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ATHELIA EPIPHYLLA ASSOCIATED WITH COLONIZATION OF SUBALPINE FIR FOLIAGE UNDER PSYCHROPHILIC CONDITIONS

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This paper documents the occurrence, association, and apparent effects of *Athelia epiphylla* Pers. on postharvest conifer residue under psychrophilic conditions in a northern Rocky Mountain coniferous forest. In the spring following a variety of autumn, 1974, harvesting practices on selected sites in Montana, intense and widespread fungal activity was noted in close proximity to or under "rotten" snow pack. The conditions afforded an immediate opportunity to assess some effects of psychrophilic microorganism activity on small-dimension materials (leaves, twigs, etc.).

Heretofore, most investigations on psychrophilic activities have dealt with total microorganism/environmental effects on substrates. There are numerous reports on the degradation or loss of plant litter, but few have attempted to assess the importance of decomposition under psychrophilic conditions. Bleak (1970) attributed the loss of biomass of grasses and forbs while under snow principally to bacterial and fungal activity, but also implicated leaching. Dry weight losses were from 28–49% during the cold season. Lousier and Parkinson (1976) reported a leaf litter dry weight loss of 26% after 12 mo, with maximum losses occurring during colder periods.

Stokes and Redmond (1966) indicated that the occurrence of psychrophilic bacteria and fungi is widespread and extremely frequent in the environment. Thus, they attribute considerable significance to these organisms as agents of biomass recycling. Furthermore,

the ability of nonobligate psychrophiles to grow at moderate as well as at low temperatures is a proviso for a wide latitude of function and activity.

One of the more important implications of litter decomposition by bacteria and fungi is the formation of considerable microbial biomass with concomitant immobilization of nutrients and their subsequent slow release (Visser and Parkinson, **1974;** Bollen, **1969;** Curlin, **1970;** Ausmus and Witkamp, **1974).** Stark **(1972, 1973)** and Todd et al. **(1973)** analyzed the nutrient content of fungal hyphae and provided substantive evidence for the role of filamentous fungi as primary nutrient recycling agents in forested ecosystems.

The detection of filamentous fungi under psychrophilic conditions is limited to a few reports (Cooke, **1944, 1955;** Miller, **1965, 1967).** Gilbertson **(1973)** provided descriptions of seven corticioid fungi that are associated with snow banks in Arizona.

Study Site Characterization.—The investigated area is within the Coram Experimental Forest, Flathead County, located between Flathead Lake and Glacier National Park, in northwestern Montana. The timber type is principally Douglas-fir/larch (ABLA/CLUN) (Pfister et al., **1977).** Elevations range from 1018–1942 m above sea level. Mean annual precipitation at lower elevations averages 78.7 cm with a mean annual temperature of 5.3 C. Mean annual summer temperature inclusive of July, August, and September averages 16.1 C (Klages et al., **1976).** When foliage and twig samples were collected in the spring, snow occurred in patches and was 30–60 cm deep.

Foliage Nutrient Analysis.—Needle samples of *Abies lasiocarpa* (Hook.) Nutt. were collected in May and June, 1975, that were visibly colonized by *A. epiphylla* (FIG. 1) or uncolonized. Several thousand such needles were collected at each of 10 random points. Analyses of various macroelements were conducted. Since we did not anticipate the opportunity to study such intense fungal activity during the winter, a pre-winter sample was not made. Therefore, data for initial macroelement content are not available. Total nitrogen was determined by the micro-Kjeldahl method (Bremner, **1965)** of foliage dried at 60 C and ground in a Wiley Mill to pass a 40-mesh screen. Total carbon was determined by dry combustion (Allison et al., **1965);** calcium, magnesium, and potassium contents were measured by atomic absorption; ash contents were obtained by heating samples to 600 F for 6 h and measuring the ash gravimetrically.

Data on macroelement content of needles prior to overwintering

FIG. 1. Extensive colonization of leaf and twig residue by *Athelia epiphylla.* (Coram Experimental Forest, May 1975.)

were not available. It is assumed that during the winter—a period of cold temperatures and high moisture content (deep snows)—a considerable amount of the soluble portion of needle contents is leached out. It is, therefore, inappropriate to make comparisons of our data with other published reports (Daubenmire, **1953;** Stark, **1980)** where sampling methods, time of year, and other ecological parameters vary.

Statistical analyses of foliage macroelement content (TABLES I–III) in May and June reflect few significant differences between months for various nutrients in either colonized (c) or uncolonized (u) samples. These exceptions were with N [uncorrected, May (u) vs. June (u)] and K [corrected, May (c) vs. June (c)]. We note that this significance is not apparent for uncorrected values of K, indicating that there is a real reduction of this element with time. Within-month

TABLE I

NUTRIENT CONTENT IN MAY OF OVERWINTERED NEEDLES OF SUBALPINE FIR ASSOCIATED WITH *Athelia epiphylla* (CORAM EXPERIMENTAL FOREST, MONTANA, 1975)

A. epiphylla	Ca	Mg	K	P	C	N	Ash
	ppm			%			
VALUES UNCORRECTED FOR WEIGHT LOSS OF ORIGINAL FOLIAGE[a]							
Present	20,390	1,005	2,780*[b]	0.11	42.5	1.4*	7.9*
Absent	15,400	1,090	5,750*	0.14	44.9	1.2*	6.4*
VALUES CORRECTED FOR WEIGHT LOSS OF ORIGINAL FOLIAGE							
Present	16,200	710*	1,975*	0.09*	34.7*	1.2	6.3
Absent	15,400	1,090*	5,750*	0.14*	44.9*	1.2	6.4

[a] All values expressed on an ovendry weight basis.
[b] Significant difference exists between pairs of values. See TABLE III.

comparisons of K indicate that during May and June considerable movement of K had occurred. Uncorrected values for Ca [June (u) vs. June (c)] were highly significant but less so for corrected values. The values for Ca of uncolonized foliage were lower than those of colonized foliage. Curlin **(1970)** ascribes the persistence (and perhaps accumulation) of Ca to the formation of oxalate or carbonate. Magnesium values became significant only when adjusted for weight loss of original foliage within months. The data on P, Mg, and particularly K indicate, generally, that prior to May and perhaps during the sampling periods there was movement of these elements from foliage tissue colonized by *A. epiphylla.*

Differences were observed for P (corrected) of colonized vs. uncolonized foliage within months. Differences between months were not observed, again indicating that much of the combined effects of leaching and fungal activity had already occurred before the May sample.

TABLE II

NUTRIENT CONTENT IN JUNE OF OVERWINTERED NEEDLES OF SUBALPINE FIR ASSOCIATED WITH *Athelia epiphylla* (CORAM EXPERIMENTAL FOREST, MONTANA, 1975)

A. epiphylla	Ca	Mg	K	P	C	N	Ash
	ppm			%			
VALUES UNCORRECTED FOR WEIGHT LOSS OF ORIGINAL FOLIAGE[a]							
Present	20,170*[b]	930	3,280*	0.12*	36.7	1.4*	7.4*
Absent	11,400*	990	5,400*	.14*	43.3	1.2*	5.7*
VALUES CORRECTED FOR WEIGHT LOSS OF ORIGINAL FOLIAGE							
Present	17,700*	825*	2,900*	.03*	31.3*	1.2	6.6
Absent	11,000*	1,030*	5,675*	.14*	43.3*	1.2	5.6

[a] All values expressed on an ovendry weight basis.
[b] Significant difference exists between pairs of values. See TABLE III.

TABLE III

SIGNIFICANCE MATRIX FOR MAJOR MACROELEMENTS OF *Athelia epiphylla* COLONIZED (C) AND UNCOLONIZED (u) FOLIAGE (CORAM EXPERIMENTAL FOREST, MONTANA, MAY–JUNE 1975)

Treatment comparisons	Ca	Mg	K	P	C	N	Ash
VALUES UNCORRECTED FOR WEIGHT LOSS OF ORIGINAL FOLIAGE							
May (u) *vs* May (c)	ns[a]	ns	$p = 0.01$	ns	$p = 0.05$	$p = 0.02$	$p = 0.01$
May (u) *vs* June (u)	ns	ns	ns	ns	ns	$p = 0.02$	ns
June (u) *vs* June (c)	$p = 0.001$	ns	$p = 0.001$	$p = 0.05$	$p = 0.05$	$p = 0.02$	$p = 0.01$
May (c) *vs* June (c)	ns	ns	ns	ns	ns	ns	ns
VALUES CORRECTED FOR WEIGHT LOSS OF ORIGINAL FOLIAGE							
May (u) *vs* May (c)	ns	$p = 0.02$	$p < 0.001$	$p = 0.001$	ns	ns	ns
May (u) *vs* June (u)	ns	ns	ns	ns	ns	ns	ns
June (u) *vs* June (c)	$p = 0.05$	$p = 0.02$	$p < 0.001$	$p = 0.01$	$p = 0.01$	ns	ns
May (c) *vs* June (c)	ns	ns	$p = 0.05$	ns	ns	ns	ns

[a]Not significant $p > 0.05$.

Nitrogen differences were detected for uncorrected values. When these values were corrected to the original foliage weight basis, they became insignificant. In view of the large quantities of fungal biomass produced, we presume that appreciable quantities of N-containing fungal biomass were present in foliage tissue and that N was not translocated away from these tissues. Witkamp and Frank **(1964)** have also associated the occurrence of noticeable fungal activity on litter with immobilization of litter nutrients. Curlin **(1970)** indicates that slow N release is a function of complexing of N with other substrates.

Within the framework of our experiment, the relative susceptibility to movement of nutrients is described as K > Mg > P > Ca > N. Mobility of nutrients was ranked by Curlin **(1970)** as K > Ca > N > P and by Parkinson and Lousier **(1974)** as K > Ca > Mg > N > P. The relative rates of nutrient release as given by Curlin **(1970)** are K > P > Ca > N, which are similar to those reflected in our data.

The phenomenon of fungal blooming under psychrophilic conditions, and associated changes in nutrient levels in conifer foliage, has some implication for forest nutrient cycling. Prescription burning is a useful tool for reducing residue volume after harvesting. Our data and field observations suggest that delaying burning of small-dimension material for at least one yr may be beneficial to nutrient cycling by providing opportunities for microbial action to effect appropriate nutrient transitions in soil, with attendant protection from leaching and volatilization. Increasing snow depth through silvicultural prescription may enhance this process. By prolonging snow pack in the spring, the time in which conditions for psychrophilic activity prevail could be extended.

Athelia epiphylla may be viewed as a primary nutrient recycling agent, an ecological role that has not been ascribed to this species before. In addition to noting the "fungal bloom" associated with *A. epiphylla*, we have also made observations on similar but more limited phenomena associated with *Byssomerulius hirtellus* (Burt) Parm. and *Corticium lepidum* (Rom.) Bourd. & Galz. These observations, plus those of temperature regimes associated with mycorrhizal fungal activity and interior temperatures of decaying logs (unpublished data), indicate that much microbiological activity in this region is, in large part, psychrophilic or near psychrophilic.

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