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Abstract

Losses of dry weight,N,P,Ca,and Mg from emergent macrophiyte litter in Theresa Marsh were studied during September 18.1977 to August 31,1978. Dry weight remains of shoot litter of Typha latifolia, Spargarxium eurycarpum,Scirpus fluviatilis in the marsh after 348 days were 47.5, 26.9, 51.4 % respectively,and for the root-rhizome litter were 59.1, 42.1, 27.8 %(Scirpus>Sparganium>Typha). Under controlled conditions,the rates of dry weight loss of Typha leaves at 18 ^{0}C in both artificial and distilled water were significantly faster than those at 10 ^{0}C; weight losses in distilled water were faster than those in artficial water at both temperature levels. Sterilized and antibiotic treated Typha leaves showed relatively stable dry weight after leaching loss in the first two weeks. Initial weight ,N,P,Ca, and Mg losses resulted chiefly from leaching. These elements accumulated in spring and summer ; N exhibited the highest accumulation (about three times the initial content in the shoot litter). In the laboratory, N accumulation occurred within 15 days,as a result of microorganisms inhabiting the litter. There were no significant increase in C and N in sterilized leaves,while increases in the controls of both antibiotic and sterilization experiment fluctuated between 38.9 - 47.9 %(C) and .39-1.43% dry

weight(N). N increases in antibiotic treatment probably resulted from adsorbtion of antibiotics. Increases in P,Ca,Mg in later stage of decomposition were attributed to micreorganisms,epiphytes,and precipitation from the solution. High C:N ratios and relatively low P,Ca,Mg in original standing crop may be the cause of low herbivore consumption,whoroas the relative increases in N,P,Ca,Mg in decomposed litter provide a more nutrient-rich substrate for detritiveres. There were significant interrelationships between nutrients in the litter(N,P,Ca,Mg)and marsh water nutrients(NH4-N,seluble reactive P,Ca,Mg). Levels of NH4-N and soluble reactive P suggested neither N nor P are limiting in the marsh water. Much of the nutrient uptake in the annual cycle is via microbial and detritrivore growth rather than by macrophyte producers. The release of energy tied up in the dead plant materials depends on the microbial degradation to make it available to highertrephic levels.

INTRODUCTION

Decomposition is the major process which results in dissipation of energy and release of nutrients stored in organic matter. Though some decomposition may accomplished through physical-chemical mechanisms,the dominant pathway utilizes biological mechanisms. The concepts of trophic level and food chain have traditionally emphasized the plant—herbivore—camiv,ro sequence,but awareness of the proportion of primary production utilized directly by decoinposers is increasing.

There have been many studies on the productivity and nutrient content of themarshspecies (o.g.BernardandMacDonald,1974;Klopatek, 1974;Lindsley, 1977;stake,1967),but little attention has been given to the decomposition of emergent macrophytes. These plants represent themain source of autochthonous litter in most marshes.

In Wisconsin,Theresa Marsh(Klopatek,1974)and McNaughton Marsh

(Lindsley,1977)were investigated in terms of productivity and nutrient fluxes. This study adds information on decomposition of Typha latifolia, Sparganium eurycarpum,and Scirpus fluviatilis ,three dominant emergent macrophytes with high productivity in Theresa Marsh(Klopatek,1975).

This work documents and compares tne rates of decomposition, losses of dry weight and mineral nutrients from the shoot and from root- rhizomparts of the three species and determined the nutrient value of tne litter in terms of crude protein. Correlations between nutrients in the marsh water and nutrients in the litter are examined.

To further elucidate interppretation of decomposition in themarsh, two laboratoryexperiments were designed to study the effects of temperature, water nutrient,antibiotics,and sterilization on decomposition of Tvpha latifolia shoot.

SITE DESCRIPTION

Theresa Marsh is a wildlife area owned and managed by the Wisconsin Department of Natural Resources. It is located on the east branch of the Rock River in Dodge and Washington Counties. The marsh lies between U.S. Highway 41 on the east and the Soo Line Railway un the west. The area of approximately 2025 ha contains 600 ha of shallow impoundment. The surrounding drainage basin consists of nearly 19,000 ha of which 90% is in pasture or under cultivation. The area was completely covered by the Green Bay lobe of late Wisconsin glacier more than 10,000 years ago. The Cincinnati shale bed lies under the entire impoundment. The soil is a Histosol of the Houghton mucky peat series. The marsh is supplied by three major inflows: Kohlsville Creek,the east branch of the Rock River,and Lorrira Creek. The watersfrom these inflows mix within the marsh before passing through the Rock River outflow.

MATERIALS AND METHODS

Field study

Two sites were sampled for each species and two .25 m quadrats were sampled at each sampling site. All bioinass within the quadrat was excavated to a depth of 30 cm n Shoots were separated from root—rhizomes and all material was washed to remove excess soil. Roots and rhizomes were washed over a brass sieve(0.5 cm mesh)using a high spray of cold tap water. The samples were cut into pieces of about 7 cm for shoot and about 10 cm for roots and rhizomes ,and then dried at 50 ^{0}C,shoots for 3 days and root-rhizome for 6 days. The dry samples were weighed and placed in 15x15 cm fiber glass bags. Weights ranged from 4.980-6.912 g for shoot and 9.574 - 17.420 g for root-rhizome material. For each species,forty bags of shoot litter and twenty four bags of root-rhizome material were deployed at each sampling site on September 18.1977. Five shoot bags and three root-rhizome bags were removed from each sampling site on October 14,1977 and November 11, 1977 and on April 22,1978 and June 7,1978. The rest were collected on August 51,1978. Water samples were obtained at a depth of 130 cm at the vegetation sampling sites on the same dates

In the laboratory,the litter bags were opened and gently washed in white trays ofdistilled water to remove soil and animals. The litterwas then dried at 50 ^{0}C for 3 days after which it was weighed and ground through a 20 mesh sieve in a Wiley Mill

Phosphorus,calcium & magnesium were determined colorimetrically by molybdenum blue method(Allen et al.,1974),glyoxalbis 2 hydroxyanil(Kerr,1960),and titan yellow method(Allen et al.,1974) respectively after mixed acid digestion with perchloric,nitric,and sulphuric acids. Total nitrogen content was measured by the indophenol blue method after Kjeldahl digestion. Crude protein was estimated by

multiplying the total nitrogen by 6.25. NH4-N of the water was measured by the Nessler method; soluble reactive P,Ca,and Mg followed the same methods used for plant material after filtering through No. 44 filter paper.

Laboratory experiments

Typha shoots used in the first laboratory experiment were from 6 month old greenhouse material,started from Typha rhizomes and sediment collected from Theresa Marsh. Drying,weight recording,bag size,and chemical analyses were similar to those used in the field experiment. Six bags were submerged in each of 12 plastic buckets, each containing 6 liters of water. Six buckets had distilled water the ether six had distilled water with $CaCO_3$ 1.498 g, MgS04 71720 2.37 g , KN03 1.60 g, KH2P04 .06 g,KCL .05 g,and NaCi .35 g. The amounts of chemicals were based on the mean values of nutrients present in Theresa Marsh water(Klopatek,1974). Six milliliter6 of a trace element mixture were added to each bucket of artificial marsh water. One Milliliter of the mixture contains $FeCl_3$ 61120 3.15mg, MnC12 41 120 .18 ug, CuSO4 51120 .01mg, ZnS04 $7H_20$ .022mg, $CoCl_3$ 61120 .Olmg,NaMoO4 21120 .006 mg(Guillard,1961). Ten milliliters of water from the growing tank were added to each bucket as an inoculum. One set of six buckets, three of which contained artificial marsh water were placed at 18 ^oC in a Sherer controlled chamber Model CEL 4-4. The other set were placed at 10 ^oC in a chamber of the same model. Light in each chamber was limited to only two 20 watt fluorescent tubes lighted 12 hr per day. Continuous aeration in each bucket was accomplished using a vinyl tube(1/8 inch diameter) connected to an air valve and air pump. A glass bottle filled with cotton served as an air filter. Bags were collected once a month,one bag from each bucket. T&experiment terminated at 184 days.

Typha shoots harvested from Theresa Marsh on August 31,1978 were used in a second laboratory experiment. Groups of five IOxIO cm fiber glass bags,each contained a known dry weight of Typha,were submerged in two liter beakers containing one liter of filtered Theresa Marsh water. Five replications were prepared as controls and five for antibiotic treatment. All samples were incubated at 10°C under four 20 watt fluorescent tubes(10 hr/day). Nystatin and cyclo - heximide in concentration of 50 mg/l were used as antifungal agents and benzyl penicillin and streptomycin 24 mg/l,as antibacterial agents. The concentration were identical with those of Kaushik and Hynes(1971). A fresh dose was added to each of the five beaker twice each week. One bag was removed from each beaker at 15,30,60,90 and 120 days.

A sterilization experiment run concurrently,used dry plant materials and filtered water of the same source. The experiment was run for 120 days under the same controlled conditions as the antibiotic experiment. Weight of the littertogether with the 250 ml flasks were recorded before sterilization at 120C under 15 lb/in pressure for 30 minutes. The loss of weight due to volatization ofvolatile components during sterilization was recorded after the flask with litter was oven dried with a cotton plug and remained closed for 2 days at 50 °C. Thirty flasks were treated in this manner,five were saved for initial nutrient analyses. Filtered water marsh which had been separately autoclaved in 25 flasks of 200 ml each,was added to the sterilized litter. Equal replications with untreated litter and filtered waterwere used as controls. Five flasks were removed for nutrient analyses at each date on the same schedule as that of antibiotic experiment. Statistical analyses employed one,two,and three way analysis of variance,significant level was set at 0.05.

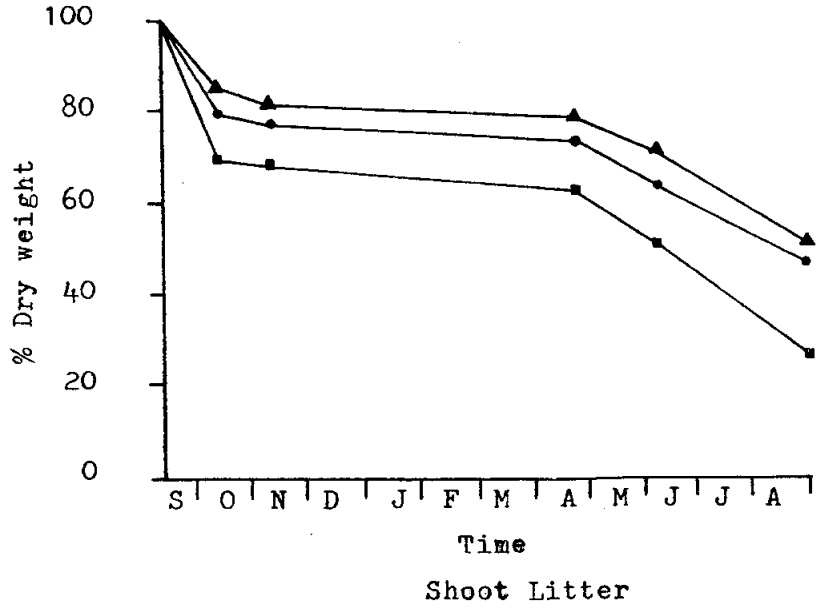
RESULTS

Weiaht loss

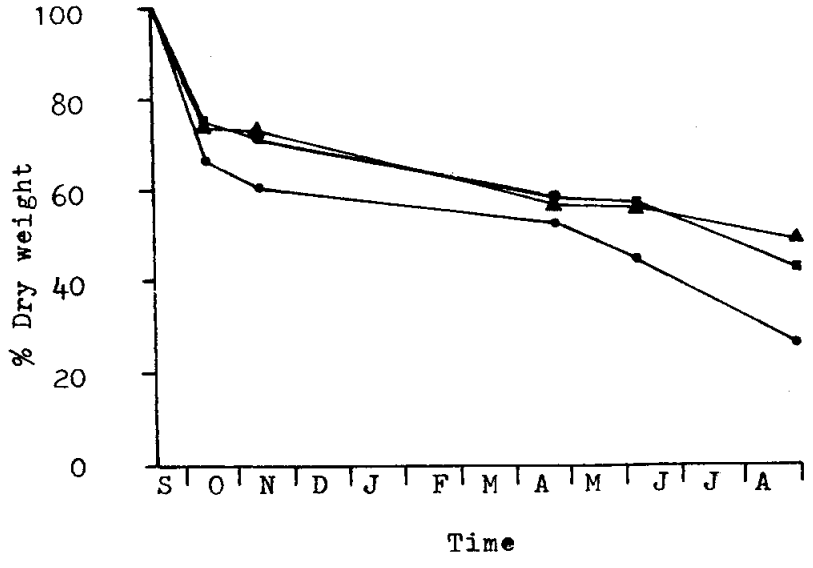
In each experiment,dry weight loss was rapid in the first month(Fig. 1). In the field,Sparganium shoot litter had the fastest rate ofdecomposition. Sparganium shoots lost 73.1% of their initial dry weight in 348 days,Typha and Scirous shoot lost 52.5 and 48.5 % in equal.time. Decay rates of root-rhizomes were faster than those of the shoots,except for .Scirpus.The patterns of root-rhizome decomposition were roughly similarto the shoots. There were rapid losses in the first month followed by very slow rate of loss during the November-April period. The rate of weight loss Increased again as the water warmed in spring and summer. After 348 days the remaining percentages of initial dry weight of root-rhizome material were 27.8, 42.1 ,59.1%(Typha < Spaganium < Scirous).

Both temperature and nutrient level of water produced significant effects on the weight loss of Typha shoot litter. The rate of decomposition in distilled water at 18 ^{O}C was faster than that in artificial water at 18 ^{O}C throughout the six month test period.At 184 days 40.5% of dry weight remained in the former and 36.3% in the latter. There was little difference between rate of weight loss in artificial water vs distilled water at 10 ^{O}C(Fig.2). After 184 days

Fig. 1 Percentage of remaining dry weight of shoot and root - rhizome litter, September 18, 1977 to August 31, 1978. ● Typha, ■ Sparganium, ▲ Scirpus.

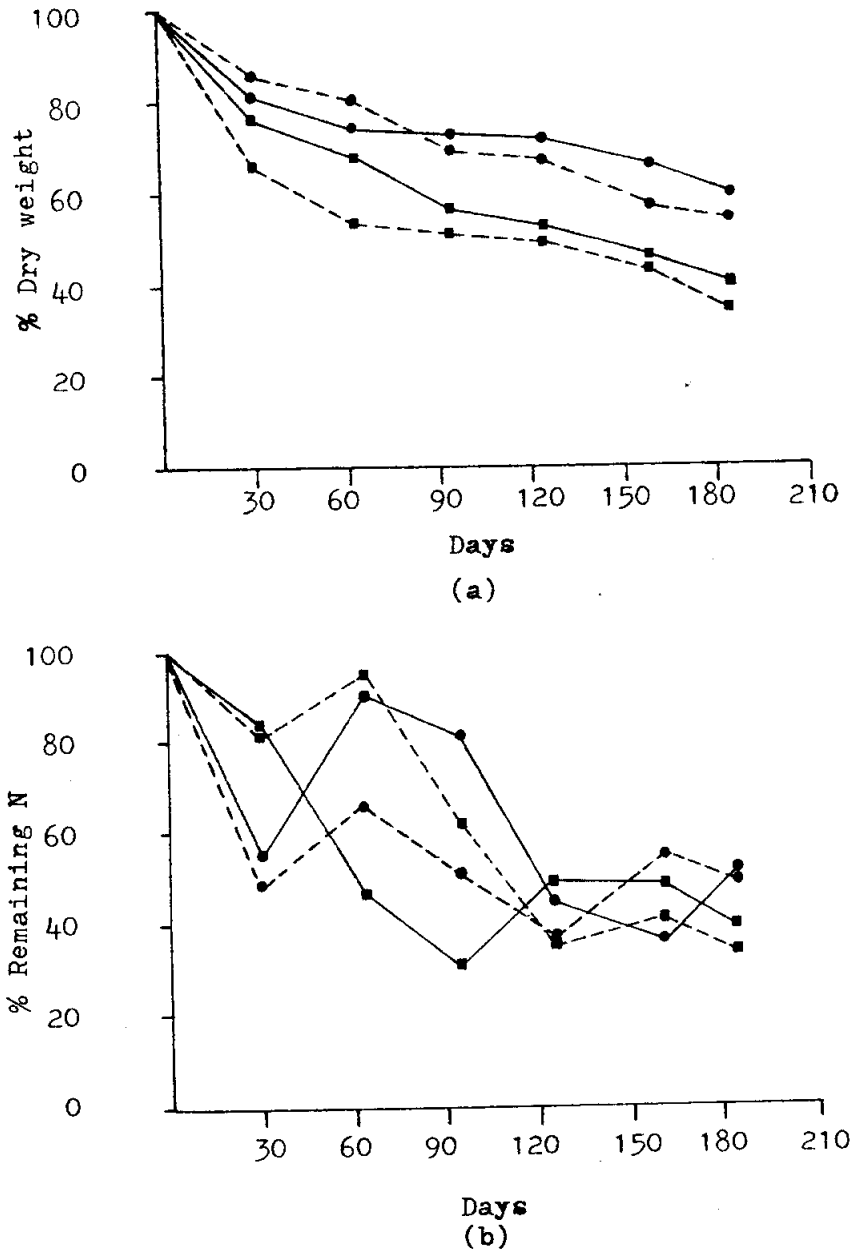


Shoot Litter



Root-Rhizome Litter

Fig. 2 Typha shoot litter, percentage of remaining dry weight (a), and nitrogen (b).--- distilled water, — artificial water, 10 °C , 18 °C



at 10C the remaining dry weight in artificial water was 60.4% and that of distilled water was 56.2%.

After an initial loss in the first 15 days,the dry weight of sterilized and antibiotic treated litter remained relatively stable throughout the 105 days. Dry weights stayed in the range of *85.4-91.8* %, indicating that antibiotic and sterilization were effective in controlling the growth and activities of microbial decomposers. In contrast ,the weight of the control bags of both antibiotic and sterilization treatments continued to decline rather steadily througout the study period(Fig.3). Dry weights at 15 days were 85.2%(antibiotic control)and 85.3%(sterilization control)of the original and declined to 70.1 and 67.2% respectively at 120 days. Differences in dry weight between treatment and control were significant in both antibiotic and sterilization experiments < 0.01).

Nitrogen and protein

Initial total nitrogen content present in the shoots were 0.83,0.60,0.43% in Sparganium,Typha,and Scirpus respectively. Initial concentrations found in the root - rhizome were O.93,0.79,0.77%(Scirpus >Typha > Sparganium). During decomposition decreases in *N* characterized the early months (October,November) ,except in Sparganium shoots which showed slight increase in Ncvember(Fig.4). Nitrogen increased in spring and continue to summer. The increases in August were great in Sparganium and Typha shoots with the remaining N about 135 and 83% of their initial contents respectively. Scirpus shoot litter reached a N peak of 0.86%dry weight in June,then dropped to 0.51% dry weight in August. The increases were less dramatic in root - rhizome litter. Increases of all species were found in April. By the end of August

Fig. 3 Percentage of remaining dry weight of shoot litter,

(a) antibiotic experiment, (b) sterilization experiment. ● control, ■ treated (antibiotic, sterilization).

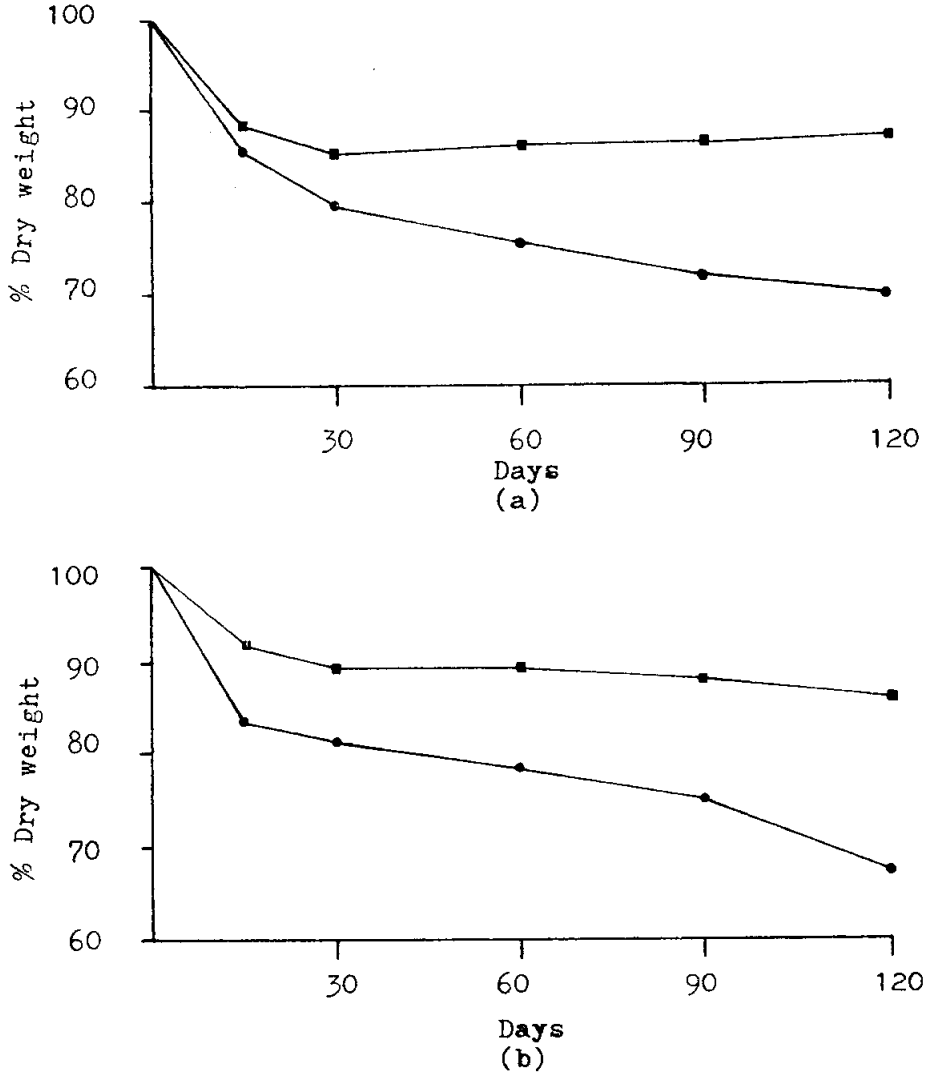
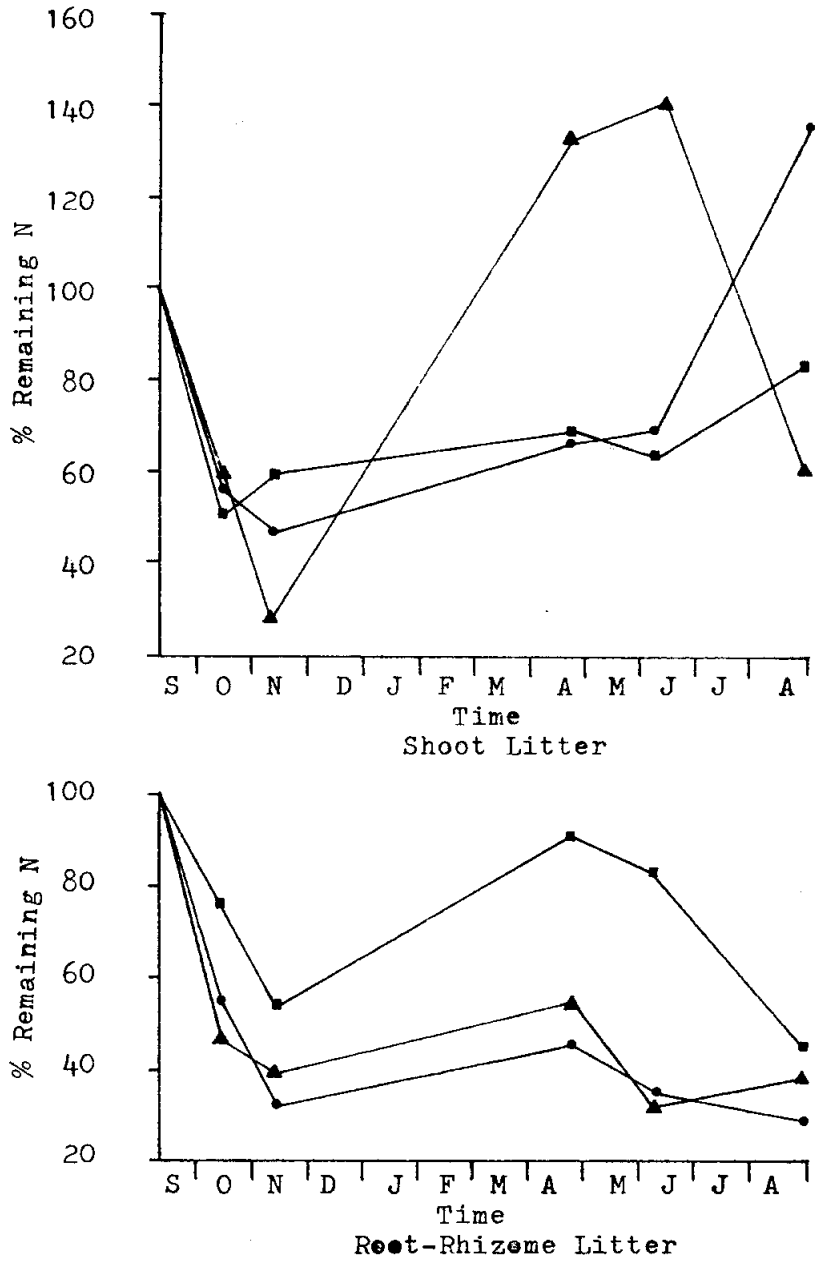


Table 1 Protein, nitrogen, phosphorus, calcium, and magnesium (as per cent of dry weight) of Typha, Sparganium, and Scirpus shoot and root - rhizome litter.

Date	Protein	N	P	Ca	Mg
Typha shoot					
9-18-77	3.73	.60	.19	1.00	.13
10-14-77	2.66	.43	.11	.72	.04
11-11-77	2.31	.37	.10	.63	.04
4-22-78	3.39	.54	.10	.74	.04
6-7 -78	4.06	.65	.10	.74	.06
8-31-78	10.58	1.69	.12	.73	.03
Sparganium shoot					
9-18-77	5.20	.83	.19	1.36	.15
10-14-77	3.73	.60	.13	.74	.05
11-11-77	4.59	.74	.12	.63	.06
4-22-78	5.67	.91	.12	.65	.06
6-7 -78	6.56	1.05	.17	.61	.10
8-31-78	16.03	2.57	.16	.76	.04
Scirpus shoot					
9-18-77	2.69	.43	.09	.57	.07
10-14-77	1.86	.30	.08	.35	.02
11-11-77	.91	.15	.07	.36	.04
4-22-78	4.59	.74	.10	.40	.04
6-7 -78	5.38	.86	.12	.45	.06
8-31-78	3.21	.51	.09	.50	.02
Typha root-rhizome					
9-18-77	4.94	.79	.30	.71	.11
10-14-77	4.15	.67	.19	.59	.05
11-11-77	2.59	.42	.13	.71	.08
4-22-78	4.25	.68	.12	.72	.07
6-7 -78	3.68	.59	.14	.72	.13
8-31-78	5.28	.85	.12	1.13	.09
Sparganium root-rhizome					
9-18-77	4.82	.77	.41	.53	.05
10-14-77	4.84	.78	.27	.63	.05
11-11-77	3.64	.58	.16	.84	.08
4-22-78	6.50	1.04	.24	.66	.06
6-7 -78	5.94	.95	.21	.49	.08
8-31-78	5.16	.83	.13	.58	.04
Scirpus root-rhizome					
9-18-77	5.79	.93	.39	.30	.04
10-14-77	3.64	.58	.26	.18	.02
11-11-77	3.16	.51	.25	.23	.02
4-22-78	4.72	.76	.28	.30	.02
6-7 -78	2.86	.46	.28	.25	.06
8-31-78	3.80	.61	.16	.25	.02

Fig. 4 Percentage of remaining N in shoot and root-rhizome litter, September 18,1977 to August 31,1978. ● Typha , ■ Sparganium , ▲ Scirpus.



Sparganium had the highest remaining N per cent (45.1%),Scirpus was a little lower(38.8%),and Typha was the lowest(29.7%).

In the laboratory experiments, N levels differed significantly ($P < .01$) both between types of water and temperatures. Nitrogen decreased in all treatments in the first month,then it incresed in the second month in all treatments except artificial water at 18° C. During the last three months remaining N in litter was relatively stable in all treatments(Fig.2b). At 184 days the percentages by dry weight of N in litter of all treatments(0.95—1.06%)were about the same level as initial content(1.1%).

Nitrogen determinations in the antibiotic experiment yielded relatively stable results with N levels at 0.75 and 0.73% dry weight at 15 and 30 days. After the first month nitrogen increased and at 120 days N level was 1.24%(135% of initial content). Nitrogen in the control increased from the 15th to 60th day,then declined to 71.9% of original value at 120 days.

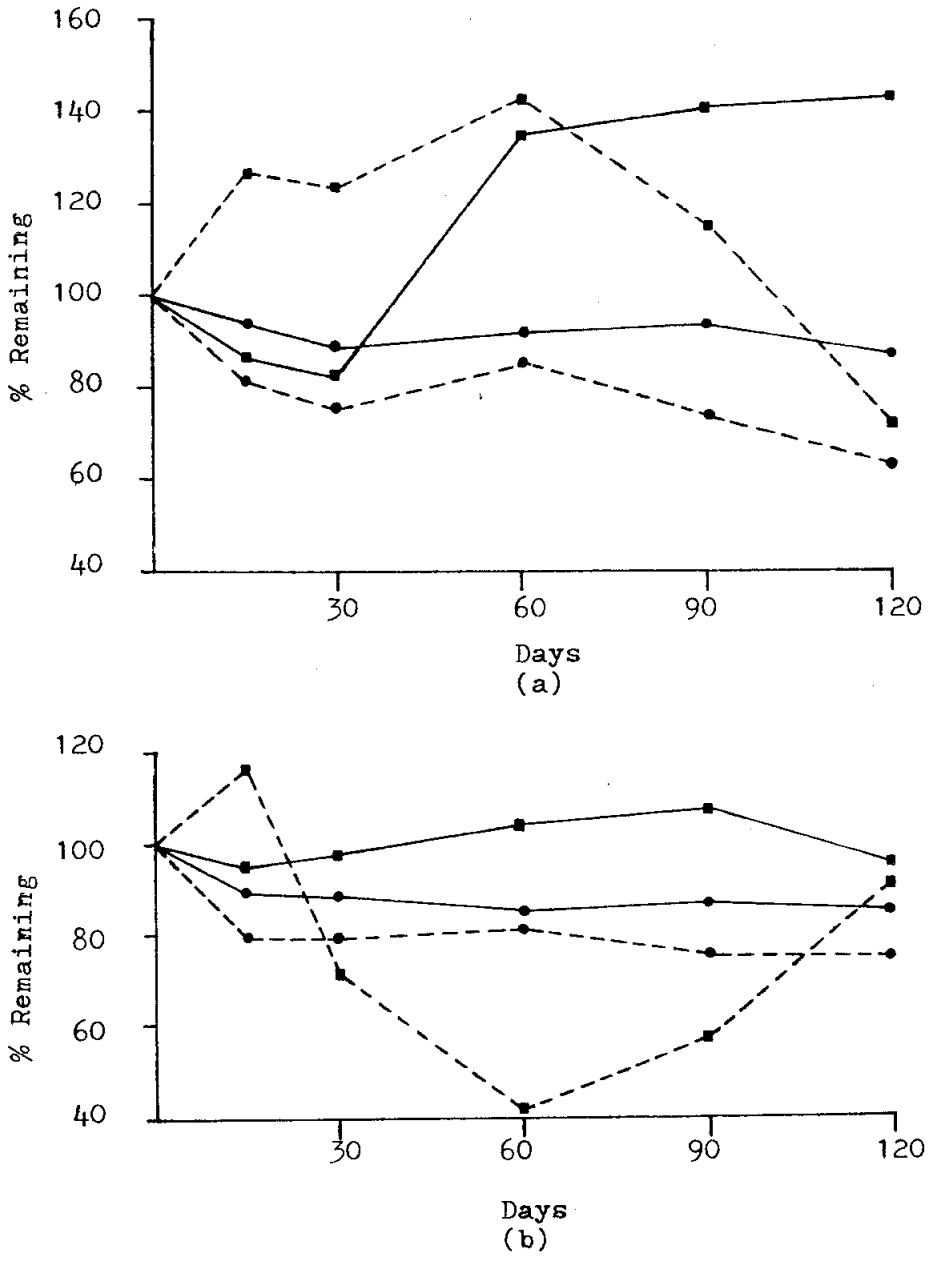
The nitrogen content in sterilized Typha litter was relatively stable throughout 120 days(0.71 - 0.88% dry weight). In contrast the control showed increases at 15 and 120 days;the lowest value,0.39% of dry weight,occurred at 60 days. Losses of 0.33 and 0.05% dry weight of C and N respectively were found after sterilization.

Computation of protein content was based upon total nitrogen, thus the patterns of litter protein were similar to those of nitrogen. In the marsh the litter of all three species was rich in protein in summer,apparently a result of accumulation of N in microbial biomass.

Phosphorus

The initial P contents of Typha,Sparganium,and Scirpus shoots

Fig.5 Typha shoot litter, percentage of remaining carbon and nitrogen. (a) antibiotic experiment, (b) sterilization experiment, carbon, nitrogen, --- control ,—treated (antibiotic, sterilization).



were 0.19, 0.19,and0.09% respectively. Phosphorus declined sharply in the first month of decomposition in all species(Fig.6). Loss rates slowed down in November. Scirpus shoot litter exhibited P increases in April and June. At 348 days the P contents of Typha,Sparganium, and Scirpus were 0.12,0.16,0.09% dry weight(28.9,22.6,53.8% remaining) respectively. Initial P concentrations of the root-rhizome were much higher than those of the shoots,especially in Sparganium(0.43%) and Scirpus(0.39%). Typha root-rhizomes had initial P content of 0.30%, which then declined throughout the experiment. Phosphorus increases (as % of remaining litter)was observed in Sparganium in April.

In the laboratory at 30 days rapid early leaching of P was evident in all treatments(Fig.7). The losses ranged from 75.9% of original content in distilled water at 18 °C to 70.3% in both artificial and distilled water at 10 °C. Temperature tended to influence this early leaching. At 63 days P content had decreased further in all treatments,except a slight increase in artificial water at 10 °C. There were slight increases in the third , fourth,and fifth months, and by 184 days the remaining P ranged from 22.6-33.7% of the original.

Calcium

Initial percentages by dry weight of Ca present in the shoots were 1.36,1.00,and 0.57(Sparganium > Typha > Scirpus). A considerable portion of the calcium(of all species)was leached in the first month (Fig.8). Calcium in Typha shoots continued to decrease in November and varied between 0.73-0.74% dry weight(34.8-54.0% remaining)durirg the rest of study. Small fluctuations were observed in the Sparganium and Scirpus shoot litter during October-August,with the ranges of 0.61 -0.76%(22.7-38.0% remaining) and 0.35-0.50%(44.5-51 .5%remaining) respe-

Fig. 6 Percentage of remaining P in shoot (a), and root-rhizome (b) litter, September 18,1977 - August 31,1978. ● Typha, ■ Sparganium, ▲ Scirpus.