Journal of the Arkansas Academy of Science

Volume 36 Article 6

1982

Leaf Detritus Processing in an Ozark Cave Stream

Arthur V. Brown
University of Arkansas, Fayetteville

Mark D. Schram
University of Arkansas, Fayetteville

LEAF DETRITUS PROCESSING IN AN OZARK CAVE STREAM

ARTHUR V. BROWN and MARK D. SCHRAM
Department of Zoology
University of Arkansas-Fayetteville
Fayetteville, Arkansas 72701

ABSTRACT

Detritus processing rates and mechanisms were investigated in an Ozark cave stream using post oak (*Quercus stellata*) leaf packs. The 5 g leaf packs lost ca. 30% of their dry weight within 84 days, resulting in a calculated K value of 0.05. This was an unexpectedly high rate of utilization. Diversity of invertebrates associated with the leaf packs was very low. *Stygobromus ozarkensis* (Amphipoda) was the only shredder. The two isopods, *Caecidotea stiladactyla* and *Lirceus* sp. were the only collectors observed other than a single species of oligochaete worm. Our data indicated that leaf detritus processing rates are virtually independent of the number or types of invertebrates associated with the leaf packs.

INTRODUCTION

The overwhelming importance of leaf detritus processing by macroinvertebrates to the trophic dynamics of stream ecosystems has been well documented (see Anderson and Sedell, 1979, and references therein). Allochthonous detritus processing forms the central theme of the recently developed River Continuum concept (Vannote et al., 1980) and the related general mathematical model for streams (see McIntyre and Colby, 1979). Woodland stream ecosystems of order 1-4 are primarily heterotrophic and most of their energy is derived from inputs of allochthonous leaf detritus (Minshall, 1967; Cummins et al., 1973; Cummins, 1974). However, autochthonous production by periphyton and aquatic macrophytes is considerably important in some epigean (surface) stream ecosystems (Minshall, 1967). Natural cave systems are certainly dependent on allochthonous materials for an energy supply because they have no autochthonous production. In contrast with epigean systems, hypogean environments remain relatively unchanged seasonally. Air and water temperatures fluctuate only slightly, there is an absence of light, and water chemistry is more stable or predictable in caves. Cave fauna are quite distinct from epigean community fauna (see McDaniel and Smith, 1976) but detritus processing mechanisms in cave streams may not be very different from those in surface streams. Considering the simplified environments of caves, regarding less fluctuation in physical and chemical parameters and decreased species diversity, they have the potential of serving as natural laboratories for study of fundamental ecological processes in a less complex ecosystem. Poulson and White (1969) have pursued the idea of using cave ecosystems in this way.

Ozark caves can be classified into three basic types; sink hole, tunnel and seepage caves (see Hubricht, 1950). Sink hole caves are of particular interest because a substantial amount of particulate organic matter such as leaf detritus may enter the system via the sink hole. This material may be distributed downstream toward the mouth of a cave and provide nutrients for the underground stream community. The primary objectives of this investigation were to determine the rate of leaf detritus processing in a sink-hole cave stream, and identify the cave organisms associated with this process.

METHODS AND MATERIALS

Dickerson Cave, located approximately 9 km north of Cherokee City, Benton County, Arkansas (T19NR34WS2), was selected for this study. The cave has an accessible length of ca. 100 m with a small permanent spring-fed stream traversing its length. There is a sink hole located near the head of the cave that is the source of allochthonous input. The sink hole area is sparsely forested with oak (*Quercus stellata* Wang).

Leaf packs (5 g) were prepared by collecting dry leaves from an oak tree (*Q. stellata*) near the sink hole, drying them to a constant weight at 55° C, and stapling them to a small plastic insert. On 26 January, 1980, 27 leaf packs were placed on the substrate of the stream 20-25 m within the cave. Three of the packs were retrieved for analysis after days 3, 7, 21, 28, 35, 42, 56, 70, and 84. Organisms found in the leaf packs were identified, counted and immediately released unharmed in the cave. This was considered necessary to avoid depletion of the cave populations. Leaves were then returned to the laboratory where they were lightly rinsed in tap water, dried to a constant weight at 55° C, and weighed. Several chemical and physical measurements were routinely taken using standard methods. These included dissolved oxygen, pH, conductivity, turbidity, flow rate, water depth, and air temperature.

RESULTS AND DISCUSSION

The physical and chemical parameters monitored remained relatively constant during the study (Table 1). Dissolved oxygen was always near saturation, pH remained between 7.2 and 7.4 and turbidity ranged from 10.5 to 16.5 NTU. Water temperature averaged 12.5° C with a drop to 10° C following a heavy snow prior to day 21. Air temperature was more variable (3-16° C) in this small cave. Flow, depth and, to a lesser extent the other parameters, showed changes on day 21 due to an influx of water from melting snow.

Table 1. Chemical and physical parameters of Dickerson Cave, Benton County, Arkansas, from 26 January through 19 April 1980.

DAY	DISSOLVED OXYGEN (MG/L)	pH	TEMPERATURE (°C) AIR	TEMPERATURE (°C) H_2O	TURBIDITY (NTU)	CONDUCTIVITY (µMHOS/CM)	DEPTH (CM)	FLOW (CM/SEC)
0	-	7.5	9	13	14	95	5.5	-
3	9.3	7.6	7	12.5	-	105	5.5	10.1
7	8.9	7.4	6	13	14.5	110	3.5	9.4
21	-	7.2	5	11	16.5	82	24.5	26.2
28	9.1	7.4	11	11.5	15.5	100	2.5	11.1
35	9.9	7.4	3	13	12	115	4.0	9.2
42	8.9	7.7	10	10	12.5	120	3.5	9.1
56	10.2	7.3	16	13	10.5	115	5.0	16.3
70	9.1	7.4	11	14	11.1	123	4.0	17.4
84	8.9	7.4	11	14	11.6	119	3.0	9.7

The leaf packs lost approximately 30% of their dry weight during the 84 day study period (Figure). There was an initial weight loss due to elution of soluble compounds during the first three days. Leaf packs then increased in weight between days 3 and 7 as they were colonized by bacteria and fungi (see Suberkropp and Klug, 1976; Cummins, 1977). However, a linear regression model of leaf weight remaining (Y) after the days of exposure (X) fit the data quite well ($Y = -0.02X + 4.7$, $r^2 = 0.90$, Figure).

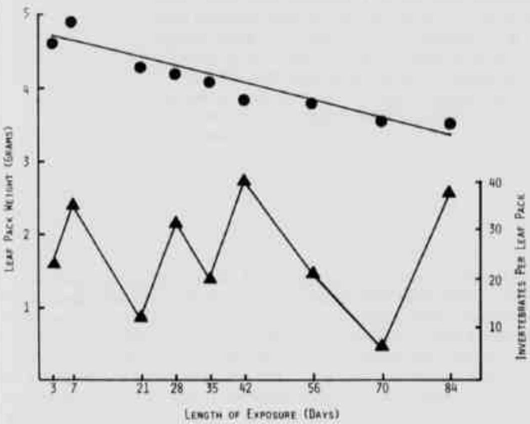

Figure. Rate of Oak (*Quercus stellata*) leaf pack utilization and numbers of associated invertebrates in Dickerson Cave, Benton County, Arkansas, from 26 January through 19 April, 1980.

The cave stream benthic macroinvertebrates which colonized the leaf packs fit into two functional group categories as discussed by Cummins (1974) and Anderson and Sedell (1979). *Stygobromus ozarkensis* (Holsinger), a hypogean amphipod, was the only shredder organism present. It occurred rather infrequently and in low numbers (see Table 2). Collectors included two isopods, *Caecidotea stiladactyla* Mackin and Hubricht (hypogean) and *Lirceus* sp. (epigean) which were considerably more numerous. An unidentified species of oligochaete worm was collected only on the final sample date. There were no sequential trends of colonization by functional groups (i.e., shredders, collectors, predators) in this study. Other organisms observed near but not in the leaf packs were crayfish, *Orconectes neglectus* (Faxon), and the salamander *Eurycea lucifuga* Rafinesque. *Orconectes* is an omnivore which occasionally feeds on detritus and would be classified as a shredder. The reduction in total organisms associated with the leaf packs on day 21 was probably caused by the increased flow of water (Figure, Table 2). Sometime between days 56 and 70 the cave was apparently (footprints were obvious) visited by spelunkers who disturbed the leaf packs, causing a second drop in the number of organisms in the packs. There was no apparent correlation between the numbers of organisms associated with the leaf packs and the rate of processing (see Figure).

Our data indicate that the rate of leaf detritus processing is independent of the number or types of invertebrates associated with the leaf packs. The processing rate in the cave as indicated by the slope of the regression line (−0.02) or by a K value (0.0498) calculated according to the method established by Petersen and Cummins (1974) are virtually identical to those reported by other investigators using similar leaf types (oak) in a variety of habitat types (see Mathews and Kowalczewski, 1969; Petersen and Cummins, 1974; Anderson and Sedell, 1979). McIntyre and Colby (1979), using their stream ecosystem model, generated a series of hypotheses including one that stated that if macroconsumers were removed from a stream section, microbial activity would process most allochthonous inputs. The results of our investigation support this hypothesis in that the leaf processing rates in the cave stream were comparable to rates in surface streams despite the depauperate fauna in the cave.

Table 2. Organisms (N/leaf pack) collected in leaf packs from Dickerson Cave, Benton County, Arkansas, from 26 January to 19 April 1980.

DAY	CAECIDOTEA (COLLECTOR)	STYGOBROMUS (SHREDDER)	LIRCEUS (COLLECTOR)	OLIGOCHAETA (COLLECTOR)	TOTAL
0					
3	16	1	7	0	24
7	29	0	7	0	36
21	7	1	5	0	13
28	27	0	5	0	32
35	18	1	2	0	21
42	35	0	6	0	41
56	21	0	1	0	22
70	7	0	0	0	7
84	33	1	1	3	38

ACKNOWLEDGEMENTS

Funding for this project was provided by NSF-EPSCOR grant ISP8011447 and the University of Arkansas.

LITERATURE CITED

ANDERSON, N. H., and J. R. SEDELL. 1979. Detritus processing by macroinvertebrates in stream ecosystems. Ann. Rev. Entomol. 24:351-377.

CUMMINS, K. W. 1974. Structure and function of stream ecosystems. BioScience 24:631-641.

CUMMINS, K. W. 1977. From headwater streams to rivers. American Biology Teacher 39:305-311.

CUMMINS, K. W., R. C. PETERSEN, F. O. HOWARD, J. C. WUYCHECK, and V. I. HOLT. 1973. The utilization of leaf litter by stream detritivores. Ecology 54:336-345.

HUBRICHT, L. 1950. The invertebrate fauna of Ozark caves. Bull. Nat. Speleol. Soc. 12:16-17.

MATTHEWS, C. P., and A. KOWALCZEWSKI. 1969. Disappearance of leaf litter and its contribution to production in the River Thames. J. Ecol. 57:543-552.

McDANIEL, V. R., and K. L. SMITH. 1976. Cave fauna of Arkansas: Selected invertebrate taxa. Proc. Ark. Acad. Sci. 30:57-61.

McINTYRE, C. D., and J. A. COLBY. 1979. A hierarchial model of lotic ecosystems. Ecol. Monogr. 48(2):167-190.

MINSHALL, G. W. 1967. Role of allochthonous detritus in the trophic structure of a woodland springbrook community. Ecology 48:139-149.

PETERSEN, R. C., and K. W. CUMMINS. 1974. Leaf processing in a woodland stream. Freshwater Biol. 4:343-368.

POULSON, T. L., and W. B. WHITE. 1969. The cave environments. Science 165:971-981.

SUBERKROPP, K., and M. J. KLUG. 1976. Fungi and bacteria associated with leaves during processing in a woodland stream. Ecology 54:707-719.

VANNTOE, R. L., G. W. MINSHALL, K. W. CUMMINS, J. R. SEDELL, and C. E. CUSHING. 1980. The river continuum concept. Can. J. Fish. Aquat. Sci. 37:130-137.