 1973–74, grows here. Quite numerous, non-fruiting, mostly small specimens of mistletoe were observed on four small trees pruned at a height of about 1.2 m. The diameter of the base of the stumps was 8, 3.5, 6.5 and 4 cm. The number of mistletoe clusters on individual trees was as follows: eight (including three growing on the trunk and five growing on branches, two of which were distinguished by their larger size); one (growing on a branch); five (including one noticeably larger than the others, all growing on branches); two (including one growing on a branch and one very small growing at the base of a trunk). Clusters of tall <i>Populus alba</i> L., <i>Betula pendula</i> Roth, <i>Tilia cordata</i> Mill. Trees and a few specimens of <i>Acer saccharinum</i> L. were present in the vicinity of the hedgerow, some of which were heavily infested with mistletoe. |
| II.  | <i>Prunus persica</i> (L.) Batsch (= <i>Persica vulgaris</i> Mill.)                             | DC3052                     | “Bielany” district in the western part of the city, near Ludwik Rydygier Hospital, the starting point of Żwirki i Wigury Street. One tree with three clumps of mistletoe growing at the top of a pollarded trunk (approx. 2.5 m high; 6.5 cm DBH) was found in a garden in front of a villa. Mistletoe shoots are plucked by residents so the size of the mistletoe clusters is not large and no fruit was observed.   |
| III. | <i>Prunus serrulata</i> Lindl.  | DC3063                     | “Zielona Brama” (Green Gate) of the Old Town, a square in front of the Arsenal erected in the 18th century (now home to the Ethnographic Museum). On 22 January 2022, one, two and three specimens of mistletoe were found on three trees (out of eight). All specimens of Japanese cherry were grafted onto native cherry trees. On 10 November 2022, only one mistletoe bush (instead of the two observed the previous year) was found on a tree growing closest to the footpath. This tree was identified as <i>Prunus serrulata</i> f. <i>taihaku</i> P.D. Sell; the other seven trees did not have the characteristics typical of this form.  |
| IV.  | <i>Quercus x rosacea</i> Bechst. (= <i>Quercus petraea</i> (Matt.) Liebl. x <i>Q. robur</i> L.) | DC3040                     | Woodland in the NW part of the city by the road leading to a disused gravel pit; one specimen of mistletoe was found on one young tree. This site is described in detail in a separate chapter of this work.   |

Table 1. continued

| No.  | Taxon  | Location in ATPOL quadrats | Remarks   |
|------|--|----------------------------|---|
| V.   | <i>Robinia x margaretae</i> Ashe (= <i>Robinia x slavini</i> Rehder) | DC3063                     | Solidarności Av. square, one tree on the escarpment to the left of the stairs leading towards the bus stop on Odrodzenia street. There are two trees with six specimens of mistletoe on one of them, including four large and two small ones, and two large mistletoes on the other tree. No fruiting specimens were found among these mistletoes. The height of the trees was 7 and 6 m and the diameter at breast height was 21 and 13 cm, respectively. Three old <i>Robinia pseudoacacia</i> L. specimens grew in the vicinity of the trees, with two, two and 17 mistletoe bushes of varying sizes.  |
| VI.  | <i>Sorbus austriaca</i> (Beck) Hedl.                                 | DC3042                     | Site a – housing estate in the northern part of the city, greenery in front of a building at 3A Sylwestra Kaliskiego St. Two large female mistletoes (ca. 80 cm in diameter) abundantly fruiting, one medium (50 cm in diameter), and one small (20 cm in diameter), both non-fruiting mistletoes were found on one of the three Austrian rowan trees growing there, which reaches a height of about 6 m and 22 cm DBH; and near 7A Sylwestra Kaliskiego St., ca. 60 m northwest of the previous address; one 6 m high tree and 11 cm DBH with two large mistletoes (ca. 90 cm in diameter) growing on branches in the mid and upper part of the crown and bearing no fruit.  |
|      |  | DC3053                     | Site b – Bartosza Głowackiego St. at the intersection with Wiązowa St. There are five trees at a car park in front of an apartment building, two of which have one large abundantly fruiting mistletoe bush each. The height of the trees is 7 and 6 m and DBH is 25 and 18.5 cm, respectively. On the taller of the two trees, a mistletoe grows on a branch in the middle of the crown on the west side, while on the lower one, mistletoe grows in the lower part of the crown at the base of a broken and withering branch close to the trunk. Near this site, several specimens of mistletoe are found on two old <i>Robinia pseudoacacia</i> trees and in great abundance on old apple trees in a neglected orchard.  |
|      |  | CC2999                     | Site c – located 1.8 km outside the northern limit of the city, by Toruń–Chełmno road 553 near the “Las Piwnicki” nature reserve and a car park of the Olek forest admin. unit. Between the road and the bike path there is an avenue of 10 25–30 year old trees; mistletoe bushes were observed on three of them on 12 January 2023. On the first tree from the city limit with a height of about 5.5 m, one fruiting mistletoe was present at the bottom of the main trunk (8.5 cm DBH), and two mistletoes (including one fruiting one) were present on the branches of one of the offshoots (6 cm DBH); two fruiting mistletoes of medium size were found on the branches of the 6th tree (height of about 6 m and 16 cm DBH); two small mistletoes without fruit were observed on the 8th tree (11 cm DBH).  |
|      |  | CC4919                     | Site d – located just outside the south-western limit of Toruń, near “Zadroże” dune (described by Nienartowicz et al., 2010) and the monument to Soviet soldiers who died in the Stalag XX-C camp and by the War Cemetery. At a distance of about 70 m south-west of the monument above the escarpment on road 15 towards the town of Inowrocław, there is a row of 18 Austrian rowan trees, including two almost dry trees, two trees with suckers from the base of the main dead trunk and one self-sown tree (there were more trees, but recently the strip under the electric line was cleared and other young specimens were cut down). On the largest of the preserved trees (about 7 m high and 22 cm DBH), one small fruiting mistletoe grows from the main trunk at a height of about 4 m.   |
| VII. | <i>Sorbus mougeotii</i> Soy.-Will. & Godr.                           | DC3043                     | Site a – Siostry Faustyny St., a square and flower beds in front of a residential building at the junction with Legionów St.; there are three trees of this host species (growing at the boundary between the estate greenery and the street), two specimens of which are parasitised by mistletoe. The trunk of the lower infected tree (4 m high) splits at a height of 90 cm into two trunks, each with a DBH of 6.5 cm, with a large (80 cm diameter) male mistletoe on the lower branch at the base of the crown of one of the trunks. The taller tree (5 m high), as a result of branching at heights of 10 and 40 cm, has three trunks with DBHs of 9, 8.5 and 6 cm. One large, abundantly fruiting female mistletoe (70 cm in diameter) and one non-fruiting one (up to 40 cm in diameter) were found on the thickest branch of the large hosts. The thinnest branch has one non-fruiting mistletoe (50 cm in diameter). An old specimen of <i>Robinia pseudoacacia</i> with eight large mistletoe bushes grows near these trees. |
|      |  | DC3057                     | Site b – “Rubinkowo” district in the eastern part of the city, the starting point of Dziewulskiego St. There are two infected trees in the residential green area near the bus stop – three non-fruiting mistletoe bushes were observed on the lower one (5 m height, 13.5 cm DBH), including two large oand one small; while the higher tree (ca. 6 m height, 19 cm DBH) hosts two large fruiting and three small non-fruiting mistletoe bushes; in addition, two small trees grow nearby, by the roadway – one small mistletoe is present on the smaller tree (3 m high and 8.5 cm DBH) and two non-fruiting mistletoes (ca. 40 and 20 cm in diameter) were present on the larger one (4 m height and 11 cm DBH). The site is located about 100 m from a lane of tall <i>Populus x canadensis</i> Moench heavily infested with mistletoe.   |
|      |  | DC3051                     | Site c – NCU campus, a square in front of the Faculty of Economics, two trees out of five are parasitised by mistletoe; on 3 November 2022, the bigger one, about 4.5 m high and 22.5 cm DBH, was found with eight specimens of mistletoe, including four fruiting specimens; the smaller tree, about 3 m high, splits at a height of 51 cm; the diameter of these trunks is 8 and 13.5 cm; mistletoe was found only on the thicker one (three fruiting specimens).   |
|      |  | DC4001                     | Site d – five Mougeot’s rowan trees (4.5–5.5 m high and DBH 11–20 cm) in the southern part of the city on the left bank of the Vistula, by a garden fence around a property at 186 Poznańska St., three of which are infected with mistletoe. A total of five fruiting mistletoes were found on these trees: one small, two relatively large, two medium.   |

Table 1. continued

| No.   | Taxon  | Location in ATPOL quadrats | Remarks  |
|-------|--|----------------------------|--|
| VIII. | <i>Tilia x juranyi-iana</i> Simonk. (= <i>T. cordata</i> Mill. x <i>T. tomentosa</i> Moench) | DC3046                     | “Rubinkowo” district in the eastern part of the city, on the Toruń Stream, near the junction of Dziewulski Street and Kasztanowa Street. A large, multi-stemmed Juranyi’s linden, about 60 years old, grows on an elevation on the edge of waterside woodland formed by mature specimens of black alder, birch and willow, next to a walking lane running along a stream. Four suckers grow at the base of the thick lined trunk. On one of them, with a diameter at breast height of 19 cm, a single cluster of mistletoe without fruit was found at a height of ca. 2 m. The main trunk splits at a height of about 1 m, but only one of the branches has survived, reaching 47 cm DBH and a height of about 16 m. In the middle part of the crown, two large fruiting mistletoes and three medium-sized mistletoes with no fruit grow on the branches. Nine shoots of varying thickness developed at the site where the second branch snapped off. A row of black locusts and clusters of hawthorns grow along the alley. Mistletoes are present sparsely on some of these trees. |

*P. serrulata*, *Sorbus austriaca*, *S. mougeotii*), and one species each represents Fabaceae (*Robinia x margarettae*), Fagaceae (*Quercus x rosacea*) and Tiliaceae (*Tilia x juranyiiana*).

The trees identified as new mistletoe hosts were mostly young, ranging from several years to about 60 years. The sites of new hosts are located both in the central part of the city (Fig. 1), where ornamental species of trees and shrubs of foreign origin have been planted in squares established on the outskirts of the Old Town since the end of the 20th century, as well as in the peripheral districts, where such species were introduced in home gardens in villa districts

or in squares in districts with predominantly multi-family housing, and native host species were preserved in abundance in woodlands located far from the city centre.

New mistletoe hosts were observed at a total of 14 sites located in 13 ATPOL squares (Fig. 1). Only one square, DC3063, contains two sites of two hosts. Those were *Prunus serrulata* and *Robinia x margarettae* growing in squares around the Old Town. Two of the seven new hosts of mistletoe, i.e., *Sorbus austriaca* and *S. mougeotii* occur at four sites. The sites of each of these hosts are located in three ATPOL squares far apart from each other.

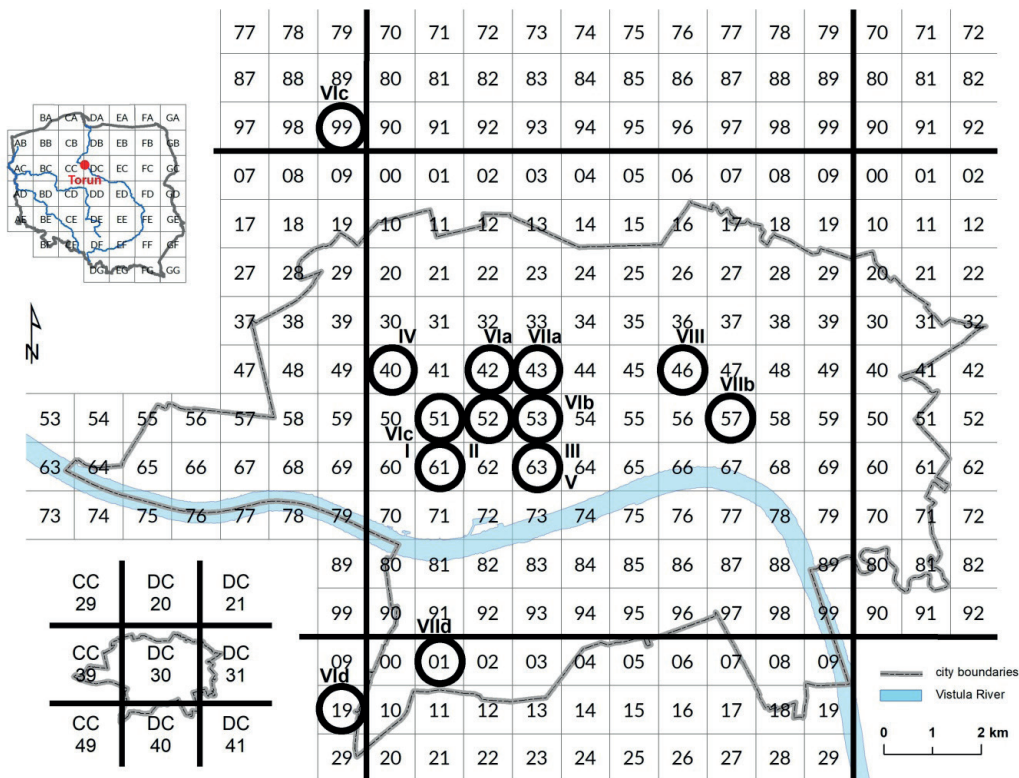


Figure 1. Localities of the described trees infested by *V. album* (see Table 1 for explanation of symbols of taxons and sites)

### 3.1. *V. album* subsp. *album* site on *Quercus x rosacea*

The native oak species in Poland are the trees most resistant to mistletoe parasitism. For this reason, finding *V. album* on a tree belonging to this genus is a unique situation.

Mistletoe on *Q. x rosacea* was spotted on 25 April 2022 in the “Barbarka” forest stretching in the north-western part of the city. The forest belongs to the State Forests and is part of the Wrzosey forest administration region within the Toruń Forest District (State Forests, Toruń Forest District, tourist map, undated). Pure pine stands dominate on infertile habitats, while mixed forests grow on more fertile sites, with both species of oak, silver birch, Norway maple and aspen, often reaching an age of well over 100 years. Parkland shrubs and trees, often of alien origin, are found in large numbers along the major forest roads. A young oak parasitised by mistletoe grows by the road leading towards a disused gravel pit located north of the Pomeranian Aero Club airfield. This road diverges in a westerly direction from the green tourist trail and the main track leading to the hamlet of Barbarka.

The infected oak grows on the edge of forest section 170, formed by 55–60 old pine stands. It is located at a distance of about 1.3 km from the starting point of the route leading towards Barbarka and to the gravel pit. This point is located on Okrężna Street, built to replace the former military road (rocade) connecting individual forts, and the nearest structures are an infantry bunker and fort VII. The distance from the oak tree to the Barbarka hamlet, calculated in a straight line along the forest section lines running NW, is approximately 1.9 km.

The height of the oak parasitised by mistletoe is 6.9 m, its diameter at breast height is 19 cm; we estimated its age at about 40–50 years. The mistletoe grows at a height of 4.4 m from the ground on the eighth branch counting from the bottom of the tree, approximately 1 m from the trunk. The diameter of the mistletoe bush is 70–80 cm (Fig. 2).

Two Canadian poplars, 22 and 28 cm DBH, grow along the road turning to the west and leading further towards the gravel pit, at a distance of 130 and 141 m from the oak tree, on the opposite road shoulder. They too are remnants of the former roadside avenue. One specimen of the European mistletoe was found on the nearer poplar and several bushes were found on the father one.

## 4. Discussion

Of the eight taxa listed, five were not included by Barney et al. (1998) on the list of *Viscum album* subsp. *album* hosts: *Crataegus nigra*, *Prunus serrulata*, *Robinia x margarettae*, *Sorbus austriaca* and *Tilia x juranyiana*. The lists compiled by Bojarczuk (1971) and Stypiński (1997) do not list any



**Figure 2.** Mistletoe-oak in Barbarka Forest (photograph by M. Kunz on 6 October 2022)

of the eight taxa either. The extensive list provided by Nicholson (1932) includes only sessile oak in addition to *Prunus persica*. Idžojtić et al. (2006) report only *Crataegus nigra* as one of mistletoe hosts in Croatia and *Prunus persica* in Slovenia. Information on the occurrence of mistletoe on *Sorbus mougeotii* in Switzerland was given by Hegi (1981) and Tubeuf (1923).

The frequency of the occurrence of mistletoe on the three mistletoe hosts is reflected in the available source materials quoted in Barney et al. (1998): only two literature references for *Sorbus mougeotii*, while as many as 14 and 15 references for *Quercus petraea* and *Prunus persica*, respectively. The occurrence of common mistletoe on native oaks, especially on sessile oak, is a rare phenomenon observed in very few European countries. Until the late 1970s, *Viscum album* subsp. *album* on *Quercus robur* L. near the town of Sztum in northern Poland, described by Preuss (1907) and later reported by Tubeuf (1923), Abromeit (1926) and Gross (1931), was considered to be the only site where such a parasitic association was observed in present-day Poland. The site is also mentioned by Bojarczuk (1970), who, in addition to *Q. robur*, mentions other American species of the genus *Quercus* – *Q. borealis* Michx., *Q. coccinea* Muenchh., *Q. palustris* Muenchh. and *Q. tinctoria* Bartr. New localities

of mistletoe on pedunculate oak were only reported by Misiewicz & Sobisz (1987) from the area of the former Słupsk Province. This was one tree growing near the town of Kępice in the central part of the province, and two trees growing in the village of Skórzewo in its southern part. This information was not included by Stypiński (1997) on his list of mistletoe hosts in Poland.

Among the hosts of mistletoe in Poland, neither the second forest-forming native oak species – the sessile oak *Q. petraea*, nor its hybrid with pedunculate oak, have been listed so far. Such an association was reported from Spain by Lopez-Saez (1994), however, the author put a question mark next to the name *Q. petraea* in the table listing the hosts of common mistletoe. The sessile oak was reported by Idžojić et al. (2006) as a host of mistletoe in Croatia, while no such parasitic association was reported from Slovenia. Of the several cases of mistletoe-oaks in the territory of present-day Ukraine, two are considered authentic – from Volhynian Ostroh observed in 1896 and from the vicinity of Kiev observed in 1912, both reported by Bojarczuk (1970). According to Bulgakova (1977), there was one oak tree parasitised by mistletoe in botanical gardens and parks of right-bank Ukraine. However, the author did not specify which species it was. Based on the most recent data collected in a computer database, the genus *Quercus* was included together with the genera *Fraxinus*, *Prunus*, *Pyrus* and *Sorbus* in the second group of hosts reaching 12–18 records (Krasylenko et al., 2020).

Briggs (2021) reports that oaks are rare hosts of mistletoe in the UK. According to Box (2019), 15 oak trees parasitised by mistletoe were recorded in this country in 2017 and 2018, including six specimens of *Q. robur*, one tree identified as a hybrid of pedunculate and sessile oaks (*Q. robur* x *Q. petraea*), six *Q. rubra* trees, one *Q. coccinea* tree and one *Q. palustris* tree. In his earlier paper, Box (2000) reported 11 mistletoe-oaks from Britain, identified as a *Q. robur* x *Q. petraea* hybrid (one 190–260 years old tree), *Q. robur* (6 trees) and *Q. coccinea* (1) and *Q. borealis* (3). In his study published 68 years earlier, Nicholson (1932), citing Bull's work from 1869 (published in 1870), reported one *Q. sessiliflora* tree with one mistletoe bush, growing in Deerfold woodland in Herefordshire. This work includes a description and drawing of the host with mistletoe. The age of the tree was estimated at 50–60 years and the diameter of the mistletoe bush – at approximately 3 feet and 6 inches, or 106.68 cm. At the time (1869), this tree was the eighth mistletoe-oak in England. The species affinity of the seven trees was not provided by the author. In his paper from the 1930s, Nicholson (1932) reported that in England mistletoe also occurs on a hybrid of pedunculate and sessile oak in Leigh Woods near Bristol (a tree and site reported earlier by Roper (1916), while *Q. robur* is a rare host of mistletoe in England. According to

the aforementioned work by Box (2019), the location and description of the site suggests that the reported hybrid of pedunculate and sessile oaks may be the specimen identified by Bull (1870) and Nicholson (1932) as *Q. sessilis*.

Frochet et al. (1994) and Urech (2008) reported that only France appears to be an exception in terms of mistletoe-oaks, as the hemiparasite was recorded on 390 native oaks (*Q. robur* and *Q. petraea*) and 463 “American oaks” (*Q. coccinea*, *Q. palustris*, *Q. rubra*). In many places in France, however, either *V. album* has disappeared from the oak in question, or the oak in question no longer exists, and there are now about 245 native oaks with *V. album*. Ramm et al. (2000) refined this number to 247 trees, including 192 (78%) trees of *Q. robur* and 55 trees (22%) of *Q. petraea*. Toni (2017) emphasises, however, that these were only isolated single specimens, far apart from each other, and the small number of recorded trees among the huge oak populations in the main mistletoe areas demonstrates that native oaks are largely resistant to *Viscum album*. The number of cases cited above is significant in view of one case of *Q. robur* parasitised by mistletoe (near Sztum) and one case of mistletoe growing on *Q. petraea* (in the town of Neef in the district of Cochem-Zell in the state of Rhineland-Palatinate) in interwar Germany and several cases on oak trees in France reported by Tubeuf (1923) and then by Gandil (1950).

An inventory of mistletoe-oaks carried out by Ramm et al. (2000) in France showed that although *Q. robur* is 3.5 times more likely to be parasitised by mistletoe than *Q. petraea*, the average number of mistletoe bushes per tree is slightly higher for the latter species – 7.1 for *Q. petraea* and 6.4 for *Q. robur*. For comparison, the authors report a mean value of 8.3 for 149 specimens of *Q. rubra* and 13.8 for 314 trees of *Q. palustris/coccinea*, and 12.9 for 89 trees of the rare host *Ulmus* sp.

On the basis of 24 random tree samples, Ramm et al. (2000) also tried to answer the question whether mistletoe shows any preference for hybrids of the two species – *Q. robur* and *Q. petraea*. They found that 14 of the 17 examined mistletoe host oaks identified as *Q. robur* were pure species, while the remaining three oaks showed a small proportion of *Q. petraea* traits. None of the seven mistletoe-oaks identified as *Q. petraea* were pure species, and all showed slight hybridisation with *Q. robur*. The authors concluded, however, that their results are inconclusive to determine preferences of mistletoe for either of the two native oak species, or for specific hybrids, unless the composition of the oak populations in the mistletoe area is factored in.

Switzerland is also a country with a frequent occurrence of mistletoe on *Q. robur* and *Q. petraea*. Hegi (1981) reports the occurrence of mistletoe on pedunculate oak in the cantons of Grisons, Geneva and Vaud and in the former Rhine Province (also known as Rhenish Prussia), but although confirmed on

cultivated American red oaks, *V. album* is completely absent in North America.

At present, native oak trees overgrown with mistletoe from Switzerland and France constitute a source material for the cultivation of mistletoe on oak trees, which has been carried out since 1949 at the Hiscia Institute for Cancer Research in Arlesheim, the canton of Basel, for the production of preparations used in cancer therapy (Toni, 2017).

The descriptions of the hosts and the hemiparasite presented in Table 1 and chapter 3.1 usually include the date of a given observation, and this is because recently the presence and abundance of mistletoe in Toruń has been changing quite drastically, mostly declining. This is particularly the case in the green space in the central part of the city, where a specialist company, contracted by the City Council, mechanically removes the mistletoe. As part of these measures, mistletoe has been cleared from the host new to Poland – *Laburnum anagyroides* Medik. at a site we recently described (Nienartowicz et al., 2021). Damage to tall greenery caused by strong winds contributes to these changes to a lesser extent.

In the vicinity of the described sites, abundant mistletoe was recorded on its most common hosts in Toruń, i.e.

*Acer platanoides*, *Populus* ssp., *Tilia cordata* and *Robinia pseudoacacia*. Probably from these specimens, the appealing fruits of mistletoe were carried by birds along with their droppings to new host taxa. Such a migration route of this hemiparasite was particularly noticeable in the case of a low hedgerow of *Crataegus nigra* (Fig. 3) growing in the immediate vicinity of tall mistletoe trees and partly even under their canopy.

Of the new mistletoe hosts, young specimens of *Sorbus austriaca*, recently frequently planted along the exit roads from Toruń, are the least resistant to mistletoe infection. The high incidence and abundance of mistletoe on this host at site Vc indicates that rows of Austrian rowan may constitute specific corridors facilitating the long-distance spread of mistletoe.

## 5. Conclusions

The information presented above demonstrates that, in view of the likely changes in the species affinity of the infested oak trees and the process of hybridization, research aimed at assessing the resistance or susceptibility to mistletoe parasitism requires genetic analysis, both of the hemiparasite



**Figure 3.** Specimens of black hawthorn infected with mistletoe at site I in grid square CD3061 (photograph by L. Rutkowski on 19 January 2023)

and its hosts, as well as the use of molecular ecology methods. The observations presented in this paper, both those made by us and by other authors, confirmed the opinion expressed by Danielewicz and Urbański (1984) that the registration of new hosts and the assessment of the degree of their infection is of great importance for a more thorough understanding of the biology of the European mistletoe, especially the formation of the ecological scale in terms of parasitising new host species and the relationship between anatomical and physiological characteristics of the host and its susceptibility or resistance to infection by the hemiparasite in question. The result of these observations and analyses may provide an answer to an interesting question: Is there coevolution between the host and the parasite in the ecological system under study? As postulated by Bojarczuk (1970), the analysis of susceptibility and resistance should also involve microorganisms present on the host bark, the activity of which may increase or hinder mistletoe infection.

The observations presented here also lead to the conclusion that, in view of the rapid changes in the vegetation structure caused by varying ecological factors, especially climate change, as well as the measures taken to mechanically remove mistletoe, it is necessary to intensify and modify the monitoring of its occurrence, especially in urban areas.

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