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)REST CANOPY ARTHROPODS AS SODIUM, POTASSIUM, ۱GNESIUM AND CALCIUM POOLS IN FORESTS

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STRACT

owalter, T.D. and Crossley, D.A., Jr., 1983. Forest canopy arthropods as sodium, ɔotassium, magnesium and calcium pools in forests. *For. Ecol. Manage.*, 7: 143—148.

Ne measured concentrations of sodium, potassium, magnesium, and calcium in forest opy arthropod functional groups collected from vegetation of clearcut and uncut hard- ɔd forests at Coweeta Hydrologic Laboratory, North Carolina during 1977 and 1978. ıctional groups differed significantly in concentrations of the four elements. Spiders had significantly highest sodium concentrations, followed in decreasing order by some ər predators and then herbivores. Caterpillars and sawfly larvae had the significantly ıest potassium and magnesium concentrations and high calcium concentration. De- vores had the significantly highest calcium concentrations. Our data indicate that rients contained in nominal biomass of canopy arthropods do not contribute signif- ıtly to litter nutrient pools.

'RODUCTION

'orest canopy arthropod populations have long been known to be dis- tive to certain forest management goals, e.g., fiber and timber produc- 1. More recent studies have suggested that forest arthropods could also ılate nutrient cycling rates and thereby stimulate forest productivity ;., Mattson and Addy, 1975; Crossley, 1977; Wickman, 1978, 1980; e and Amman, 1980; Zlotin and Khodashova, 1980; Schowalter, 1981). əse effects would contribute to forest management goals, especially ı, wildlife and livestock production. Because forests are often managed multiple uses, including fiber and timber production, recreation, range, ɹershed, and fish and wildlife, more information is needed on the poorly ɔwn effects of forest arthropods on forest nutrient cycling processes hese affect forest attributes valued for multiple uses.

Canopy arthropods could affect forest nutrient cycling processes through ɛcts on nutrient uptake by vegetation, nutrient transfer to litter, and rient mineralization from litter (see Schowalter, 1981; Schowalter al., 1981; Swank et al., 1981). One potentially important arthropod ɛct is the concentration of nutrients in arthropod tissues added to the ɜst floor (Reichle et al., 1973; Schowalter et al., 1981; Seastedt and e, 1981). Certain forest floor arthropod species have been shown to centrate major cations in body tissues (Reichle et al., 1969; Gist and ssley, 1975); changes in abundance of these species could significant-nfluence litter standing crops of major cations, especially calcium (Gist Crossley, 1975; Seastedt and Tate, 1981). Similarly, changes in the n and concentration of litterfall nutrients as a result of changes in the ndance of particular canopy arthropod species could influence litter cessing and nutrient retention by forest floor arthropods (Seastedt and e, 1981).

'he canopy arthropod community includes many species which peri-ɔally escape population control by climate, host suitability and/or pred-rs, and which could represent nutrient pools ultimately added to forest ɔr nutrient pools (Schowalter et al., 1981; Seastedt and Tate, 1981). ɑough trophic level differences in major cation concentrations have viously been reported for forest canopy arthropods (Reichle and Cross- 1969; Schowalter et al., 1981), trophic level resolution could mask entially important accumulation of major cations by specific arthropod ɔies within trophic levels. Changes in population size of such species ld have important consequences for the rate and distribution of nutri- transfer from the forest canopy to the forest floor, hence for forest ductivity.

)ur purposes in this paper were to examine differences in major cation centrations among canopy arthropod functional groups and to con-ɪr the importance of canopy arthropods as sources of litter nutrients. do this, we compared major cation concentrations between arthropod ɹps collected from vegetation on a clearcut, naturally-regenerating ɪershed and on an undisturbed watershed in North Carolina and related ɜe data to annual inputs of major cations to litter.

ΓERIALS AND METHODS

Ve collected canopy arthropods from a clearcut watershed and an un-urbed watershed at the Coweeta Hydrologic Laboratory, operated the U.S. Forest Service, about 25 km south of Franklin, North Carolina ɪg methods described by Schowalter et al. (1981). Arthropods were ɪd at 45°C to constant weight. Canopy arthropod biomass was low 0.001 g arthropod/g foliage) and accounted for less than 5% foliage ɔoval. Because of the few individuals per species and small individual weights, we could not attempt measurements of nutrient content in ɪvidual species but chose instead to combine species into functional ɔups (Crossley et al., 1976) for nutrient analysis. Functional groups semble the guilds of Root (1967), i.e., a group of species using a simr resource in a similar manner, and were defined by a combination of aracteristics, including trophic level, feeding mechanism, growth rate d capacity for movement between trees.

Functional group samples were ashed by slowly increasing furnace temrature from 250°C to 475°C and leaving them for 4 h. Since all saməs could not be ashed simultaneously, blanks and standards were ashed th each block of samples. Cooled samples were dissolved in 5 ml conntrated nitric acid and dried over low heat, followed by a second ashing nducted as described above. After adding 5 ml concentrated nitric acid the twice-ashed samples and warming them for 2 h, we added 5 ml 30% drogen peroxide slowly to each sample. Final dilution was made with ionized water.

Major cation concentrations were measured on a Perkin-Elmer Model '3 atomic absorption spectrophotometer. Addition of 1000 ppm lananum chloride to aliquots of each sample prevented chemical interference reading concentrations of calcium and magnesium; 1000 ppm sodium loride were added to fresh aliquots for potassium measurements. No lditives were used to measure sodium concentrations. Readings were corcted as indicated by measurements of cation concentrations in blanks and andards.

ESULTS AND DISCUSSION

Table I presents concentrations of sodium (Na), potassium (K), magsium (Mg), and calcium (Ca) in individual canopy arthropod functional ɔups pooled for watersheds and years. Since concentrations of all four əments were distributed non-normally, tests of differences between funcɔnal groups were performed on log-transformed data which were norally distributed.

Concentrations of all four major cations differed significantly between thropod functional groups, probably reflecting differences in nutrient quirements. In general, predators had higher Na concentrations but lower , Mg, and Ca concentrations than did herbivores. Trophic level differces in nutrient concentration have been reported previously for forest nopy arthropods (Reichle and Crossley, 1969; Schowalter et al., 1981). ɔwever, trophic level differences can be seen to reflect the contributions specific functional groups which had particularly high concentrations one or more nutrients (Table I). Spiders had the significantly highest ı content and also had relatively high concentrations of the other eleents. Caterpillars and sawfly larvae had the significantly highest conntrations of K and Mg and had high Ca concentrations. Orthoptera also ıd high concentrations of K and Ca. These arthropod groups tend to ɔminate mature forest canopy arthropod communities in terms of bio-

Nutrient concentrations, $\bar{x}$ (S.D.), and analysis of variance of log-transformed nutrient concentrations in forest canopy arthropod functional groups, pooled over watersheds and years

Functional Group	N^a	Na (μg/g)	K (μg/g)	Mg (μg/g)	Ca (μg/g)
Defoliators					
Caterpillars and sawfly larvae	13	3 500 (2 100) c	49 000 (19 000) a	3 200 (1 300) a	5 700 (7 200) a, b
Orthoptera	7	2 900 (1 400) c	27 000 (8 000) b	1 400 (340) b, c	2 900 (1 400) b
Beetles	11	3 400 (770) c	11 000 (4 200) c, d	2 200 (760) b	1 100 (330) c
Leaf-miners	1	3 100 c	9 600 c, d	1 600 b	1 600 b, c
Siphon-feeders					
Aphids	12	4 600 (2 000) b, c	15 000 (12 000) c, d	2 100 (520) b	1 500 (2 500) c
Leafhoppers, etc.	19	3 200 (950) c	12 000 (4 300) c, d	2 100 (690) b	1 300 (570) c
Other herbivores					
Adult Lepidoptera	4	4 500 (2 600) b, c	12 000 (5 500) c, d	1 700 (620) b	990 (440) c
Flower-feeders	3	3 400 (220) c	11 000 (6 300) c, d	1 400 (150) b, c	920 (120) c
Bark beetles	5	3 800 (1 500) c	9 200 (4 700) c, d	2 000 (740) b	930 (300) c
Fungus-feeders	1	3 000 c	12 000 c, d	1 400 b, c	1 100 c
Detritivores	3	3 900 (1 900) c	10 000 (6 100) c, d	1 000 (950) c	66 000 (110 000) a
Omnivores					
Ants	9	5 100 (1 300) b, c	9 200 (4 100) c, d	1 500 (230) b, c	2 400 (840) b, c
Predators					
Spiders	9	8 100 (2 600) a	15 000 (7 200) c	2 000 (510) b	1 800 (520) b, c
Beetles	4	3 800 (1 200) b, c	6 700 (1 200) c, d	1 300 (230) b, c	1 100 (290) c
Assassin bugs	4	5 300 (1 800) a, b, c	9 500 (6 100) c, d	1 700 (700) b, c	1 700 (800) b, c
Neuroptera	2	4 400 (1 200) b, c	2 900 (890) d	1 500 (670) b, c	1 200 (480) c
Flies and wasps	3	3 700 (1 600) c	7 600 (3 000) c, d	1 400 (570) b, c	640 (260) c
Parasitoid wasps	3	3 100 (810) c	4 200 (3 200) d	1 200 (100) b, c	1 400 (920) b, c
Phalangida	1	5 600 a, b, c	15 000 b, c	1 600 b, c	2 500 b, c
Aquatic insect adults	2	7 800 (2 600) a, b	11 000 (1 800) c, d	2 800 (1 600) a, b	7 100 (7 100) a, b
Source	D.f.	Mean squares			
Model	19	0.509*	2.167*	0.575*	1.962*
Error	96	0.138	0.256	0.145	0.469

*$P < 0.0001$

[a] N = sample size.

Means in columns followed by the same letter do not differ at the $P = 0.05$ level by Duncan's multiple range test.

BLE II

mental standing crops in living canopy arthropods and in litter and annual elemental uts to litter in mature hardwood forests at Coweeta Hydrologic Laboratory, North rolina

urce	Element (kg/ha)		
	Ca	K	Mg
cipitation and throughfall[a]	8.1	30.5	3.1
nual litterfall[a]	44.5	18.1	6.6
ter biomass[b]	112	24.7	—
thropod biomass[c]	0.01	0.04	0.001

ata from Seastedt and Crossley (1980).
ata from Seastedt and Tate (1981).
ata from Schowalter et al. (1981).

iss. Detritivores had the significantly highest Ca concentrations but are presented in the canopy by small biomass. Terrestrial adult stream in- cts had high concentrations of Na, Mg and Ca but are also represented the canopy by small biomass (Reichle et al., 1973; Crossley et al., 1976; howalter et al., 1981).

Because caterpillars and sawfly larvae, Orthoptera, and spiders typical- dominate canopy arthropod communities in mature hardwood forest osystems and were found to have the significantly highest concentra- ons of Na, K, Mg and Ca, large populations of these arthropods could repre- it important sources of litter nutrients. Table II summarizes major cation nding crops in living canopy arthropods (Schowalter et al., 1981) and ter (Seastedt and Tate, 1981) relative to annual input of nutrients to ter (Seastedt and Crossley, 1980) in mature hardwood forests at Co- eta. Comparable data for Na dynamics are not available. A compilation data reported by Henderson et al. (1978), Whittaker et al. (1979) and astedt and Crossley (1981) indicates that annual input of Na to litter less than 5 kg/ha, compared to 0.04 kg/ha in canopy arthropod biomass chowalter et al., 1981). These data indicate that elemental standing ops in living canopy arthropod biomass are normally small relative to ier sources of litter nutrients.

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