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Parasitoid community and parasitism in galls of the three Western Palaearctic oligo- and unilocular Diplolepis species (Hymenoptera: Cynipidae)

Zoltán László* & Hunor Prázsmári

Hungarian Department of Biology and Ecology, Faculty of Biology and Geology, University Babeş-Bolyai, Strada Clinicilor 5–7, 400006 Cluj-Napoca, Romania. E-mails: laszlozoltan@gmail.com, prazsmarihunor@gmail.com

Abstract – Three Western Palaearctic *Diplolepis* Geoffroy, 1762 species are known to cause oligo- and unilocular galls on wild roses: *Diplolepis spinosissimae* (Giraud, 1859), *D. eglanteriae* (Hartig, 1840) and *D. nervosa* (Curtis, 1838). Several studies have focused on the species composition of parasitoid communities developing inside these galls; however their parasitism rates are still unknown. We analysed galls collected in the eastern Carpathian Basin (Hungary and Romania). Here we report for the first time parasitism rates from these species' galls. With 6 figures.

Key words – *Rosa*, *Diplolepis eglanteriae*, *D. nervosa*, *D. spinosissimae*, parasitism rates, Carpathian Basin

INTRODUCTION

Every naturalist came at least once across a type of a conspicuous gall, like the oak apple or robin's pincushion. In the Holarctic, cynipids are among the most common gall inducers. Cynipids belong to the order Hymenoptera with parasitoid ancestors and relatives (Liljeblad & Ronquist 1998, Liu *et al.* 2007). They include species that cause galls that are among the most structurally complex ones (Csóka *et al.* 2004). Two cynipid groups are frequently met in the Holarctic: those which induce galls on oaks, and those which cause galls on wild roses. Both groups are more speciose in the Nearctic than in the Western Palaearctic (Stone *et al.* 2002). In the Western Palaearctic oak gall inducers are more frequent than rose gall inducers (Abe *et al.* 2007). Rose gall inducers (*Diplolepis*) are represented in Europe by only six species (Zhang *et al.* 2019).

In galls, also in those caused by cynipids, beside gall inducers a whole set of species occur which form communities (Redfern 2011). These communities are composed by the gall inducers, the inquilines and the parasitoids.

*Corresponding author.

The inquiline species usually do not feed on the gall inducer, but consume gall tissues (Sanver & Hawkins 2000). Parasitoids feed on gall inducer larvae and usually belong to Chalcidoidea or Ichneumonoidea (Askew *et al.* 2006, 2013). Since parasitoids feed upon gall inducers and thus are the controlling populations of gall inducer species, parasitoid effect is considered the major evolutionary force acting towards the diversification of gall structures (Stone & Cook 1998). The hypothesis depicting the effect of parasitoids on gall structure evolution is known as the enemy hypothesis of the adaptive significance of gall formation (Stone & Schönrogge 2003). From the perspective of gall structure diversification and the population dynamics of gall inducers the parasitoids are of major importance, thus their quantitative characteristics are especially important.

Estimating proportions of gall inducers attacked by parasitoids remains an important objective in the evaluation of parasitoids or natural enemies. A traditional approach to the approximation of this proportion is by collection of gall samples and by determination of the ratio of parasitised individuals to all gall inhabitants. These estimations are more reliable if galls are collected systematically from several locations and in consecutive years. But in many cases systematic collecting is difficult to achieve. One of the obstacles that should be overcome is in close relationship with the phenology and locularity, thus the size of galls.

Some galls are easy to observe, but several other closely related species may remain usually unobserved. These galls are found mostly after cautious search because they are minute and growing on leaves from which or with which they fall down from the host plants in autumn. Moreover, also because of their small sizes they remain hidden on the ground or below the leaf litter after falling. They can be easily spotted only in the late spring or summer. When collected in the spring or summer, the young larvae inside them will not finish their development because of starvation. Therefore, even when collected, the failure of reaching the end of their full development may be high so the success to acquire adults for identifications may be small. All these circumstances lead to difficulties in the determination of the ecological aspects of these galls.

We studied three difficult rose gall species from the viewpoint of collecting and hatching: *D. spinosissimae*, *D. eglanteriae* and *D. nervosa*. For these three species there are no available data regarding parasitism rates. Collected galls were dissected after storing for a few weeks under low temperatures (4°C). All the inhabitants were sorted to the following groups: 1) dried larvae or pupae, 2) living gall inducer or parasitoid larvae and 3) hatched gall inducer or parasitoid adults. We report parasitism rates for these three species for the first time.

Diplolepis spinosissimae (Giraud, 1859)
(Figs 1–2)

Material examined – ROMANIA: **Cluj county**: 36 galls, Bădeşti (Bádok), N46.978172°, E23.627862°, 1.VIII.2018, leg. Z. László & H. Prázsmári; 18 galls, Bârlea (Ónok), N46.975740°, E23.754435°, 22.VI.2017, leg. Z. László & H. Prázsmári; 12 galls, Borșa-Cătun (Bánffytanya), N46.887795°, E23.707159°, 29.VI.2017, leg. Z. László & H. Prázsmári; 50 galls, Chidea (Kide), N46.962469°, E23.5994592°, 31.VII.2018, leg. Z. László & H. Prázsmári; 4 galls, Chidea (Kide), N46.963155°, E23.587565°, 1.VIII.2018, leg. Z. László & H. Prázsmári; 16 galls, Fânațele Clujului (Kolozsvári Szénafüvek), N46.836653°, E23.624393°, 1.VIII.2018, leg. Z. László & H. Prázsmári; 14 galls, Feiurdeni (Fejérd), N46.895856°, E23.621026°, 28.VI.2017, leg. Z. László & H. Prázsmári; 19 galls, Feiurdeni (Fejérd), N46.8971°, E23.628666°, 1.VIII.2018, leg. Z. László & H. Prázsmári; 11 galls, Feleacu (Erdőfelek), N46.711320°, E23.593503°, 7.VIII.2018, leg. Z. László & H. Prázsmári.

Remarks – From collected galls, 10% of the chambers contained adults. These usually belonged to *Eurytoma* sp. and *Pteromalus* sp. From the remaining chambers, 43% contained gall inducer or parasitoid larvae, while 47% contained dried inhabitants. Unparasitised gall inducers represented 11% of the analysed inhabitants, while parasitoids represented 74% of the community (Table 1). The difference to 100% was dried and/or unidentifiable larvae or pupae.

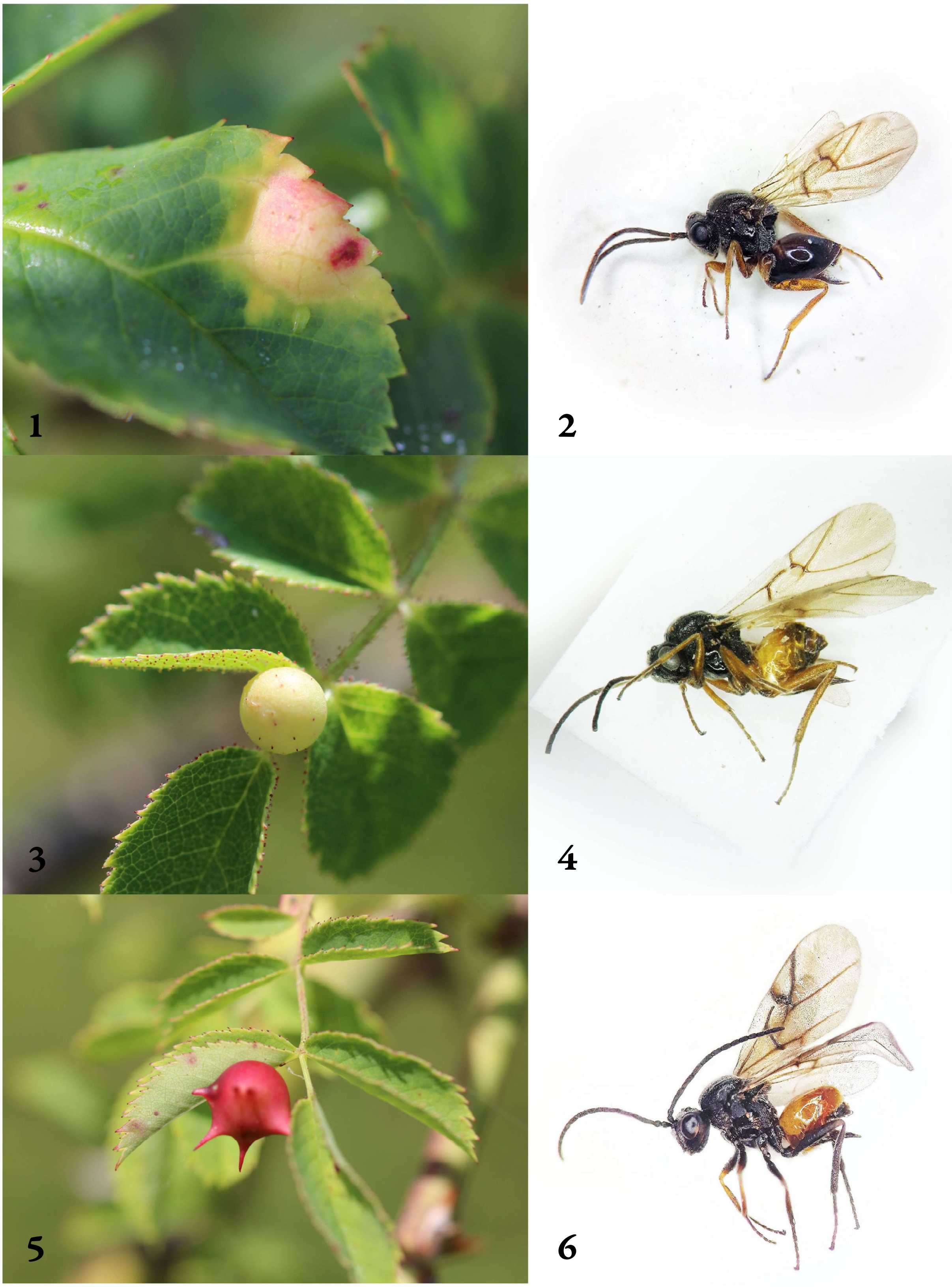
Table 1. Parasitism rates in galls of the three oligo- and unilocular rose galls from the Carpathian Basin with relative frequencies of the different parasitoid genera

	D. spinosissimae	*D. nervosa*	*D. eglanteriae*
No. of galls	181	73	98
No of chambers	289	73	98
Diplolepis sp.	0.11	0.12	0.17
All parasitoids	0.74	0.79	0.81
Torymus sp.	0.00	0.05	0.01
Eurytoma sp.	0.23	0.31	0.09
Eupelmus spp.	0.05	0.10	0.09
Pteromalus sp.	0.38	0.26	0.13
Orthopelma sp.	0.01	0.07	0.01
Stepanovia sp.	0.07	0.00	0.00
Periclistus sp.	0.00	0.05	0.00
Total	0.86	0.96	0.98

Diplolepis eglanteriae (Hartig, 1840)
(Figs 3–4)

Material examined – ROMANIA: **Cluj county:** 4 galls, Bădeşti (Bádok), N46.978172°,E23.627862°,1.VIII.2018,leg.Z.László&H.Prázsmári;2galls,Bârlea (Ónok), N46.975740°, E23.754435°, 22.VI.2017, leg. Z. László & H. Prázsmári; 8 galls, Bârlea (Ónok), N46.975740°, E23.754435°, 31.VII.2018, leg. Z. László & H. Prázsmári; 2 galls, Borșa-Cătun (Bánffytanya), N46.887795°, E23.707159°, 29.VI.2017, leg. Z. László & H. Prázsmári; 5 galls, Chidea (Kide), N46.962469°, E23.5994592°, 31.VII.2018, leg. Z. László & H. Prázsmári; 6 galls, Chidea (Kide), N46.963155°, E23.587565°, 1.VIII.2018, leg. Z. László & H. Prázsmári; 4 galls, Ciurila (Csürülye), Moara de Vânt (Állatsimogató), N46.672307°, E23.55609°, 7.VIII.2018, leg. Z. László; 14 galls, Cluj-Napoca (Kolozsvár), Botanic Garden, N46.762044°, E23.58847°, 6.VIII.2018, leg. Z. László; 22 galls, Fânațele Clujului (Kolozsvári Szénafüvek), N46.833903°, E23.635137°, 12.X.2014, leg. Z. László & H. Prázsmári; 18 galls, Fânațele Clujului (Kolozsvári Szénafüvek), N46.836653°, E23.624393°, 1.VIII.2018, leg. Z. László & H. Prázsmári; 2 galls, Feiurdeni (Fejérd), N46.895856°, E23.621026°, 28.VI.2017, leg. Z. László & H. Prázsmári; 8 galls, Feiurdeni (Fejérd), N46.8971°, E23.628666°, 1.VIII.2018, leg. Z. László & H. Prázsmári; 1 gall, Pădureni (Fejérdi-Fogadók), N46.860795°, E23.611838°, 7.VI.2017, leg. Z. László & H. Prázsmári. – **Harghita county:** 2 galls, Voslobeni (Vasláb), Peștera Súgó (Súgó barlang),N46.667087°, E25.651902°, 6.VII.2017, leg. Z. László & H. Prázsmári.

Remarks – Because of the difficulties regarding the correct identification of *D. eglanteriae* galls we considered only those unilocular galls that had no sign of any structures on their surface (e.g. low ridges or warts) (Fig. 3). From collected galls, 42% of the chambers contained adults. These usually belonged to *Eurytoma* sp., *Eupelmus* spp. and *Pteromalus* sp. From the remaining chambers, 17% contained gall inducer or parasitoid larvae, while 41% contained dried inhabitants. Unparasitised gall inducers represented 17% of the analysed inhabitants, while parasitoids represented 81% of the community (Table 1). The difference to 100% was dried and/or unidentifiable larvae or pupae.



Figs 1–6. Galls and females: 1–2 = *Diplolepis spinosissimae* (Giraud, 1859), 3–4 = *D. eglanteriae* (Hartig, 1840), 5–6 = *D. nervosa* (Curtis, 1838) (photos by Zoltán László)

Diplolepis nervosa (Curtis, 1838)
(Figs 5–6)

Material examined – HUNGARY: **Hajdú-Bihar county:** 2 galls, Püspökladány, N47.321502°, E21.070999°, 4.VII.2004, leg. Z. László. – ROMANIA: **Cluj county:** 19 galls, Bârlea (Ónok), N46.975740°, E23.754435°, 22.VI.2017, leg. Z. László & H. Prázsmári; 5 galls, Bârlea (Ónok), N46.975740°, E23.754435°, 31.VII.2018, leg. Z. László & H. Prázsmári. – **Satu-Mare county:** 35 galls, Lazuri (Lázári), N47.90911°, E22.884986°, 22.IX.2018, leg. Z. László & H. B. Nagy.

Remarks – Because of the difficulties regarding the correct identification of *D. nervosa* galls, we considered only those unilocular galls that had large spines or signs of any structures on their surface (e.g. low ridges or warts) (Fig. 5). From collected galls 33% of the chambers contained adults. These usually belonged to *Eurytoma* sp., *Eupelmus* spp. and *Pteromalus* sp. parasitoids. From the remaining chambers 29% contained gall inducer or parasitoid larvae, while 38% contained dried inhabitants. Unparasitised gall inducers represented 12% of the analysed inhabitants, while parasitoids represented 79% of the community (Table 1). The difference to 100% was dried and/or unidentifiable larvae or pupae.

DISCUSSION

Galls collected in June, July and August had still developing larvae inside, therefore we emphasize that collecting galls is better later in the autumn, before leaf fall. However, the majority of inhabitants can be identified based on larval morphology to a generic level. The parasitism was rather high, between 74–81%, having a relatively low gall inducer ratio (11–17%). A relatively large part of the galls contained dried larvae and pupae.

The analysed three species have oligo- and unilocular galls, which are considered inferior to multilocular ones from the perspective of gall inducer defence against parasitoids (Atkinson *et al.* 2002, 2003). In the case of the other two Western Palaearctic species, *D. rosae* (Linnaeus, 1758) and *D. mayri* (Schlechtendal, 1877), there were reported even higher parasitism values. However, when carefully comparing the three oligo- and unilocular galls with *D. rosae*, a species having relatively high chamber number, it seems that the female survival rate is higher than in the case of the galls with a smaller chamber number (László & Tóthmérész 2013). Relative frequencies, calculated from the catalogue of Askew *et al.* (2006) based on specimen numbers of parasitoids and inducers taken from the literature, of *D. spinosissimae* (12%) are at the same levels as found based on our data, but *D. eglanteriae* (4%) and *D. nervosa* (4%) have smaller relative frequencies. This difference between our results and those compiled from the catalogue may be due to methodological issues. On one hand, maybe less gall inducer females will hatch from fully developed galls than we have encountered in the earlier opened ones; on the other hand, in the catalogue the hatching efficiency cannot be inferred since total number of collected galls are not known.

Our main conclusions are that soft oligo- and unilocular galls are indeed difficult to analyse due to their phenology, since it is hard to estimate the perfect time for gall collection; several samples from the same population should be collected in the summer and autumn; parasitism rates are not as high as would be predicted based on the enemy hypothesis of the adaptive significance of gall formation.

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REFERENCES

Abe Y., Melika G. & Stone G. N. 2007: The diversity and phylogeography of cynipid gallwasps (Hymenoptera: Cynipidae) of the Oriental and eastern Palearctic regions, and their associated communities. – *Oriental Insects* **41**: 169–212. https://doi.org/10.1080/00305316.2007.10417504

Askew R. R., Melika G., Pujade-Villar J., Schönrogge K., Stone G. N. & Nieves-Aldrey J. L. 2013: Catalogue of parasitoids and inquilines in cynipid oak galls in the West Palaearctic. – *Zootaxa* **3643**: 1–133. https://doi.org/10.11646/zootaxa.3643.1.1

Askew R. R., Plantard O., Gómez J. M., Nieves M. H. & Nieves-Aldrey J.-L. 2006: Catalogue of parasitoids and inquilines in galls of Aylacini, Diplolepidini and Pediaspidini (Hym., Cynipidae) in the West Palaearctic. – *Zootaxa* **1301**: 1–60. https://doi.org/10.11646/zootaxa.1301.1.1

Atkinson R. J., Brown G. S. & Stone G. N. 2003: Skewed sex ratios and multiple founding in galls of the oak apple gall wasp Biorhiza pallida. – *Ecological Entomology* **28**: 14–24. https://doi.org/10.1046/j.1365-2311.2003.00483.x

Atkinson, R. J., McVean G. A. T. & Stone G. N. 2002: Use of population genetic data to infer oviposition behaviour: Species specific patterns in four oak gallwasps (Hymenoptera: Cynipidae). – *Proceedings of the Royal Society B: Biological Sciences* **269**: 383–390. https://doi.org/10.1098/rspb.2001.1820

Csóka G., Stone G. N. & Melika G. 2004: Biology, ecology and evolution of gall-inducing Cynipidae. – In: Raman A., Schaefer T. M. & Withers C. W. (eds.): *Biology, Ecology and Evolution of Gall-inducing Arthropods*. Science Publishers, Enfield, New Hampshire, pp. 569–636.

László Z. & Tóthmérész B. 2013: The enemy hypothesis: correlates of gall morphology with parasitoid attack rates in two closely related rose cynipid galls. – *Bulletin of entomological research* **103**: 326–335. https://doi.org/10.1017/S0007485312000764

Liljeblad J. & Ronquist F. 1998: A phylogenetic analysis of higher-level gall wasp relationships (Hymenoptera: Cynipidae). – *Systematic Entomology* **23**: 229–252. https://doi.org/10.1046/j.1365-3113.1998.00053.x

Liu Z., Engel M. S. & Grimaldi D. A. 2007: Phylogeny and geological history of the cynipoid wasps (Hymenoptera: Cynipoidea). – *American Museum Novitates* **3583**: 1–48. https://doi.org/10.1206/0003-0082(2007)3583[1:PAGHOT]2.0.CO;2

Redfern M. 2011: *Plant galls*. – HarperCollins Publishers, London, 576 pp.

Sanver D. & Hawkins B. A. 2000: Galls as habitats: The inquiline communities of insect galls. – *Basic and Applied Ecology* **1**: 3–11. https://doi.org/10.1078/1439-1791-00001

Stone G. N. & Cook J. M. 1998: The structure of cynipid oak galls: Patterns in the evolution of an extended phenotype. – *Proceedings of the Royal Society B: Biological Sciences* **265**: 979–988. https://doi.org/10.1098/rspb.1998.0387

Stone G. N. & Schönrogge K. 2003: The adaptive significance of insect gall morphology. – *Trends in Ecology* & *Evolution* **18**: 512–522. https://doi.org/10.1016/S0169-5347(03)00247-7

Stone G. N., Schönrogge K., Rachel J., Bellido D. & Pujade-Villar J. 2002: The population biology of oak gall wasps (Hymenoptera: Cynipidae). – *Annual Reviews of Entomology* **47**: 633–668. https://doi.org/10.1146/annurev.ento.47.091201.145247

Zhang Y. M., László Z., Looney C., Dénes A. L., Hanner R. H. & Shorthouse J. D. 2019: DNA barcodes reveal inconsistent species boundaries in Diplolepis rose gall wasps and their Periclistus inquilines (Hymenoptera: Cynipidae). – *Canadian Entomologist* **151**: 717–727. https://doi.org/10.4039/tce.2019.59