Acta Hydrobiol., 37 (1995), 4, 197–203. Kraków, December 1995

Alder, *Alnus incana* (L.) Mnch., leaf decomposition in a high mountain stream*

Joanna GALAS

Karol Starmach Institute of Freshwater Biology, Polish Academy of Sciences, ul. Sławkowska 17, 31-016 Kraków, Poland

(Received 5 April 1995, Accepted 15 December 1995)

Abstract – Processing of *A. incana* leaves was investigated in the Sucha Woda stream (High Tatra Mts, Poland). The leaf litter (about 1 g dry weight) was placed in plastic boxes with netting of three mesh sizes: fine (0.3 mm), medium (1 mm), and coarse (5 mm). Three replicates were collected from the water after 27, 55, 82, 111, and 139 days. The rate of breakdown was much higher for leaves from the coarse mesh boxes (0.014) than for those from the medium (0.0034) and fine (0.0025) mesh boxes.

Key words: mountain stream, litter decomposition, *Alnus incana*, leaves.

Tempo rozkładu liści olchy szarej (*Alnus incana* (L.) Mnch.) w potoku wysokogórskim. Rozkład liści olchy badano w potoku Sucha Woda (Tatry Wysokie) Porcje liści (około 1 g suchej masy) umieszczano w plastykowych pojemnikach zamkniętych siatkami o małych (0.3 mm), średnich (1 mm) i dużych (5 mm) okach. Próby te badano po 27, 55, 82, 111 i 139 dniach (3 powtórzenia). Wskaźnik rozkładu w pojemnikach z dużymi otworami (0.014) był znacznie większy niż w pojemnikach z otworami średnimi (0.0034) i małymi (0.0025).

1. Introduction

Breakdown of leaf litter originating from riparian vegetation is the most important process that can affect the stream energy budget (Kaushik and Hynes 1971). It is known that leaf decomposition in water is due to microbial and invertebrate action and also to abiotic factors (Webster and Benfield 1986). Leaves of different plant species are processed in streams at different breakdown rates, usually expressed as the decay coefficient k day^{-1} (Petersen and Cummins 1974).

Several works on decomposition rates have been done on the leaves of the genus *Alnus* (Chauvet 1987, Gessner 1991, Scheiring 1993, Pozo 1993). Its species are common and widespread in North America and throughout Europe. These are nitrogen fixing trees whose leaves decompose more rapidly in water than those of other species (Kaushik and Hynes 1971, Petersen and Cummins 1974). In Poland, grey alder, *Alnus incana* (L.) Mnch., occurs mostly along mountain rivers.

* This work was supported by the State Committee for Scientific Research (Project number 40439 91 01).

The aim of this study was to determine the processing rates of *A. incana* leaves placed in plastic boxes with different mesh size openings in a high mountain stream. The results are compared with the decomposition rates of various alder species from western Europe and North America.

2. Study area

The experiment was carried out on the Sucha Woda stream (49°18' N, 20°04' E) in the High Tatra Mountains, southern Poland. The study site was situated at an altitude of 775 m, in the submontane zone where the dominant tree species on the banks were grey alder, *A. incana*, and Norway spruce, *Picea abies* (L.) Karst.

At the study site, the stream bed is 8–10 m wide. The bottom consists of gravel and boulders. The water temperature varied from 1 to 11 °C, while the mean pH was 7.5 (range: 7.3–8.1) and alkalinity 1.33 mval dm^{-3} (0.78–1.84) throughout the period of study. Nutrients were present in low concentrations: NO_3 — 0.6–0.8 mg dm^{-3}; PO_4 — 10–35 µg dm^{-3} (K. Wojtan unpubl.). The stream was more fully described by Galas (1993).

3. Material and methods

Autumn-shed leaves of grey alder were collected from the study area in November 1991. They were air-dried for several days, weighed, and about 1 g was placed in plastic boxes of 120 cm^3 volume (fig. 1). Each of these boxes had a 5 cm^2 plastic mesh covering the open top. Fine (0.3 mm), medium (1 mm), and coarse (5 mm) mesh sizes were used in the study. All the boxes were placed in plastic baskets, containing some heavy stones and covered tightly with large (2 cm) mesh netting (fig. 2). They were placed randomly between the stream riffles and secured to the bank to prevent their floating.

Breakdown rates were measured between 21 January and 8 June 1992. Once a month three boxes of each mesh size openings were taken for examination. In the laboratory the macroinvertebrates and debris were removed (Pozo 1993), while leaves were dried at 60 °C for 48 h and weighed. The rate of leaf material loss was expressed as the percentage of initial sample weight after a given time. Decay coefficients (k) were determined for the litter using the exponential decay model (Petersen and Cummins 1974). The t-test was used to test differences between k values.

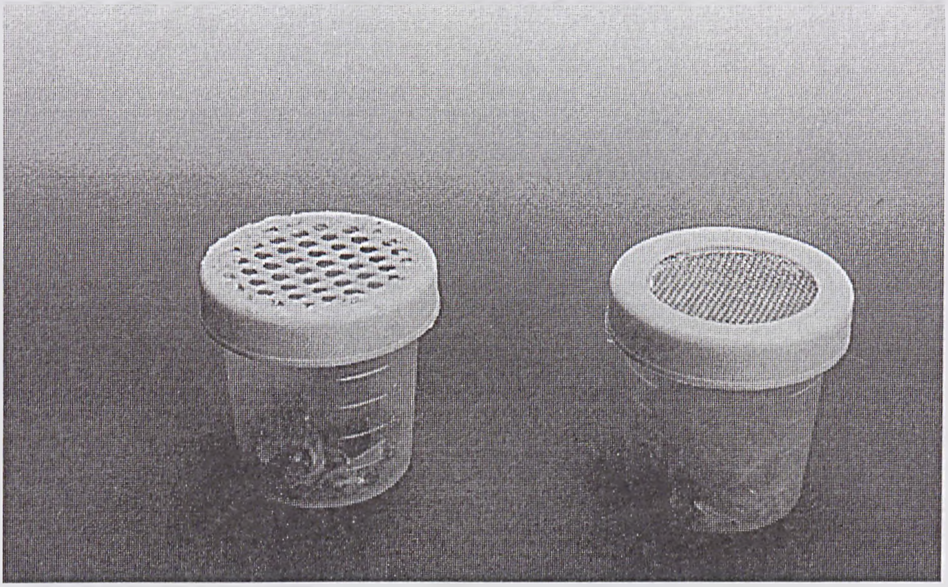

Fig. 1. Decomposition boxes with coarse (5 mm, left) and fine (0.3 mm, right) mesh (photo P. Stos).

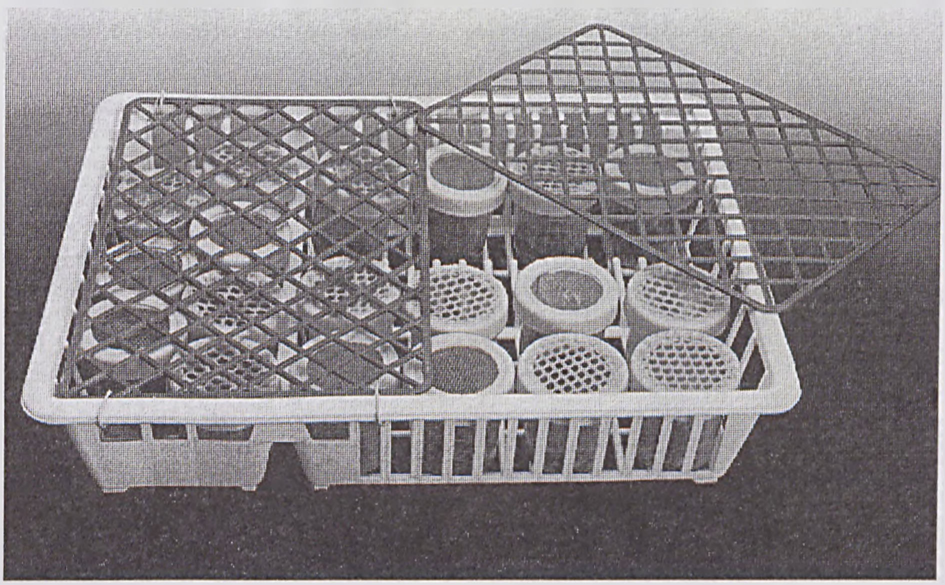

Fig. 2. Basket containing decomposition boxes, covered by net with large (2 cm) mesh (photo P. Stos).

4. Results

The loss in mass of the leaves over time is shown in fig. 3. The initial leaching from the leaves in the coarse mesh and medium mesh boxes was 21 and 26% respectively, while in the fine mesh boxes only 8% of leaves decomposed. After 55 days of the experiment the weight of leaves in the coarse mesh boxes had decreased by 71%. The processing was much slower and varied from 18 to 25% of the initial weight in the medium and fine mesh boxes between 27 and 139 days of the experiment The leaves in the coarse mesh boxes disappeared completely within 139 days.

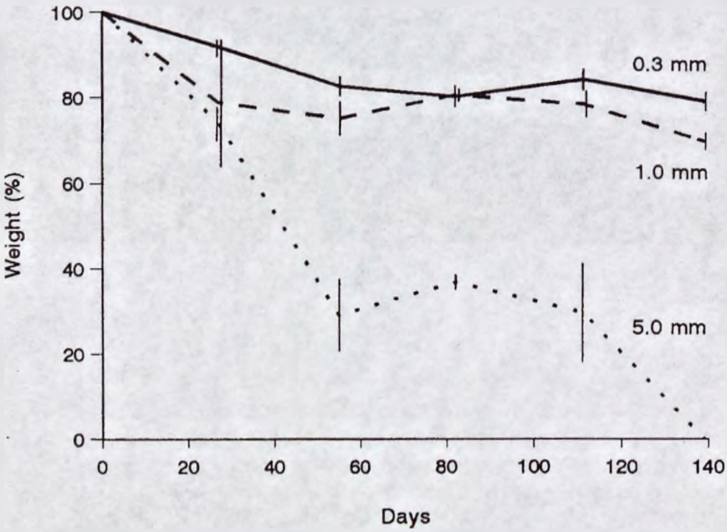

Fig 3. Changes in dry weight of *Alnus incana* (L.) Mnch. leaf litter in boxes with 0.3, 1 and 5 mm mesh size (vertical bars: ±SD of three replicates).

The *k* values obtained in the present study are presented in Table I, and compared with those of the alder species used in other studies. The breakdown rate of the leaves in the coarse mesh boxes was significantly faster than in the medium mesh and fine mesh ones ($p < 0.001$). No significant differences were found between the *k* values of the alder leaves in the medium and fine mesh boxes.

Table I Processing coefficient *k* for leaves of various species of the genus *Alnus* (after Petersen and Cummins 1974).

k day^{-1}	Mesh size (mm)	Range of temp. (°C)	Altitude (m)	Duration of study (days)	Remarks
A. incana (L.) Mnch.					
0.0025	0.3	1.0–11.0	775	139	mountain stream[1]
0.0034	1	"	775	139	"
0 0140	5	"	775	139	"
0.0014	0 3	3.5–5.0	1228	600	mountain cave stream[2]
0.0013	5	"	1228	600	"
A. glutinosa (L.) Gaertn.					
0 0075	0 2			365	woodland stream[3]
0.0040	0 3	6.0–15.0		210	River Rhone[4]
0.0065	2	6.0–5 0		180	River Garonne (France)[5]
0 0143	5		950	106	low order stream (Spain)[6]
0.0206	9	0.8–10.2	940	42	3rd order stream (France)[7]
0.0314	9	3.3–12.0	890	196	3rd order stream (France)[8]
0.0130	10	0.2–20.0		180	ponds[9]
0.0110	10	6 0–15.0		210	River Rhône[4]
A. rugosa (Du Roy)					
0 0012	3			210	river (Ontario)[10]
0.0062	20			84	2nd order stream (Michigan)[11]
0 0231	20		380	84	2nd order stream (Alaska)[11]
0 0058	leaf pack*			115	4th order stream (Michigan)[12]
A. crispa (Ait.) Pursh					
0 0259	20		380	84	2nd order stream (Alaska)[11]
0 0163	20			84	2nd order stream (Michigan)[11]
A. rubra Bong.					
0 0168	leaf pack*	1.0–15 0	800	250	*Mack Creek (Oregon)*[13]
A. tenuifolia Nutt.					
0.0462	leaf pack*	1.7–13 3	2420	66	River Colorado[14]
0.0308	leaf pack*	0 (mean)	2410	168	3rd order stream (Colorado)[15]
0.0513	leaf pack*	0–13 0	480	90	subarctic stream (Alaska)[16]
A. serrulata (Aiton)					
0 0074	leaf pack*	5.7–12 2		89	1st order stream (Alabama)[17]

* Leaf pack construction followed the method of Petersen and Cummins (1974).

[1] this study, [2] J. Galas et al. 1996, [3] Triska 1970, [4] Chergui and Pattee 1990b, [5] Chauvet 1987, [6] Pozo 1993, [7] Gessner 1991, [8] Gessner and Chauvet 1994, [9] Chergui and Pattee 1990a, [10] Kaushik and Hynes 1971, [11] Irons et al. 1994, [12] Stout et al. 1985, [13] Sedell et al. 1975, [14] Short and Ward 1980, [15] Short et al 1980, [16] Cowan et al. 1983, [17] Scheiring (1993)

5. Discussion

In the study *A. incana* leaves in the coarse mesh boxes decomposed rapidly, with k = 0.014. According to Petersen and Cummins (1974), leaves with k values above 0.01 are considered as "fast" decomposing. Grey alder leaves in the boxes with openings consisting of medium and fine mesh decomposed slower but within the range of rates published for other alder species (Table I).

Alder leaves are known to decompose rapidly in comparison with other riparian trees, e.g. those of Pinaceae which need more than 5 years for complete disappearance (Petersen and Cummins 1974, Sedell et al. 1975, Webster and Benfield 1986, Galas 1996). Grey alder usually requires less than one year for complete disappearance. Leaf packs of *Alnus tenuifolia* Nutt. were completely decomposed in 112 days (Short et al. 1980), while *A. incana* leaves in the present study decomposed completely after five months in boxes with 5 mm mesh size openings. This rapid alder litter breakdown may result from high nitrogen and protein content (Kaushik and Hynes 1971, Petersen and Cummins 1974, Hart and Howmiller 1975). This enhanced microbial degradation and increased invertebrate utilization of the leaves (Short et al. 1980). Alder leaves are preferentially chosen over the leaves of other trees by shredders (Cowan et al. 1983, Chergui and Pattee 1990a, Basaguren and Pozo 1994).

The variation in processing rates between species of the genus *Alnus* may result from the different mesh sizes used in decomposition experiments (Table I). Fine mesh size eliminates most invertebrates, resulting in slower breakdown (k = 0.001–0.008 day^{-1}), while all macroinvertebrates have admission to the alder litter in the coarse mesh bags or naked leaf packs. The consequence is a faster weight loss (k = 0.006–0.05 day^{-1}). Similar results of macroinvertebrate action on decomposition of alder leaves are observed with various plant families (Webster and Benfield 1986). In this study the most abundant taxa were Chironomidae, which mainly colonized boxes with all types of mesh size — *Corynoneura* sp. and Orthocladiinae juv. at the beginning of the experiment (February–March), and *Micropsectra* sp. and unidentified as larvae species from genera *Cricotopus* and *Orthocladius* at the end of the experiment (May–June). On the other hand, with regard to biomass of fauna functional groups, the shredders Trichoptera (Limnophilidae) were more common in boxes with coarse mesh openings.

Several studies suggest that litter processing is temperature dependent and that seasonal changes may alter the processing rates significantly (Kaushik and Hynes 1971, Irons et al. 1994). Studies of the alder leaf decomposition were made at various temperatures (range 0–20 °C, Table I). On the other hand some authors found that alder leaves can decompose rapidly even at a temperature of 0 °C (Short et al. 1980, Cowan et al. 1983) or even that temperature does not control the rate of alder leaf breakdown (Hart and Howmiller 1975, Grifith and Perry 1991, Stewart 1992). In this study, water temperature ranged from 1 to 11 °C and decay coefficient of *A. incana* leaves in the coarse mesh boxes was 0.01. In a similar decomposition study of grey alder leaves in a high mountain cave, the temperature varied from 3.5 to 5 °C, and with the same mesh size k was 0.001 (Galas et al. 1996). These tenfold differences in k value are probably due to the lack of large shredders in the water of the cave, hence water temperature does not greatly affect decomposition processes.

Acknowledgements – The author wishes to thank Dr. Andrzej Kownacki for making his data concerning the macroinvertebrates available for this paper, and Piotr Stos, M.Sc. for taking the photographs.

References

Basaguren A. and Pozo J. 1994. Leaf litter processing of alder and eucalyptus in the Agüera stream system (Northern Spain). 2. Macroinvertebrates associated. Arch. Hydrobiol., 132, 57–68.

Chauvet E. 1987. Changes in the chemical composition of alder, poplar and willow leaves during decomposition in a river. Hydrobiologia, 148, 35–44.

Chergui H. and Pattee E. 1990a. The influence of season on the breakdown of submerged leaves. Arch. Hydrobiol., 120, 1–12.

Chergui H. and Pattee E. 1990b. The processing of leaves of trees and aquatic macrophytes in the network of the river Rhône. Int. Rev. ges. Hydrobiol., 75, 281–302.

Cowan C.A., Oswood M.W., Buttimore C.A. and Flanagan P.W. 1983. Processing and macroinvertebrate colonization of detritus in an Alaskan subarctic stream. Holarctic Ecology, 6, 340–348.

Galas J. 1993. Particulate organic matter in the high mountain stream Sucha Woda (the High Tatra Mts, Poland). Acta Hydrobiol. 35, 203–212.

Galas J. 1996. Depositional processes and suspension of particulate organic matter in a high mountain stream above the timber line. Arch. Hydrobiol., Spec. Iss. Adv. Limnol., 47, 449–454.

Galas J., Bednarz T., Dumnicka E., Starzecka A. and Wojtan K. 1996. Litter decomposition in a mountain cave water. Arch. Hydrobiol., 138, 199–211.

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

Gessner M.O and Chauvet E. 1994. Importance of stream microfungi in controlling breakdown rates of leaf litter. Ecology, 75, 1807–1817.

Griffith M.B. and Perry S.A. 1991. Leaf pack processing in two Appalachian mountain streams draining catchments with different management histories. Hydrobiologia, 220, 247–254.

Hart S.D. and Howmiller R.P. 1975. Studies on the decomposition of allochthonous detritus in two southern California streams. Verh. Int. Ver. Limnol., 19, 1665–1674.

Irons J.G. III, Oswood M.W., Stout R.J. and Pringle C.M. 1994. Latitudinal patterns in leaf litter breakdown: is temperature really important? Freshwater Biol., 32, 401–411.

Kaushik N.K. and Hynes H.B.N. 1971. The fate of the dead leaves that fall into streams. Arch. Hydrobiol., 68, 465–515.

Petersen R.C. and Cummins K.W. 1974. Leaf processing in a woodland stream. Freshwater Biol., 4, 343–368.

Pozo J. 1993. Leaf litter processing of alder and eucalyptus in the Agüera stream system (North Spain). 1. Chemical changes. Arch. Hydrobiol., 127, 299–317.

Scheiring J.F. 1993. Effects of surface-mine drainage on leaf litter insect communities and detritus processing in headwater streams. J. Kansas Entomol. Soc., 66, 31–40.

Sedell J.R., Triska F.J. and Triska N.S. 1975. The processing of conifer and hardwood leaves in two coniferous forest stream. 1. Weight loss and associated invertebrates. Verh. Int. Ver. Limnol., 19, 1617–1627.

Short R.A. and Ward J.V. 1980. Leaf litter processing in a regulated rocky mountain stream. Can. J. Fish. Aquat. Sci., 37, 123–127.

Short R.A., Canton S.P. and Ward J.V. 1980. Detrital processing and associated macroinvertebrates in a Colorado mountain stream. Ecology, 61, 727–732.

Stewart B. 1992. The effect of invertebrates on leaf decomposition rates in two small woodland streams in Southern Africa. Arch. Hydrobiol., 124, 19–33.

Stout R.J., Taft W.H. and Merritt R.W. 1985. Patterns of microinvertebrate colonization on fresh and senescent alder leaves in two Michigan streams. Freshwater Biol., 15, 573–580.

Triska F.J. 1970. Seasonal distribution of aquatic Hyphomycetes in relation to the disappearance of leaf litter from a woodland stream. Ph.D. thesis, University of Pittsburg, PA.

Webster J.R. and Benfield E.F. 1986. Vascular plant breakdown in freshwater ecosystems. Ann. Rev. Ecol., 17, 567–594.