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Parasitism, phenology and sex ratio in galls of *Diplolepis rosae* in the Eastern Carpathian Basin

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Summary: The Rose Bedeguar gall is the most abundant rose gall in Europe. Nevertheless, life history of the community composers is less known, and community characteristics from the Eastern part of the Western Palearctic is scarcely reported. Here we provide community characteristics of the galls of *D. rosae* including species abundances, life history and sex ratio of the inducer from a large-scale dataset from the Carpathian Basin. Our results summarize and complete the knowledge of the community composition. In our samples two species from the abundant parasitoids showed significant differences compared with European mean abundances: *O. mediator* had significantly higher, and *G. stigma* had significantly lower abundances in our samples. From the least abundant parasitoids three species out of five showed significant differences compared with European mean abundances: *C. inflexa*, *E. urozonus* and *T. rubi* had significantly lower abundances in our samples. We found clear difference between the species phenologies in the community from the Carpathian Basin and other European territories in the number of emergence peaks from South towards the North. Our findings suggest that there is no latitudinal gradient in the sex ratio of the inducer, and confirm the patchy variability of sex ratios.

Key words: *Diplolepis rosae*, Europe, sex ratio, phenology, parasitism rate

Introduction

The Bedeguar gall wasp (*Diplolepis rosae* (Linnaeus, 1758)), and the hymenopteran community inhabiting its galls are well-known. Still, the species complex of *D. rosae* galls is not a classic system for ecological research and it is not used as a model system for studying ecological hypothesis despite the fact that there is a considerable literature published on the gall inducer, and the gall community (summarized until 2005 by Randolph, later papers by László and Tóthmérész 2006, 2008, 2011a, 2011b, Rizzo and Massa 2006).

The gall wasp *D. rosae* is the most abundant galling species on *Rosa* shrubs in Europe. *D. rosae* usually parasitizes *Rosa canina* Linnaeus, 1753, but galls also occur on other rose species (Schröder 1967, Stille 1984, Kohnen *et al.* 2011). *D. rosae* induces multicellular galls. Females of *D. rosae* emerge from galls in early spring and lay their clutches in new rose buds within one or two months. The new gall finishes its development in late summer and pupae overwinter within the gall.

Parasitoid pressure on *D. rosae* galls is high (Stille 1984, László and Tóthmérész 2006). The most abundant and primary parasitoid species are *Orthopelma mediator* (Thunberg, 1822), *Torymus bedeguaris* (Linnaeus, 1758), *Glyphomerus stigma* (Fabricius, 1793) and *Pteromalus bedeguaris* (Thomson, 1878). There are other species in the community: the inquiline species *Periclistus brandtii* and *Caenacis inflexa* (Ratzeburg, 1848) are exclusively the parasitoid of this inquiline. Other species like *Torymus rubi* (Schrank, 1781), *Eupelmus urozonus* Dalman, 1820, *Eupelmus vesicularis* (Retzius, 1783), *Eurytoma rosae* Nees, 1834 can be the parasitoids of the gall inducer and the inquiline too (Nordlander 1973, Redfern and Askew 1992).

Regarding community composition Randolph (2005) summarised the published data from Askew (1960, 1984), Blair (1945), Nordlander (1973), Schröder (1967) and Stille (1984). The data given by Randolph (2005) were completed by Rizzo and Massa (2006) who published data mainly from Sicily (Italy), but also presented a small dataset from the Western part of Hungary.

There are less data published about the life history of the rose bedeguar; these are also summarised in Randolph (2005) and completed with Sicilian data in Rizzo and Massa (2006). Two species of the community (*G. stigma* and *T. bedeguaris* (Randolph 2005)) are known to emerge later. However, Rizzo and Massa (2006) found more than two species emerging later. In addition, there are possibly bivoltine species as *E. rosae* and *E. urozonus* (Randolph 2005). There is no detailed knowledge on the life history of inquiline species, though it is known that they emerge later in June and July in Britain (Randolph 2005).

The gall inducer is parthenogenetic; Hoffmeyer (1925) suggested a latitudinal gradient in the sex ratio (from South to North). Later Schröder (1967), Randolph (2005) and Rizzo and Massa (2006) claims that there is not enough evidence to support this prediction. It is reported that the percentage of males varies between 0–5% in Europe (Randolph 2005). But Rizzo and Massa (2006) showed that in Sicily (4.3–30.3%) and Hungary (23.8%) there was a surprisingly high percentage of males.

We provide further data on the community of *D. rosae* from the Carpathian Basin with emphasis on the abundances, phenology of community composers and the sex ratio of the gall inducer. Until now there were no detailed data published from the Eastern part of Europe. Furthermore, despite of the published data regarding community structure and species abundances (review of Randolph 2006 and Italian by Rizzo and Massa 2006) there isn't any comprehensive study available on community patterns in Europe.

Material and methods

There were seven sampling sites studied for three years (2004, 2005 and 2006) (Fig. 1), located in the Transylvanian Plateau (Romania), in the Bükk Mountain (Hungary), and in the Great Hungarian Plain (Hungary). Sampling sites were dry pastures or the forested edges of these pastures. Sampling sites were: (1) Târgu-Mureş, Mureş county, Romania, elevation: 452 m; (2-4) Cluj-Napoca, Cluj county, Romania, elevation: 472 m; (5) Berettyóújfalu, Hajdú-Bihar county, Hungary, elevation: 105 m; (6) Derecske, Hajdú-Bihar county, Hungary, elevation: 95 m; (7) Emőd, Borsod-Abaúj-Zemplén county, Hungary, elevation: 125 m. At the first four and the seventh sites the following plant species were abundant: *Rubus* spp., *Hippophae rhamnoides*, *Prunus spinosa*; the study sites were bordered by oak-hornbeam forests. At the fifth and sixth sites among the *Rosa* spp. shrubs there were scattered *Prunus spinosa* shrubs, and at lower elevations there were patches of *Phragmites australis*. The sixth site was nearby a young sessile oak (*Quercus petraea*) plantation.

Locations of the study plots (50×50 meters) were chosen randomly within sites. Within each site there were three repetitions regarding time and space. We sampled a total of 58 plots (in 2004 at site 5 we sampled only one plot and at site 7 we sampled no plots).

We recorded the coordinates of each bush in the plots with a GPS unit. Galls were collected from infected rose bushes in February and March each year. After sampling, galls were stored individually in plastic cups with cellophane cover, which enabled air exchange and were kept under standard laboratory conditions. Emerged specimens were retrieved every month, then stored in 70% ethanol until identification. R language and environment was used for the statistical analyses (R Development Core Team 2011).

Results

Quantitative relationships of gall inhabitants. There were a total of 1481 rose bushes in the analysed 72 plots; we collected 890 galls from 491 bushes from which 12731 gall inhabitants emerged. The quantitative relationships are presented in Fig. 2. From the total emerged specimens 22.08% (SD ± 10.90%, df = 20) were gall inducers, while the remaining were inquilines or parasitoids. The most abundant gall inhabitant was the parasitoid *G. stigma* with 18.60% (SD ± 11.41, df = 20), which was followed by the inquiline *P.*

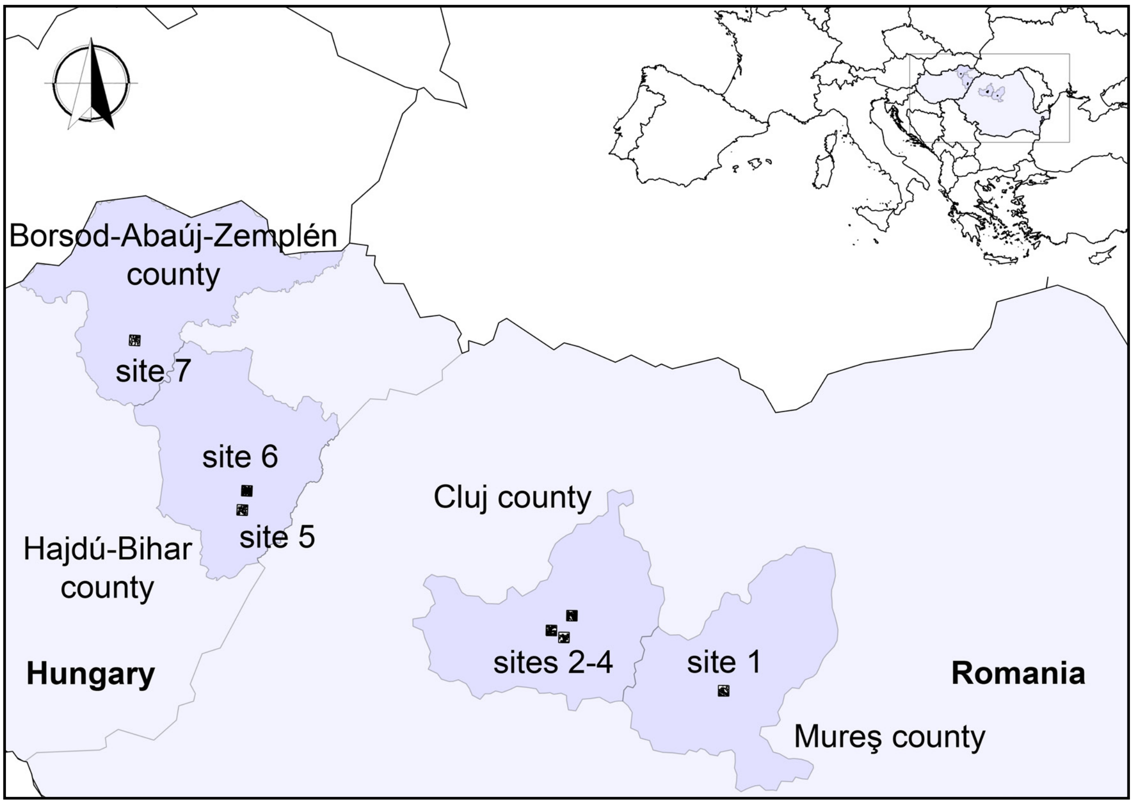

Fig. 1. Locations of sampling sites in Romania and Hungary.

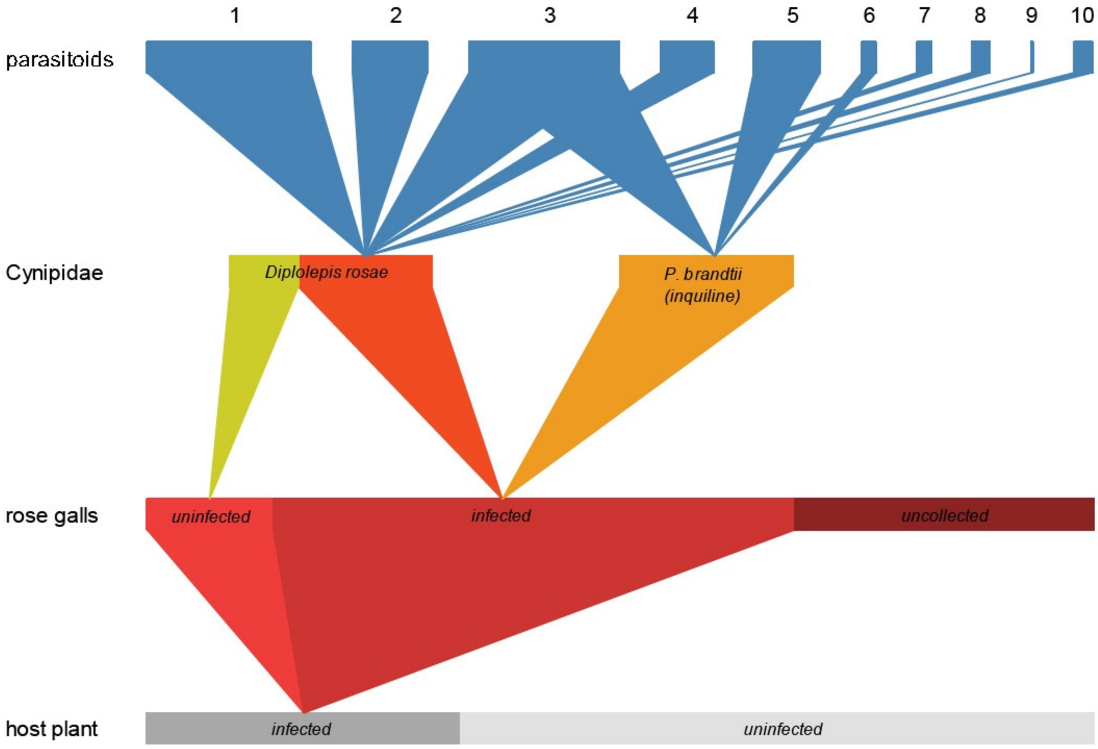

Fig. 2. Quantitative host-plant – herbivore – parasitoid relationships in the community of *D. rosae* galls. 1: *O. mediator*, 2: *T. bedeguaris*, 3: *G. stigma*, 4: *P. bedeguaris*; 5: *C. inflexa*, 6: *E. rosae*, 7: *T. rubi*, 8: *E. urozonus*, 9: *E. vesicularis*, 10: *S. eurytomae*.

brandtii with 16.71% (*SD* ± 10.38, *df* = 20). The parasitoid *O. mediator* was represented by 15.64% (*SD* ± 9.48, *df* = 20). The other two common parasitoids of the gall inducer *T. bedeguaris* and *P. bedeguaris* were represented by 8.15% (*SD* ± 5.47, *df* = 20) and 6.16% (*SD* ± 2.85, *df* = 20), respectively. The parasitoid of the inquiline *C. inflexa* was present in 5.98% (*SD* ± 6.07, *df* = 20). The parasitoid *E. urozonus*, was represented by 2.30% (*SD* ± 2.50, *df* = 20). Each of the other parasitoid species were present by less then 2% (*SD* ± 2.50, *df* = 20). *E. rosae* had 1.48% (*SD* ± 1.54, *df* = 20), *T. rubi* had 1.43% (*SD* ± 2.01, *df* = 20), *Stepanovia eurytomae* (Nees, 1834) had 1.35% (*SD* ± 2.72, *df* = 20), while the most rare was *E. vesicularis* with 0.12% (*SD* ± 0.28, *df* = 20).

We found significant differences in the case of several species (Table 1) when testing the difference in species' abundance in the community of *D. rosae* galls between the samples from the Carpathian Basin and other parts of Europe. Two species from the abundant parasitoids showed significant differences: *O. mediator* had significantly higher, and *G. stigma* had significantly lower abundances in our samples. From the least abundant parasitoids three species out of five showed significant differences: *C. inflexa*, *E. urozonus* and *T. rubi* had significantly lower abundances in our samples.

Phenology of gall inhabitants. The gall inducer showed the highest emergence rates in April, which had a steep decrease until July. No specimens of *D. rosae* were recorded in August. Only a few specimens were recorded in September, which was the last month with recorded emergence (Fig. 3). Life histories of the two most abundant species were different (Fig. 3). *O. mediator* and *P. bedeguaris* had emergence peaks in April. In May and June their emergence decreased abruptly. *T. bedeguaris* and *G. stigma* had their emergence peaks in May, and had quite high abundance even in June. In the other months their frequency was low; usually zero (Fig. 3). The inquiline species had its emergence peak in May, also had high emergence in April, while in other months showed very low emergence. The parasitoids of the inquiline had their emergence peaks in April, with inferior specimen numbers in the following two months. The other parasitoids from the community emerged in April and May. Regarding later emergence of species, with the exception of *O. mediator*, *T. rubi*, *E. urozonus*, *E vesicularis*, each had a few emerged specimens even in August and September, but there were no emergence peaks in these months (Fig. 3).

Sex ratio of the inducer. In 2004 the sex ratio of the inducer *D. rosae* was 6.98; from the emerged 980 specimens only 64 were males. In 2005 the sex ratio was 5.89; from the emerged 1078 specimens there were 60 males. In 2006 the sex ratio was 3.92; from the total of 1164 specimens only 44 were males. Regarding sites the highest male presence was recorded at site 6 (12.52%), while the lowest presence at site 2 (0.93%). The variance between years was 2.40, while between sites it was 14.87. However, the difference between variances was not significant (*F-test*: $F_{2,7}$ = 6.19, p = 0.29).

The mean sex ratio for years was 5.60% (*SD* = 1.55) for the gall inducer, while the mean sex ratio for sites was 5.00% (*SD* = 3.85). Thus, there was no significant difference between the year and sites means (*Student t-test*: t = 0.25, df = 9, p = 0.80). The over-

Table 1. Differences between the European mean abundances (Randolph 2005, Rizzo and Massa 2006) and the abundances of species from the community of *D. rosae* galls from the Carpathian Basin (*One-sample t-test*).

species	*t*	*df*	*p*
D. rosae	0.53	10	0.605
P. brandtii	-0.12	10	0.903
O. mediator	3.35	10	0.007
G. stigma	-2.67	10	0.023
T. bedeguaris	0.68	10	0.514
P. bedeguaris	0.73	10	0.483
C. inflexa	-3.83	10	0.003
E. rosae	0.14	10	0.892
E. urozonus	-3.66	10	0.004
T. rubi	-4.74	10	0.001

all sex ratio was of 5.50% . The change of sex ratio within a vegetation period showed a decrease towards autumn; the highest value was achieved in April (6.45 ± 2.34), while it was zero after July (Fig. 4).

Discussion

Quantitative relationships of gall inhabitants. The qualitative (presence-absence) composition of the community was in concordance with the previously published data from Europe (Randolph 2005, Rizzo and Massa 2006). In addition to typical species of the community in our data there were also present species like *E. vesicularis* and *Stepanovia eurytomae* (Nees, 1834). *E. vesicularis* was present only in a few cases (0.12%), while *Stepanovia eurytomae* reached 1.48%.

The most abundant species were the inquiline *P. brandtii*, and two of the main parasitoids *O. mediator* and *G. stigma* (Fig. 2). The inquiline, considering previously published data from Europe (Randolph 2005, Rizzo and Massa 2006) is present everywhere with moderate to high abundances; the only known absence was reported in Sicily (Rizzo and Massa 2006). The ichneumonid *O. mediator* is present across Europe, being scarce only in Spain (Schröder 1967), while everywhere else is one of the most abundant species (Randolph 2005). With the exception of the data from Sweden (Nordlander 1973) where there were no individuals of *G. stigma*, this species was present in all samples. It was scarce in Britain and Austria (Randolph 2005), and moderate to abundant in Czech Republic, France, Germany, Italy (Sicily), Spain and Switzerland (Randolph 2005).

Moderately abundant species were *C. inflexa*, the parasitoid of the inquiline and another two main parasitoids of the gall inducer (*T. bedeguaris* and *P. bedeguaris*, Fig. 2). *C. inflexa* in Europe was usually reported as having low to moderate abundances, being absent from Spain (Schröder 1967), Sicily (Rizzo and Massa 2006) and having high abundances in Austria (Schröder 1967) and Sweden (Nordlander 1973). The chalcidoid *T. bedeguaris* is present in whole Europe (Randolph 2005, Rizzo and Massa 2006) with moderate to high abundances. *T. bedeguaris* showed high abundances in Southwest France and Switzerland (Schröder 1967), although in other samples showed moderate abundances, between 4.4 and 10.6% (Randolph 2005). The chalcidoid *P. bedeguaris* is present in whole Europe (Randolph 2005, Rizzo and Massa 2006) with absence only in the samples studied by Stille (1984). However, in other samples from Sweden it is present with low abundances (Nordlander 1973). It shows high abundance only in the samples from Spain (Schröder 1967), although everywhere else it is moderately abundant, showing abundances between 2.26 and 11.3% (Randolph 2005, Rizzo and Massa 2006).

Regarding species showing low abundances (Fig. 2) *E. rosae* is present everywhere in Europe with the exception of the samples of Stille (1984), and it shows its highest abundance again in Sweden (Nordlander 1973). Considering other countries its abundances are between 0.3 and 2.2% (Randolph 2005, Rizzo and Massa 2006). *E. urozonus* is a common species with abundances between 0.2 and 1.81%

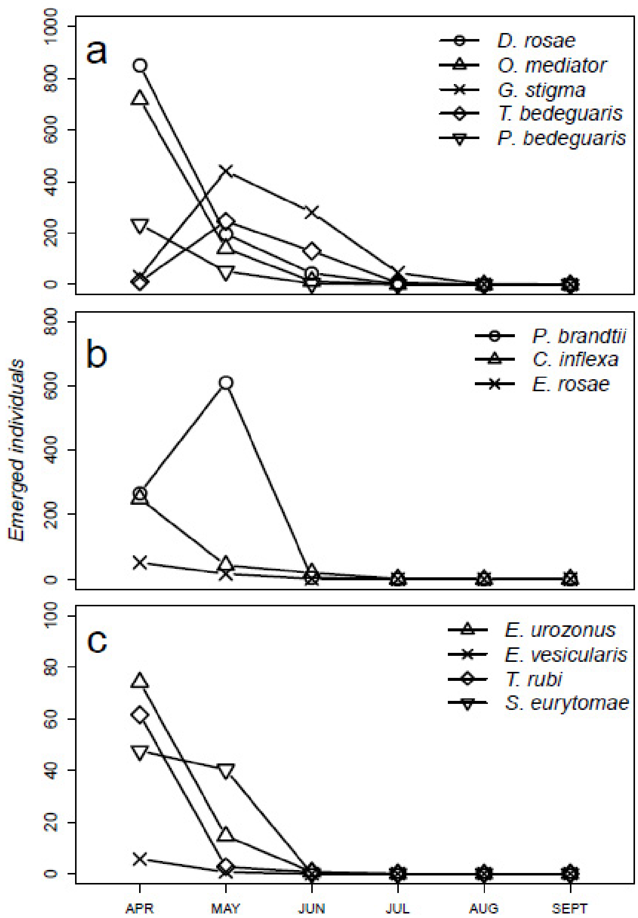

Fig. 3. Phenology of the community. a) the gall inducer and its most abundant parasitoids; b) the inquiline and its parasitoids; c) the least abundant parasitoids.

(Randolph 2005, Rizzo and Massa 2006). *T. rubi* is absent from France (Schröder 1967), Sweden (Stille 1984) and Sicily (Rizzo and Massa 2006) and show the highest abundance in the samples of Nordlander (1973) from Sweden. Abundance data are not reported for *E. vesicularis* in the review of Randolph (2005). It is not present in Britain, but it is present in France (Randolph 2005). *S. eurytomae* is recorded in France, but it seems that it mainly occurs in *D. mayri* galls. We have no other data regarding its occurrence.

Species abundances from our samples from the Carpathian Basin showed resemblance to those from all Europe, but almost half of the community showed significant difference from the European mean species abundances (Table 1). The differences for the two most abundant parasitoid species may predict longitudinal or latitudinal gradient in their distribution. The abundance of *G. stigma* was more than twofold and in the case of *O. mediator* more than one time higher in the Carpathian Basin than the European mean. Regarding the differences in the case of the least abundant species these may be assigned to more localized factors since the difference between European mean and Carpathian Basin abundances was less than one time higher than the European mean. The most important difference between the community from the Carpathian Basin and other communities of Europe was the consistent presence of *E. vesicularis* and *S. eurytomae* in the Carpathian Basin.

Phenology of gall inhabitants. Regarding the phenology of species there are two groups: i) species with an emergence peak in April; in May these species show considerable fall in their emergence; and ii) species with an emergence peak in May, followed by a decrease until June. In the first group (emergence peak in April) the species *S. eurytomae* has considerable emergence peak also in May (Fig. 3c) while in the second group (emergence peak in May) the inquiline had an abrupt decrease from May to June (Fig. 3b).

In Randolph's (2005) data only *D. rosae* and *O. mediator* begin their emergence in April, while several species begin their emergence in May (like *P. bedeguaris*, *E. rosae* and *E. urozonus*) and *G. stigma*, *T. bedeguaris* in June. Furthermore, *E. rosae* and *E. urozonus* were bivoltine, showing two emergence peaks. In Sicily (Rizzo and Massa 2006) *D. rosae* showed two emergence peaks, one in April and one in June, while *O. mediator* and *T. bedeguaris* showed three peaks, in April, June and October. Furthermore, *G. stigma* and *P. bedeguaris* had two emergence peaks, in May-June and October. The species *E. rosae* had a peak in October while *E. urozonus* in March.

There is a clear difference between the phenologies from the Carpathian Basin and other European territories as we recorded for each species only one emergence peak (Fig. 3). Based on the data of Rizzo and Massa (2006) there is a decrease in the number of emergence peaks from South towards North. Considering the data given by Randolph (2005) we found

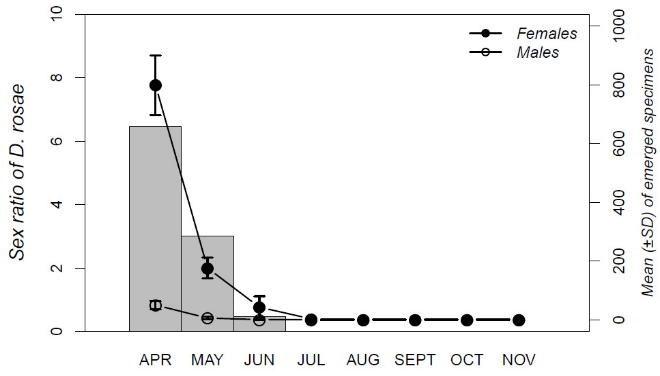

Fig. 4. Phenology (filled and empty circles) and sex ratio (bars) of the gall inducer *D. rosae*.

again a difference, by a shift of emergence peaks from earlier months to later ones with at least one month, and by a diminution of emergence peak numbers for at least two species. Therefore, we predict again a latitudinal and longitudinal gradient in the number of emergence peaks for certain species and emergence peak timing for several species.

Sex ratio of the inducer. The sex ratio of the inducer in our samples was high (between site mean: 5.00%, *SD* = 3.85) compared to the data provided by Randolph (2005), where the mean ratio was 1.34% (*SD* = 1.43). Comparing our results to the data given in Randolph (2005) completed by the data given in Rizzo and Massa (2006) we have again higher sex ratio (sex ratio: 1.36%, *SD* = 1.58). If we consider the Hungarian data from Rizzo and Massa (2006) (sex ratio: 2.76%, *SD* = 5.81) the difference is diminished, because of the extremely high sex ratio from this sample (23.8%). Regarding our results we consider that sex ratios as high as observed by Rizzo and Massa (2006) in the Hungarian sample may occur locally, but on larger scales the ratio diminishes. In our samples the maximum sex ratio observed on one site was 12.52% (site 6), but the overall mean was 5.00%. Such sex ratios as the one from the Carpathian Basin were also encountered in Britain (Askew 1960), Denmark (Hoffmeyer 1925) and Sicily (Rizzo and Massa 2006). There is a huge latitudinal and longitudinal difference between the four previous locations and there are low differences between the ratios. Thus, we confirm the prediction of Rizzo and Massa (2006) that the sex ratio of the gall inducer *D. rosae* shows no latitudinal gradient. More likely that there is a a patchy fluctuation in the sex ratio.

Summary The community of the rose gall *D. rosae* from the Carpathian Basin resembled those from Europe, but almost half of the communities showed remarkable difference from the European mean species abundances. Based on these differences we predict a longitudinal or latitudinal gradient in the community composition through Europe.

We found clear difference between the species phenologies in the communities from the Carpathian Basin and other European areas in the number of emergence peaks from South towards the North. Thus, we predict a latitudinal and also a longitudinal gradient in the number of emergence peaks for certain species. Our findings confirms that there is no latitudinal gradient in the sex ratio change of the gall inducer *D. rosae*.

We also plea for the potential usefulness of the community in testing ecological hypotheses. The species *D. rosae* is common in many habitat types and in large geographical scale, and easily observable. It is a native species in the Western Palearctic, and it is also introduced in the Nearctic (Randolph 2005, Shorthouse 2001). Ultimately, *D. rosae* communities can be treated as three-level ecological systems perfectly fit for field and laboratory experiments.

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References

Askew R.R. (1960) Some observations on *Diplolepis rosae* (L.) (Hym., Cynipidae) and its parasites. *Entomologist's monthly Magazine* 95: 191-192.

Askew R.R. (1984) The biology of gall wasps. In: Anantakrishnan N. T. (ed.): Biology of gall insects. Edward Arnold, London. pp: 223-271.

Blair K.G. (1945) Notes on the economy of the rose galls formed by *Rhodites* (Hym. Cynipidae). *Proceedings of the Royal Entomological Society of London, Series A* 20: 26-31.

Hoffmeyer E.B. (1925) Bemaerkninger om danske galhvespe. *Entomologiske meddelelser, Kobenhavn* 16: 1-8.

Kohnen A., Wissemann V. and Brandl R. (2011) No host-associated differentiation in the gall wasp *Diplolepis rosae* (Hymenoptera: Cynipidae) on three dog rose species. *Biological Journal of the Linnean Society* 102: 369-377.

László Z. and Tóthmérész B. (2006) Inquiline effects on a multilocular gall community. *Acta Zoologica Academiae Scientiarum Hungaricae* 52: 373-383.

László Z. and Tóthmérész B. (2008) Optimal clutch size of the gall wasp *Diplolepis rosae* (Hymenoptera: Cynipidae). *Entomologica Fennica* 19: 168-175.

László Z. and Tóthmérész B. (2011a) High host plant aggregation involves uniform gall distribution and high prevalence: the case of wild roses and Bedeguar gall wasps (*Diplolepis rosae*). *North-Western Journal of Zoology* 7: 112-117.

László Z. and Tóthmérész B. (2011b) Parasitoids of the bedeguar gall (*Diplolepis rosae*): Effect of host scale on density and prevalence. *Acta Zoologica Academiae Scientiarum Hungaricae* 57: 219-232.

Nordlander G. (1973) Parasitic wasps in galls of *Diplolepis rosae* (L.) and *D. mayri* Schlechtd. (Hymenoptera: Cynipidae) (Hym.: Ichneumonoidea, Chalcidoidea, Cynipoidea). *Entomologisk Tidskrift* 94: 148-176.

R Development Core Team (2011) R: A Language and Environment for Statistical Computing. R Foundation for Statistical Computing, Vienna, Austria.

Randolph S. (2005) The Rose Bedeguar gall and its insect community. The British Plant Gall Society, Bury St. Edmunds, UK.

Redfern M. and Askew R.R. (1992) Plant galls. Naturalists' Handbook 17. Richmond Publishing Company, Slough, UK.

Rizzo M.C. and Massa B. (2006) Parasitism and sex ratio of the bedeguar gall wasp *Diplolepis rosae* (L.) (Hymenoptera: Cynipidae) in Sicily (Italy). *Journal of Hymenoptera Research* 15: 277-285.

Schröder D. (1967) *Diplolepis* (= *Rhodites*) *rosae* (L.) (Hym.: Cynipidae) and a review of its parasite complex in Europe. *Technical Bulletin of the Commonwealth Institute of Biological Control* 9: 93-131.

Shorthouse J.D. (2001) Galls induced by cynipid wasps of the genus *Diplolepis* (Cynipidae, Hymenoptera) on cultivated shrub roses in Canada. In: Zieslin N. and Agbaria H. (eds.): *Proceedings of the III International Symposium on Rose Research and Cultivation. Acta Horticulturae (ISHS)* 547: 91-92.

Stille B. (1984) The effect of hosptlant and parasitoids on the reproductive success of the parthenogenetic gall wasp *Diplolepis rosae* (Hymenoptera, Cynipidae). *Oecologia* 63: 364-369.

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