Biologia
https://doi.org/10.1007/s11756-024-01651-3

ORIGINAL ARTICLE

# Effectiveness of Malaise trap and sweep net sampling in sawfly research (Hymenoptera: Symphyta)

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Received: 19 July 2023 / Accepted: 19 February 2024


## Abstract
Malaise traps and sweep nets are commonly used to study sawfly faunas, seasonality and communities. Here we analyse a large dataset obtained with these methods in Slovakia and Hungary over the last two and a half decades. The dataset included collections from twenty-one sites, each covering the entire growing season, eleven of which were obtained with the Malaise trap and ten with the sweep net. We conclude that both methods are suitable for faunistic studies of sawflies (Hymenoptera, Symphyta), although they may lead to certain biased results for some Symphyta groups. Special attention should be paid to Siricidae, Orussidae, Xiphidriidae and Cimbicidae, which were only weakly recorded with both methods. Argidae, Blennocampinae, Dolerinae and Tenthredininae were underrepresented in the Malaise trap samples and Allantinae in the sweep net samples. Both methods gave equally good results in measuring species richness in an one-year study. Ideally, they should be used together as they complement each other well. The net method has a great advantage in determining the exact population density. In contrast, the Malaise trap collections were often heavily dominated by only a few species, with males being preferentially trapped. Use of Malasie trap should be preferred for the study of seasonal flight activity.

**Keywords** Malaise trap · Sweep net · Effectivity · Comparision · Selectivity · Hymenoptera · Symphyta

## Introduction

For studies on the local fauna and communities of sawflies (Hymenoptera, Symphyta), various sampling methods are used, of which the Malaise trap and net sweeping are the most common. The Malaise trap is a tent-like trap that is a very efficient method for collecting flying insects. The trap takes advantage of the positive phototaxis of most insects which, after entering the trap and hitting the baffle, move upwards to a light opening and are eventually caught in the collecting jar. With a single Townes-type Malaise trap set at one site throughout the season, it was possible to collect a large number of Symphyta species, often numbering more than a hundred in Central Europe (Ritzau 1995; Taeger and Taeger 1997; Roller 2006). When operated continuously in a habitat, the trap allows the capture of species with possible crepuscular or nocturnal activity (known from the tropics - Malaise 1945) and a large number of additive species, i.e. not associated with host plants near the trap (Smith and Barrows 1987). Several authors have pointed out some peculiarities of collecting Symphyta with tent-type traps (tent-window and Malaise traps). The larger and fast-flying species, especially members of the Siricidae, Cimbicidae, Pamphiliidae and *Tenthredo* species, tend to be underrepresented, whereas smaller species, especially of the subfamilies Blennocampinae and Nematinae, are often represented in large numbers in trap collections (Liston 1984; Pschorn-Walcher and Taeger 1995; Ritzau 1995). Another feature is the clear dominance of males in trap collections (Pschorn-Walcher and Taeger 1995; Ritzau 1995). The effectiveness and selectivity of collecting Hymenoptera with Malasie traps depends on their technical features, such as mesh size, mesh configuration and colour (Darling and Packer 1988; Achterberg 2009; Sheikh et al. 2016).

Sampling of sawflies with sweep nets is also widely used (e.g. Haris 2009, 2010, 2011, 2018a, b, 2020, 2021a, b) and, if standardised, can be used not only to determine species

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representation but also for other characteristics of the local species community. However, systematic recording of flying insects with a net throughout the season requires a high personal effort. There are only a few studies comparing the efficiency of the Malaise trap and sweep net in catching sawflies, and these were limited to a single habitat or a small area (Smith and Barrows 1987; Ritzau 1995; Taeger and Taeger 1997; Balázs and Haris 2020). In the present study, we took a different approach and used a large amount of data collected over 25 years of Symphyta collection with the sweep net or the Malaise trap at different sites in Hungary and Slovakia (Central Europe, Carpathian Basin). Being aware of the limitations of our diverse dataset, we draw some conclusions on the advantages and disadvantages of these two methods and the data obtained for various ecological studies on sawflies, and discuss them with previous small-scale studies.

## Materials and methods

Material was collected using either a sweep net or a Malaise trap during at least one growing season at each study site. The sampled sites and sampling characteristics are listed in Table 1. For most sites, the descriptions and faunistic lists have already been published (see references in Table 1). Additional characteristics of the sites with previously unpublished data are as follows: Horša, Slovakia, 48°15’7.88 “N, 18°41’57.30 “E, Horšianska dolina National Nature Reserve; Bokroš, Slovakia, 47°44’50.82 “N, 18°15’40.20 “E, Bokrošské slanisko nature reserve; Tvrdošovce, Slovakia, 48°5’57.84 “N, 18°2’0.84 “E, Panské lúky nature protected site; Virt, Slovakia, 47°45’38.34 “N, 18°20’6.18 “E, Marcelovské piesky nature protected site.

The Malaise traps used were of the Townes type and were supplied by the company “Entomologické pomôcky a literatúra” - RNDr. O. Šauša, Bratislava, with a height at the highest point of 203 cm and a ground plan of 183 × 122 cm (Fig. 1). The traps were made of white (canopy and side roof walls) and black (baffle walls) tulle, the support structures were made of foldable duralumin tubes and the collection containers were made of polyethylene. The entire trap was erected and braced on site with ropes and pegs like a tent. The placement and orientation of the trap in the field was according to Townes (1972). At each site, the so-called natural corridors were selected, which are used by the insects for migration and where they stay in large numbers (different ecotones of forest, bush or water habitats). The traps were usually oriented so that the front wall with the collection vessel faces an open and bright space. The actual placement of the traps was influenced by the need to protect the traps from premature damage. For this reason, the traps were often placed in gardens or other fenced or more or less hidden areas. The collection vessel was filled with 70–96% ethanol with isopropanol. Each trap was emptied regularly at specific intervals of 2–10 days (Table 1).

The net used for sweeping was a specially made net ending with a PVC pipe section to which strong double nylon bags were attached with a rubber ring to prevent the insects from escaping (Fig. 2). The insects caught by this net try to escape towards the light and end up in the nylon bags from which the light comes. The diameter of the net is 400 mm, the depth 500 mm, the diameter of the plastic tube 50 mm and the length of the shaft 550 mm. The average area of a sampling site was 35,000 m² (3.5 ha). At each sampling site, a single person performed 200 net strokes from one corner to the other and another 200 net strokes in perpendicular direction. The shrub layer and the lower tree layer were also sampled. On one day, 3–5 sites were examined.

Biodiversity indices were interpreted and applied according to Daly et al. (2018) and Tonnanga et al. (2017). The nomenclature of sawflies used follows the latest monograph of European sawflies (Lacourt 2020). The higher classification used follows the section Hymenoptera of Fauna Europaea (Achterberg 2013). The current numbers of species recorded in Hungary and Slovakia were taken from Roller and Haris (2008) and Macek et al. (2020) and supplemented by more recent records from the studies by A. Haris and L. Roller cited in the references.

## Results

In the last two and a half decades we have regularly collected Symphyta in Hungary and Slovakia for faunistic and ecological studies. In total, we analysed data from 11 sites sampled with the Malaise trap and 10 sites sampled with the sweep net (Table 1). For most sites, faunistic lists with the number of individuals have already been published (see Table 1 for references). Previously unpublished data from the four study sites Bokroš, Horša, Tvrdošovce and Virt can be found in Online Resource 1.

### General efficiency

In terms of the number of sawfly specimens collected, the Malaise trap method outperformed the manual method (sweep net) by a factor of three (613 compared to 1921 on average per locality; Tables 2 and 7; *t*-test $p = 0.00248$). This result is due to the long (5–8 months) and continuous exposure of the trap, which also influenced the daily yield of this method. In contrast to the trap, the manual method was used on average 26 days per site per year. The maximum daily catch during the seasonal peak of sawflies could also be higher with the Malaise trap. Maximum 212 individuals of 43 species were collected with the Malaise trap in Mošovce

**Table 1** Study localities and sampling characteristics

| Name | State | Landscape unit | Habitat (dominant) | Sampling method | Sampling period | Sampling interval [days] | No. of collecting days | Reference |
|---|---|---|---|---|---|---|---|---|
| Börzsöny | HU | Börzsöny Mts | mixed oak maple forest, beech forest | NS | 07.04. – 20.08.2011 | - | 26 | Haris (2011) |
| Cserhát | HU | Cserhát Mts | mixed oak maple forest, beech forest | NS | 27.03. – 20.08.2021 | - | 33 | Haris (2021a) |
| Dráva | HU | Danube-Dráva Nat Park | juniper scrub, oak forest, alder forest | NS | 04.04. – 20.08.2020 | - | 26 | Haris (2020) |
| Keszthely | HU | Keszthely hills | Pannonian-Balkanic oak forest | NS | 30.03. – 23.08.2019 | - | 17 | Haris (2019) |
| South Somogy 1 | HU | Inner Somogy flatland | oak and oak- hornbeam forests on sand dunes | NS | 31.03. – 01.06.2012 | - | 25 | Haris (2012) |
| South Somogy 2 | HU | Inner Somogy flatland | oak and oak- hornbeam forests on sand dunes | NS | 01.04. – 08.10.2017 | - | 19 | Haris (2018a) |
| North Somogy | HU | Outer Somogy hills | oak-hornbeam forest | NS | 05.04. – 15.08.2018 | - | 23 | Haris (2018b) |
| Vértes | HU | Vértes Mts | Medio-European limestone beech forest, oak-hornbeam forest | NS | 03.04. – 23.08.2010 | - | 35 | Haris (2010) |
| Zselic 1 | HU | Zselic hills | Illyrian beech forest, thermophilous deciduous forest | NS | 03.04. – 20.08.2009 | - | 29 | Haris (2009) |
| Zselic 2 | HU | Zselic hills | Illyrian beech forest, thermophilous deciduous forest | NS | 04.04. – 21.08.2022 | - | 29 | Haris (2022) |
| Bokroš | SK | Podunajská rovina plain | salt marsh | MT 1 x | 21.04. – 20.09.2017 | 7 | 189 | This study |
| Devín | SK | Malé Karpaty Mts | Pannonian thicket, garden | MT 2 x | 01.03. – 28.10.1994 | 2 | 232 | Roller (1998) |
| Horša | SK | Podunajská pahorkatina upland | Pannonian thicket | MT 1 x | 16.03. – 05.10.2017 | 7 | 230 | This study |
| Hriňová | SK | Veporské vrchy Mts | extensively used orchard | MT 1 x | 05.05. – 26.10.1995 | 1 | 168 | Roller (2006) |
| Ivanka pri Dunaji | SK | Podunajská rovina plain | Pannonian thicket, garden | MT 1 x | 01.04. – 06.11.1992 | 1 | 220 | Roller (1999) |
| Javorina | SK | Vysoké Tatry Mts | boreo-alpine riparian gallery | MT 1 x | 10.04. – 30.09.1992 | 1 | 173 | Roller (1999) |
| Malacky | SK | Borská nížina lowland | willow osier scrub | MT 1 x | 10.03. – 30.10.2021 | 7–10 | 235 | Roller et al. (2022) |
| Mošovce | SK | Velká Fatra Mts | beech and spruce forests, garden | MT 1 x | 10.04. – 30.09.1992 | 1 | 173 | Roller (2006) |
| Pernek | SK | Borská nížina lowland | thermophilous oak forest, garden | MT 1 x | 8.04. – 28.10.1994 | 1 | 203 | Roller (1999) |
| Tvrdošovce | SK | Podunajská rovina plain | edge of salt marsh | MT 1 x | 26.02. – 15.10.2018 | 7 | 217 | This study |
| Virt | SK | Podunajská rovina plain | vegetated Pannonian inland dune | MT 4 x | 26.02. – 01.09.2018 | 7 | 171 | This study |

*SK* Slovakia, *HU* Hungary, *No. x MT* number of Malaise traps, *NS* net sweeping

on 21 May 1992, while 67 individuals of 28 species were caught with the net in Belső Somogy on 6 May 2012.

The samples analysed contained a total of 460 species, of which 375 were collected with Malaise traps and 304 with the sweep net (219 species are the same for both methods). The number of species collected with only one method was also higher with the Malaise trap (156 compared to 85 with the sweep net). Nevertheless, sampling with each of the two

**Fig. 1** Townes type of the Malaise trap (Photo: Ľ. Vidlička)

methods analysed resulted in a comparable number of species per site (*t*-test $p = 0.88358$; Table 7). On average, 110 (Malaise trap) and 112 (sweep net) species were found at a study site in one year (Table 2).

## Species representation

The methods performed differently in terms of the proportion of species collected. The proportion of predominant sawfly species was significantly higher (3 times on average) when the chosen method was the Malaise trap (between 7.5 and 59%, 29% on average, Table 3) compared to the sweep net method (between 7 and 20%, 11% on average, Table 3).

Comparing the number of sampled species of the Symphyta families with the known numbers in the countries where sampling was carried out, some deviations from the expected numbers become apparent (Tables 4 and 5). Several Symphyta groups were rarely collected in both methods studied, these groups are: Siricidae, Orussidae, Xiphidriidae and Cimbicidae. For Argidae and Blennocampinae, Dolerinae and Tenthredininae of Tenthredinidae, the Malaise trap was less efficient than the sweep net. In contrast, Allantinae were underrepresented in the sweep net samples (Tables 4 and 5).

A closer look at the number of individuals in the samples identified some species that may have been caught in excess. Several species were caught in large numbers (abundance over 100 and relative abundance over 5% per season and site) at certain sites using the Malaise trap. Besides the most dominant species (Table 3), these are *Amauronematus toeniatus* (Serville, 1823), *Ametastegia carpini* (Hartig, 1837), *Am. tenera* (Fallén, 1808), *Allantus cinctus* (Linnaeus, 1758), *Al. cingulatus* (Scopoli, 1763),

**Fig. 2** Sweep net with PVC pipe section to which a transparent double nylon bag for the insect sample is attached (Photo: A. Haris)

*Athalia circularis* (Klug, 1815), *At. liberta* (Klug, 1815), *Claremontia tenuicornis* (Klug, 1816), *Empria sexpunctata* (Serville, 1823), *Macrophya alboannulata*, *M. sanguinolenta* (Gmelin, 1790), *Nematus lucidus* (Panzer, 1801), *Priophorus compressicornis* (Fabricius, 1804), *Tenthredo mesomela* Linnaeus, 1758, *Te. velox* Fabricius, 1798, *Tenthredopis stigma* (Fabricius, 1798) and *Sharliphora parva* (Hartig, 1837).

The species collected in large numbers using only the sweep net were: *Arge melanochra* (Gmelin, 1790), *Cephus spinipes* (Panzer, 1800), *Ce. pygmeus* (Linnaeus, 1767), *Eutomostethis ephippium* (Panzer, 1798), *Eu. luteiventris* (Klug, 1816), *Macrophya montana* (Scopoli, 1763) and *Tenthredo temula* Scopoli, 1763.

Finally, the species that were collected very efficiently with both methods were: *Aglaostigma aucupariae* (Klug, 1817), *Athalia circularis* (Klug, 1815), *At. cordata* Serville, 1823, *At. rosae* (Linnaeus, 1758), *Cladius pectinicornis* (Geoffroy, 1785), *Macrophya alboannulata* Costa, 1859, *Pachyprotasis rapae* (Linnaeus, 1767), *Pristiphora armata* (Thomson, 1862), *Pteronidea myosotidis* (Fabricius, 1804), *Pt. bergmanni* (Dahlbom, 1835), *Taxonus agrorum* (Fallén, 1808) and *Tenthredopsis nassata* (Linnaeus, 1767).

**Table 2** Number of Symphyta specimens and species collected per season at the study sites with the sweep net or the Malaise trap

| **Net sweeping** | **Börzsöny** | **Cserhát** | **Dráva** | **Keszthely** | **S Somogy 1** | **S Somogy 2** | **N Somogy** | **Vértes** | **Zselic 1** | **Zselic 2** | | **AVG** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| No. of specimens | 628 | 573 | 668 | 404 | 635 | 543 | 508 | 687 | 754 | 730 | | 613 |
| No. of species | 129 | 110 | 100 | 95 | 123 | 105 | 89 | 128 | 122 | 116 | | 112 |
| **Malaise trap** | **Bokroš** | **Devín** | **Horša** | **Hriňová** | **Ivanka** | **Javorina** | **Malacky** | **Mošovce** | **Pernek** | **Tvrdošovce** | **Virt** | **AVG** |
| No. of specimens | 1,311 | 1,929 | 637 | 2,184 | 2,315 | 3,033 | 1,236 | 4,203 | 2,532 | 953 | 795 | 1,921 |
| No. of species | 80 | 119 | 82 | 116 | 110 | 121 | 95 | 181 | 132 | 71 | 105 | 110 |

### Representation of males and females

The methods analysed differed significantly in the sampling of males and females (Fig. 3). A strong shift in favour of the proportion of males over females was measured in the sawfly material of the Malaise traps, on average 59.5 versus 40.5% (Table 6). This generally indicates a higher flight activity of males compared to females. At certain sites, males accounted for 70% or more of the trapped specimens, and in the extreme case in Javorina even 82%. In contrast, the sweep net samples contained more females with an overall sex ratio of 2:3, indicating a higher number of females in the swept vegetation (Table 6). Females dominated in nine out of ten sample sets, as much as 77% in Zselic in 2009. Even in this case, the data seem to indicate a greater flight activity of males.

### Species diversity

The suitability of the Symphyta sample sets collected by two different methods was evaluated for the ecological assessment of the local communities. Using different indices for species diversity (Shannon index, Simpson index) and indices for equitability and dominance (Dominance index, Berger-Parker index, Margalef-Richness index, Menhinick index, Equability index, Gini coefficient and Búzás and Gibson index), notable differences were found between the sets collected with the Malaise trap and those collected with the sweep net (Table 7, Online Resource 2). Despite a similar number of species recorded per site by both methods, the diversity and equitability of sawfly communities in the datasets obtained with the Malaise trap were lower and typically contained one or a few clearly dominant, i.e. very numerous species (Table 3). This phenomenon could be due to the higher flight activity of some species, especially males.

## Discussion

Analysis of samples of sawflies collected with Malaise traps and sweep nets revealed differences between these two methods that should be taken into account when planning faunistic or ecological studies on this group of insects. First, both methods collect certain groups of sawflies poorly or differently, as already noted in studies on smaller material (Smith and Barrows 1987; Ritzau 1995; Taeger and Taeger 1997; Balázs and Haris 2020). We confirmed these observations for larger and/or fast-flying species of Siricidae, Orussidae, Xiphidriidae and Cimbicidae, which are poorly caught with both the Malaise trap and the sweep net. This could be partly because we sampled near to the ground, whereas many members of these taxa inhabit trunks and crowns of woody plants. In

**Table 3** Number and proportion of the predominant species collected at the study sites with the sweep net or the Malaise trap

| Net sweeping | | | | Malaise trapping | | | |
|---|---|---|---|---|---|---|---|
| Species | Number | Dominance [%] | Study site | Species | Number | Dominance [%] | Study site |
| *Arge melanochra* (Gmelin, 1790) | 74 | 11 | Vértes | *Allantus didymus* (Klug, 1818) | 78 | 12 | Horša |
| *Athalia rosae* (Linnaeus, 1758) | 85 | 13 | Drava | *Ametastegia equiseti* (Fallén, 1808) | 326 | 13 | Pernek |
| *Athalia rosae* (Linnaeus, 1758) | 114 | 20 | Cserhát | *Athalia cordata* Serville, 1823 | 568 | 26 | Hriňová |
| *Cephus pygmaeus* (Linnaeus, 1767) | 51 | 10 | N Somogy | *Athalia rosae* (Linnaeus, 1758) | 531 | 27.5 | Devín |
| *Eutomostethus ephippium* (Panzer, 1798) | 83 | 15 | S Somogy 1 | *Athalia rosae* (Linnaeus, 1758) | 770 | 59 | Bokroš |
| *Eutomostethus luteiventris* (Klug, 1816) | 48 | 8 | S Somogy 2 | *Cladius pectinicornis* (Geoffroy, 1785) | 174 | 7.5 | Ivanka p. D. |
| *Macrophya albicincta* (Schrank, 1776) | 50 | 7 | Zselic 1 | *Cladius pectinicornis* (Geoffroy, 1785) | 199 | 25 | Virt |
| *Macrophya montana* (Scopoli, 1763) | 78 | 11 | Zselic 2 | *Empria liturata* (Gmelin, 1790) | 117 | 12 | Tvrdošovce |
| *Pteronidea myosotidis* (Fabricius, 1804) | 48 | 8 | Börzsöny | *Pachyprotasis rapae* (Linnaeus, 1767) | 1,154 | 27.5 | Mošovce |
| *Pteronidea myosotidis* (Fabricius, 1804) | 32 | 8 | Keszthely | *Pteronidea bergmanni* (Dahlbom, 1835) | 472 | 38 | Malacky |
| | | | | *Taxonus alboscutellatus* Niezabitowski, 1899 | 1,169 | 38.5 | Javorina |

**Table 4** Number of species belonging to the families and subfamilies of Symphyta in the material collected with the sweep net and in Hungary

| | **Börzsöny** | **Cserhát** | **Dráva** | **Keszthely** | **S. Somogy 1** | **S. Somogy 2** | **N. Somogy** | **Vértes** | **Zselic 1** | **Zselic 2** | **Hungary total** |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Xyelidae | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 7 |
| Pamphiliidae | 1 | 0 | 1 | 3 | 5 | 3 | 3 | 3 | 3 | 4 | 38 |
| Megalodontesidae | 1 | 0 | 1 | 1 | 0 | 0 | 1 | 0 | 1 | 0 | 7 |
| Cephidae | 6 | 6 | 8 | 5 | 8 | 4 | 8 | 5 | 7 | 7 | 22 |
| Xiphydriidae | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 10 |
| Siricidae | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 5 |
| Orussidae | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 |
| Argidae | 8 | 11 | 7 | 6 | 4 | 3 | 4 | 14 | 8 | 8 | 42 |
| Blasticotomidae | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 |
| Cimbicidae | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 22 |
| Diprionidae | 1 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 1 | 1 | 15 |
| Dolerinae | 9 | 9 | 15 | 12 | 13 | 14 | 11 | 9 | 10 | 17 | 37 |
| Selandriinae | 4 | 2 | 3 | 2 | 7 | 6 | 3 | 2 | 2 | 0 | 16 |
| Allantinae | 19 | 19 | 17 | 15 | 17 | 17 | 14 | 17 | 18 | 14 | 60 |
| Heterarthrinae | 2 | 5 | 1 | 2 | 4 | 1 | 2 | 3 | 3 | 2 | 35 |
| Blennocampinae | 12 | 14 | 12 | 12 | 15 | 19 | 12 | 13 | 11 | 13 | 42 |
| Tenthredininae | 35 | 22 | 20 | 23 | 27 | 21 | 18 | 42 | 41 | 27 | 109 |
| Nematinae | 29 | 22 | 12 | 12 | 19 | 16 | 13 | 17 | 18 | 23 | 146 |
| Symphyta | | | | | | | | | | | **616** |

Key: ≥40 % ≥30 % ≥20 % ≥10 % ≥5%

The percentage of species found at the study site out of the total number of species in Hungary, which is higher than 5%, is shaded grey in different intensities (see Key)

**Table 5** Number of species belonging to Symphyta families and subfamilies in the material collected with the Malaise trap and in Slovakia

| | Bokroš | Devín | Horša | Hriňová | Ivanka | Javorina | Malacky | Mošovce | Pernek | Tvrdošovce | Virt | Slovakia total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Xyelidae | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 6 |
| Pamphiliidae | 2 | 5 | 2 | 1 | 1 | 5 | 2 | 3 | 3 | 3 | 1 | 42 |
| Megalodontesidae | 0 | 2 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 6 |
| Cephidae | 6 | 5 | 4 | 3 | 4 | 0 | 2 | 3 | 6 | 6 | 9 | 19 |
| Xiphydriidae | 0 | 0 | 0 | 1 | 0 | 0 | 2 | 0 | 0 | 0 | 1 | 5 |
| Siricidae | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 14 |
| Orussidae | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 |
| Argidae | 4 | 5 | 3 | 3 | 6 | 1 | 0 | 6 | 5 | 4 | 6 | 35 |
| Blasticotomidae | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| Cimbicidae | 1 | 0 | 1 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 22 |
| Diprionidae | 0 | 2 | 0 | 1 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 16 |
| Dolerinae | 2 | 5 | 4 | 8 | 9 | 7 | 6 | 12 | 11 | 5 | 8 | 40 |
| Selandriinae | 0 | 1 | 1 | 3 | 1 | 5 | 2 | 9 | 1 | 0 | 1 | 18 |
| Allantinae | 20 | 26 | 21 | 22 | 29 | 16 | 25 | 26 | 27 | 16 | 20 | 65 |
| Heterarthrinae | 3 | 2 | 1 | 3 | 2 | 1 | 8 | 8 | 6 | 3 | 3 | 38 |
| Blennocampinae | 7 | 8 | 6 | 8 | 13 | 5 | 8 | 14 | 11 | 9 | 12 | 43 |
| Tenthredininae | 23 | 30 | 18 | 28 | 25 | 24 | 7 | 43 | 28 | 11 | 24 | 109 |
| Nematinae | 12 | 27 | 20 | 34 | 20 | 56 | 33 | 54 | 31 | 14 | 20 | 212 |
| Symphyta | | | | | | | | | | | | 694 |

Key: ≥40 % ≥30 % ≥20 % ≥10 % ≥5%

The percentage of species found at the study site out of the total number of species in Slovakia, which is higher than 5%, is shaded grey in different intensities (see Key)

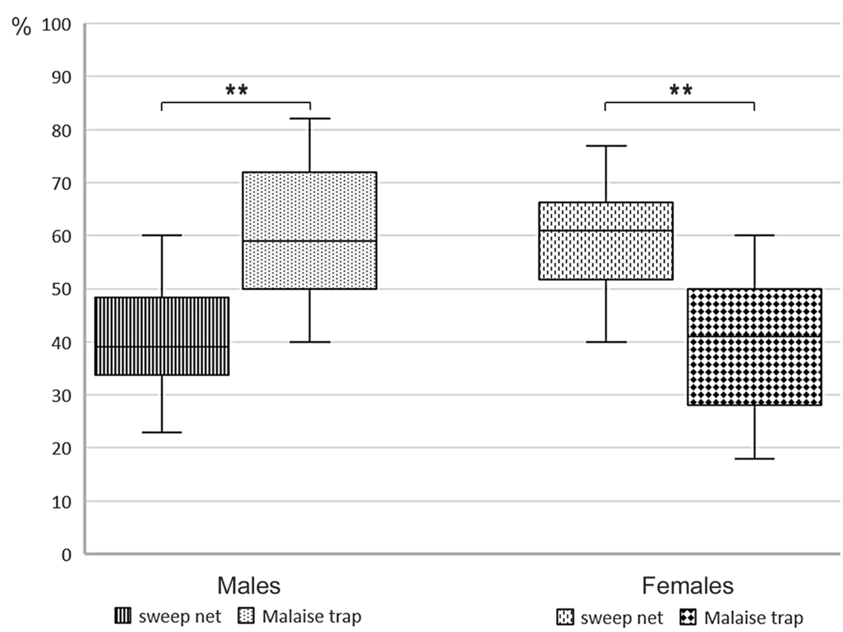


**Fig. 3** Differences in the sex ratio of Symphyta collected with the Malaise trap and the sweep net. Two asterisks indicate that the ratio differs significantly between the methods (*t*-test)

addition, the escape response of the large species in the trap may be different from that of most sawflies. They may drop and crawl out after hitting the impact wall, like many beetles (Coleoptera) that are known to be less effectively caught by the Malaise trap (Skvarla et al. 2021). Most other groups (families and subfamilies of Tenthredinidae) were equally or slightly better represented in the sweep net samples and only Allantinae were better represented in the trap samples. On the other hand, previous studies have shown that Blenocampinae and Nematinae are often caught in large numbers in trap collections (Liston 1984; Pschorn-Walcher and Taeger 1995; Ritzau 1995). In our

**Table 6** Sex ratio of Symphyta collected per season at the study sites with the sweep net or the Malaise trap

| **Net sweeping** | **Börzsöny** | **Cserhát** | **Dráva** | **Keszthely** | **S Somogy 1** | **S Somogy 2** | **N Somogy** | **Vértes** | **Zselic 1** | **Zselic 2** | | **AVG** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Males [%] | 30 | 39 | 49 | 39 | 37 | 41 | 60 | 35 | 23 | 48 | | 40.1 |
| Females [%] | 70 | 61 | 51 | 61 | 63 | 59 | 40 | 65 | 77 | 52 | | 59.9 |
| **Malaise trap** | **Bokroš** | **Devín** | **Ivanka** | **Javorina** | **Hriňová** | **Horša** | **Malacky** | **Mošovce** | **Pernek** | **Tvrdošovce** | **Virt** | **AVG** |
| Males [%] | 43 | 54 | 73 | 82 | 50 | 40 | 72 | 66 | 59 | 66 | 50 | 59.5 |
| Females [%] | 57 | 46 | 27 | 18 | 50 | 60 | 28 | 34 | 41 | 34 | 50 | 40.5 |

**Table 7** Overall diversity values of Symphyta communities sampled with sweep nets (mean values of 10 sites) and Malaise traps (mean values of 11 sites), with a value indicating higher diversity and equitability shaded in grey

| **Measure** | **Net sweeping** | **Malaise trap** | **Difference** |
|---|---|---|---|
| No. of specimens | 613 | 1921 | ** |
| No. of species | 112 | 110 | NS |
| Simpson Index | 0.03 | 0.10 | ** |
| Shannon Index log2 | 5.72 | 4.82 | ** |
| Dominance Index | 0.97 | 0.90 | * |
| Menhinick Index | 4.54 | 2.67 | *** |
| Equitability Index | 0.84 | 0.72 | * |
| Buzas and Gibson's Index | 0.48 | 0.29 | *** |

Asterisks indicate a significant difference between the sampling methods, which was determined using a t-test (*$p<0.05$; **$p<0.01$; ***$p<0.001$; NS not significant). Further measured values and values for specific sites can be found in the Online resource 2

trap samples, representatives of Allantinae, Nematinae and to a lesser extent Tenthredininae predominated. The Malaise trap seems to be very effective in sampling specific species and communities associated with the host plant in question (Holuša 2002; Beneš and Holuša 2015; Roller et al. 2022). If the trap is placed in a habitat suitable for species of interest, these species can account for more than 30% of the total seasonal sample. In addition to common species, numerous rare species and species characteristic of the biotope can also be found in larger numbers. For example, more than 1,000 individuals of *Taxonus alboscutellatus* Niezabitowski, 1899, a species with a restricted range and considered rare in Central Europe (Taeger et al. 1998; Macek 2017), were caught with one trap in a single season in Javorina.

Another difference between the sampling methods studied is the different sex ratio of the sawflies collected. In the samples from the Malaise traps, the sex ratio is often male dominated. At some study sites, males account for 60–80% of all sawflies trapped (Ritzau 1995; this study). The dominance of males is very striking in certain species. For example, only 3 males of *Allantus didymus* (Klug, 1818) were caught with the sweep net, while 57 males and 2 females were caught with the Malaise trap in the same area and sampling period (Cerová vrchovina, Slovakia) (Balázs and Haris 2020). On the other hand, females often dominated in the sweep net samples.

For the inventory of the local sawfly fauna, the Malaise trap offers a rather efficient and economical tool to obtain large amounts of data with minimal effort. More specimens can be collected per site and season with the trap than with the net. However, this is not reflected in the species richness, which was almost the same for trap and net samples. If fieldwork with the net is carried out regularly and frequently (2–4 times per week) during the season with intense adult activity, the Malaise trap and the sweep net are equally well suited to assess local species richness. Finally, to obtain as complete a species list as possible in a single season from a sampled site, we recommend the use of both sampling methods together, because they complement each other well (Ritzau 1995; Taeger and Taeger 1997; Balázs and Haris 2019, 2020).

For the study of seasonality of sawflies, the Malaise trap is well suited to determine the beginning, end and course of the activity period (especially flight activity) of adults (Roller 1998, 2006; Roller et al. 2022). The sweep net can also be used to track temporal and spatial changes in population density and species richness. When using the net, regular and frequent visits need to be adapted to the seasonal flight pattern of sawflies at a given site. The general seasonal patterns for sawfly communities identified by both sampling methods in the Pannonian and Anatolian zoogeographical regions can be found, for example, in Kaplan et al. (2023).

Since the Malaise trap primarily captures flying insects, its samples reflect the actual flight activity rather than the actual diversity of sawflies at the site (Taeger and Taeger 1997). Furthermore, sawfly activity is sex- and species-specific, making the trap unsuitable for determining the actual (true) population density of sawflies. As a rule, the most active species predominate in the trap samples, which has a negative effect on the measured diversity and equitability of sawfly communities. The sweep net, on the other hand, can provide more reliable quantitative data if used correctly and methodically. If the area covered by a sweep net is known, the density per square metre can be determined (e.g. Haris 1994a, b, 1995). The sweep net is thus a perfect tool for measuring population density, especially in structurally homogeneous, open and non-forested biotopes. The Malaise trap, on the other hand, only allows a relative estimate of population density, but can be useful for actively flying species in strongly structured biotopes where net coverage is limited, such as scrub and forest.

Our study does not have an experimental design, but is an attempt to use and compare a large and diverse data set from faunal studies in the Carpathian Basin (Slovakia and Hungary). We tried to compare data from a large number of net collections from Hungary with a roughly equal number of Malaise trap samples from Slovakia. The collections were made in a variety of habitats and in different years. So it is clear that many parameters affecting the effectiveness of the sampling method make it difficult to compare quantitative data in particular. Nevertheless, our robust dataset could partially compensate for such biases. On the other hand, two sampling methods carried out at the same site and in the same year, which are considered methodologically correct, can compete with each other and also lead to biases. We have shown that the qualitative differences between the samples obtained (range of taxa and sex ratio) are largely consistent with previous studies conducted at one site. Therefore, we believe that most of our conclusions are reliable and helpful for the sampling design of faunistic and ecological studies on sawflies.

## Conclusion

In summary, both methods (sweep net and Malaise trap) are well suited to study the species richness of sawflies in different habitats. The Malaise trap is a good tool for determining the characteristics of flight activity and for analysing seasonal changes in species richness. However, it is not suitable for measuring absolute population density and biases the diversity measured. With replicates of standardised traps, comparable data from different habitats or even different zoogeographical regions would be relatively easy to obtain. The large bycatch in trap sampling and the placement-dependent results (Matthews and Matthews 1970) should also be considered when deciding whether to use the Malaise trap and, if so, how and where to place it. Systematic sampling with the sweep net requires more manpower and time in the field, as well as high precision. On the other hand, under certain conditions it is not only possible to follow temporal and spatial changes in population density and species richness, but also to measure the actual population density.

**Supplementary Information** The online version contains supplementary material available at https://doi.org/10.1007/s11756-024-01651-3.

**Acknowledgements** This study was supported in part by projects no. 2/0070/23 and 2/0074/21 of the Slovak Grant Agency VEGA. We would like to thank Ľ. Korčeková (Pernek), J. Púpavová (Hriňová), K. Šmidáková (Ivanka pri Dunaji), I. Horský (Javorina), J. Minárik (Mošovce) and M. Semelbauer (Malacky) for assistance with the use of the Malaise traps.

**Funding** Open access funding provided by The Ministry of Education, Science, Research and Sport of the Slovak Republic in cooperation with Centre for Scientific and Technical Information of the Slovak Republic

**Data Availability** All data has either already been published or is contained in the supplementary files.

## Declarations

**Conflict of interest** The authors have no competing interests to declare that are relevant to the content of this article.



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