DECOMPOSITION OF SALIX AND POPULUS LEAVES IN THE AREA OF LAKE BALATON AND KIS-BALATON WETLAND

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Összefoglalás

A vízbe kerülő avar bomlása nagymértékben meghatározza az anyagforgalmi folyamatok alakulását, így annak vizsgálata kiemelt fontosságú. Kísérletünkben célul tűztük ki meghatározni fűz és nyár avar lebontási ütemét egy téli és egy nyári időszakban, makrogerinctelen szervezetek jelenlétében és azok hiányában, a Balaton és a Kis-Balaton területén. Ehhez a szakirodalomban is alkalmazott avarzsákos módszert alkalmaztuk, kis és nagy lyukbőségű zsákokkal. Meghatároztuk a bomlási ütemét, illetve a víz kémiai tulajdonságait (pH, vezetőképesség, NH_4^+, NO_3^-, SO_4^{2-}, PO_4^{3-}, Cl^-). A nyári időszakban az avar bomlása lényegesen gyorsabb ütemben történt, mint télen. A két víztest esetében elmondható, hogy az avar gyorsabban bomlott a Balatonban, mint a Kis-Balatonban. A vízkémiai változók tekintetében megállapítható, hogy nincs szignifikáns különbség sem a víztestek, sem a mintavételi helyek között.

Kulcsszavak: avar lebontás, fűz, nyár

Abstract

Decomposition of plant litter in water influences metabolic processes, so its investigation has a major priority. In our study the aim was to determine *Salix* and *Poplar* leaf mass loss in a winter and in a summer period in presence and deprivation of macroinvertebrates in the area of Lake Balaton and Kis-Balaton Wetland. As a common method in the literature, leaf litter bag technique was used with small and big mesh sizes. Decomposition rates and chemical parameters of the water (pH, conductivity, NH_4^+, NO_3^-, SO_4^{2-}, PO_4^{3-}, Cl^-) were determined. In summer decomposition was much faster, than in winter. In respect of the two study sites, leaves decomposed faster in Lake Balaton, compared to Kis-Balaton Wetland. In respect of the water chemical variables there was no significant difference between the water bodies and the sampling sites, either.

Keywords: leaf litter decomposition, *Salix*, *Willow*

Introduction

Deciduous leaf litter represents a major energy source for the food webs in fresh water habitats (Fisher et al., 1973). The decomposition rate of leaves depends on abiotic factors such as temperature, flow, physical abrasion (Petersen & Cummins, 1974), pH (Faye, 2006), nitrate and phosphate concentrations (Pozo, 1993), and biotic factors such as initial litter quality (Melillo et al., 1984), invertebrates and microbial colonization (Abelho, 2008). During leaf-litter decomposition, a succession of organisms takes place expressing an adjustment of biological communities to the direct environment (Frankland, 1998). Microorganisms colonizing leaves (Graça, 1993; 2001) accelerate leaf litter mineralization and enhance food quality for shredders (Gessner et al., 1999). Shredders comminute leaf litter into smaller parts and may consume fungi directly or compete with them for food resources (Prokhorov et al., 2007; Suberkropp, 1998).

The decomposition process can be affected by changes in biodiversity at various levels including species richness of microbial communities (Duarte et al., 2006), detritivorous invertebrates (Schälder & Brandl, 2005), and plant litter itself (Kominoski et al., 2007). In the last century, forested areas have been destroyed in many parts of Europe, especially lowland areas. The wood itself was used for many industrial purposes; the bare areas were used for pasture (Fujisaka et al., 1993).

An experiment was carried out to study leaf litter decomposition in two Hungarian midland freshwater habitats. Litterbags were filled with leaves of two species and placed into the water. The aim of the study was to determine leaf mass loss in litterbags in a winter and in a summer period that can correlate to bed morphology, chemical parameters or temperature. Other important factor was to investigate the impact of presence and deprivation of macroinvertebrates during the decomposition process. We hypothesized that leaf breakdown is slower in the water period and in the lack of shredding organisms.

Materials and methods

Site description

A lake (Lake Balaton: surface area 596 km^2; average depth 3.3 m) and a wetland (Kis-Balaton Wetland: 68 km^2) were chosen in southwestern Hungary to carry out the research. The study sites were Keszthely Bay (17°14'46.3" E and 46°43'32.1" N) and Kis-Balaton Wetland, Ingói Bay (17°11'46.4" E and 46°38'37.4"N N)(Fig. 1.).

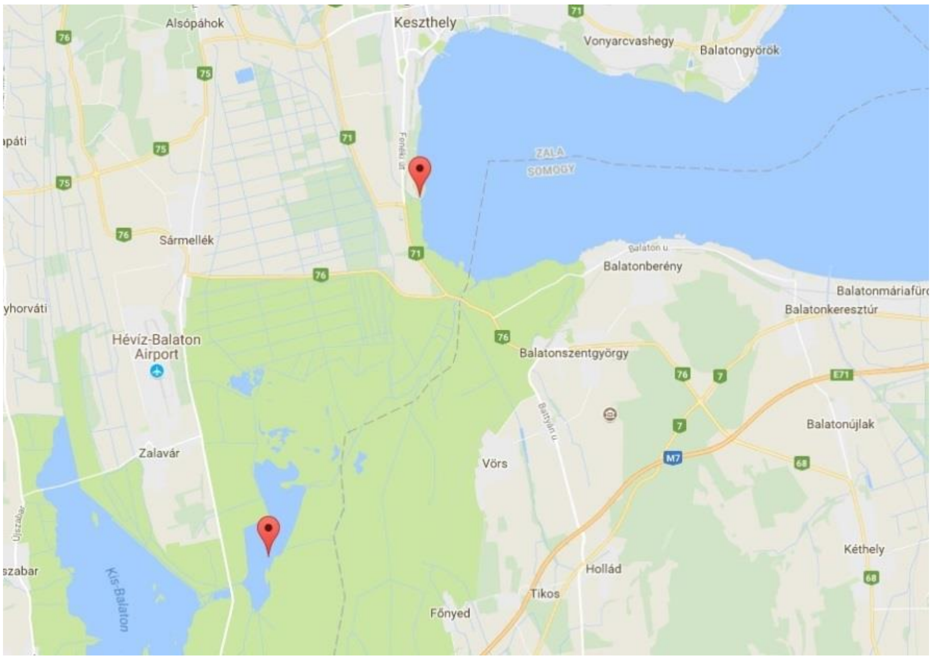

Figure 1: The locations of the two study sites (https://www.google.hu/maps)

At the sampling sites the dominant tree species is *Populus tremula* and *Salix Alba*. The depth of water is 1-2 m. The bed is composed of psammal/psammopelal (*Φ*>6 µm to 2 mm, sand/sand with mud, including organic mud und sludge), and at some points argyllal (*Φ*<6 µm silt, loam, and clay (inorganic).

Leaf-litter bags

Populus tremula and *Salix alba* leaves were collected shortly after the fall (2016 September) put into big paper boxes to avoid breaking and transported to the laboratory. The leaves were dried at 70 °C to constant mass and 10 g were put into two kinds of litter bags (following the method of Gessner, 2005). The size of the bags was the same (10 cm×10 cm), but the mesh size differed: 3 mm (leaf litter bag) and 900 µm (plankton net bag) mesh sizes were used to deprive and let the macroinvertebrates in. The bags contained only one kind of leaf, the leaves were not mixed. The top of the bags was glued carefully to keep the litter inside. Leaf litter bags were fixed to plastic racks and incubated *in situ* at 1 m depth below the surface in the littoral zone. In the field bags were sprinkled to avoid leaf-litter break before they were placed into the water. The experiment was set up twice, in a winter (30 November 2016 - 17 May 2017) and in a summer (25 May 2017 - 3 August 2017) period. At once three litterbags were collected from each site. The oven dry mass of the cleaned leaves were measured in the laboratory, to determine leaf mass loss. Exponential decay coefficients (*k*) for leaves were calculated by using the exponential decay curve below. Regression analysis assuming negative exponential decay was used (Boulton & Boon, 1991): $M_t = M_0 e^{-kt}$, where M_t is mass at time t, M_0 is mass at time 0, k is exponential decay coefficient and t is time in days. Based on their daily decay coefficients, leaves have been classified as “fast” ($k > 0.01$), “medium” ($k = 0.005$-0.01) and “slow” ($k < 0.005$) (Bärlocher et al., 2005; Petersen & Cummins, 1974).

The halving times of the detritus were calculated using the formula proposed: $T_H = \ln2 \cdot k^{-1}$. Only those data were adverted, where the bags were not empty.

Physical and chemical parameters of the water

Conductivity and pH and were measured in the field with a multi-parameter field sensor (Neotek-Ponsel Odeon). Water samples were taken each time, the main chemical variables (NO_3^-, NH_4^+, SO_4^{2-}, PO_4^{3-} and Cl^-) were analyzed in laboratory (Lovibond MultiDirect photometer).

Results and discussion

Leaf mass loss

Decay curves are well characterized by exponential decay models for all leaf species at both sites in both seasons (Fig. 2.). In summer decomposition was much faster, than in winter. In respect of the two study sites, leaves decomposed faster in Lake Balaton, compared to Kis-Balaton Wetland.

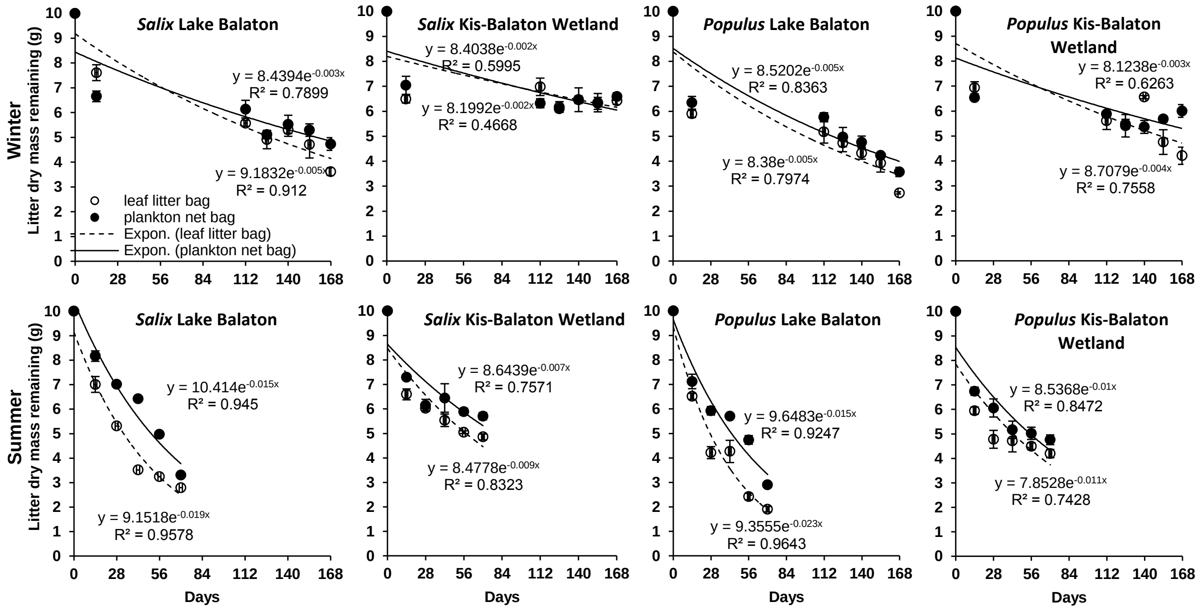

Figure 2: The litter dry mass of Salix and Poplar leaves remaining in the litterbags in Lake Balaton and Kis-Balaton Wetland in the winter and summer period

In Lake Balaton the leaf litter decay in the bags was fast for double reasons. On one hand, there is a shortage of food and on the other, drifting is higher in the open water bed, than at the other location.

Table 1: Exponential decay coefficients (k) and halving times of Salix and Populus in the winter and summer period in Lake Balaton and Kis-Balaton Wetland

Season	Leaf litter	Study site	Type of bag	Exponential decay coefficient±SD	Decomposition category	Halving time (day)
Winter	*Salix*	Lake-Balaton	leaf litter bag	0.0081 ± 0.0051	medium	85.1
			plakton net bag	0.0090 ± 0.0090	medium	76.8
		Kis-Balaton Wetland	leaf litter bag	0.0081 ± 0.0102	medium	85.9
			plakton net bag	0.0073 ± 0.0080	medium	95.4
	Populus	Lake-Balaton	leaf litter bag	0.0121 ± 0.0115	fast	57.1
			plakton net bag	0.0105 ± 0.0098	fast	65.9
		Kis-Balaton Wetland	leaf litter bag	0.0086 ± 0.0079	medium	80.5
			plakton net bag	0.0089 ± 0.0096	medium	77.7
Summer	*Salix*	Lake-Balaton	leaf litter bag	0.0190 ± 0.0068	fast	36.5
			plakton net bag	0.0114 ± 0.0043	fast	61
		Kis-Balaton Wetland	leaf litter bag	0.0143 ± 0.0083	fast	48.5
			plakton net bag	0.0111 ± 0.0060	fast	62.5
	Populus	Lake-Balaton	leaf litter bag	0.0217 ± 0.0073	fast	31.9
			plakton net bag	0.0148 ± 0.0062	fast	46.8
		Kis-Balaton Wetland	leaf litter bag	0.0178 ± 0.0102	fast	38.8
			plakton net bag	0.0163 ± 0.0090	fast	42.6

Exponential decay coefficients (k) and halving times of *Salix* and *Populus* in the winter and summer period in Lake Balaton and Kis-Balaton Wetland are shown in Table 1. Higher decomposition rates were detected in summer, compared to the winter period. The *k*-values of *Populus* leaves were higher than that of for *Salix* in Kis-Balaton Wetland in two mesh size litterbags.

Using two mesh sizes has an effect on macroinvertebrate flow and activity. Bigger mesh size results faster fragmentation, catabolism and leaching (Danell & Sjöberg, 1979; Brock et al., 1985; Neely, 1994). In our study this was detectable only in the summer period. Seasonal investigation causes faster mass loss in the summer period (Wrubleski et al., 1997). The timing of leaf collection, and its water content (dried or fresh) also contributes to the observed fluctuation of leaf litter decay rates (Gessner 1991).

The degree of leaf litter decomposition shows a declining trend, which is confirmed by the experiment of Pérez-Corona et al. (2006) in Spain.

One leaf litterbag contained only one kind of leaf. However, because of natural input and drift, some leaves may have attached to the outer surface of the bags. Recent research shows that mixed leaf species accelerate leaf litter decomposition (Markus & Gessner, 2009).

Physical and chemical parameters of the water

The seasonal average values of the water chemical variables (Tab. 2.) at the sampling locations corresponded, at average, to similar values from streams in the Carpathian Basin (Kovács et al., 2006). The pH values of the study sites were slightly alkaline. Nitrate was under range during the study period. The water chemical results of the surveyed areas are in line with expectations in Hungary. Based on the measured water chemistry parameters, it is concluded that the water chemical conditions of the sites were not extremely good and not extremely poor either. There was no significant difference between the water bodies and the sampling sites, either.

Table 2: Physical and chemical parameters of the water in the winter and summer period in Lake Balaton and Kis-Balaton Wetland

	Winter		**Summer**	
	Lake Balaton	**Kis-Balaton Wetland**	**Lake Balaton**	**Kis-Balaton Wetland**
pH	8.3 ± 0.5	8.0 ± 0.4	8.7 ± 0,6	8.8 ± 0.2
conductivity (µS cm^{-1})	661 ± 48.9	701 ± 151	823 ± 517	597 ± 120
NH_4^+ (mg l^{-1})	0.47 ± 0.13	0.59 ± 0.15	0.53 ± 0.28	1.14 ± 0.19
SO_4^{2-} (mg l^{-1})	90.4 ± 16.2	82.1 ± 27.9	108 ± 32.8	72 ± 9.96
PO_4^{3-} (mg l^{-1})	0.22 ± 0.06	0.37 ± 0.34	0.21 ± 0.07	0.4 ± 0.24
Cl^- (mg l^{-1})	17 ± 6.4	12 ± 3.2	24 ± 3.7	10 ± 4.5

Conclusion

In conclusion, leaf mass loss was faster in summer, compared to the winter period. Due to higher drifting in Lake Balaton, a greater fragmentation of leaves was detectable. Using big mesh size allows macroinvertebrate actions, which makes fragmentation, catabolism and leaching faster. In our study the results show that the activity of macroinvertebrates is not essential to increase the decomposition rates in the winter season.

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References

Abelho, M. 2008. Effects of leaf litter species on macroinvertebrate colonization during decomposition in a Portuguese stream. *International Review of Hydrobiology*. **93**. 358-371.

Bärlocher, F. 2005. Leaf mass loss estimated by litter bag technique. In Graça, M.A. S., Bärlocher, F., Gessner, M.O. (eds) (2005) Methods to study litter decomposition: a practical guide. Springer, Dordrecht, The Netherlands: 37–42.

Boulton, A.J., Boon, P.I. 1991. A review of methodology used to measure leaf litter decomposition in lotic environments: time to turn over an old leaf? *Australian Journal of Marine and Freshwater Research*. **42**. 1-43.

Brock, T.C.M., DeLyon, M.J.H., Van Laar, E.M.J.M., Van Loon, E.M.M. 1985. Field studies on the breakdown of *Nuphar lutea* (L.) SM. (Nymphaeaceae), and a comparison of three mathematical models for organic weight loss. *Aquatic Botany*. **21**. 1-22.

Danell, K., Sjoberg, K. 1979. Decomposition of Carex and Equisetum in northern swedish lake: dry weight loss and colonization by macroinvertebrates. *Journal of Ecology*. **67**. 191–200.

Duarte, S., Pascoal, C., Cassio, F., Bärlocher, F. 2006. Aquatic hyphomycete diversity and identity affect leaf litter decomposition in microcosms. *Oceanologia*. **147.** 658-666.

Faye, L.M., Beth, R.L., Ormerod, S.J. 2006. The effects of low pH and palliative liming on beech litter decomposition in acid-sensitive streams. *Hydrobiologia*. **571**. 373-381

Fisher, S.G., Chauvet, E. 1993. Energy flow in Bear Brook, New Hampshire: an integrative approach to stream ecosystem metabolism. *Ecological Monographs.* **43**. 421-439.

Frankland, J.C. 1998. Fungal succession-unravelling the unpredictable. *Mycological Research*. **102**. 1-15.

Fujisaka, S., Bell, W., Thomas, N., Hurtado, N.L., Crawford, E. 1996. Slash-and-burn agriculture, conversion to pasture, and deforestation in two Brazilian Amazon colonies. *Agriculture, Ecosystems & Environment*. **59**. 115-130.

Gessner, M.O., Chauvet, E., Dobson, M. 1999. A perspective on leaf litter breakdown in streams. *Oikos*. **85**. 277-384.

Gessner, M.O. 2005. Ergosterol as a measure of fungal biomass. *In*: Graça, M.A.S., Bärlocher, F., Gessner, M.O. eds. Methods to Study Litter Decomposition: A Practical Guide. Springer, Berlin. p.189-195.

Gessner, M.O. 1991. Differences in processing dynamics of fresh and dried leaf litter in a stream ecosystem. *Freshwater Biology*. **26**. 387–398.

Graça, M.A.S. 1993. Patterns and processes in detritus based stream systems. *Limnologica*. **23**. 107-114.

Graça, M.A.S. 2001. The role of invertebrates on leaf litter decomposition in streams-a review. *International Review of Hydrobiology*. **86**. 383-393.

Kominoski, J.S., Pringle, C.M., Ball, B.A., Bradford, M.A., Coleman, D.C., Hall, D.B., Hunter, M.D. 2007. Nonadditive effects of leaf-litter species diversity on breakdown dynamics in a detritus-based stream. *Ecology*. **88**. 1167-1176.

Kovács, Cs., Kahlert, M., Padisák, J. 2006. Benthic diatom communities along pH and TP gradients in Hungarian and Swedish steams. *Journal of Applied Phycology*. **18**. 105-117.

Markus, H., Gessner, M.O. 2009. Functional leaf traits and biodiversity effects on litter decomposition in a stream. *Ecology*. **90**. 1641-1649.

Melillo, J.M., Naiman, R.J., Aber, J.D., Linkins, A.E. 1984. Factors controlling mass loss and nitrogen dynamics on plant litter decaying in northern streams. *Bulletin of Marine Science*. **35**. 342-356.

Neely, R.K. 1994. Evidence for positive interactions between epiphytic algae and heterotrophic decomposers during the decomposition of Typha latifolia. *Archiv für Hydrobiologie*. **129**. 443-457.

Pérez-Corona, M. E., Pérez Hernández, M. C., Bermúdez de Castro, F. 2006. Decomposition of alder, ash, and poplar litter in a mediterranean riverine area. Universidad Complutense de Madrid, Madrid, Spain

Petersen, R.C., Cummins, K.W. 1974. Leaf processing in woodland stream. *Freshwater Biology*. **4**. 343-368.

Pozo, J. 1993. Leaf litter processing of alder and eucalyptus in the Agüera stream system (North Spain). I. Chemical changes. *Archiv für Hydrobiologie*. **127**. 299-317.

Prokhorov, V.P., Bodyagin, V.V. 2007. The ecology of aero-aquatic hyphomycetes. Vestnik Moskovskogo Universiteta. *Biologiya*. **1**. 19-24.

Schädler, M., Brandl, R. 2005. Do invertebrate decomposers affect the disappearance rate of litter mixtures? *Soil Biology and Biochemistry*. **37**. 329-337.

Suberkropp, K. 1998. Microorganisms and organic matter decomposition. *In*: Naiman, R.J., Bilby, R.E. eds. River Ecology and Management: Lessons from the Pacific Coastal Ecoregion. Springer, New York. 120-143.

Wrubleski, D.A., Murkin, H. R. - van der Valk, A. G. – Nelson, J.W. 1997. Decomposition of emergent macrophyte roots and rhizomes in a northern prairie marsh. *Aquatic Botany*. **58**. 121–134.