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RESEARCH ARTICLE

Biodiversity assessment under cocoa (*Theobroma cacao* L.) plantations of Tamil Nadu

■ **N.S. VIGNESH, M. MAHESWARI AND P. DORAISAMY**

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SUMMARY : World over the scientific community is working for improving biodiversity beyond protected areas. In this context, lot of scientific research has been conducted in agro plantations, which is increasingly projected as the second best option to protected areas. Among the plantation crops, cocoa has received special attention as it grows under the canopy of diverse shade plants. There are many scientific studies to show that cocoa agro forests are environmentally preferable to other forms of agricultural activities in tropical regions. Research conducted in Latin America indicates that the capacity of cocoa plantations to conserve birds, ants and other wildlife is greater than in any other anthropogenic land use systems. The influence of cocoa plantations on faunal biodiversity was studied under cocoa intercropped plantations in comparison with coconut monoculture plantations at two different ago climatic zones of Tamil Nadu namely Western zone (Pollachi and Theni) and Cauvery Delta zone (Thanjavur). The similarity matrix at Western zone and Cauvery Delta zone were 53.4 and 48.14 per cent, respectively which indicated a drastic change in the floral diversity. ANOSIM gives the R values of 0.86 and 0.53 for Western zone and Cauvery Delta, respectively which belongs to category 'distinguish' and hence, indicates greater dissimilarity. The Shannon (H') indices for avian diversity at Western zone and Cauvery Delta were 1.23 and 0.76 which were invariably higher compared to coconut mono culture plantations (1.03 and 0.69). The dendrogram classified the data into 23 clusters and further analysis indicates that the coconut mono culture at Western zone did not form close cluster and exhibited minimum similarity with other samples. Cocoa as an intercrop in coconut enhances the faunal, floral and avian diversity. Cocoa cultivation also improves the soil physical, chemical and biological properties and lead to a better carbon and nutrient dynamics, apart providing additional income to the farmers with the existing land. Hence, it is a win-win strategy to cultivate cocoa as an intercrop under coconut plantations.

Key Words :
Cocoa plantations, Coconut monoculture, Biodiversity

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Author for correspondence :
N.S. VIGNESH
Department of Environmental Sciences, Tamil Nadu Agricultural University, COIMBATORE (T.N.) INDIA
Email: vigneshns2009 @gmail.com

See end of the article for **Coopted authors'**

Tropical protected areas are insufficient to preserve biological diversity and ecosystem services, even under the most optimistic scenarios. Indeed, the maintenance of biodiversity is likely to be determined by agricultural and forest land uses outside of formally protected areas. Not only do matrix lands provide valuable environmental and biodiversity conservation benefits (e.g., wildlife habitat, linkage between protected areas, watershed protection, C sequestration, etc.), they provide food and cash income for millions of rural households and comprise the basis of regional and national economies in many tropical countries.

It is not obvious to many, that the agro-plantation industry, through its monoculture is causing major erosion of biodiversity in many rural agricultural areas. Habitat transformations like urbanization and plantations lead to loss or alternation of biodiversity and there is a need for scientific management.Reconciling development with conservation of biological diversity is need of the day. Agro-plantations over the years rapidly expanded in India, with large tracks of land being converted into monoculture areas. The ensuing biodiversity aspects have received very little attention from the scientific community. There

is urgent need to undertake such biodiversity studies in major monoculture plantations in India. This is even more important in states like Tamil Nadu, as large-scale plantations of coconut, tea, coffee and rubber occupy large areas of land near the Western Ghats, which is a biodiversity hot-spot (Asare, 2005).

Indian is the third largest producer of coconut in the world with a share of 15.90 per cent in area and 25.40 per cent in production. Kerala accounts for 40 per cent of total area under coconut (ICCO, 2007). In India, coconut is either grown as mono crop or as a major component in multiple cropping systems. Cocoa is found to be an opt intercrop in coconut plantations, In 2011, 4309 thousand tonnes of cocoa was produced globally. The largest producing countries are Côte d'Ivoire, Ghana and Indonesia which included 34, 24, and 14 per cent of the world total production (ICCO, 2012). In India, cocoa cultivation is largely confined to southern states, *viz.*, Kerala, Karnataka, Tamil Nadu and Andhra Pradesh. Cocoa is usually planted under coconut and arecanut plantations as it has an imminent capacity to share the alley spaces of tall growing coconut and arecanut plantations and its combining ability with the microclimatic conditions available in such perennial gardens. India produces 12954 metric tonnes of cocoa from around 46318 hectare of cocoa cultivated, out of which Tamil Nadu covers an area of 9347 ha with a production 900 MT (Directorate of Cashew and Cocoa Development, 2011). The major cocoa growing areas under Tamil Nadu are Coimbatore, Thanjore and Theni districts.

In this context, there is an urgent need to document biodiversity in all agro-plantations types in India. A compilation of such data could give crucial insights as to 'what minimum' is required for each type of plantation to sustain economics of plantation as well as preservation of biodiversity. Such information would also be a useful guide for planning for environmentally sound and biodiversity friendly development. Therefore, considering the multiple benefits of cocoa plantations and enhanced cocoa under coconut cultivations, an investigation has been taken up to assess the biodiversity in cocoa plantation.

EXPERIMENTAL METHODOLOGY

For assessing the biodiversity, coconut monoculture and coconut and cocoa intercropping areas were selected in Western zone (Pollachi and Theni) and Cauvery delta zones (Thanjavur) of Tamil Nadu. Theni is a district in the western Tamil Nadu state of south India. It is known for the large scale trading of cardamom, coffee, grapes, chilly and textiles. The district is surrounded by Western Ghats. Thanjavur is an important agricultural centre located at the heart of the region, known as the "Rice bowl of Tamil Nadu". Pollachi experiences temperate climatic conditions throughout the year. Due to the close proximity of the Western Ghats, abundant rainfall can also be expected during the monsoon seasons. In the selected plantations, cocoa leaf litter was quantified as per the method adopted by Chandravanshi (2003).

The floral diversity was estimated by Quadrate Methods. By following net sweeps, light trap, Pit-fall traps, Scented traps, Sticky trap methods, the faunal diversity was measured. Estimation of avian diversity was made by using open line transects (Bibbly *et al.*, 1998). Since, long continuous transects are more appropriate than restrictive Point Count methods to cover larger areas within the limited time available and to record highest proportions of species, it was followed. Moreover, the distant and loud and frequent calls of species can be heard from a distance of 50 meters.

Binocular Nikon Monarch 10*42 was used to identify birds. Birds were identified using above referred binoculars or by calls; the number of birds and species were recorded in each of the areas. Species identification was based on Grimmet *et al.* (2002). For data interpretation and analysis, Biodiversity Professional Version-2 software was used for calculation of biodiversity indices as described by MaAleece in 1997. Calculation of various biodiversity indices, cluster analysis and analysis of similarity were undertaken using the above mentioned software. The data were statically analyzed, the biodiversity indices such as Species Evenness and Richness, Shannon-Weiner Index, Simpson Index (D), Multivariate Analysis-Bray-Curtis similarity and Analyses of Similarity (ANOSIM).

EXPERIMENTAL FINDINGS AND DISCUSSION

The quantification of cocoa leaf litter fall revealed significant variations among different ages of cocoa plantations. It plays a major role in the variation of biodiversity as it gives a better nesting habitat to the faunal species and encourages the faunal diversity. Litter fall also acts as mulch and controls the weed intensity perhaps it may alter the floral diversity. The increased insect population by the litter fall of cocoa plantation leads to a better alternative source for the avian groups so there will be an enhancement in the avian diversity.

Total quantity of leaf litter were recorded to be 3555.5, 4134, 4788.9, 5456.2 and 6136.5 kg ha^{-1}, in two, four, six and ten years old cocoa plantations, respectively. Maximum quantity of leaf litter was recorded in ten years old cocoa plantations followed by younger aged cocoa plantations of descending order. The Bhat *et al.* (2002) also encountered such type of variation in the leaf litter fall pattern in their study.

The comparison of floral diversity in coconut monoculture and with cocoa intercropped areas at Western zone and Cauvery Delta zones of Tamil Nadu are given in

Table 1. There was a reduction in the weed density and intensity of different weed species and the Shannon index values for Western and Cauvery Delta zones which were 1.32 and 1.08 under coconut monoculture and 1.14 and 0.98 under cocoa intercropped with coconut plantations. These results can be substantiated by the effects of competition for light, water and nutrients, as well as a potential effect of microclimate. Cocoa canopy cover will lead mulching effect preventing germination and growth of ground floral species. These observations corroborate with the findings of Chikoye and Ekeleme (2010). Nevertheless, further studies are needed to evaluate the impact of cocoa and non-cocoa plantations on the germination of seeds of the dominant weed species identified in this study.

In the present investigation, it was also inferred that the broad leaved weeds have been drastically reduced by the introduction of cocoa in coconut plantations. The observations on weed density, frequency, relative density and abundance revealed that the weed density was found to be higher in coconut monoculture soils even though similar weed management practices were followed. This might be due to the reason that the cocoa leaf fall may act as a mulching layer and prevent weed seed germination and also the microclimatic conditions, habitat heterogeneity, resource availability and interactions with other species may reduce the weed population. The results are in line with the herbaceous vegetation.

The faunal diversity was also altered by the introduction of cocoa plantation under coconut at Western zone and Cauvery Delta zones of Tamil Nadu (Table 2). The Shannon index value revealed an increase in the faunal diversity under cocoa intercropped coconut plantations. Shannon index values of 1.11 and 0.85 and 1.27 and 0.99 under coconut monoculture and cocoa intercropped coconut, respectively were recorded at Western zone and Cauvery Delta, respectively. This describes from the fact that cocoa plantations can resemble forests in terms of tree cover and several management aspects have an impact on insect richness

Table 1: Influence of cocoa cultivation on floral diversity of Tamil Nadu

Particulars	Coconut monoculture		Cocoa intercropped coconut	
	Western zone	Cauvery delta zone	Western zone	Cauvery delta zone
Mean individuals	49.10	50.30	24.15	29.60
Standard deviation	32.80	34.50	20.40	28.10
Standard error	8.45	8.90	5.25	7.20
Total species	14	13	13	11
Shannon index	1.32	1.08	1.14	0.98
Simpsons index	10.58	10.41	9.26	8.56

Table 2: Influence of cocoa cultivation on faunal diversity of Tamil Nadu

Particulars	Coconut monoculture		Cocoa intercropped coconut	
	Western zone	Cauvery delta zone	Western zone	Cauvery delta zone
Mean individuals	5.60	7.20	15.40	21.60
Standard deviation	11.75	15.10	20.10	28.30
Standard error	3.00	3.90	5.20	7.30
Total species	9.00	8.00	13.00	12.00
Shannon index	1.11	0.85	1.27	0.99
Simpsons index	3.06	2.94	6.03	6.03

Table 3: Influence of cocoa cultivation on avian diversity of Tamil Nadu

Particulars	Coconut monoculture		Cocoa intercropped coconut	
	Western zone	Cauvery delta zone	Western zone	Cauvery delta zone
Mean individuals	36.63	2.15	39.95	2.18
Standard deviation	26.60	7.33	31.30	6.62
Standard error	6.85	28.00	8.05	28.33
Total species	13.00	11.00	12.00	10.00
Shannon index	1.03	0.69	1.23	0.76
Simpsons index	9.49	3.26	9.92	4.04

directly by affecting resources or indirectly through microclimatic changes and changes in species assemblages. Similar results were suggested by Faria *et al.* (2006) who observed no less than 240 species of litter and tree dwelling insects in an acre of a Ghanaian cocoa agro-system. There was a drastic increase in the midges population up to 12 fold in the cocoa intercropped plantations which might be due to the moist habitats with rich of rotting plant material, where insects feed and breed will improve the insect population.

Introduction of cocoa under coconut plantation showed a greater influence on the avian diversity under Western zone and Cauvery Delta zones of Tamil Nadu, India (Fig. 1and 2). There was an addition of four species of birds which were observed only in cocoa intercropped area, *viz.*, Asian Koel, Common Flameback, Shikra and Thick Billed Flowerpecker. Also there was an increase in avian population by 8.3 per cent and 2.3 per cent over coconut monoculture at Western zone and Cauvery Delta zone, respectively. This may be due to habitual adaptation of birds towards introduced cocoa plantation and these results were in coordination with Botero and Baker (2001) who noticed such increase in bird species and correlate with diversified cropping system. The Shannon index for cocoa intercropped with coconut was 1.23 and 0.76 whereas for coconut monoculture, they were 1.03 and 0.69,

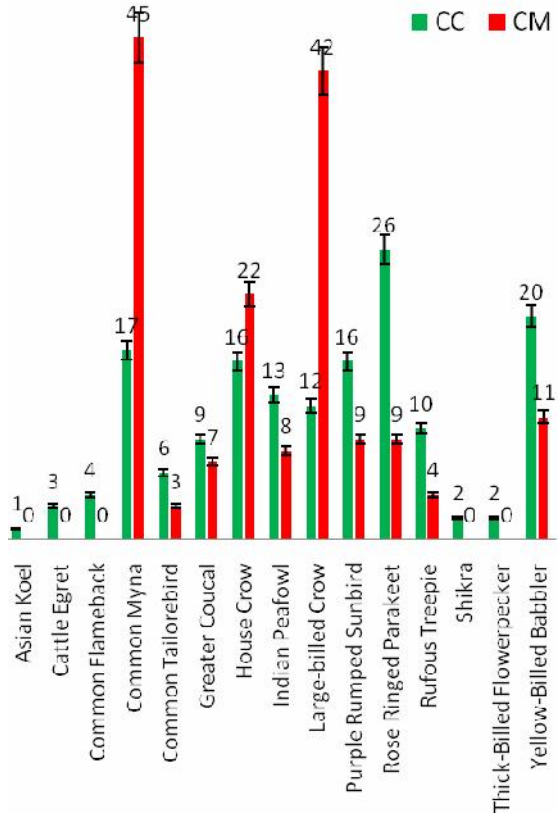
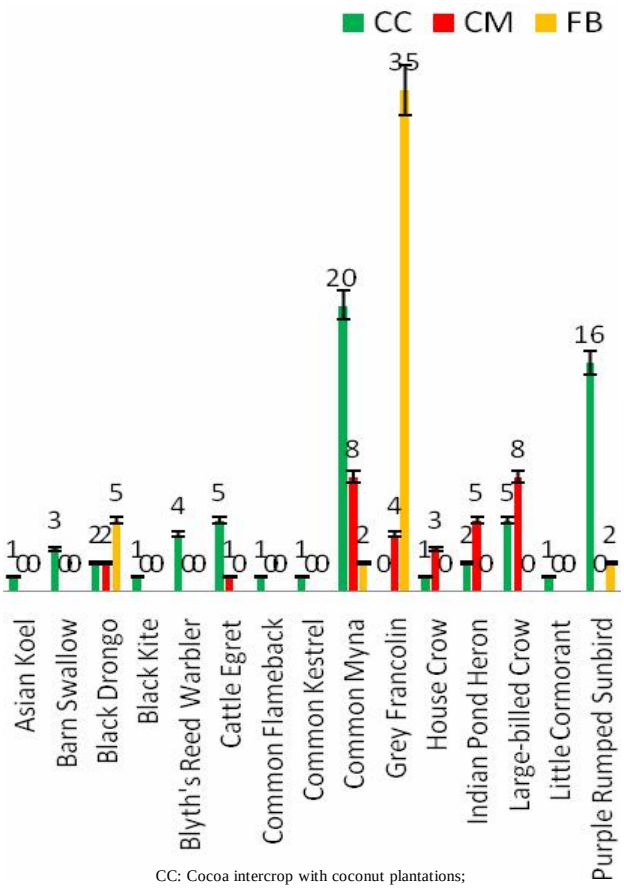
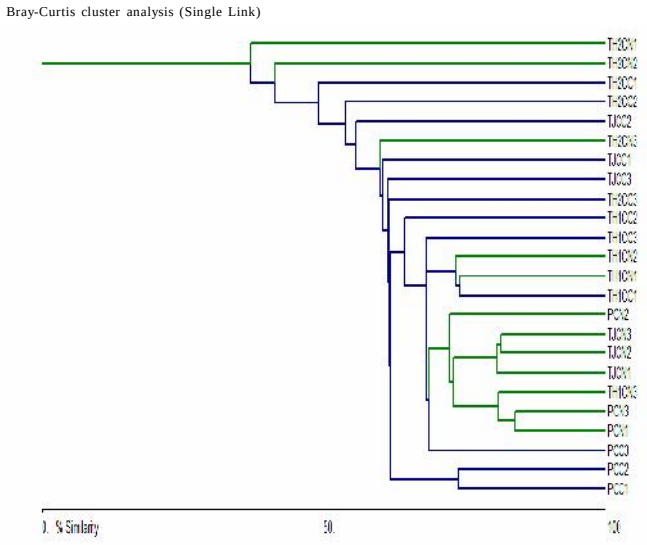


Fig. 1 : Influence of cocoa cultivation on avian population at Westren Zone



CC: Cocoa intercrop with coconut plantations;
CM: Coconut mono culture plantations; FB: Forest Border

Fig. 2: Influence of cocoa cultivation on avian population at Cauvery Delta Zone



TJ=Thanjvur; TH= Theni; P=Pollachi; CC=Cocoa intercropped plantations;
CN=Coconut mono culture plantation, 1, 2 and 3= Samples Numbers

Fig. 3: Bary-Curtis cluster analysis (Single link) for avian diversity

respectively zone (Table 3). This may be due to increased number of insects on account of high litter fall from the cocoa and improved environmental factors like, decreased temperature; increased shade etc.

The other multivariate analysis namely, Bray-Curits cluster analysis indicated the variation in diversity between the coconut monoculture and cocoa introduced plantations in two different zones of Tamil Nadu by forming different clusters (Fig. 3).

Conclusion:

In general, the cocoa cultivation provided higher opportunities for better biodiversity when compared to coconut monoculture areas. Overall there was an increase in species and population of floral, faunal and avian species in all the sites of observations. The field observations unequivocally demonstrated the positive impact of cocoa as an intercrop with coconut plantations in improving the soil nutrient status and biological health keeping the enhanced biodiversity.

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Coopted Authors' :

M. MAHESWARI AND P. DORAISAMY, Department of Environmental Sciences, Tamil Nadu Agricultural University, COIMBATORE (T.N.) INDIA

Email: maheswarisekar2004@yahoo.com, dhurai54@gmail.com

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