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Euphorbia fusiformis and Co-Existed Plants: An Interspecific Covariance Analysis for Experimental Designing of its Conservation

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ABSTRACT

The actual logical basis for the individualistic hypothesis is primarily based on gradient analyses in which plant species are mostly found to be distributed independently along the environmental gradients. However, continua along gradients are correlative patterns and do not exactly identify the processes of continuum occurrence, and thus not necessarily be precluded the possibility of interdependent interactions within plant communities. Euphorbia fusiformis, a rare medicinal geophytic herb of the family Euphorbiaceae was found to be grown with 20 associated plants in a very small patch (1 sq. km) of a lateritic dry deciduous forest of Eastern India. Interspecific covariance analysis using Pearson's Correlation Coefficient and its supportive interspecific association using multiple species case model of Euphorbia fusiformis with its other co-existed plants along with their detailed analysis of community structure was performed to understand whether any interdependent interaction in the community exists or not. The study reveals a strong positive covariance in abundance of E. fusiformis and other 5 associated plant species (Buchanania lanzan, Phoenix acaulis, Pavetta indica, Madhuca latifolia and Hemidesmus indicus) existed in the community that supports true possibilities of strong positive interaction among these plants within the community. The present study indicates that co-existence of the population of B. lanzan, P. acaulis, P. indica, M. latifolia and H. indicus would be helpful in facilitating to increase the population size of E. fusiformis during ex- situ conservation programs. Moreover, this highly specific, less distributed medicinal herb (belong to CITES II category) may be regenerated with viable population in the same type of edaphic and climatic conditions when the positively co-varied plant species associated with it are well maintained.

Keywords: *Co-existed plants, Interspecific covariance analysis, medicinal plant, conservation.*

INTRODUCTION

A good number of plant species throughout the world are very less dispersive as they are found to be occurring in some specific geographical localities. *Euphorbia fusiformis* Buch.-Ham. ex D. Don is such a species which had its restricted distribution only in few localities of two countries: India and Nepal[1]. Interestingly, inspite of belonging to a large family Euphorbia (having around 8000 species under 300 genera worldwide), and a large genus Euphorbiaceae (having 7500 species under 7 subgenera), this species is ranked under such a subgenus *Rhizanthium* which is too small to have only 10 geophytic species as compared to other subgenera, and very localised to some regions of India, Nepal and Africa[1]. *Euphorbia fusiformis* is one of the very less known succulent, perennial, dwarf herbs grown up to 15 cm to 20 cm. long root tapering at both ends having stunted geophytic growth with flushing of 3-5 leaves per year specifically during monsoon months which is only the above ground vegetative part of this plant.

Flowers develop during spring (March to May) after shedding all the leaves. In India this species is reported to be distributed only in few pockets of Uttar Pradesh, Maharastra, Nagar Haveli, Andhra Pradesh, Karnataka and Tamil Nadu, and West Bengal where as in Napal it is restricted to some lower altitudes [1-6]. In west Bengal this plant was only restricted to a single patch in the lateritic floor of Gonpur[6]. Traditionally this plant had its use among the tribal society of India mainly in the treatment of rheumatism, paralysis, gout, arthritis, abdominal disorder, abdominal tumour, headache, diarrhoea, chronic wound cracks, skin disease and eczema[7-9]. *Euphorbia fusiformis* has been traditionally used by the santal tribal community of Gonpur forest areas of West Bengal in the treatment of poor lactation[10]. This species deserves its high demand in traditional societies but due to its localized distribution in few pockets of the world for their stunted vegetative growth and probably poor success in reproductive strategy either in production of abortive seeds or failure of germination, its population is under alarming pressure. Thus conservation with proper designing of its habitat for ex-situ multiplication is required to increase its population and to reduce threats for demands.

It is note worthy that different biotic components *e.g.* associated plants most of the time perform very significant role that modify their habitat condition such a way that regulating either positively or negatively for the existing community as well as for the plant of interest [11]. Study of co-existed associates especially whose abundance co-varies with the plant of interest is essential for ex-situ or in-situ conservation of a rare taxa[12,13]. Though significant correlation with the abundance of coexisted species' informs nothing about the exact underling reasons why they might be so. However, detection of significant interspecific covariation can be extremely helpful in generating suitable hypothesis to explain such pattern, which then may lead to further experimental research. Outcomes of this field of study is indispensible for ex-situ as well as in-situ conservation during afforestration programme especially for those plants which have very specific habitat preference. Interspecific covariance analysis using Pearson's Correlation Coefficient and its supporting interspecific association using multiple species case model of *Euphorbia fusiformis* with its other co-existed plants along with their detailed habitat and analysis of community structure in the present study may helpful for experimental designing of its ex-situ conservation of this rare CITES II category taxa.

MATERIALS AND METHODS

Study area

During the study of the floristic diversity of Birbhum district, this rare medicinal herb (*Euphorbia fusiformis*) was found to be growing as the undergrowth of lateritic *Shorea robusta* forest especially at a shady, moist and humus rich area of Gonpur forest (Fig. 1). Interestingly it was only found to be grown in a 1km X 1km forest patch near Ghaga tribal village [24º 04' 46.53"N to 24º 04' 40.87"N and 87º 40' 54.63"E to 87º 40' 54.70"E, 194 ft (60 m)] and it is the only locality of distribution of this plant according to [6] in their first report of this plant from West Bengal.

Gonpur forest (24º06'25.09" N to 24º03'02.83" N and 87º38'41.09" E to 87º41'18.59" E), the second largest forest of the district Birbhum is situated in the northern part covering an area of 11.58 Sq. km. Northwestern part of this forest is quite undulated which is actually an extension of Chota Nagpur plateau. This forest has a higher elevation and during rainy season the top soil is eroded from north-western part. Soil in western part of this forest is red loamy type where as eastern side is purely lateritic. Except a large water body in the eastern side of the forest and the central canal (which dries up during winter and post monsoon), the forest is devoid of other water sources like river, lake etc. The temperature ranges from 11°C to 42.9°C with an average annual rainfall of 109 mm. The major dominated trees in the forest are *Shorea robusta*, *Buchanania lanzan, Madhuca latifolia, Semecarpus anacardium, Gardenia latifolia, Terminalia bellirica, Diospyros melanoxylon* and others. The associated climbers and lianas like *Asparagus racemosus, Tylophora indica, Combretum decandrum, Mucuna pruriens, Tinospora cordifolia, Abrus precatorius, Ziziphus rugosa, Gouania tiliaefolia, Ventilago denticulata, Erycibe paniculata, Quisqualis indica, Tiliacora racemosa, Derris scandens, Dioscorea bulbifera, Mimosa rubicaulis, Cayratia pedata, Dioscorea pentaphylla* form a dense canopy in the western side of the forest with quite thicken ground cover.

The south-eastern side of the forest is comparatively lesser dense canopy (much more discontinuous canopy) with low diversity of climbers and lianas. A *Santal* population of 6768 individuals in 1300 families residing in 18 forest fringe villages were very potential regarding the medicinal use of different forest floristic resources and found to access this plant from this forest to increase milk production of cattle and also in case of poor lactation in humans as and when required.

Data collection and processing

For community analysis, 6 sampling units (SUs) (Quadrats of 20.88 Sq. m. sizes) were plotted (small number of quadrats are plotted for their very localized and small distribution). Quadrats are plotted randomly in their habitat to avoid biased sampling. Structural Parameters like Density (D), Abundance (A), Relative Density (RD), Relative Frequency (RF) and Importance Value Index (IVI) were estimated by using standard procedure [14-16].To study the interspecific co-variation (if any) existed between *Euphorbia fusiformis* and other 21 plant species co-existed in the community, Pearson's Correlation coefficient (Eq. 1) was calculated based on abundance data of *Euphorbia fusiformis* and other phytoassociates (Ludwig and Reynolds 1988).

$$r(i,k) = \frac{\sum_{j=1}^{N} Y_{ij}Y_{kj} - \{(\sum_{j=1}^{N} Y_{ij})(\sum_{j=1}^{N} Y_{kj})/N\}}{\sqrt{\left[\sum_{j=1}^{N} Y_{ij}^2 - \{(\sum_{j=1}^{N} Y_{ij})^2/N\}\right]\left[\sum_{j=1}^{N} Y_{kj}^2 - \{(\sum_{j=1}^{N} Y_{kj})^2/N\}\right]}} \quad \text{…. .(Eq. 1)}$$

N = the total number of SUs (N = a+b+c+d), Y_{ij} =the abundance of i^{th} species in j^{th} SU, Y_{kj}= the abundance of the k^{th} species in the j^{th} SU.

To study the inter-specific association (if any) existed between *Euphorbia fusiformis* and other 21 co existed plant species present in this plant community, Multiple Species Association model was adopted (Multiple Species Association model was adopted here for the large no. of co-existed species). To show the multiple species association, at first species association comparison matrix was prepared [17]. Schluters VR (variance ratio) test was also performed based on null association model to test simultaneously for significant association between different coexisted plant species including *Euphorbia fusiformis* [18]. For that, first we computed the total sample variance (Eq. 2) and next we have estimated the variance in total sample number (Eq. 3). Finally the variance ratio (VR) was calculated using the standard formula (Eq. 4). The expected value under the null hypothesis of independence is 1. VR>1 suggests that, overall, the species exhibit a positive association. If VR<1, a net negative association is suggested. A statistic (*W*) provided by [18] was also calculated to test for significant departure from the expected value of no association. Value of statistic, *W*, was used to test whether deviations from 1 are significant or not. If the species are not associated, then there is a 90% probability that *W* lies between limits by the Chi-square distribution.

$$\sigma_{\mathrm{T}}^2 = \sum_{i=1}^{s} p_i(1-p_i) \text{ ……(Eq. 2)}$$

$$S_{\mathrm{T}}^2 = \frac{1}{N}\sum_{j=1}^{N}(T_j - t)^2 \text{ ……(Eq. 3)}$$

$$VR = S_T^2 / \sigma_T^2 \text{ ……(Eq. 4)}$$

RESULTS AND DISCUSSION

Euphorbia fusiformis was found to be co-existed with 20 flowering plants distributed into 20 genera and 15 families which indicate high taxonomic diversity (Table 1). The forest is mainly tropical deciduous type with moderately undulated topography; so, most of the plants sheds leaves during winter when water content is very little in the soil [18].

Few plants have their perinating organs *e.g.* bulbill of different species of *Dioscorea*, where as tough, tuberous root with reserve food is the adaptive mechanism of *Euphorbia fusiformis* to overcome the adverse water stress situation. During winter they drop their leaves and the rest of their body was found to be buried under soil until spring to develop aerial part to flower (Fig. 2). As the forest is mostly dominated by *Shorea robusta*, its relative density, relative frequency, abundance as well as IVI value is also highest among all tree species followed by *Buchanania lanzen* and *Holarhenna antidicentrica*. Whereas in case of shrubs, climbers & lianas and herbs, IVI value of *C. spinarum, S. zeylanica and C. orchioide*s were highest respectively in the community which depict these species have the major role in maintenance the structural as well as functional aspect of the community (Fig. 3). In Pearson's correlation coefficient (PCC), out of 20 species, only 5 species show significant covariation (P=0.05) with *E. fusiformis* which means the abundance of *E. fusiformis* tends to change with *Buchanania lanzan, Phoenix acaulis, Pavetta indica, Madhuca latifolia* and *Hemidesmus indicus* and interestingly all co-vary positively with that species in this community (Table 2). Here abundance pattern for *E. fusiformis* always increases when *B. lanzan, P. acaulis, P. indica, M. latifolia* and *H. indicus* increase in the community or in other words increasing abundance perhaps lead to enhancement of the abundance of *E. fusiformis* through modifying some of the biotic or abiotic factors in their micro climate suitable for growth and development of that plant[11, 13]. Schluters VR (variance ratio) test for multiple species association reflects there is a 90% probability that no significant association exists between *E. fusiformis* and other 20 co-existed plants (Table 2). As significant negative multiple species association oppose the cooperative approach of 5 correlated plants with *E. fusiformis* in their community, what we have found in the PCC test, this experiment parallely supports that there is no cumulative negative impact exerted by the co-existed plants to *E. fusiformis*, which may have been controversial to the result of PCC test.

Table 1. Structural parameters of *E. fusiformis* and 20 other co-existing plants

Plant species	Family	D	RD	FQ%	AB	RF	IVI
Tree							
Shorea robusta C. F. Gaertn	Dipterocarpaceae	0.98	12.21	100.00	20.50	6	18.21
Buchanania lanzan Spreng.	Anacardiaceae	0.73	9.14	100.00	15.33	6	15.14
Holarrhena antidysenterica (L.) Wall.	Apocynaceae	0.68	8.54	100.00	14.33	6	14.54
Antidesma ghaesembilla Gaertn	Euphorbiaceae	0.47	5.86	100.00	9.83	6	11.86
Madhuca latifolia J. F. Macber.	Sapotaceae	0.33	4.07	100.00	0.00	6	10.07
Cleistanthus collinus (Roxb.) Hook.f.	Euphorbiaceae	0.08	0.99	83.33	2.00	5	5.99
Semecarpus anacardium L. f.	Anacardiaceae	0.09	1.09	66.67	0.00	4	5.09
Shrub							
Phoenix acaulis Roxb.	Arecaceae	0.18	2.28	100.00	3.83	6	8.28
Carissa spinarum L.	Apocynaceae	0.51	6.36	83.33	12.80	5	11.36
Randia sp.	Rubiaceae	0.34	4.27	83.33	8.60	5	9.27
Pavetta indica L.	Rubiaceae	0.04	0.50	16.67	5.00	1	1.50
Syzygium fruticosum DC.	Myrtaceae	0.18	2.28	66.67	5.75	4	6.28
Acacia catechu (L. f.) Willd.	Fabaceae	0.12	1.49	66.67	3.75	4	5.49
Ziziphus oenoplia (L.) Mill.	Rhamnaceae	0.16	1.99	66.67	5.00	4	5.99
Dillenia pentagyna Roxb.	Dilleniaceae	0.04	0.50	50.00	1.67	3	3.50
Climbers & Lianas							
Smilax zeylanica Wight	Liliaceae	0.25	3.08	100.00	0.00	6	9.08
Dioscorea bulbifera L.	Dioscoreaceae	0.01	0.10	16.67	1.00	1	1.10
Hemidesmus indicus R.Br.	Apocynaceae	0.06	0.79	66.67	2.00	4	4.79
Herb							
***Euphorbia fusiformis* Buch.- Ham. ex. D. Don**	**Euphorbiaceae**	**0.56**	**6.95**	**100.00**	**11.67**	**6**	**12.95**
Curculigo orchioides Gaertn.	Hypoxidaceae	1.95	24.43	100.00	41.00	6	30.43
Grewia hirsute Vahl	Tiliaceae	0.25	3.08	100.00	5.17	6	9.08

D: Density; RD: Relative Density; Ab: Abundance; F%: Frequency; RF: Relative Frequency; IVI: Importance Value Index;

Table 2. Interspecific covariation showing Pearson's correlation coefficient and Interspecific association using Multiple species case model

Sp. No.	Plant species	Abundance						Sp. Pair	PCC	Interspecific association (Multiple species case)			
		SU-3	SU-2	SU-1	SU-4	SU-5	SU-6			TSV	VTSN	VR Index	W test statistics
1	*E. fusiformis*	27	6	5	5	2	25	1--2	0.1463				
2	*S. robusta*	22	20	26	12	22	21	1--3	-0.755				
3	*B. lanzan*	10	13	25	15	20	9	1--4	**0.9251***				
4	*H. antidysenterica*	24	12	7	15	6	22	1--5	0.4227				
5	*P. acaulis*	4	4	4	4	3	4	1--6	**0.9616***				
6	*A. ghaesembilla*	18	9	7	7	2	16	1--7	0.6523				
7	*C. spinarum*	20	0	2	5	18	19	1--8	0.6799				
8	*Randia* Sp.	11	8	7	8	0	9	1--9	-0.292				
9	*P. indica*	0	0	0	5	0	0	1--10	**0.981***				
10	*M. latifolia*.	13	4	5	4	1	14	1--11	**0.9406***				
11	*S. anacardium*	4	2	1	0	0	4	1--12	-0.575	**2.055**	**1.555**	**0.756**	**4.538**
12	*S. fruticosum*	0	0	3	12	7	1	1--13	-0.444				
13	*C. collinus*	2	3	2	1	2	0	1--14	0.5153				
14	*S. zeylanica*	8	12	1	1	1	8	1--15	-0.292				
15	*D. bulbifera*	0	0	1	0	0	0	1--16	-0.204				
16	*D. pentagyna*	0	3	0	0	1	1	1--17	0.7741				
17	*A. catechu*	5	4	2	0	0	4	1--18	0.8059				
18	*H. indicus*	3	2	1	0	0	2	1--19	**0.8994***				
19	*C. orchioides*	55	42	40	32	25	52	1--20	-0.487				
20	*G. hirsute*	2	14	5	3	5	2	1--21	-0.703				
21	*Z. oenoplia*	0	9	3	5	3	0						

SU: Sampling Unit; PCC: Pearson's correlation coefficient; TSV: Total Sample Variance; VTSN: Variance in Total Species Number; VR: Variance Ratio.

Fig. 1. Distribution of *Euphorbia fusiformis* in India and in Gonpur forest of West Bengal

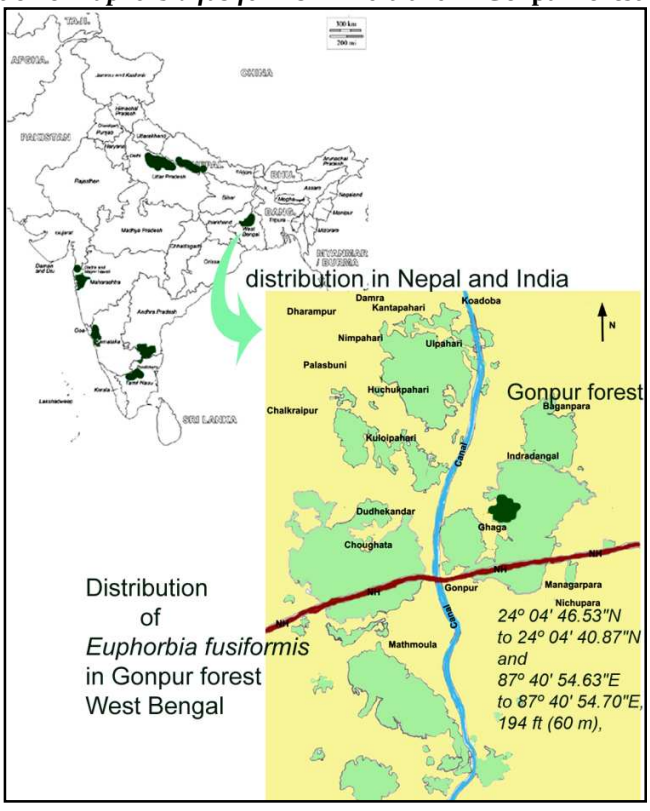
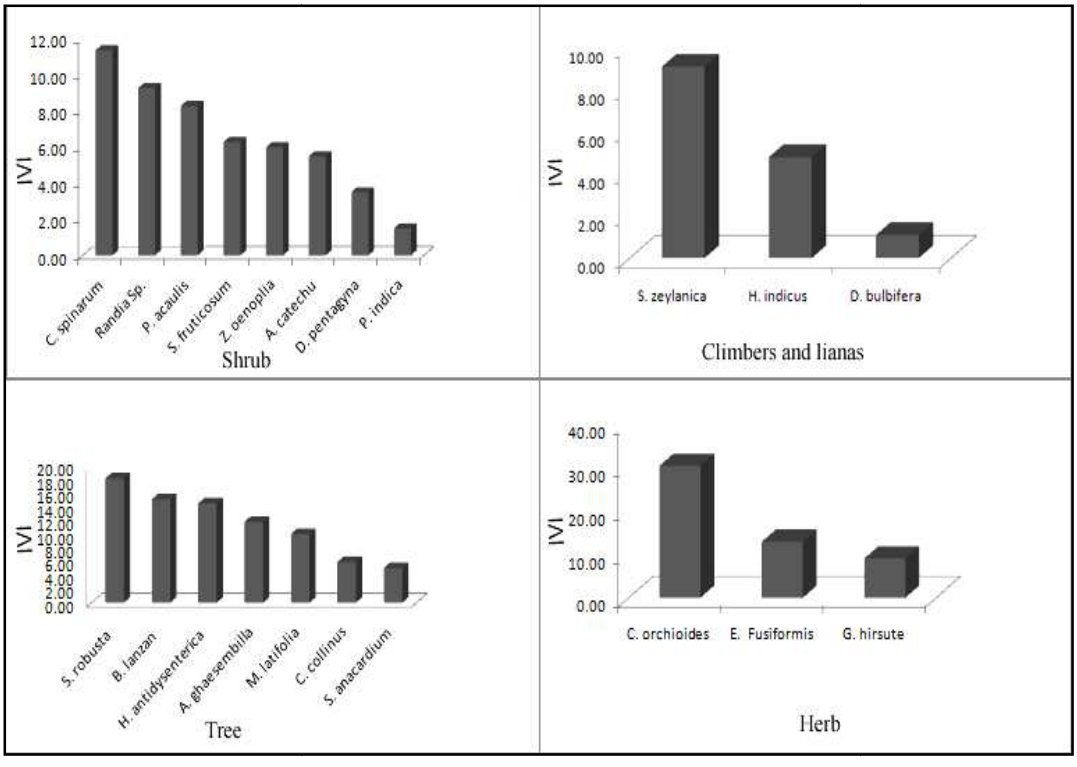


Fig. 2. *Euphorbia fusiformis* Buch.-Ham. ex D. Don

A- Stages of flowering and fruiting , D- root stocks; B & E- *E. fusiformis* with other associated plants in Gonpur Forest; C- plant habit

Fig 3. Importance Value Index (IVI) of different coexisted herbs, shrubs, climbers & lianas and trees in the community of *E. fusiformis*



CONCLUSION

It is also worth to mention that the detection of a statistically significant correlation between *E. fusiformis* and other correlated species abundance pattern tells us nothing about the possible underlying reasons why this might be so [17]. However it can be hypothesized that cumulative response of these significant correlated plants access environmental factors and modify their environment in such a way which is conducive for growth and regeneration of *E. fusiformis* [11, 19]. The present study suggests that co-existence of the population of *B. lanzan, P. acaulis, P. indica, M. latifolia* and *H. indicus* will facilitate to increase the population size of *E. fusiformis* during ex- situ conservation programs as they have strong positive covariance with each other in their abundance in the community. Based on the result of our study, when growing these less distributed medicinal herb (belong to CITES II category) species outside regenerated and managed forests, conservation efforts may be more effective if careful attention is paid to positively co-varied species.

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