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Litterfall Deposition in Subtropical Woodlands, Northeastern Mexico

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Abstract

Litterfall is one of the fundamental processes of nutrient cycling in forest ecosystems. In northeastern Mexico, the main type of vegetation, known as the Tamaulipan thornscrub, is composed of diverse, dense and spiny shrubs and trees which are distinguished by a wide range of taxonomic groups exhibiting differences in growth, leaf life spans, growth dynamics, and phenological development. During one year (November 2004 to October 2005) the monthly pattern of litterfall and their respective components, in the subtropical thornscrub woodlands, northeastern Mexico, were quantified at three sites (Los Ramones, China and Linares counties, in Nuevo Leon state of Mexico). Total litterfall ranged from 4,619 to 7,171 kg•ha^{-1}. Leaves represented the main component with a deposition that ranged from 3,100 to 4,715 kg•ha^{-1}. Branches deposition ranged from 545 to 1,546 kg•ha^{-1}, and reproductive structures (flowers, fruits and seeds) deposition varied from 382 to 545 kg•ha^{-1}. The contribution of other litterfall components such as bark and insect feces ranged between 270 and 820 kg•ha^{-1}. Differences in spatial and temporal litterfall deposition among sites are related to plant phenology, community plant structure and environmental variables such as extreme temperatures and heavy rainfall events.

2 Background and Aim of the Study

Litterfall and litter decomposition are key fundamental processes in nutrient cycling of forest ecosystems (PAUSAS, 1997; BAKER III *ET AL.*, 2001). In addition to this processes, throughfall and stemflow are the main sources to maintain soil fertility to the forest floor (SILVA AND GONZÁLEZ, 2001; VASCONCELOS AND LUIZÂO, 2004). Despite of the great number and well documented floristic studies carried out at the Tamaulipan thornscrub or subtropical thornscrub woodlands, northeastern Mexico, there are not investigations that have addressed the spatial and temporal patterns of litterfall deposition, in spite of the importance of this process for

nutrient cycling in this type of vegetation which is distinguished and dominated by a wide range of taxonomic groups exhibiting differences in growth patterns, leaf life spans, textures, growth dynamics, and phenological development (REID *ET AL*., 1990). This is of key importance in forest communities where sustainable litterfall production is an essential part of the aboveground net primary production and depends upon the nutritional status of soil, such as those found in the northeastern region of Mexico, whose vegetation depends on the biogeochemical cycles of plant nutrients contained in plant detritus (VASCONCELOS AND LUIZÂO, 2004). Therefore, this region provides an opportunity to investigate litterfall production of native vegetation in order to gain a better understanding of how to sustain and improve productivity in response to changes in resource availability. Thus, the aim of this study was to assess the spatial and monthly pattern of litterfall throughout an annual cycle and to characterize and quantify the seasonal constituents of the litterfall production in three representative sites of the subtropical thornscrub woodlands, northeastern Mexico.

3 Methods

3.1 Study Site

The study was carried out at three research sites: Los Ramones county (24º47´NL, 99º32´WL), China county (25º40´NL, 99º27´WL), and Linares county (25º31´NL, 99º17´WL). These sites are located in the state of Nuevo Leon, Mexico and representative of the main type of vegetation known as the Tamaulipan thornscrub, northeastern Mexico (SPP–INEGI, 1986). The dominant soils are deep, dark-gray, lime-gray, lime-clay vertisols, with montmorillonite, which shrink and swell noticeably in response to changes in soil moisture content. For the three sites, in general, the climate is typically subtropical and semi-arid with a warm summer. Mean monthly air temperature ranges from 14.7^{o}C in January to 22.3^{o}C in August, although daily low and high temperatures of -2^{o}C and 45^{o}C, respectively, are common during the winter and summer, respectively. Average annual precipitation is 805 mm with a bimodal distribution. Peak rainfall months are May, June and September.

3.2 Litter Sampling Frequency and Deposition

At each site, litterfall deposition was evaluated in an undisturbed thornscrub experimental plot (20 m x 20 m). At each plot, seven (replications) litter traps were scattered over the entire area. Each trap covered an area of 0.16 m^2 (0.40 m x 0.40 m) and was placed approximately 0.30 m above the soil level to intercept litterfall. Contents of traps were collected at approximately 30 day intervals between November 18, 2004 and October 17, 2005. At each sampling date, research site and trap, the collected litter was sorted into the following categories: leaves, twigs or branches (<2 cm in diameter), and others (unidentified, fine plant residues such as bark, pieces of insect bodies or feces). The samples were then dried to a constant weight at 65^{o}C for 72h and weighed to the nearest milligram. Litter deposition is reported on a monthly (kg•ha^{-1}) or annual (kg•ha^{-1}•year^{-1}) basis.

3.3 Statistical Analyses

To detect significant differences among sites in litter deposition, a one-way analysis of variance design was used at each sampling date. Separate analyses were made for each of the main constituents of the litterfall and for the total annual litter deposition. Differences were validated using the Tukey's honestly significant difference (HSD) test and were considered statistically significant at P=0.05 (STEEL AND TORRIE, 1980). Assumptions of normality for litter deposition at a given sampling date were tested using the Kolmogorov-Smirnov test (STEEL AND TORRIE, 1980). All applied statistical methods were according to the SPSS (Statistical

Package for the Social Sciences) software package (standard released version 9.0 for Windows, SPSS Inc., Chicago, IL).

4 Results

4.1 Litter Production

There were significant differences among sites in the deposition of leaves and branches only in three (Jan-17-05, Feb-16-05 and Mar-17-05) and one (Feb-16-05). Likewise, significant differences among research sites in four sampling dates (Jan-17-05, Feb-16-05, Mar-17-05, and Oct-17-05) were also detected (Table 1). The deposition of reproductive structures and other constituents of litterfall did not differ significantly among research sites during the experimental period. On a monthly litterfall deposition basis, Figure 1 shows the seasonal variation of litterfall deposition. On Jan-17-05, minimum (350 kg•ha^{-1}) and maximum (1,787 kg•ha^{-1}) deposition values were detected for Los Ramones and Linares sites. The increase in litterfall on this sampling date, might be associated to freezing temperatures (-2.0^{o}C) registered in Linares county site on December 24, 2005, as a result of a stationary cold weather front, which could caused leaf death and consequently abscission. Moreover, in this date, leaves contributed to about 82% of the total litterfall deposition. Conversely, higher (P<0.05) litterfall deposition detected in China county with respect to Los Ramones and Linares county for the sampling dates of Feb-16-05 and Mar-17-05 may be related to the shedding of plant structures as an important ecological process in subtropical woodlands which reduce surface area for transpiration (STROJAN *ET AL*., 1979) or to trigger vegetative or reproductive buds during the spring season. In addition, results are also related to the low contribution of leaf tissue in the plant community of Linares due to the frost registered in December, which might have caused leaf and plant tissue death and consequently, a lag time in leaf production.

Table 1: *F* and *P* values from one-way ANOVA to detect significant differences among research sites on the quantity of main constituents of the litterfall deposition at different sampling dates. Statistically significant probabilities (P≤0.05) are shown in boldface.

	Litter Constituent									
Sampling Date	Leaves		Reproductive Structures		Branches		Others		Total	
	F	*P*	*F*	*P*	*F*	*P*	*F*	*P*	*F*	*P*
Nov-18-04	0.67	0.52	0.36	0.70	0.15	0.86	2.64	0.10	0.84	0.45
Dec-15-04	0.87	0.44	0.56	0.58	0.09	0.91	0.70	0.51	0.20	0.82
Jan-17-05	8.03	**0.004****	0.68	0.52	0.98	0.39	0.45	0.64	7.28	**0.005****
Feb-16-05	7.20	**0.005****	1.63	0.22	5.33	**0.02***	0.34	0.72	7.96	**0.004****
Mar-17-05	4.00	**0.04***	0.73	0.50	1.35	0.28	0.44	0.65	5.21	**0.02***
Apr-18-05	2.22	0.14	0.10	0.90	1.17	0.33	0.87	0.43	1.90	0.18
May-18-05	1.37	0.28	0.53	0.60	0.60	0.56	0.76	0.48	1.02	0.38
Jun-20-05	2.10	0.15	0.40	0.68	0.90	0.42	1.69	0.21	1.36	0.28
Jul-19-05	2.48	0.11	3.02	0.07	1.48	0.25	1.45	0.26	2.32	0.13
Aug-17-05	1.38	0.28	0.67	0.52	2.92	0.08	3.33	0.06	1.81	0.19
Sep-21-05	2.64	0.10	0.57	0.57	0.37	0.69	2.35	0.12	2.96	0.08
Oct-17-05	3.05	0.07	0.41	0.67	0.56	0.58	3.36	0.06	3.72	**0.05***
Annual	3.50	**0.05***	0.33	0.72	3.22	0.06	3.17	0.07	4.75	**0.02***

**Significant at P≤0.01; *Significant at P≤0.05.

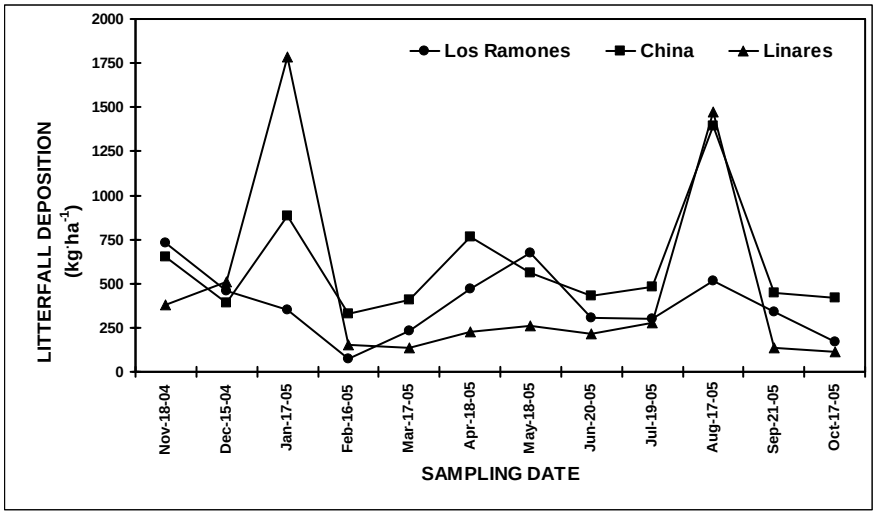

Figure 1. Seasonal variation of litterfall deposition at three research sites, northeastern Mexico.

Although no significant differences in litterfall deposition was detected on Aug-17-05 among sites (Figure 1), the trend to rose an increase in Linares and China sites may be related to the strong winds effects of the Hurricane Emily occurred in this region on July 20, 2005. Branches represented the main constituent of litterfall on this sampling date and its contribution was 59%, 39% and 6% of the total litterfall deposition observed in Linares, China and Los Ramones, respectively.

On an annual basis, total litter deposition during the experimental period (November 2004 to October 2005) at Los Ramones, China and Linares was 4,619, 7,171, and 5,670 $kg \cdot ha^{-1} \cdot year^{-1}$, respectively. Leaves represented the main component with a deposition that ranged from 62 to 67% of total annual litter production. Branches at Los Ramones, China and Linares was 12, 17 and 27%, respectively, of total annual litter production. Reproductive structures (flowers, fruits and seeds), deposition ranged from 6 (China and Linares) to 12% (Los Ramones) of total annual litter production.

At Los Ramones, litterfall annual distribution showed a constant monthly deposition of about 400 $kg \cdot ha^{-1}$ without significant peaks. At China, three main deposition peaks were identified: winter, spring and summer. These peaks contributed to 42% of total annual litterfall deposition. In contrast at Linares, two significant deposition peaks were detected. One corresponds to winter and the second one to summer. These peaks represented 57% of total annual litterfall deposition (Figure 2).

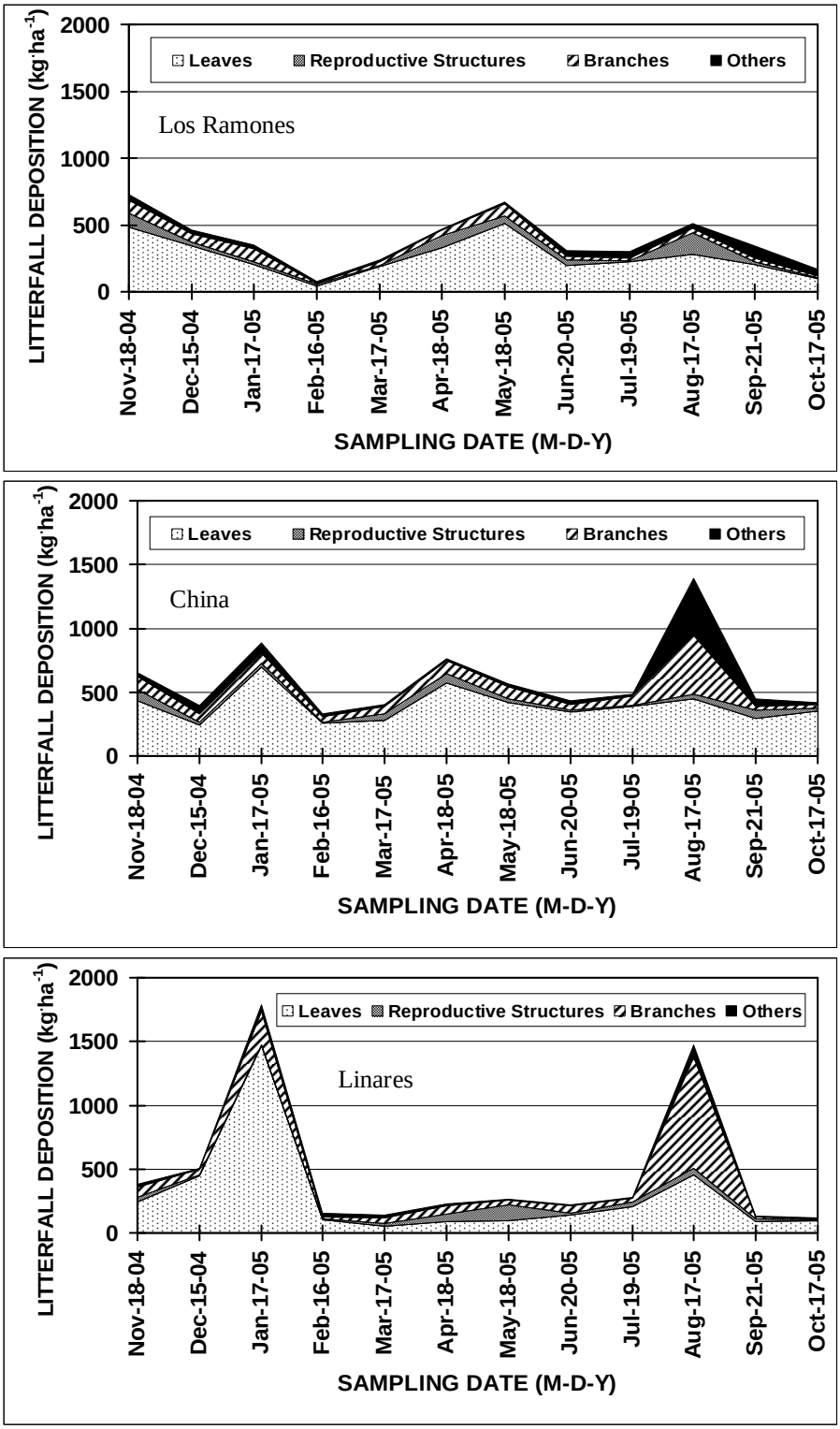

Figure 2. Seasonal contribution of litterfall constituents at three research sites, northeastern Mexico.

5 Conclusions and Recommendations

Total annual litterfall deposition at Los Ramones, China and Linares was 4,619, 7,171, and 5,670 $kg \cdot ha^{-1} \cdot year^{-1}$, respectively.
Leaves represented the main component with a deposition that ranged from 3,100 to 4,715 $kg \cdot ha^{-1}$. Branches deposition ranged from 545 to 1,546 $kg \cdot ha^{-1}$, and reproductive structures (flowers, fruits and seeds) deposition varied from 382 to 545 $kg \cdot ha^{-1}$. The contribution of other litterfall components such as bark and insect feces ranged between 270 and 820 $kg \cdot ha^{-1}$.
Climatic conditions affected the spatial and seasonal litterfall deposition.
Further studies are recommended to characterize the decomposition and nutritional dynamics of litterfall constituents in order to understand the role of biogeochemical nutrient cycling of subtropical woodlands.

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