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Litter pattern over sand dunes of Aravalli forest at Ajmer (Rajasthan)

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Abstract
The sand dunes at Ajmer (Rajasthan) selected for the investigation i.e. Pushkar valley base (dominated by *A.tortilis)*, Leela sewri (dominated by *A.sengal*) and Pachkund (dominated by *Eucalyptus camaldudensis*) are situated in 48sqkm area in the North-West foot hills of Nagpahar, a prominent mountain belt of central Aravallis. Stabilized sand dunes of Ajmer are different in respect of quantity and quality of litter production. Except for Pachkund the other two sand dunes i.e. Leela sewri and Pushkar valley base have low stature and scattered distribution of trees, therefore, production of litter in these sites is comparatively low than heavily vegetated sand dunes. Maximum litter fall takes place from March to April under each plantation. A decrease in amount of litter was observed up to August. When individual tree species are considered, *E. camaldulensis* was by far the greatest producer of litter followed by *A. tortilis* and *A.senegal*. The Pachkund area, which received comparatively very high litter, showed complete stabilization with characteristic soil conditions. While the other two sites receive very low amount of litter are comparatively less stabilized and some times a major area is converted in to active dune during the summers, such dunes are partially stabilized only during the rainy season. It may be concluded that both moisture and litter play an important role in the process of stabilization.

Keywords: Ajmer,ground litter, sand dunes

INTRODUCTION

Litter fall which is limiting in sand dunes may be an important index to soil fertility for agriculture crops and has been shown to increase seedling survival in arid environments (Evans and young, 1970). Once tree species are recruited their litter fall patterns put an impact on herbaceous vegetation structure and nutrient dynamics of the sand dune ecosystem (Sharma and Upadhyay 2002). Fowler (1988) has demonstrated negative as well as positive effects of litter on seedling growth and survival of some grasses. Therefore litter is a relevant factor to decide a 'safe-site' or 'micro site' for seed germination and establishment (Harper et al., 1961). An extensive work on litter production in forests of the world has been prepared by Bray and Gorham (1964). Plenty of literature is available on litter production in tropical forests (Singh and Joshi 1982, Proctor et al 1983, Bhat, 1990, Gupta and Rout 1992, Jena 1998, Pandit and Jena 2000). However little is known about the litter dynamics of man made forestry of arid lands. In the present investigation litter pattern over stabilized sand dunes of Aravalli forest at Ajmer were studied.

MATERIAL AND METHODS

The ground litter sampling method was followed to estimate litter production (Medwecka Kornas, 1971). For the present study repeated periodical samples of the amount of litter of various plant species was taken on the soil surface. The amount of litter production and successive addition at monthly intervals could not be estimated from 'litter trap' method, because litter traps were removed by the local people. For collection of litter, four quadrates (1x1m) were made under each tree plantation viz. *Eucalyptus camaldudensis, Acacia senegal and A.tortilis* at different sites. Litter was collected at monthly intervals and taken to the laboratory. The composite litter samples were separated in to the woody twigs and non-woody components (leaves, seeds) and a miscellaneous category, which includes buds, scales, small fragments of bark and unidentified plant debris. Each component of litter was oven dried at 80˚c for 24 hrs and the dry weight was taken to estimate the monthly variation in the amount of total litter under each plantation.

Site of Study

The area of the study is located at a distance of 10 km N-W to Ajmer, a centrally situated city of Rajasthan lies between 26˚25' and 26˚29' N latitude and 74˚37' and 74˚42' E longitude. The area is represented by Aravalli hillocks, sand dunes, sandy plains agricultural fields and fresh water bodies (Fig-1&2). The region may be regarded as 'ecotone' between NW drier and SE humid climate. The sand dunes selected for present investigation i.e. Pushkar valley Base (dominated by *A.tortilis)* , Leela sewri (dominated by *A.sengal*) and Pachkund (dominated by *Eucalyptus camaldudensis)* are situated in 48 sq.km area in the north-west foot hills of Nagpahar, a prominent mountain belt of central Aravallis. A major part of these sand dunes and sandy plains is stabilized (under the sand dune stabilization programmes by the Forest Department) with plantations of some indigenous (*Prosopis cineraria, P.chilensis*) exotic but acclimatized well (*A.sengal, Maytenus emarginata*) and exotic (*A.tortilis, E. camaldulensis*) plant species.

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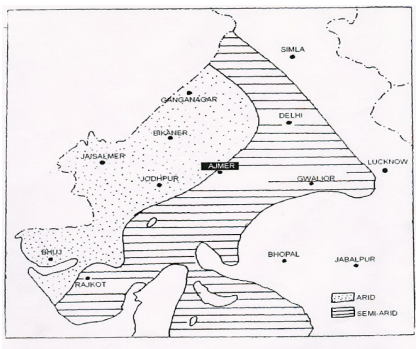

Fig.1 : North-west part of India showing arid (dotted area) and semi-arid (horizontal lined area) of Rajasthan. Ajmer is situated in the transistional zone between arid and semi-arid

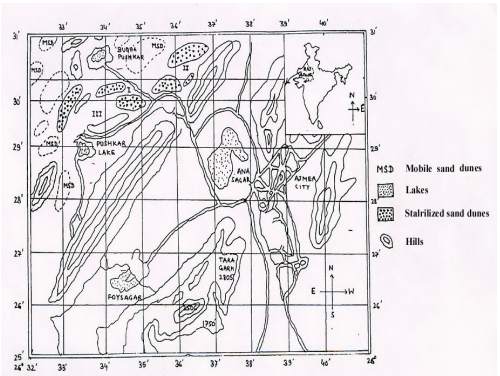

Fig. 2 : Map of Ajmer Aravalli region showing sites of study
I Leela Sewri, II Pushkar Valley Base, III Pachkund area

RESULTS AND DISCUSSION

Except for Pachkund sand dunes, the sand dunes selected for the present study (i.e. Leela sewri and Puskar valley Base) have low stature and widely scattered nature of individual plants, therefore production of litter is more difficult than heavily vegetated lands. At Pushkar Valley Base and Leela sewri sand dunes, the litter fall on the surface may be seen at the beginning of summer season. This litter consists of mostly small dead leaves and stems of woody and herbaceous plant species. Leaves and Flowers are usually small and winds readily disperse them. As a result most litter accumulates in wind protected areas around the bases of shrubs or in depressions in the soil surfaces, where overland flow of water also augments accumulation.

The total amount of various litter categories collected in each month under various tree plantations is shown in table-1 to 4 and Fig-3a. Estimated values of total litter fall show that maximum litter fall takes place from March to April under each plantation, a decrease in amount of litter was observed up to August. This amount increases in September followed by low amount in October and then increases in December. In general, optimum peak month is May for *A. senegal* and April for *A. tortilis* and *Eucalyptus camaldulensis*, while two sub optimal peaks may be observed in September and December.

Table1. Monthly litter fall (g/m2) collected under Acacia senegal trees at Leela Sewari sand dunes at Ajmer (Rajasthan)

Component	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Stem	31.52 ±5.21	13.33 ±1.71	45.64 ±3.00	56.21 ±4.10	14.02 ±1.11	35.32 ±2.00	43.57 ±4.15	07.07 ±1.23	23.53 ±3.04	22.21 ±2.21	14.20 ±1.17	22.80 ±3.15
Leaves	07.14 ±1.18	29.07 ±2.27	38.35 ±3.09	14.00 ±1.00	10.17 ±1.50	15.32 ±2.14	26.56 ±3.16	02.04 ±0.17	04.90 ±1.00	03.24 ±1.10	03.83 ±1.04	24.60 ±2.02
Seeds	00.50 ±0.10	02.63 ±1.25	02.50 ±0.85	01.00 ±0.08	09.32 ±1.15	01.50 ±0.34	02.50 ±0.52	- -	00.01 ±0.00	01.02 ±0.80	01.20 ±0.75	- -
Miscellaneous	16.20 ±1.15	13.78 ±2.14	34.20 ±5.00	35.05 ±2.18	13.57 ±2.01	04.00 ±1.02	09.20 ±1.15	01.40 ±0.80	12.58 ±2.20	02.26 ±1.00	01.50 ±0.05	03.78 ±1.05
TOTAL	55.36	58.81	120.69	106.25	47.08	56.14	81.83	11.14	4.01	28.73	20.73	51.18

Table 2. Monthly litter fall (g/m2) collected under Acacia tortilis trees at Pushkar valley base at Ajmer (Rajasthan)

Component	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Stem	91.01 ±3.67	58.59 ±7.00	24.31 ±1.20	38.32 ±2.81	37.49 ±2.80	20.50 ±1.44	22.60 ±1.76	08.70 ±1.00	18.56 ±2.01	26.67 ±3.12	12.25 ±2.00	26.53 ±2.18
Leaves	09.96 ±1.77	23.02 ±4.01	13.92 ±1.02	36.20 ±3.16	22.61 ±2.16	18.55 ±0.85	21.40 ±3.50	03.20 ±1.00	09.76 ±2.10	00.70 ±0.05	20.25 ±2.00	09.06 ±1.75
Seeds	00.49 ±0.08	00.81 ±0.10	02.62 ±0.25	27.67 ±2.98	02.35 ±0.85	00.75 ±0.03	00.52 ±0.02	11.60 ±1.25	02.23 ±0.15	00.30 ±0.01	00.89 ±0.15	02.03 ±0.28
Miscellaneous	27.61 ±3.14	28.14 ±1.76	48.53 ±3.35	52.97 ±5.02	26.26 ±1.75	25.60 ±2.00	09.30 ±1.03	13.70 ±2.85	12.70 ±1.18	20.40 ±1.15	23.49 ±4.00	36.65 ±5.02
TOTAL	69.47	104.56	89.38	175.16	88.71	65.40	53.80	37.20	43.25	48.07	56.88	74.27

These patterns of total amount of litter fall were influenced by phenology of individual tree species and also by some of the eco-climatic factors such as rainfall and humidity. As observed during the present study maximum litter fall in May and April is associated with the autumn season where all the three tree species shed old foliage parts. Suboptimal peak observed in September may be due to maximum rainfall in previous month by which a part of foliage sheds due to mechanical force imposed on tree canopies. The second suboptimal peak in December occurs because of some addition of dried ground vegetation.

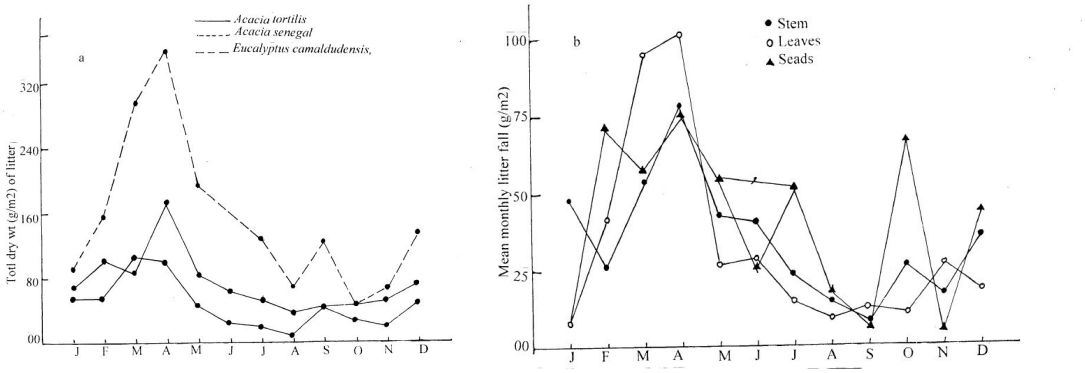

Fig 3. (a) Monthly litterfall pattern of three different species (b)Monthly litterfall pattern of three different categories of *Eucalyptus camaldudensis*

When individual tree species are considered (Table-3), *E. camaldulensis* (Fig-3a) was by far the greatest producer of litter, followed by *A.tortilis* (Fig-4a). Under *A.senegal* (Fig-4b) plantation, except for March where it is more than *A. tortilis*, minimum amount of total litter was collected in each month of the year of study. Out of the total annual litter for the three sites i.e. Pushkar valley base, Leela sewri and Pachkund, 53. 90% is contributed by *E. camaldulensis* alone, while rest of the litter is contributed by *A.tortilis* (26.29%) and *A.senegal* (19.79%) (Table-5).

Table 3. Monthly litter fall (g/m2) collected under Eucalyptus camaldulensis trees at Pachkund area of Ajmer (Rajasthan)

Component	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Stem	48.03 ±4.40	26.39 ±3.18	54.56 ±5.75	79.83 ±10.00	43.10 ±5.05	41.64 ±7.00	24.30 ±1.15	17.70 ±1.00	07.26 ±1.20	26.71 ±2.18	16.26 ±1.70	36.53 ±3.95
Leaves	07.25 ±1.16	42.88 ±3.35	95.24 ±9.17	102.25 ±23.00	26.02 ±5.15	27.87 ±1.70	13.70 ±1.10	09.70 ±1.00	12.32 ±2020	10.40 ±2.14	26.67 ±3.18	17.90 ±1.75
Seeds	06.51 ±1.64	73.79 ±5.25	58.79 ±7.00	76.19 ±6.14	54.04 ±5.18	25.62 ±2.15	52.40 ±7.10	18.60 ±1.05	06.56 ±1.22	67.34 ±4.00	04.43 ±1.15	44.17 ±3.18
Miscellaneous	29.40 ±2.20	14.94 ±1.70	90.96 ±7.44	105.33 ±0.25	74.41 ±8.00	65.00 ±3.15	41.70 ±2.20	28.40 ±2.17	15.63 ±1.00	20.76 ±1.60	20.74 ±1.44	39.99 ±4.10
TOTAL	91.19	158.09	292.19	363.60	197.57	160.13	132.10	74.40	41.77	125.21	68.10	138.59

Table 4. Yearly total litter fall (g/m2) and percent contribution of different parts to the total litter collected under different tree species at the study site of Ajmer

COMPONENT	Acacia senegal			Acacia tortilis			Eucalyptus camaldulensis		
	TOTAL	MEAN	%	TOTAL	MEAN	%	TOTAL	MEAN	%
Stem	330.85	27.50	48.61	317.53	26.46	35.18	422.31	35.19	22.84
Leaves	179.22	14.93	26.39	208.63	17.38	23.13	392.20	32.68	21.21
Seeds	022.18	18.48	03.26	052.26	04.35	05.79	487.62	40.63	26.34
Miscellanious	147.52	12.29	21.72	323.35	26.94	35.85	546.36	45.53	29.55
TOTAL	678.97	56.58		901.77	75.14		1848.49	154.04	

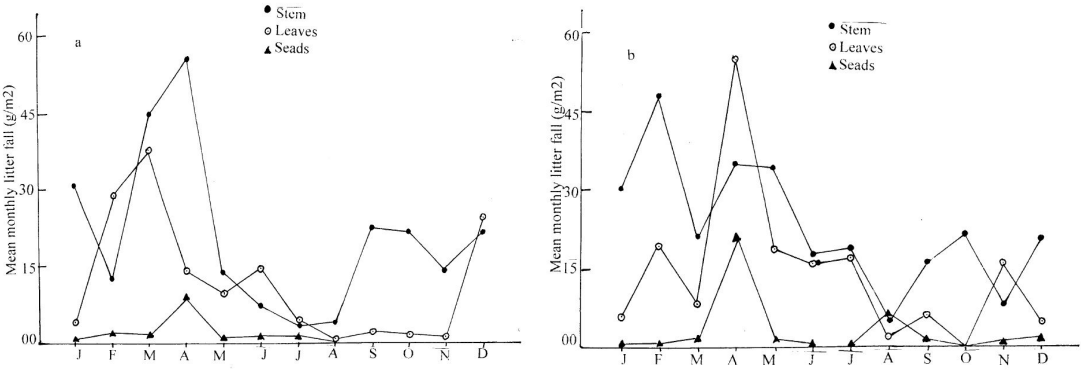

Fig 4. (a) Monthly litterfall pattern of three different categories of (a) *Acacia senegal* and (b) *A. tortilis*

Total litter collected under each plantation was separated in to stem, leaves, seeds and an unidentified partially decomposed category i.e. miscellaneous. Data on these four litter categories are presented in Table-4 and Fig-3a. Contribution by each litter category under various plantations for different months was also expressed in percentage (Table-5 & Fig-5).

Table 5.Percent of monthly litter fall (g/m2) collected under *A. senegal, A. tortilis* and *E. camaldulensis* trees at the three different study sites of Ajmer

Components	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
A.senegal												
Stem	09.75	04.03	13.82	17.03	04.70	10.70	13.20	02.33	7.12	6.72	4.30	06.90
Leaves	03.98	16.22	21.39	07.81	05.67	08.54	14.81	01.13	2.73	1.80	2.13	13.72
Seeds	00.27	01.31	01.39	00.55	05.20	00.83	01.39	-	-	0.56	0.66	-
Miscellaneous	10.98	09.34	23.18	23.75	09.19	02.71	06.23	00.94	8.52	1.53	1.01	02.56
Total	08.15	08.66	17.77	15.64	06.93	08.26	12.05	01.64	6.04	4.23	3.05	07.53
A.tortilis												
Stem	9.76	15.93	07.65	12.06	11.80	6.45	07.11	02.73	05.84	8.39	3.85	08.35
Leaves	4.77	11.03	06.67	26.93	10.83	8.89	10.25	01.53	04.67	0.33	9.70	04.34
Seeds	0.93	01.54	05.01	52.94	04.49	1.43	00.99	21.43	04.26	0.57	1.70	03.88
Miscellaneous	8.53	08.70	15.00	16.38	08.12	7.91	02.87	04.23	13.37	6.30	7.26	11.33
Total	07.70	11.59	09.91	19.42	09.83	7.25	05.96	04.12	04.79	5.33	6.30	08.23
E.camaldulensis												
Stem	11.37	06.24	12.91	18.90	10.20	09.86	05.75	04.19	1.71	6.32	3.85	04.23
Leaves	01.84	10.91	24.28	26.07	06.63	07.10	03.49	02.47	3.14	2.65	6.80	04.56
Seeds	01.33	15.13	11.96	15.62	11.08	05.25	10.74	03.81	1.34	3.80	0.90	09.05
Miscellaneous	05.38	02.73	16.48	19.27	13.61	11.89	07.63	05.19	2.86	3.79	3.79	07.31
Total	04.93	08.55	16.13	10.67	10.68	08.66	07.46	04.02	2.25	6.77	3.68	07.49

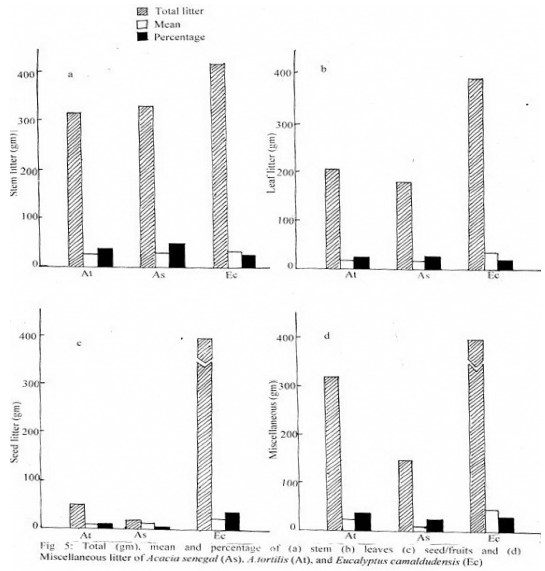

Fig 5: Total (gm), mean and percentage of (a) stem (b) leaves (c) seed/fruits and (d) Miscellaneous litter of *Acacia senegal* (As), *A.tortilis* (At), and *Eucalyptus camaldudensis* (Ec)

Fig 5.

As shown in Table-6 the total litter collected from three sites is 3429. 23 gm/m2 of which stem, leaves and seed/fruits constitute 31.19% 22.74% and 16.39% respectively, while miscellaneous category also contributes a sizeable quantity i.e. 29.66%. The order of the various litter categories under each plantation may be given as.

Table 6. Yearly total litter (g/m2) collected under each tree plantation and percent contribution.

Plant species	Total litter	% Contribution
Acacia senegal	678.97	19.79
Acacia tortilis	901.77	26.29
Eucalyptus camaldulensis	1848.49	53.90
Grand Total	3429.23	

A. tortilis
Stem > Leaf > Seeds / Fruits < Miscellaneous

A.senegal
Stem > leaf > sods / fruits Miscellaneous

E. camaldulensis
Stem > Leaf < Seeds / Fruits Miscellaneous

In these orders miscellaneous category is placed near the litter category by which it is slightly smaller or greater.

Data on stem litter reveal that it is the largest category of total plant litter and hence stem litter provides maximum amount of organic matter to the stabilized sand dunes. Fragments of these branches mixed with upper sand layers and form a sizeable amount of litter in each locality.

The following order of litter quantities of various tree plantations was observed for each litter category:

Stem
E-camaldutensis > *A-senegal* > *A-tortilis*

Leaves and seed / Fruits
E-camaldulensis > *A-tortilis* > *A-senegal*

Miscellaneous
E.camaldulensis > *A-tortilis* > *A-senegal*

It was interesting to note that stem litter provides maximum amount of organic matter to the stabilized sand dunes. This is because of terminal branches by local people for cattle food. Fragments of these branches mixed with upper sand layers and form a sizeable amount of litter in each locality.

CONCLUSION

The study reveals that the litter fall is highest in May and April because all the tree species shed all foliage portions during the autumn season. At this stage some input of various tree species is flown and accumulated in the sandy gap areas. Suboptimal peaks were observed in September because of mechanical force imposed on tree species by rains in previous months.

The sand dunes of Ajmer are thus find input of organic matter through litter fall, which accelerate the succession trend of the sand dunes. The present study indicated that litter fall received by the dune surface is chiefly dependent on the nature of tree species and their phonologies (Ackerman and Bamberg, 1974). Thus Pachkund area is characterized by thick layer of leaf litter of *E.camaldulensis*. However, moisture and temperature conditions of the sand dunes are more important for further processes. Trees of *A.tortilis* and *A.senegal* provide very low amount of litter and even part of it is transported by wind. It has been reported that litter fall pattern and its requirement for the cereal communities is significant because high organic matter is being added for the last many years. In view of these characteristics, sand dunes of Ajmer region are slightly different from the extreme desert region of Rajasthan where litter fall seems to be a limiting factor because of sparse vegetation (Mack, 1977, and West, 1979).

The impact of the total amount of litter was observed during the field surveys. The Pachkund area, which receives comparatively very high litter, is completely stabilized with characteristic soil conditions (high values of organic matter, water holding capacity and nutrients). While the other two sites receive very low litter are comparatively less stabilized and some times a major area is converted into active dune during the summers, and only partially stabilized during the rainy season, therefore, both moisture and amount of litter play an equal role in the process of stabilization.

According to Bhat and Gadgil (1987), higher litter production may be because of herb layer production which is mainly dependent upon biotic and abiotic factors, higher density of individual and canopy structure (Prasad et al., 1987) and also because of dead herbaceous plants.

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