research report

SEED DISPERSAL AND SEEDLING SURVIVAL PATTERNS IN A WIND-DISPERSED SPECIES *Bombax malabarica* L. (BOMBACACEAE)

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Key Words : *Bombax malabarica*, seed density, seedling survival, wind dispersal, Karnataka, BR Hills, dispersal distance, seed shadow.

Abstract

Patterns of seed density and seedling survival were investigated in a wind-dispersed tree species *Bombax malabarica* in BRT sanctuary, southern India. Seed density showed a typical leptokurtic distribution where the seed density decreases with the distance away from the tree. Inter tree variation with respect to dispersal distances was high because the seed dispersal distances and slope of regression between distance and seed density varied with height. The seedling survival was low at close to the tree than at 20 m away. It is argued that seedling survival probability is shaped by density-dependent mortality factors unlike the seed survival patterns in other wind- dispersed species which are generally size related.

Introduction

Seed dispersal distances are determined by dispersal agents and associated morphological characters of seeds and fruits. In most wind-dispersed species, large number of seeds were deposited under the parent tree (Levin & Kerstern 1974, Hutchings 1980). This leptokurtic pattern of seed dispersion results in large scale predation of seeds close to the parent tree (Janzen 1970). Seeds are dispersed for longer distances will escape predation because of escape the factors affecting density dependent mortality (Janzen 1970). It is also argued that due to reduced predatory pressure lower seed density away from the parent tree, seeds will have higher survival probabilities (Augspurger 1983, Clark & Clark 1984, Schupp 1988, Kitajima & Augspuger 1989). Aerodynamic properties such as wing loading and size may also influence dispersal distances in wind-dispersed species (Green 1980, Augsperger & Hogan 1983, Morse & Schmitt 1985, Ganeshaiah & Uma Shaanker 1991, Sinha & Davidar 1992).

There are less reports available on seed morphology and dispersal abilities in field conditions and on how dispersed seeds perform in the field (Morse & Schmitt 1985). Therefore this study was conducted to examine the patterns of seed dispersion and survival of seedlings in *Bombax malabarica* at different dispersal distances.

Materials and Methods

1 The Site - Biligirirangan Temple Wildlife (BRT) Sanctuary is located in Mysore district (77^o - 77^o 16$'$ E and 11^o 47$'$ - 12^o 9$'$) with an area of 540 km^2 and a unique vegetation comprising of scrub thorny, deciduous, evergreen and shola forest types. The floristics are given by Barnes (1944), Kamathy *et al.* (1964) and Ramesh (1989). The terrain is highly undulating, ranging from 600 m above MSL at plains of Yelandur, Kollegal and Chamarajnagar to 1800 m above MSL at Honnamatti and Seematti peaks. The sanctuary harbours many large mammals such as elephant, tiger, panther, gaur, sloth bear, spotted deer, sambar, barking deer etc.

The BRT sanctuary experiences monsoonal climate receiving both southwest and northeast monsoons. A major part of rain is during May-October. Average rainfall varies from 1499 mm and 1440 mm annually at Bedguli and BR hills respectively to 1850 mm annually at Honnamatti. The temperature is moderate ranging from 10 to 30^{o}C.

2. Study organism - *Bombax malabarica* L. (Bombacaceae) is a tall canopy tree occurring in moist and dry deciduous forests of peninsular India. The tree grows to a height of 23 - 27 m and bears large bright red flowers during February to April. These flowers attract many bird pollinators such as brahmini myna, common myna, parakeets, bulbuls etc. Flower buds are often predated by common langurs. Immediately after flowering, the trees start fruiting. When fruits dehisce and a lot of seeds are released embedded in silky cotton. Seeds are surrounded by cotton in the fruit and when fruit bursts open, the cotton will be exposed. This exposed cotton will be carried by wind and hence seeds are dispersed. It is commonplace to see cotton released from these trees form a white carpet on the ground below the trees. This cotton is collected and used in making mattresses.

3. Methods - Five isolated trees, (i.e., which did not have any conspecifics within a 70-80 m radius) were selected.

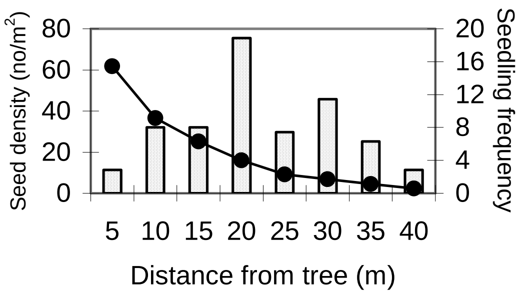

Figure 1: The pattern of seedling survivorship at different distances away from the parent (bars) and seed density patterns (lines with astericks

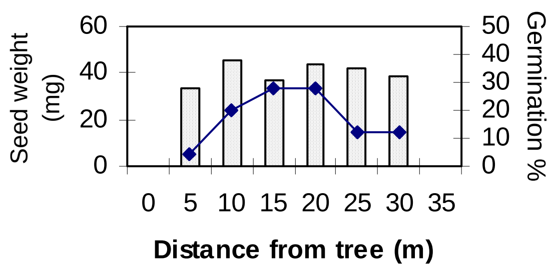

Figure 2: Variation in seed weight (bars) at different distances from the parent tree and the variation in germination patterns of seeds (line with astericks)

Starting from the base of each tree 1 m^2 quadrats were laid in three different directions. Six quadrats were laid in each direction and the number of seeds in each quadrat were counted and only a portion of seeds were collected. The seeds were pooled according to the distance from the tree at which they were found. From this seed pool, 25 seeds were randomly selected and their individual weights were recorded. Mean seed weights were calculated and statistical differences between groups were computed using Student's t-test. The proportion of broken or chaffy seeds from this lot was computed and their statistical differences were computed using binomial test (Zar 1984). The diameter of each tree at breast height (DBH) was measured using diameter tapes and its height using SUNNTO clinometer.

Twenty five seeds were selected randomly from each seed lot of different distances from the tree and were tested for germination. Seeds were placed in a petri dish and incubated at 30°C. Seeds were observed for germination once every two days until 10th day. The proportion of seeds germinated in each group was recorded and the statistical differences were computed using a binomial test as given by Zar (1984).

About two months after the dispersal of seeds, the site was visited once again to count the number of seedlings surviving. Two of the isolated trees previously selected were used for these observations and the distance of the seedlings from the parent tree was measured. The distribution of the distances thus measured were classified using appropriate class intervals and mean and skewness (g1) as given by Snedecor and Cochron (1974) were calculated. Average seedling distance for each tree was calculated.

Seed density with distance from the parent tree was pooled over all the trees and analyzed for distribution pattern. Pearson's correlation (r) coefficients were calculated between distance and seed density. Densities were log transformed and correlation coefficient was calculated. Similarly, the density data for each tree was regressed with the distance, coefficient of determination (r^2) and slopes (regression coefficients) for each tree was calculated. The difference between slopes of different trees were also calculated. The regression equation obtained for each tree was used to calculate the seed shadow distance (the distance over which seeds dispersed). This indicates the distance to which each tree can disperse its seeds. Spearman's correlation coefficients (r_s) between tree height and seed shadow distance and tree height and slope were calculated.

Results

Seed density, when log transformed, decreased typically as a function of distance away from the tree (Figure 1). The decrease was linear with an equation Y = 4.25 - 0.09 X (log distance). The coefficient of determination was very high (r^2=0.94, df=4, p<0.05) indicating high correlation between traits. The correlation of untransformed seed density with distance was also negative and high (r=-0.89, Y = 59.7 - 2.36 X, df=4, p<0.05). The differences in slopes, for the same, between trees was significant and the coefficient of determination was also high (Table 1). The correlation between slope and height of trees was high although not significant (r=0.78, df=3, p>0.05) probably indicating that slopes increase with height of the tree but with no statistical rigor. Tree height determines the slope i.e., the proportion of seeds falling close to the parent tree are high in shorter trees than taller ones. Seed shadow distance and height were also positively related (r_s= 0.83, n=5, p<0.2) but at low statistical significance levels. Similarly the relation between slope and seed shadow distance was high (r_s = 0.94, n=5, p>0.1). These relations between seed shadow distance, slope and height of the tree indicate the inter-relation between these three parameters in determining the density of seeds on ground at different distances from the tree. The distribution of seedlings showed a negative skewness indicating the probability of success of seeds dispersed farther are high (g1=-0.66, n=62, P<0.05). The seed density decreases as a function of distance from the tree and the seedling survival followed a normal distribution with a negative skew (Figure 1). Although seed density decreased, seedling density increased at intermediate distances and decreased later. The average distance of seedlings from the tree was not significant between two trees for which seedling success pattern was observed (20.75 ± 9.78 and 18.71 ± 8.88 are mean and standard deviations respectively for tree 1 and tree 2. There were 33 seedlings in tree 1 and 29 in tree 2; t=0.91, P>0.2)

Seed weights at different distances did not show any monotonic (decreasing or increasing) pattern but were significantly different between groups (Figure 2). The seeds collected at distance 7, 17 and 22 m showed significantly higher means over seeds collected at distance 2, 12 and 27 meters (Table 2). The proportion of seeds that were broken or chaffy did not differ at different distances of dispersal (Table 2) indicating that proportion of chaffy and broken seeds are same at all dispersal distances. The percent of seeds germinating although were high at intermediate distances i.e., 12 and 17 m away from parent tree than either proximal to or far way from the parent (Table 2) but showed no statistical difference. Only the seeds very close (2 m) to the parent tree showed significantly lower germination per cent than seeds which were found at 12 and 17 m away from the tree. All others were not statistically significant. There seems no relation between the average weight of the seed and germinability of seeds at corresponding distances from the parent tree (Figure 2, r_s=0.45, n=6, p>0.05). Seeds at this distance were infected by fungus. Seed weight did not have relation with per cent germination (r_s = 0.45, n=5, p>0.3).

Discussion

The pattern of seed density in *Bombax malabarica* also followed usual leptokurtic distribution as a function of the distance away from the parent tree (Green 1980). The difference between trees exists with respect to dispersal distances, it was not significant partly because of the lower sample size. It may also be that the difference between trees is due to the effect of neighbors around the focal trees influencing the dispersal distances. However, the tree height seems to influence the seed shadow distance positively and hence taller trees showed an advantage over shorter trees regarding dispersal distance (Sinha and Davidar 1992). Therefore it can be suggested that taller trees are successful in efficiently dispersing their seeds apart from having other advantages in the community.

In wind-dispersed species the seeds with higher mass do not get dispersed for longer distances because of reduced wing loading factor (Ridley 1930, Rabinowitz & Rapp 1981, Augspurger & Hogan 1983, Ganeshaiah and Uma Shaanker 1991, Sinha and Davidar 1992). Hence it is argued that there is a trade-off between dispersal distance and seedling survival probability determine the seed size (Ganeshaiah and Uma Shaanker 1991). But in *Bombax malabarica,* average seed size do not decrease with dispersal distance although seed weights vary over different distances from the tree. However, the seeds deposited at intermediate distance showed higher weight. However, dispersal of seeds in the field are strongly influenced by various factors unrelated to seed morphology creating more variation within a seed shadow of an individual tree. Seeds with high mass are known to have dispersed for long distances (Sheldon & Burrows 1973, Morse and Schmitt 1985) although in controlled conditions they were found to behave in the predicted manner (Green 1980).

Thus, the dispersal pattern of *B. malabarica* differs with those of single seeded samaras where many theoretical and empirical models of seed dispersion have been postulated. The seeds are carried by wind along with cotton which

Table 1: Various parameters measured for five observed trees on DBH, Height, Seed shadow distance, Coefficient of Determination (R^2) and Slope.

Tree No	DBH (cm)	Height (m)	Seed Shadow (m)	R^2	Slope * Mean ± SD
1	69	23.1	51.30	0.95	-0.074 ± 0.021 [a]
2	33	17.4	42.13	0.93	-0.093 ± 0.029[ab]
3	27.5	16.8	31.54	0.82	-0.135 ± 0.077[ab]
4	32	18.3	30.58	0.94	-0.109 ± 0.033[ab]
5	64	19.2	57.31	0.96	-0.087 ± 0.020[ab]

* Values followed by the same alphabet do not differ significantly at P<0.05

Table 2: Table showing mean seed weight, proportion of chaffy broken seeds and seed germination percent at different distances away from the parent tree.

Distance from the parent tree (m)	Seed Weight * (mg) n=25 Mean ± SD	Proportion of broken and chaffy seeds[1]	Germination per cent[1] (n=25)
2	33.9 ± 11.8[a]	0.131 (32/268) [a]	4.0 [a]
7	45.3 ± 11.73[b]	0.087 (25/287)[ab]	20.0[ab]
12	36.5 ± 13.16[a]	0.113 (11/97) [ab]	28.0 [b]
17	43.8 ± 12.24[b]	0.089	28.0 [b]
22	45.2 ± 12.30[b]	0.042	12.0[ab]
27	38.8 ± 12.50[ab]	0.045	12.0[ab]

* Values followed by the same alphabets do not differ significantly at P<0.05
1 Values in parenthesis indicate the actual number of chaffy seeds in denominator and total number of seeds collected in denominator.

adhere to seeds. This cotton gives required buoyancy for seeds to be dispersed in air. Probably, in *Bombax malabarica* the dispersal distance depends on the amount of cotton and number of seeds being carried. Greater the amount of cotton greater will be the buoyancy and hence the dispersal distance, assuming the same number of seeds and other environmental conditions. Similarly, assuming equal amount of cotton, the greater the number of seeds, lesser will be the distance travelled by one bout of cotton with seeds. Along with cotton chaffy seeds, broken seeds and fully developed seeds will also be dispersed. Assuming the occurrence of chaffy seeds are random throughout a fruit, it is possible to expect same proportion of chaffy seeds at different dispersal distances. Therefore, probably the generalistic patterns of decreasing seed size over the distance as described in other species does not hold true here. Therefore the probability of survival of seedlings does not seem be to decreasing because of factors associated with seed sizes, although the seedling survival pattern follow an expected pattern (Janzen 1970, Kitajima & Augspurger 1989). Therefore it may be stated that, probably, density dependent mortality factors are shaping the seedling distribution in *B. malabarica*.

The data on seed germination does show that seeds at intermediate distances i.e., 17 and 22 m away from the tree have higher germination per cent. The seeds falling very close to the parent tree seems to have greater pathogenic (fungal) infection than seeds falling at farther distances (pers. observation) therefore indicating density dependent factors operating on seeds deposited close to the parent tree. Per cent germination appear same at all distances away from the tree thus suggesting that germination *per se* may not be controlling the seedling survival patterns. Thus, it can be argued that in *B. malabarica* probably there are two selective forces acting on the survival of seedlings. The density dependent factors such as herbivore or parasitic pressure, inter-seedling competition and allelopathic effects may result in reduced survival of seedlings growing proximal to the parent tree. On the other hand seeds dispersed away from the parent tree may be experiencing uncertainty factors such as safe site. Although the uncertainty of factors affecting dispersal of seeds are high (Houle 1992), the seedling survival pattern in *Bombax malabarica* which suggest that the seedlings far away from the parent may be experiencing patches which are unsafe (Morse and Schmitt 1985). Thus, seedling survival probabilities in *Bombax malabarica* appears to be determined by the density dependent factors and spatial heterogeneity factors (safe sites) than by size-related factors as reported in other wind-dispersed species.

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