QUALITY ASSESSMENT OF HABITATS USING PHYTOPHAGOUS HOVERFLIES (Diptera: Syrphidae)

ABSTRACT: Biodiversity has strongly declined throughout the world mainly due to human activities. Thus, standardized indicators are needed more than ever before to effectively monitor anthropogenic disturbance and its impact on ecosystems. In this study, hoverfly species of two largest phytophagous genera (Cheilosia and Merodon) were chosen as bioindicators to assess the quality of 15 sites located in Serbia; in or around mountains Fruška Gora, Kopaonik, Stara Planina, Dubašnica and Pčinja region. Sufficiently close associations with particular habitats (each having its own characteristic assemblage) make phytophagous hoverflies perfect candidates for such a role. Syrph the Net database was used as a useful tool for assessing quality of habitats and detecting differences between them.

KEYWORDS: biodiversity, bio indicators, conservation, diversity, insects, Syrph the Net

INTRODUCTION

The damage to biodiversity caused by human activities is rapidly increasing (Souza et al., 2014), and the negative impacts are mainly associated with the increase in cultivated land surfaces and urbanization. More than ever, standardized indicators are needed to monitor responses of human-modified ecosystems to disturbances, which would allow designing effective conservation measures.

The family Syrphidae is the most species-rich (Rotheray and Gilbert, 2011) and among the most diverse Dipteran insect families regarding habitat preferences and larval biology (Thompson and Rotheray, 1998). Hoverflies can be found in almost every terrestrial and many aquatic habitats, having considerable importance in ecosystems by providing crucial ecosystem services such as pollination (van Rossum 2010; Petanidou et al., 2011) and biological pest
control (Thomson and Hoffmann, 2009). The larvae are zoophagous (especially aphids) (30%), saprophagous (30%) or phytophagous (20%), while the diet of the remainder is mixed (Castella, 2008). In this paper, we focus on two large phytophagous genera, *Cheilosia* Meigen, 1822 with nearly 300 species present in the Palaeartic (Peck, 1988) and *Merodon* Meigen, 1803 with 160 species distributed over the Palaeartic and Afrotropical regions (Ståhls et al., 2009). Adults of various species of the genus *Merodon* have a preference for flowers of the family Apiaceae (Hurkmans, 1993), while adults of the genus *Cheilosia* predominantly feed on flowers of *Salix* spp. in early spring and, during the summer, species visit various white and yellow flowers (Ståhls et al., 2008). More than 50% of European species of *Cheilosia* are present on the Balkan Peninsula (Vujić, 1996). On the other hand, genus *Merodon* is predominantly distributed in Mediterranean region in Europe (Speight, 2014).

The role of hoverflies as bioindicators has been particularly recognized through the Syrph the Net (StN) database which has been successfully used for habitat evaluations (Speight and Castella, 2001; Velli et al., 2010; Sommaggio and Burgio, 2014; Petremand et al., 2017). The database compiles habitat preferences and other ecological, biological and distribution information for more than 900 European hoverfly species (Petremand et al., 2017). The main output of StN is “biodiversity maintenance function” (BDMF), representing the ratio between the observed number of species to the total number predicted by StN (Speight, 2000). It is used as an estimator of site quality: if BDMF is less than 50% (less of 50% expected species were recorded for a given site), the site may be considered degraded (Speight et al., 2000).

Brown (1991) identified 12 “desirable qualities” for insect indicator taxa in order to be efficient: taxonomically and ecologically highly diversified, species have high ecological fidelity, relatively sedentary, species narrowly endemic, or if widespread, well differentiated, taxonomically well known, easy to identify, well studied, abundant, non-furtive, easy to find in the field, damped fluctuations (always present), easy to obtain large random samples of species and variation; functionally important in ecosystem, response to disturbance predictable, rapid, sensitive, analyzable and linear, and associates closely with and indicates other species and specific resources. In addition to a majority of these criteria hoverflies met, hoverflies of Serbia are particularly well studied (Glumac, 1955, 1959; Vujić and Glumac, 1994; Vujić, 1996; Vujić and Šimić, 1994; Šimić et al., 2009; Šimić and Vujić, 1984, 1996; Radenković, 2008; Nedeljković et al., 2009; Vujić et al., 2013; Vujić et al., 2016). This is of the utmost importance when applying StN analysis.

General aims of this study were (I) to calculate biodiversity maintenance function and (II) to assess and compare habitat quality of 15 different study sites in Serbia. Specific aim was to inspect the relationship between two indices (BDMF and Shannon diversity index) often used in environmental assessment studies.
MATERIAL AND METHODS

To select our research sites, we looked for ecological preferences of species from the genera *Merodon* and *Cheilosia*. Thus, the sites were selected to represent a range of lowland and highland landscapes, covering broad spectrum in micro and macro-habitats diversity, as well as land-use intensity. A more detailed description of the site selection process can be found in Popov (2017). Overall, we selected 15 sites located in or around mountains Fruška Gora, Kopaonik, Stara Planina, Dubašnica and Pčinja Region (Figure 1).

Hoverflies were surveyed along transects between 09:00 and 01:00 p.m. on sunny days with little or no wind. Specimens were counted during peak flight periods, from April to the end of August, using entomological net. The StN database consists of information on adult hoverfly species collected using Malaise traps; however use of entomological net has also been successfully applied in StN analyses (Kassebeer, 1993; Marcos-Garcia, 1990). Entomolo-
gical net is the most common method used for capturing hoverflies and several papers suggest it to be more reliable than trapping. For example, a 4-year study conducted in Balkan area using Malaise trap sampling showed that out of 50 hoverfly species collected, only one belonged to the genus *Cheilosia* (Šimić and Vujić, 1984). Moreover, one study in the Mediterranean revealed net sampling to be more representative than trapping – 40 of 59 species (67.8%) sampled using Malaise traps and 45 of 59 (76.3%) by netting (Petanidou et al., 2011). In addition, entomological net is a suitable technique for recording rare species and to obtain species lists, the latter being one of the objectives of this research study.

Inventory completeness, defined as observed species richness in relation to estimated richness, was calculated using a non-parametric species richness estimator, CHAO2 (Chao et al., 2000).

We calculated BDMF for each of the 15 analyzed sites. Firstly, list of predicted species was produced by considering regional list of species and pairing the habitat preferences of each species with the habitats available at a given site (Speight and Castella, 2001). Afterwards, we compared the list of hoverflies caught on the study sites with the list of species predicted for an identical environment for a given region. A detailed description of the process of calculating BDMF can be found in Speight et al. (2000).

Thereafter, we analyzed the relationship between BDMF and Shannon diversity index. Considering the relatively small sample size (n=15), a non-parametric statistical test was used for the analysis of relationship between the two indices. For this purpose, the Spearman’s rank correlation coefficient was calculated in MATLAB.

### RESULTS AND DISCUSSION

Estimates for inventory completeness (CHAO2) ranged from 85.1 to 100% of the potential species richness within the sites (Table 1). These findings show that we managed to collect sufficient samples for characterising hoverfly assemblages.

*Table 1.* Inventory completeness: observed richness as a percentage of total expected richness according to the CHAO2 estimator. S=observed species of *Merodon* and *Cheilosia* genera

<table>
<thead>
<tr>
<th>Site</th>
<th>S</th>
<th>CHAO2</th>
<th>Completeness (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>DUB 1</td>
<td>41</td>
<td>42.20</td>
<td>97.10</td>
</tr>
<tr>
<td>DUB 2</td>
<td>22</td>
<td>23.00</td>
<td>95.60</td>
</tr>
<tr>
<td>DUB 3</td>
<td>41</td>
<td>41.40</td>
<td>99.00</td>
</tr>
<tr>
<td>DUB 4</td>
<td>21</td>
<td>21.10</td>
<td>100.00</td>
</tr>
<tr>
<td>GLA 1</td>
<td>6</td>
<td>6.00</td>
<td>100.00</td>
</tr>
</tbody>
</table>
The results presented in the Table 2 and Figure 2 were analysed processing the collected phytophagous hoverfly species with StN. Mean BDMF was 50.7%; the highest value (75.9) was observed for site KOP2, whereas the lowest value was found for site PCI1 (16.7%). According to the BDMF values, more than 70% of investigated sites currently can be considered as degraded habitats, with BDMF values < 50%. Only one site (KOP2, Samokovska reka river) presented a sufficiently high BDMF to be considered as a site of a high habitat quality, with BDMF value > 75%.

If we take into account all the investigated sites, the SyrphTheNet analysis has predicted total of 72 species of the genera *Cheilosia* and *Merodon*. The highest number of species (61) was predicted for sites DUB1 and DUB2. An additional parameter StN analysis provides is the ratio between the observed, but not predicted species and the observed species. A high number of species observed but not predicted can be found when there is a migration from surrounding habitats and/or where additional habitats have not been included in the analysis. The highest number of species observed, but not predicted (23) was found for site DUB3 (Lazareva reka canyon), most probably due to the unique variety of pre-glacial habitats.
Table 2. Summary of results obtained with Syrph the Net.

<table>
<thead>
<tr>
<th>Sites</th>
<th>Expected species by StN</th>
<th>Observed not expected</th>
<th>Observed not expected (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>DUB 1</td>
<td>61</td>
<td>12</td>
<td>29.3</td>
</tr>
<tr>
<td>DUB 2</td>
<td>61</td>
<td>5</td>
<td>22.7</td>
</tr>
<tr>
<td>DUB 3</td>
<td>30</td>
<td>23</td>
<td>56.1</td>
</tr>
<tr>
<td>DUB 4</td>
<td>30</td>
<td>8</td>
<td>38.1</td>
</tr>
<tr>
<td>GLA 1</td>
<td>8</td>
<td>3</td>
<td>50.0</td>
</tr>
<tr>
<td>GLA 2</td>
<td>30</td>
<td>19</td>
<td>57.6</td>
</tr>
<tr>
<td>KOP 1</td>
<td>36</td>
<td>15</td>
<td>42.8</td>
</tr>
<tr>
<td>KOP 2</td>
<td>54</td>
<td>11</td>
<td>21.1</td>
</tr>
<tr>
<td>KOP 3</td>
<td>36</td>
<td>11</td>
<td>50.0</td>
</tr>
<tr>
<td>KOP 4</td>
<td>36</td>
<td>10</td>
<td>33.3</td>
</tr>
<tr>
<td>PCI 1</td>
<td>30</td>
<td>2</td>
<td>28.6</td>
</tr>
<tr>
<td>PCI 2</td>
<td>30</td>
<td>5</td>
<td>35.7</td>
</tr>
<tr>
<td>STA 1</td>
<td>31</td>
<td>10</td>
<td>52.6</td>
</tr>
<tr>
<td>STA 2</td>
<td>8</td>
<td>2</td>
<td>50.0</td>
</tr>
<tr>
<td>STA 3</td>
<td>57</td>
<td>6</td>
<td>20.0</td>
</tr>
</tbody>
</table>

The lowest value of Shannon’s diversity index (Figure 3) was calculated for the site on Stara planina (STA2 1.33). This site is located near a human settlement and it is characterized by the presence of crop farming and grazing. The highest values of the Shannon index (over 3) were calculated for the sites in Kopaonik and Dubašnica Region (DUB1 = 3.56, DUB3 = 3.28, KOP4 = 3.22 and KOP = 3.6).

Figure 3. Phytophagous hoverfly Shannon Diversity Index calculated for 15 study sites in Serbia.
To address the specific objective, we examined the correlation between BDMF and Shannon index. The results showed a statistically significant positive correlation between the two indices ($r = 0.85791$, $p<0.05$). Shannon index is one of the most widely used diversity indices in ecological research. Beside species richness, it takes the relative abundances of different species into account. On the contrary, StN analysis is based only on the absence or presence of species in a given environment, which may be an advantage when having a restricted dataset.

It has been shown that Cheilosia species are sensitive to environmental disturbance, especially within forests (Jovičić et al., 2017). Undisturbed forest habitats characterized by high BDMF and Shannon index values (e.g. Samokovska reka river) enable species to have continuity of the microclimate they prefer. If the microclimate changes, these species may become endangered. In order to preserve species, we have to protect broad forested areas, while also controlling for other direct human impacts, including environmental disturbance in open areas.

**CONCLUSION**

Our results show that some sites (i.e. Samokovska reka river and Lazareva reka canyon) support populations of various hoverfly species that are recognized as playing an important role in ecosystem functioning. Developing a long term monitoring program for the target hoverfly species which will reflect the diversity of other taxa within a given habitat is of the utmost importance for species protection and conservation. Syrph the Net database of European hoverflies seems to be an appropriate tool for quality assessment of habitats and biodiversity management.

**ACKNOWLEDGEMENTS**

This work was funded by the Ministry of Education, Science and Technological Development of the Republic of Serbia, Grant No. 043002 (“Biosensing technology and global system for continuous research and integrated management of ecosystems”) and by the Provincial Secretariat for Science and Technological Development (“Evaluation of Ecological Networks in AP Vojvodina as support for nature conservation”).

**REFERENCES**


ПРОЦЕНА КВАЛИТЕТА СТАНИШТА ПРИМЕНОМ ФИТОФАГНИХ ОСОЛИКИХ МУВА (Diptera: Syrphidae) КАО БИОИНДИКАТОРА

Снежана Д. ПОПОВ, Злата З. МАРКОВ, Снежана Р. РАДЕНКОВИЋ Анте А. ВУЈИЋ

Универзитет у Новом Саду, Природно-математички факултет
Департман за биологију и екологију
Трг Доситеја Обрадовића 2, Нови Сад 21000, Србија

РЕЗИМЕ: У последњих неколико деценија биодиверзитет опада у целом свету. Таква ситуација изискује постојање стандардних индикатора помоћу којих ћемо моћи ефикасно да пратимо промене у екосистемима које се дешавају, пре свега, као последица негативног утицаја антропогеног фактора. У овом истраживању за биоиндикаторе су изабране два највећа фитофагна рода осоликих мува
(родови *Cheilosia* и *Merodon*) и урађена је процена квалитета 15 локалитета у Србији који се налазе на планинама Копаоник, Фрушка гора, Стара планина, Дубашница и у долини реке Пчиње. Фитофагни родови су се показали као одлични кандидати за биоиндикаторску улогу, пре свега због своје повезаности са специфичним стаништима. У анализи је коришћена Syrph The Net база, предiktivna алатка за процену квалитета станишта.

КЉУЧНЕ РЕЧИ: биодиверзитет, биоиндикатори, диверзитет, инсекти, конзервација, Syrph The Net база