DIVERSITY OF CYNIPID WASPS ON OAKS IN THE URBAN GREENERY OF NITRA

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Abstract
In this study, we focused on analysis of spectrum and trophic relationships of gall-inducing species from the family *Cynipidae* associated with the genus *Quercus* in the urban environment of Nitra city. The research was carried out in 2022-2025. We have also evaluated the visual attractiveness of the galls and which parts each species uses to create galls. We have found 36 species of gall-inducing cynipid wasps, on 6 oak species, which were planted in urban greenery of Nitra city. Our results reveal that the majority of cynipid wasps develop on pedunculate oak (*Quercus robur*) and turkey oak (*Quercus cerris*). The most preferred part for gall formation is bud (24 species) and leaf (13 species). The least preferred part for gall formation was the roots. In 4 species, the part of development of the sexual generation is unknown. The galls of the agamous generation are more visually attractive. The sexual generation produces mostly inconspicuous types of galls from buds or male catkins. All found cynipid wasp species are native, except *Andricus quercusfoliatus*, which has native range in southern parts of North America and Mexico.

Key words: Hymenoptera, Quercus, gall, entomofauna, biodiversity

Introduction

Galls of cynipid wasps have been important resources to human societies for millennia (Csóka, 1997, Csóka et al., 2005). Modern scientific study of the galls and their inhabitants dates back at least as far as Malpighi's 'De Gallis' (1687). Later reviews and biology of cynipids were addressed by Askew (1984), Shorthouse, Rohfritsch (1992), and Stone et al. (2002). In Slovakia, gall wasps were dealt with, for example, in works by Červenák (1958), Hrubík (1976), Hrubík, Požgaj (1988), Kelbel (2002, 2004), Skuhravý et al. (1998).
Galls of cynipid wasps are structures developed exclusively for the benefit of the gall inducer (Romanes, 1889, Cockerell, 1890). Gallwasps use various coatings of sticky resins or hairs and spines of varying lengths as protection (Stone, Cook, 1998). Many cynipid galls change color during development, usually from green to red. There is evidence that female parasitoids recognize color and use it to assess host quality (Askew, 1961, Czecuga, 1977). The definition of genera in the classification of Cynipidae (Hymenoptera), especially in the tribe Cynipini, is problematic (Dailey, Menke, 1980). The alternation of asexual and sexual generations in many genera creates morphological variation among adults, which significantly complicates classification (Melika, Abrahamson, 2002). They are the second most species-rich group of gall-inducing insects after the midges (Diptera: Cecidomyiidae) (Melika, 2006). The Cynipinae are divided into two main trophic groups: gall-inducing and gall-associated inquilins, which together form 6 tribes (Melika, 2006, Abe et al., 2007). The biology of these tribes and their possible phylogenetic relationships are described in Stone et al. (2002) and Csóka et al. (2005). The six tribes of gall-inducing wasps include five gall-inducing tribes and one obligate inquilin, which predominantly attack galls of other cynopods. The majority of gall wasps induce galls on oaks and other Fagaceae (Lithocarpus, Chrysolepis, Castanopsis and Castanea) or roses (Rosa) (Ronquist, Nieves-Aldrey et al., 2015, Melika, 2006, Melika, Abrahamson, 2002). Aproximately 1 370 cynipid gall wasps species are currently recognized, although Nordlander (1984) has estimated that the actual number is between 3000 and 6000 (Csóka et al., 2005). Biodiversity increases the recreational attractivity of landscape settings (Gao et al., 2019) .In this paper, we focus on the fauna of the species spectrum of gall wasps Cynipidae on oak trees growing in the urban environment of the city of Nitra. In addition to the species composition, we also evaluated the visual attractiveness of the galls of individual gall wasp species as a potential interesting visual element in natural settings.

Materials and methods

The research was carried out in Nitra city in 2022–2025. The Nitra city is situated in the southwestern part of Slovakia (N48°18'53" E18°5'28"). It lies 167 m above sea level. Climate is characterized as a semi-arid and humid. The average annual total precipitation is about 600 mm. The average annual

temperature is about 9.5ºC. The cynipid wasps species monitoring in field conditions was realized monthly throughout the year. For monitoring, we selected street areas, housing estates, and park areas in the city where oak trees occur. Individual gall wasp species were determinated mainly according to collected samples of galls. Monitorovali sme agamous aj sexual generation. Zaznamenávali sme u každej generácie, na ktorej časti stromu jednotlivé druhy vytvárajú a ich hostiteľské dreviny. Visual attractiveness was assessed according to the following categories:
1. Multicolored or single-colored lump, reasonably large and distinctive in shape with possible outgrowths or trichomes. Easily visible on the plant. Long-term durability of the lump even after the fruits, inflorescences and assimilation organs have fallen.
2. Multicolored or single-colored lump, reasonably large and distinctive in shape with possible outgrowths or trichomes. Easily visible on the plant. Short-term durability of the lump. After the fruits, inflorescences and assimilation organs have fallen, it loses its visual attractiveness.
3. Multicolored or single-colored lump, smaller in size, but distinctive in shape, with possible outgrowths or trichomes. Less visible on the plant. Long-term durability of the lump even after the fruits, inflorescences and assimilation organs have fallen.
4. Multicolored or single-colored lump, smaller in size, distinctive in shape, with possible growths or trichomes. Less visible on the plant. Short-term durability. After the fruits, inflorescences and assimilation organs fall off, it loses its attractiveness.
5. Inconspicuous in color and shape, difficult to see on the plant, durability long-term or short-term, without significant visual attractiveness.

Results
During research on gall wasps occurring on oaks in urban greenery in the city of Nitra, we identified a total of 8 oak species, from which 6 were infested by cynipid gall wasps. *Quercus rubra* and *Q. palustris* showed no presence of galls. Most gall wasps were associated with native oak species. The only introduced species was *Quercus* × *turneri* 'Pseudoturneri', where only one parent is native (see Table 1). In total, 36 species of gall wasps (Cynipidae) were recorded. The highest number of gall wasp species was found on *Q. robur* (33 species), *Q. cerris* (15 species), and *Q. petraea* (14 species). The most preferred plant parts for gall formation were buds (24 species), leaves (13 species), and catkins (8 species). The least preferred part was the root (1 species). Table 1 also shows data on gall types produced by the agamous and sexual generations. Based on the evaluation of visual attractiveness, the agamous generation produces more attractive gall types compared to the sexual generation. Only *Chilaspis nitida* (category 2), *Andricus conificus* (cat. 1), *Neuroterus quercusbaccarum* (cat. 2), and *Biorhiza pallida* (cat. 2) produce visually attractive galls in the sexual generation. The visual attractiveness levels of individual gall wasp species by generation type are listed in Table 1.Most of the recorded gall wasp species are native. The only non-native species is *Andricus quercusfoliatus*, whose native range is in the southern parts of North America and Mexico. It was found on *Q. virginiana*. For four gall wasp species recorded in Nitra, the gall type of the sexual generation is unknown. For this reason, their visual attractiveness was not evaluated.

Discussion and Conclusion
As the results show cynipid gall wasps have a high diversity on oaks growing in urban settings of the city of Nitra. Similar results were published by Ronquist, (2015) and Csóka et al. (2005). Native oak species contribute significantly to urban biodiversity, therefore making it more attractive for recreation in the urban environment (Gao et al. 2019). Non-native oak species growing in Nitra were less infested by galls. Sporadic occurrence was on *Q.* × *turneri* or absent altogether on *Q. rubra*, and *Q. palustris*. Gall wasps often create visually attractive types of galls that are easily noticeable on trees, and many of them enhance the aesthetic appearance of oaks. From a visual perspective, bud galls are the most attractive, and they are also the most common type. This fact is also reported in the research of Kelbel (2004). The research shows that oaks and gall wasps contribute not only to biodiversity in the urban landscape but also to the visual enhancement of green spaces in the city. They therefore represent a potentially interesting element in the context of recreation.

Tab. 1: List of gall inducing cynipid wasps found in the city of Nitra

Serial number	Species name	Generation agamous/sexual	Host plant in Nitra	Atractivity agamous/sexual
1.	*Cynips quercuscalicis* (Burgsdorff, 1783)	acorn/catkin	Q. robur, Q. cerris	1/4
2.	Cynips quercusfolii Linnaeus, 1758	leaf/bud	Q. robur, Q. petraea	2/5
3.	Andricus caputmedusae (Hartig, 1843)	bud/bud	Q. robur, Q. dalechampii	1/5
4.	Chilaspis nitida (Giraud, 1859)	leaf/catkin	Q. cerris, Q. robur	3/2
5.	Andricus hungaricus (Hartig, 1843)	bud/bud	Q. robur	1/5
6.	Cynips divisa Hartig, 1840	leaf/leaf,	Q. robur	3/4
7.	Cynips disticha Hartig, 1840	leaf/catkin	Q. robur, Q. petraea	4/5
8.	Cynips longiventris Hartig, 1840	leaf/bud	Q. robur, Q. petraea	2/5
9.	Andricus glutinosus (Giraud, 1859)	bud/bud	Q. robur	3/5
10.	Trigonaspis megaptera (Panzer, 1801)	leaf/bud	Q. robur, Q. petraea	4/4
11.	Andricus inflator Hartig, 1840	bud/shoot	Q. robur, Q. petraea	4/3
12.	Andricus foecundatrix Hartig, 1840	bud/catkin	Q. robur	2/5
13.	Andricus solitarius (Boyer de Fonscolombe, 1832)	bud/catkin	Q. robur, Q. cerris	4/5
14.	Andricus testaceipes Hartig, 1840	shoot/leaf	Q. robur, Q. petraea, Q. cerris	4-5/4
15.	Andricus lucidus (Hartig, 1843)	bud/catkin	Q. robur, Q. petraea, Q. cerris	1-2/5
16.	Andricus kollari (Hartig, 1843)	bud/bud	Q. robur, Q. petraea	1/5
17.	Andricus grossulariae Giraud, 1859	Acorn/catkin	Q. robur, Q. cerris	1/4
18.	Andricus conificus (Giraud, 1859)	bud/shoot	Q. cerris, Q. robur	3 or 1/1
19.	Neuroterus anthracinus (Curtis, 1838)	leaf/bud	Q. robur, Q. petraea, Q. cerris, Q. x turneri	4/5
20.	Andricus coriarius (Hartig, 1843)	bud/bud	Q. petraea, Q. dalechampii, Q. robur	1/5
21.	Andricus conglomeratus (Giraud, 1859)	bud/bud	Q. robur, Q. cerris	1/5
22.	Andricus curvator (Hartig, 1840)	bud/leaf	Q. robur L., Q. petraea, Q. x turneri	3/4
23.	Neuroterus numismalis (Fourcroy, 1785)	leaf/leaf	Q. robur, Q. petraea, Q. dalechampii	3/5
24.	Neuroterus quercusbaccarum (L., 1758)	leaf/catkin, leaf	Q. robur	4/2
25.	Neuroterus albipes (Schenck, 1863)	leaf/leaf	Q. robur	4/4
26.	Cerroneuroterus lanuginosus (Giraud, 1859)	leaf/catkin	Q. cerris	3/5
27.	Biorhiza pallida (Olivier, 1791)	root/bud	Q. robur, Q. petraea, Q. cerris	5/2

28.	**Andricus truncicola (Giraud, 1859)**	**bud/bud**	**Q. dalechampii, Q. robur, Q. cerris**	**1/5**
29.	**Aphelonyx cerricola (Giraud, 1859)**	**shoot/unknown**	**Q. cerris, Q. turneri**	**1/-**
30.	**Andricus lignicolus (Hartig, 1840)**	**bud/bud**	**Q. cerris, Q. robur**	**1/5**
31.	**Andricus dentimitratus (Rejtő, 1887)**	**acorn/unknown**	**Q. robur**	**1/-**
32.	**Andricus aries (Giraud, 1859)**	**bud/bud**	**Q. robur**	**1/5**
33.	**Andricus galeatus (Giraud, 1859)**	**bud/unknown**	**Q. robur**	**1/-**
34.	**Andricus polycerus (Giraud, 1859)**	**bud/bud**	**Q. robur**	**1/5**
35.	**Andricus corruptrix (von Schlechtendal, 1870)**	**bud/bud**	**Q. robur, Q. petraea, Q. cerris**	**3/5**
36.	**Andricus quercusfoliatus (Ashmead, 1881)**	**bud/unknown**	**Quercus virginiana**	**4/-**

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Souhrn
V této studii jsme se zaměřili na analýzu spektra a trofických vztahů hrčkotvorných druhů z čeledi Cynipidae spojených s rodem *Quercus* v urbanizovaném prostředí města Nitra. Výzkum probíhal v letech 2022–2025. Hodnotili jsme také vizuální atraktivitu jednotlivých hálok a části stromů, které jednotlivé druhy využívají k tvorbě hrček. Zjistili jsme 36 druhů hrčkotvorných vosiček na 6 druzích dubů vysazených v městské zeleni Nitry. Naše výsledky ukazují, že většina druhů se vyvíjí na dubu letním (*Quercus robur*) a ceru (*Quercus cerris*). Nejpreferovanější částí pro tvorbu hálok jsou pupeny (24 druhů) a listy (13 druhů). Nejmenší zájem byl o kořeny. U čtyř druhů není známo, na které části stromu se vyvíjí sexuální generace. Hálky agamní generace jsou vizuálně atraktivnější. Sexuální generace vytváří převážně nenápadné typy hálok z pupenů nebo samčích jehněd. Všechny zjištěné druhy hrčkotvorných vosiček jsou původní, s výjimkou *Andricus quercusfoliatus*, jehož přirozený areál rozšíření se nachází v jižních částech Severní Ameriky a Mexika.

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