Review on Agriculture and Rural Development 2023 vol. 12 (1-2) ISSN 2677-0792
DOI: 10.14232/rard.2023.1-2.67-72

COMPARATIVE ANALYSIS OF THE MACROINVERTEBRATE FAUNA OF ECOLOGICALLY STABLE AND TRADITIONAL GARDEN PONDS

Bence Tamás[1]*, Orsolya Ivett Hoffmann[1], Ákos Malatinszky[2]

[1] Department of Animal Biotechnology, Institute of Genetics and Biotechnology, Hungarian University of Agriculture and Life Sciences, Gödöllő, HUNGARY
[2] Department of Nature Conservation and Landscape Management, Institute for Wildlife Management and Nature Conservation, Hungarian University of Agriculture and Life Sciences, Gödöllő, HUNGARY

*corresponding author: tamasbence17@gmail.com

Abstract: Freshwater habitats are considered to be highly vulnerable globally. For some species, mainly invertebrates, artificial ponds created in urban gardens give suitable habitat or function as stepping stones. However, traditional garden ponds use expensive pieces of equipment with high energy demand and might release harmful chemicals into their environment. In contrast, the ecologically stable garden ponds, which are distinguished from the traditional garden ponds by their design and the complex ecosystem that maintains them, offer a solution for the problems of eutrophication and succession and maintain optimal water quality in an environmentally and cost-effective way. This study aimed to compare the aquatic macroinvertebrate fauna diversity between traditional garden ponds and ecologically stable garden ponds designed and constructed by the first author. Five ponds of both types were examined, by collecting biological specimens from 90 sampling points. Altogether 42 species were identified, and one taxon at the genus level. Our statistical analysis indicates that the ecologically stable ponds host a much richer macroinvertebrate fauna in terms of species abundance compared to traditional garden ponds.

Keywords: diversity, fauna, freshwater, limnology, macroinvertebrate, pond

1. Introduction

There is an increasing demand to develop climate-adaptive and circular cities everywhere on Earth (Knuijt 2020). Green space design often uses small watercourses, such as garden ponds, to bring the landscape to the cities. This way it contributes to making urban areas healthier and more resilient and offering recreational ecosystem services.

Nowadays, the installation of hobby garden ponds and ornamental fish keeping in them is becoming increasingly popular all over Europe. These systems function as decorative elements in gardens. Their water is recirculated by electronic devices, and cleaned by pumps and filters. These types of equipment consume not only energy but also produce waste. In addition, using chemicals and algaecides, which are harmful to nature and the environment, is unavoidable. Despite this, the ponds still need to be cleaned every six months and organic and inorganic material dumped into the lake needs to be removed continuously to prevent the lake from filling up. These interventions are environmentally damaging, costly and time-consuming, and their contribution to maintaining biodiversity is also questionable (Padisák 2005).

Ecologically stable garden ponds offer solutions to these problems. An ecologically stable garden pond can function as a self-sustaining and self-cleaning system without any equipment, which makes it different from a Low-Maintenance Ecosystem Pond, and without chemicals, still the owners can keep ornamental fish in it, which distinguishes it from natural ponds or wildlife ponds, thanks to properly selected flora and fauna. Freshwater habitats are among the most vulnerable and will be at even greater risk in the future (Reid et al. 2018) as a consequence of the rapidly changing climate (Woodward et al. 2010). Their vulnerability is compounded by the pollution of surface water resources and the destruction of aquatic habitats (Dudgeon et al. 2006). Especially in case of invertebrates, garden hobby ponds on private plots provide shelter (Hill et al. 2021). These smaller aquatic habitats and their immediate terrestrial environment can interact (Hill et al. 2021). There are very few publications on the macroinvertebrate fauna of goldfish ponds or other ponds on private plots for hobby purposes (Heinoa et al. 2017). Artificial ponds provide stepping stones for invertebrates between natural waters, which are increasingly needed as there are fewer and fewer of them (Hassall 2014).

The conservation value of traditional garden ponds is essentially low compared to a natural pond (Hill et al. 2021). Ecologically stable garden ponds, distinguished from traditional garden ponds by their design and the complex ecosystem they maintain, offer a solution for eutrophication, filling up and water quality in an environmentally and cost-efficient way.

Since 2010 we built ecologically stable garden ponds, which we have included in our research. When designing the pond beds, we tried to select the plant species at each depth level according to the plant communities native to our country, using the habitat knowledge guide by Bölöni et al. (2011) as a guide.

2. Materials and methods

The research on macroinvertebrate fauna was designed based on the methodology of Boda et al. (2016), which deals with natural water bodies and provides a lot of useful information on invertebrate collection. In our study, we compared the macroinvertebrate fauna of five traditional and five ecologically stable garden ponds in the Vác area. While selecting the ponds, they needed to be close in size and not too far apart (including having a traditional and an ecologically stable pond close together), as these factors influence the composition of the biota. Based on the new official Hungarian landscape classification, the study sites are situated in the Danubian Plain region of the Great Hungarian Plain subprovince, within the Vác–Buda Danube Valley microregion of the Vác–Pest Plain microregion group (Csorba et al. 2018).

Samples were collected monthly, except during the winter months in 2020 and 2021, from the lakeshore region, the surface of the deeper parts of the ponds surface and the benthic zones. The number of samples taken from each water body was the same. The pond habitats were divided into three groups (1. open water surface, 2. riparian vegetation and 3. underwater vegetation). Three samples were taken from each group. Considering the location of the ponds, 2 traditional and 3 ecologically stable ponds are in the more urban areas of the city, while 3 traditional and 2 ecologically stable ponds are located in the suburbs.

Invertebrates were collected mainly with hand nets with a handle length of 1.5 m, a side length of 30x30 cm and a nominal hole size of 1 mm and 0.5 mm. The vegetation, the top layer of sediment and the water surface were also examined. Samples were taken by hand from dangling landmarks and tree branches. Captured specimens of large species that could be identified in the field were released, and other samples were preserved in 4% formalin. Preserved samples obtained from each pond were stored according to site category (Boda et al. 2016).

The identification was carried out using a stereo microscope with the help of Hungarian and international identification books.

A two-sample t-test was used to determine whether differences between the macroinvertebrate populations of the two pond types could be statistically detected. To test the reliability of the t-test, a normality test was also performed. Since we were working with a small sample, we used the p-value of the Shapiro-Wilk test.

3. Results

During the study of the macroinvertebrate fauna, we identified 42 taxa to species level and 1 taxon to genus level by identifying 340 specimens observed or collected from 90 sampling points (*Figure 1*), such as according to classification we found in the ecologically stable garden pond: Cnidaria: 2; Platyzoa: 2; Clitellata: 1; Hirudinoidea: 2; Mollusca: 7; Malacostraca: 1; Araneae: 2; Ephemeroptera: 1; Odonata: 4; Heteroptera: 6; Coleoptera: 4; Trichoptera: 1; Diptera: 9

In the traditional garden pond we found: Cnidaria: 1; Platyzoa: 2; Hirudinoidea: 1; Mollusca: 4; Malacostraca: 1; Ephemeroptera: 1; Odonata: 2; Heteroptera: 3; Coleoptera: 2; Diptera: 5.

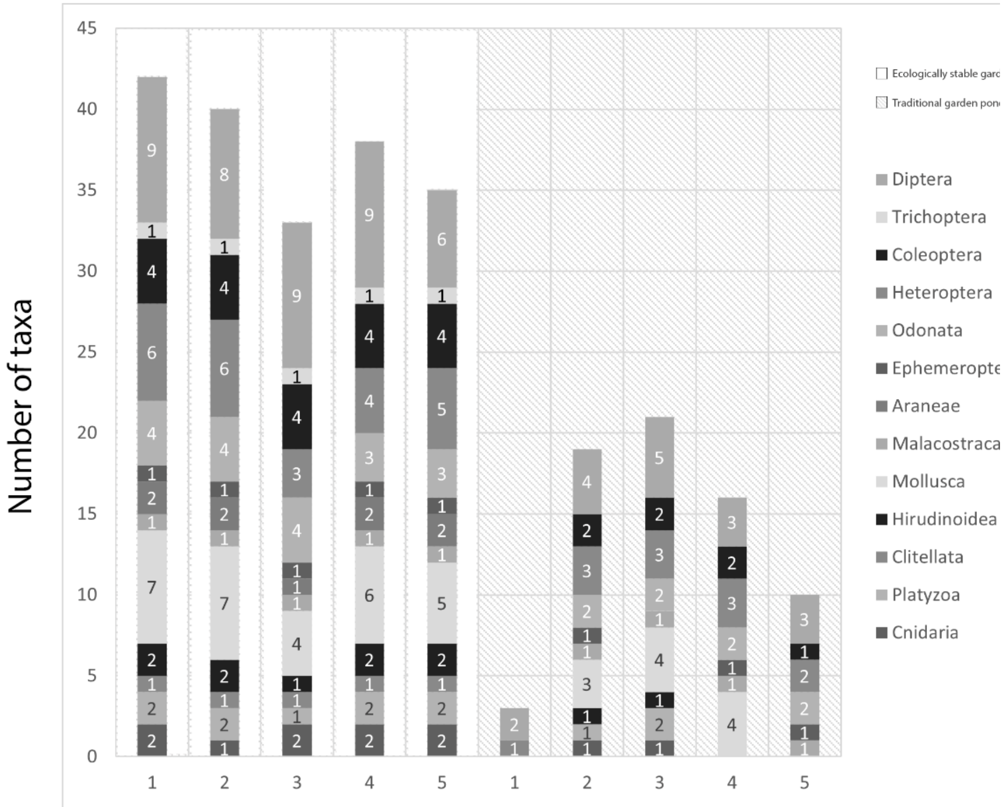
The Levene's test showed a p value of 0.241, so we accepted the hypothesis H0 that there was no significant difference in variance between the two samples, $\alpha=0.05$.

For the conventional two-sample t-test, our H0 hypothesis is that there is no significant difference between the expected values of the two samples. The corresponding p-value is less than 0.001, so our H0 hypothesis is rejected, the result is significant at α level, there is a detectable difference between the expected value of the two samples.

The normality test allowed us to retain the null hypothesis that the distribution of the population is equal to the normal distribution, and thus the t-test result was considered reliable.

Most literature data on the freshwater macroinvertebrate fauna of Vác and its surroundings can be found in publications that focus on the Danube, the largest natural water body in the area (Csabai et al. 2009). It is possible to compare our data with the macroinvertebrate fauna of the Danube because most of the native species we have identified have been detected in both standing and running water, as reported by Boda et al. (2016) and Kriska (2008). Csabai et al. (2009) found the following strains in the Little Danube section near the settlement of Kismaros: Crustacea: 9; Ephemeroptera: 3; Odonata: 6; Coleoptera: 34; Heteroptera: 15; Trichoptera: 2; Diptera: 33.

Figure 1: Number of taxa identified in the studied ponds



4. Discussion

Our study shows that the macroinvertebrate fauna of the studied ecologically stable garden ponds around Vác is more diverse than that of the traditional garden ponds, but at the same time, the latter also provide habitat and dispersal opportunities for invertebrates. In both types of ponds, we identified the zebra mussel (*Dreissena polymorpha*), an invasive species in our country, and in traditional garden ponds the alien acute bladder snail (*Physella acuta*). Our results show that any water body provides a useful habitat and a source of water and nutrients for species native to our country, but the more complex biodiversity that develops in an ecologically stable garden pond also contributes to the survival of endangered species.

In England, Hill and Wood (2014) studied 26 lakes near Loughborough (13 close-to-natural, field ponds, and 13 traditional garden ones) and reported 135 macroinvertebrate taxa from close-to-natural ponds and 44 from garden ponds; while 10 among them occurred only in the garden ponds. In a garden pond with the highest macroinvertebrate diversity level, 23 taxa were found. In another research, Hill and colleagues (2015) surveyed 13 garden ponds, 12 ponds in parks and 16 other artificial ponds in Loughborough. They found the greatest macroinvertebrate diversity in the park ponds, while the garden ponds hosted the fewest taxa. We found two species exclusively in traditional garden ponds, while 23 species occurred only in ecologically stable garden ponds. The two species found in traditional ponds were the acute bladder snail *Physella acuta* and a malaria mosquito the *Anopheles maculipennis*, which are also common in water bodies in urbanized conditions.

As a nature-based solution, garden ponds carry the high potential to address several urban challenges such as climate mitigation by evaporative cooling, optimizing air quality and rainwater harvest and water treatment, representing co-benefits and multifunctionality (Atanasova et al. 2021). Moreover, they help restore and maintain the water cycle (by rainwater management) and may substitute the urban drainage systems to a certain extent as absorbers (and users) of rainwater and thus, might play roles in the local circular economy. Urban ponds, especially the ecologically stable ones that maintain optimal water quality in an environmentally and cost-effective way, may thus contribute to the new EU Circular Economy Action Plan (European Commission 2020) which focuses, among others, on restoring and maintaining the water cycle, nutrient recovery and reuse, and energy efficiency, all that require actions to shift from linear to circular resource management.

References

Atanasova N., Castellar J.A., Pineda-Martos R., Nika C.E., Katsou E., Istenič D., Pucher B., Andreucci M.B., Langergraber G. (2021): Nature-Based Solutions and Circularity in Cities. Circ.Econ.Sust. 1: 319–332. https://doi.org/10.1007/s43615-021-00024-1

Boda P., Móra A., Csabai Z. (2016): Az Ugrai-rét komplex vízi makrogerinctelen faunafeltáró kutatása. Crisicum 9: 93-131.

Bölöni J., Molnár Zs., Kun A. (eds.) (2011): Magyarország Élőhelyei Vegetációtípusok leírása és határozója. ÁNÉR 2011. MTA Ökológiai és Botanikai Kutatóintézete, Vácrátót, 442 p.

Csabai Z., Móra A., Kálmán Z., Soós N. (2009): Hidrobiológiai vizsgálatok a Kis-Duna (Kismaros) területén – vízi gerinctelen szervezetek. http://matyasfaegyesulet.hu/wp-content/uploads/2012/06/kismaros_jelentes2009.pdf

Csorba P., Ádám Sz., Bartos-Elekes Zs., Bata T., Bede-Fazekas Á., Czúcz B., Csima P., Csüllög G., Fodor N., Frisnyák S., Horváth G., Illés G., Kiss G., Kocsis K., Kollányi L., Konkoly-Gyuró É., Lepesi N., Lóczy D., Malatinszky Á., Mezősi G., Mikesy G., Molná, Zs., Pásztor L., Somodi I., Szegedi S., Szilassi P., Tamás L., Tirászi Á., Vasvári M. (2018): Landscapes. In: Kocsis, K. (Ed.-in-chief): National Atlas of Hungary: Natural environment.. Budapest, Research Centre for Astronomy and Earth Sciences, Hungarian Academy of Sciences, pp. 112–129.

Dudgeon D., Arthington A.H., Gessner M.O., Kawabata Z.I., Knowler D.J., Lévêque C., Naiman R.J., Prieur-Richard A.H., Soto D., Stiassny M.L.J., Sullivan C.A., (2006): Freshwater biodiversity: importance, threats, status and conservation challenges, Biological reviews of the Cambridge Philosophical Society 81(2): 163-82.

European Commission (2020): A new Circular Economy Action Plan – For a cleaner and more competitive Europe. Communication from the Commission to the European Parliament, the

Council, the European Economic and Social Committee and the Committee of the Regions. https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52020DC0098&from=EN

Hassall C. (2014): The ecology and biodiversity of urban ponds. Wiley Interdisciplinary Reviews: Water 1(2): 187-206.

Heinoa J., Binib L.M., Anderssonc J., Bergstend J., Bjelkee U., Johansson F. (2017): Unravelling the correlates of species richness and ecological uniqueness in a metacommunity of urban pond insects. Ecological Indicators 73: 422-431.

Hill M.J., Wood P.J. (2014): The macroinvertebrate biodiversity and conservation value of garden and field ponds along a rural-urban gradient. https://repository.lboro.ac.uk/articles/journal_contribution/The_macroinvertebrate_biodiversity_and_conservatio n_value_of_garden_and_field_ponds_along_a_rural-urban_gradient/9481337/1

Hill M.J., Mathers K.L., Wood P.J. (2015): The aquatic macroinvertebrate biodiversity of urban ponds in a medium-sized European town (Loughborough, UK), Hydrobiologia, 760: 225–238

Hill M.J., Greaves H.M., Sayer C.D., Hassal C., Milin M., Milner V.S., Marazzi L., Hall R., Harper L.R., Thornhill I., Walton R., Biggs J., Ewald N., Law A., Willby N., White J.C., Briers R.A., Mathers K.L., Jeffries M.J., Wood P.J. (2021): Pond ecology and conservation research priorities and knowledge gaps, Ecosphere, 12(12) Article e03853

Knuijt M. (2020): Liveable Green Cities: Integrating Climate Adaptive Solutions and Circular Economy into the Built Environment. In: Roggema, R. (eds): Designing Sustainable Cities. Contemporary Urban Design Thinking. Springer, Cham. https://doi.org/10.1007/978-3-030-54686-1_6

Kriska Gy. (2008): Édesvízi gerinctelen állatok határozó. Nemzeti Tankönyvkiadó, Budapest, 368 p.

Padisák J. (2005): Általános Limnológia. ELTE Eötvös Kiadó, Budapest, 310 p.

Reid A.J., Carlson A.K., Creed I.F., Eliason E.J., Gell P.A., Johnson P.T.J., Kidd K.A., MacCormack T.J., Olden J.D., Ormerod S.J., Smol J.P., Taylor W.W., Tockner K., Vermaire J.C., Dudgeon D., Cooke S.J. (2018): Emerging threats and persistent conservation challenges for freshwater biodiversity. Biological Reviews 94 (3): 849–873

Woodward G., Perkins D.M., Brown L.E. (2010): Climate change and freshwater ecosystems: impacts across multiple levels of organization. Philosophical Transactions of The Royal Society B Biological Sciences 365(1549): 2093-2106