SPECIES RICHNESS AND IMPACT OF GALL-FORMING INSECTS ON TURKEY OAK (*QUERCUS CERRIS*) IN HERNEACOVA FOREST

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Abstract. *Gall-forming insects are some of the most highly evolved herbivores in the world. Diptera and Hymenoptera are among the most dominant gall-forming groups, with estimated species ranging from 1300 (gall wasps) to 13000 (gall midges). The complex relationship between gall-forming midges and wasps and the host plant, Turkey oak, is considered to be a highly evolved association. Galls can contain multi-trophic, closed and complex communities with a variety of residents, including the gall inducer, parasitoids, hyperparasitoids and inquilines. The aim of the paper was to provide a list of gall-forming insects associated with Quercus cerris present in the Herneacova Forest (Timis County), under the climatic conditions of the year 2023. In autumn 2023, samples representing Cynipidae (Hymenoptera) and Ceciidomidae (Diptera) galls were collected from Quercus cerris trees. 2 observations were made in each cardinal direction, for a total of 8 points/observation. The visual inspection method was used, which consisted of visiting each observation point at a slow walking pace for a minimum of 30 minutes to 1 hour, with an interval of 10 to 14 days. In the Herneacova Forest, 9 species of gall - forming insects were collected and identified. The taxonomic structure revealed species belonging to orders Diptera and Hymenoptera, and families Ceciydomidae and Cynipidae. The following species are included in the list: Dryomyia circinans, Janetia cerris, Neuroterus numismalis, Neuroterus lanuginosus, Cynips quercusfolii, Andricus lignicola, Andricus kollari, Andricus quercus-salicis, Andricus caputmedusae.*

Keywords*: gall-forming insects, species richness, impact, Quercus cerris, forest.*

INTRODUCTION

Turkey Oak (*Quercus cerris*) is a large, fast-growing deciduous tree native to southern Europe and Asia Minor, usually one of the dominant deciduous species in mixed forests. In Romania, it is widespread in the lowlands, especially in the silvosteppe and forest areas of Muntenia and Oltenia, from where it climbs in altitude and in the hilly areas, up to an altitude of 500-600 m, also in western Transylvania and Banat it often occurs on hills (NEGULESCU & SĂVULESCU, 1965). It is useful species for reforestation, erosion control and soil conservation because it is a pioneer species that can rapidly colonize open areas. It is often preferred as a tree in urban landscaping because it can withstand air pollution, is relatively drought tolerant, and has an attractive appearance. Turkey oak is also used locally in traditional medicine, while it is also an ecologically important species, as many animals consume its acorns and young shoots (SIMEONE ET AL., 2019). As with most oak species, the turkey oak has experienced periods of decline that have been attributed to a variety of interacting biotic and abiotic causes (AMORINI ET AL., 1996; GOTTSCHALK & WARGO, 1997; COLANGELO ET AL., 2018). Of these causes, biotic causes have been more prevalent, with insects being responsible for both the loss of foliage and the loss of reproductive capacity.

Turkey oak is one of the tree genera with the highest species richness of phytophagous insects. Considerable differences in the number of species recorded on the same host species were found by SOUTHWOOD (1961) for the UK, ALTENKIRCH (1986) for Germany and CSÓKA

(1997, 1998) for Hungary. The argumentation of the results of the three studies is related to the *Quercineae* flora, which is much richer in the Eastern European Carpathians. Furthermore, more oak species occur naturally here than in Germany or Great Britain. The richness of phytophagous insects is certainly influenced by these facts. CSÓKA (2006) reported 658 phytophagous insect species feeding on *Quercus* sp. Of these, the orthopteran, thysanopteran and heteropteran species are generally polyphagous, and these can be considered more as secondary insect pests of *Quercus*. In contrast, quercivorous (oak-feeding) *Diptera* species are strictly specialized on their primary hosts, with average host specificity indices up to 1.5 (extremely high). The situation is identical for the quercivorous *Hymenoptera*, where we find the same high level of host specificity and host fidelity. In the case of quercivorous Lepidoptera, only about one third are strictly specialized on *Quercus*. The mean host specificity index of 4.7 indicates a more oligophagous behavior. In total, 46.7% of the quercivorous insects (307 species) are specialized in the *Quercus cerris*. This figure clearly shows the irreplaceable role of *Quercus cerris* in maintaining phytophagous biodiversity. Among the gall insect species present in *Q. cerris*, highly sophisticated interactions are very common.

Therefore, the aim of the present paper is to highlight the diversity of the quercivorous gall-forming fauna present in the Herneacova Forest (Timis County), under the climatic conditions of the year 2023, with the main study species being the *Quercus cerris*, due to the highest occurrence of this tree species in the Herneacova Forest.

MATERIAL AND METHODS

Study area

For the establishment of the quercivorous gall-forming fauna, the experimental field was located in 2023 in the northern part of Timiș County - Herneacova Forest (45°51′26″N 21°30′57″E).

The geomorphological conditions in the forestry under study are favourable for the main species, oaks, turkey oaks, hungarian oaks. The lack of water and the excess of light and heat in the sunny areas are the limiting factors for forest vegetation. The majority of the area occupied by the forestry under study is in the main basin of the Bega river (in the area where it is canalised).

The general climate, which is characteristic for the forested area in the territory of O.S. Recaș/Herneacova Forest, is very homogeneous, it is defined as a temperate continental climate with discrete Mediterranean influences. The complex interaction between the solar radiation, the relief features and the atmospheric circulation, which is characteristic for this area, determine the climate of the studied area. The average annual temperature is 22.8 degrees Celsius. Air temperature shows significant monthly and annual fluctuations. The variations in temperature are particularly pronounced between the lower altitudes and the higher altitudes. At an altitude of 100 metres, the average vertical temperature gradient is 0.5 to 0.6 degrees Celsius.

The total amount of precipitation, as well as its distribution pattern, favours the development of forest vegetation, especially since, about 2/3 of it falls during the vegetation period. The precipitation in the form of snow falls from the second ten days of November to the second ten days of March. On average, the earliest snowfall occurs in early December and the latest in the final ten days of February.

The turkey oak (*Quercus cerris*) is the most widespread species of the forest species studied. It occupies 49% of the forest area of the forestry and is found throughout the territory.

Specimen collection

Between September and December 2023, samples representing the galls of *Cynipidae* (*Hymenoptera*) and *Cecyiidomidae* (*Diptera*) were collected from the trees of turkey oak

(*Quercus cerris*) in Herneacova Forest (Timis County). We used the same collection method at each observation point during our surveys. We made 2 observations in each cardinal direction, 8 points/observation in total. The procedure was to make a visual inspection at each observation point using a slow walking pace for at least 30 minutes to 1 hour, at 10 to 14 day intervals (Figure 1). At each observation point, galls on leaves, shoots and/or fruiting bodies of *Quercus cerris* were inspected from the base of the tree to a height of 2 m. Brief characteristics of the habitat were noted. All galls collected were recorded. Local abundance was also noted.

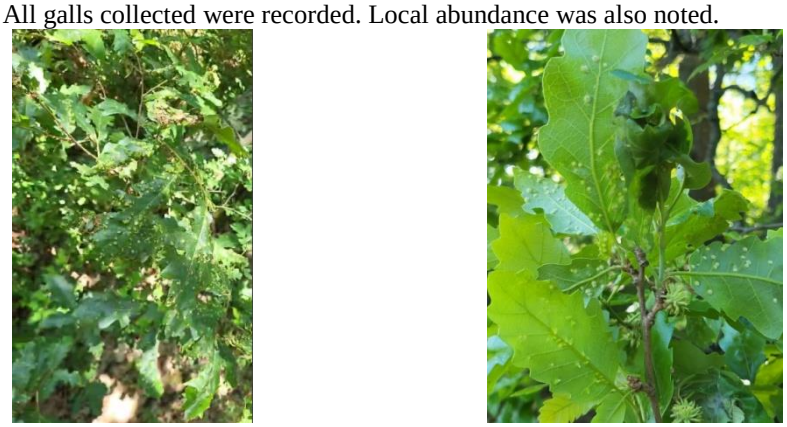

Figure 1. Aspects from the study site, Herneacova Forest (Timis County), 2023

To study the galls, biological material was collected from the forest, prepared and preserved in the Laboratory of Phytosanitary Diagnosis of the Faculty of Agriculture, and identified using the Kruss microscope.

The identification of the galls from the experimental field / Herneacova forest was made with the help of specialist literature: CAMERON, 1893; ANANTHAKRISHAN, 1984; WEIS ET AL., 1988; MOUND, 1994; ABRAHAMSON ET AL., 1997; PRICE ET AL., 1998; GONCALVES-ALVIM & FERNANDES, 2001.

RESULTS AND DISCUSSIONS

In the forests of our country, but not only there, the gall-forming insects that live on deciduous trees are of particular economic importance due to their high diversity and abundance, as they form a large part of the biodiversity of a region.

The advantages of using galling insects to study diversity in mixed forests are: - the gall-forming communities often include species belonging to several orders or families, providing us with a wide range of species for comparison; - the gall structure is sedentary and permanent, allowing us to sample species richness even when the different developmental stages, in particular the adult, are absent; last but not least - the host plant species/organ attacked are usually restrictive, having a different shape for each insect species, which facilitates using the morphostructure of the attack to identify species and determine local abundance.

Previous studies (PRICE ET AL., 1987; FERNANDES & PRICE, 1988; PRICE ET AL., 1998) support the idea that local patterns of specific gall insect species richness rise as hygrothermal stress rises. The existence of high soil water stress is also an alternative explanation for the high abundance of gall insect species in a given area. It is known that soil water deficit leads to nutrient deficiencies, but also to the accumulation of toxic elements, all of which have profound effects on woody vegetation and, of course, to the overpopulation of gall insect populations (PRICE ET AL., 1998; GONÇALVES-ALVIM & FERNANDES, 2001).

Therefore, in order to highlight the diversity of the quercivorous gall-forming fauna present in the Herneavova Forest (Timis County), 9 species of insects were collected and identified in the 8 observation points present on *Quercus cerris*. These species belonged to the orders *Diptera* and *Hymenoptera*, respectively to the families *Ceciydomidae* and *Cynipidae*. The taxonomic structure according to the genus shows the presence of 5 genera: *Dryomyia* (with 1 species), *Janetia* (1 species), *Neuroterus* (2 species), *Cynips* (1 species), *Andricus* (4 species) (table 1). The highest richness was found in the genus *Andricus*.

Table 1.

Composition of the quercivorous gall-forming fauna present in Herneavova Forest (Timis County), 2023

Order	Family	Species	Parts of plant under attack	Generation
Diptera	*Ceciydomidae*	*Dryomyia circinans (Giraud, 1861)*	*leaves*	*sexual*
		Janetia cerris (Kollar, 1850)	*leaves*	*sexual*
Hymenoptera	*Cynipidae*	*Neuroterus lanuginosus (Giraud, 1859)*	*leaves*	*agamic*
		Neuroterus numismalis (Geoffroy, 1785)	*leaves*	*agamic*
		Cynips quercusfolii (Linnaeus, 1758)	*leaves*	*agamic*
		Andricus lignicola (Hartig, 1840)	*the axial and apical buds*	*agamic*
		Andricus kollari (Hartig, 1843)	*shoots*	*agamic*
		Andricus caputmedusae (Hartig, 1843)	*shoots*	*agamic*
		Andricus quercus-salicis (Borgsdorf, 1783)	*fructification*	*agamic*

Studying the information from the Romanian literature, namely the work "Zoocecidii din România" published by BORCEA (1912), we observe that he systematized for the first time the information related to the insect galling species in our country, highlighting for the order *Diptera*, the presence of 67 insect galling species, of which 43 species present on trees and shrubs, at that time 4 species were mentioned on *Quercus*, and of these 4 species present on the turkey oak tree (*Quercus cerris*). For the *Hymenoptera*, 78 species were mentioned in the same publication. 55 of these were gall-forming species on *Quercus*, including 15 on *Quercus cerris*.

A rich gall-forming entomofauna can be observed when comparing the data obtained with those mentioned above. Of the 4 species of quercivorous *Diptera* reported by BORCEA (1912), 2 are also found in the present research; and of the 15 species of quercivorous *Hymenoptera* mentioned in the same work, 7 are also present in the forest of Herneacova.

New species, mostly from wooded areas, were included in the list of galling insects published by BORZA & GHIUȚĂ (1942). From that date up to the present day, a large number of new species have been reported in the fauna of our country. The presence of the species *Janetia cerris* in the turkey oak, in green urban landscapes, is mentioned for the first time by VÎRTEIU ET AL. (2023).

The galls produced by these insects have been analysed. In the following lines, brief information and original pictures of these galls collected in Herneacova Forest are presented.

Diptera: Ceciydomidae

Dryomyia circinans - the galls produced by this pest are 5-7mm in diameter, beige with light greyish inlays. Abundant pubescence covers the entire surface. The galls form a small ring

with raised edges and a hole in the centre, into which the larval chamber opens, on the upper surface of the ant. On the underside it is protruding, forming a slightly flattened, dense and hairy disc which forms the larval chamber containing a single larva (Figure 2 A - D). It is common to find several galls on a single leaf. It is a univoltine species that overwinters as a larva on plant debris on the surface of the soil and pupates in the spring.

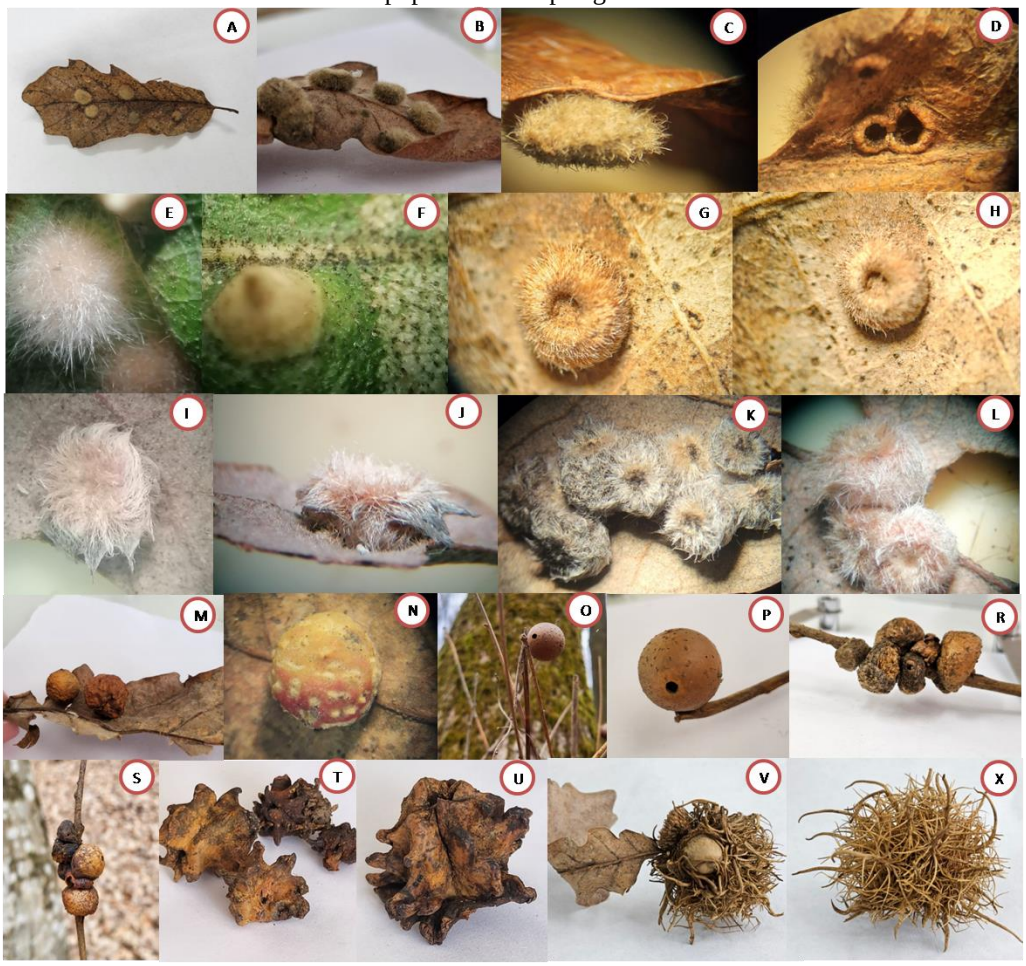

Figure 2. The turkey oak gall – forming insects: A - D - *Dryomyia circinans:* under and upperside leaf galls; E – F - *Janetia cerris:* upper and underside leaf galls; G – H - *Neuroterus numismalis:* underside leaf galls; I – L - *Neuroterus lanuginosus:* underside leaf galls; M – N - Agamic leaf gall induced by *Cynips quercusfolii*; O – P - Agamic shoot gall induced by *Andricus kollari*; R – S - Agamic axial and apical bud gall induced by *Andricus lignicola;* T – U - Acorn cup gall induced by *Andricus quercus-salicis*; V – X - Acorn cup gall induced by *Andricus caputmedusae,* November 2023, Herneacova Forest (photos by Arsine & Virteiu)

Janetia cerris – attack is visible on both sides of the leafblade. On the upper side, a smooth, conical prominence, about 2 to 3 mm in height, of a slightly golden yellow colour, containing the larval cavity, can be observed. Correspondingly, on the underside of the leaf there is a hairy, slightly protruding, circular, hairy disc, about 5 mm in diameter, which serves as a "plug" for the larval chamber and which opens up at maturity. Each gall is covered with very

dense pubescence, which is initially whitish and then reddish-grey (Figure 2 E - F). The galls are often deformed, with the lower edges waved. The larva is red. When mature in autumn, the galls open by dropping the hairy disc on the underside of the leaf and the pupa falls to the ground in the plant debris where it remains until the adult emerges the following spring.

Hymenoptera: Cynipidae

Neuroterus numismalis - the galls develop on the lower sides of the leaf blades, less frequently on the upper sides, resulting in round, flattened (discoid) galls with a small depression in the centre, similar to a coin, up to 3 mm in diameter and 1 to 1.5 mm in height. They are yellowish-brown or light brown in colour and have a silky texture with radial, concentric stripes and a larval chamber in the interior (Figure 2 G - H). The galls are present on the leaves of Quercus genus in summer and fall to the ground in autumn, with the emergence of the adults of the agame generation in the following spring.

Neuroterus lanuginosus - the galls appear on the underside of the leaves and are usually in clusters. They are 5 - 7 mm in diameter, round, flat (discoid) and completely covered with long hairs. The central hairs are orange-brown and the lateral ones are greyish white (Figure I - L). There are many horizontal cavities in the tissue around the central larval chamber. Groups of 4 to 8 often occur on leaves.

Cynips quercusfolii - galls on *Quercus* sp. leaves, grouped and rarely solitary, usually in the upper part of the canopy. Spherical in shape with a glabrous, smooth, shiny surface, 10-15 mm in size. The wall of the gall is soft, juicy, spongy and reddish in colour, later becoming reddish brown (Figure 2 M - N). The larval chamber, also spherical with a thin wall, is located in the centre. The pods are formed in May and mature in September-October.

Andricus kollari - the galls are of bud origin, spherical in shape and 10-25 mm in diameter. They have a woody consistency and a smooth, sometimes knotless, shiny surface, yellow in colour, turning brown as they mature (Figure 2 O - P). The spherical larval nest is located in the centre of the gall and the parenchyma is arranged in a radial pattern around it. When the adult emerges the following summer, it exits through an opening in the side of the gall.

Andricus lignicola - galls derived from the transformation of axillary and apical buds of *Quercus* sp., are ovoid rather than spherical, with a scaly surface, initially slightly greyish, later brownish at maturity, 8-12 mm in diameter, with a larval chamber inside (Figure 2 R - S). The galls are usually clustered (4-8 or more) and the exit hole is always closer to the point of attachment of the galls to the branch, have a woody structure and may persist for years.

Andricus quercus-salicis - the galls are 15 - 20 mm in height and 18 - 25 mm in diameter at the base, they develop between the acorn and the cup and then cover the acorn partially or completely. It has between 5 - 9 prominent, wavy, interrupted carinae, forming sharp, sharp-edged projections from place to place (Figure 2 T - U). At the top of the gall there is a circular opening which communicates with the inner, larval, chamber. At first the galls are sticky and have a greenish-smoky colour, later they become brownish and are very hard when they mature.

Andricus caputmedusae - the galls are simple, walnut-sized, disc-shaped, attached to the cup of the young acorn (which contains a larval chamber/internal gall with thin inner walls), from the edge of which thick, 3-4 cm long, filiform, radiating, interlaced in all directions, greenish, becoming yellowish-brown when mature. When mature, the galls fall to the ground, where the adults emerge in the spring of the following year (Figure 2 V - X).

CONCLUSIONS

A wide variety of galls on *Quercus cerris*, many with attractive colors and fine textures and relatively little known, inspire us to continue researching. These investigations are needed

to better understand the species composition and the impact of gall-forming pests *on Q. cerris*, in the context of recent and future climate change.

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