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Diversity and composition of riparian vegetation across forest and agro-ecosystem landscapes of river Cauvery, southern India

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Abstract: The study aims to examine tree species richness, and composition and diversity of riparian forests across forest and agro-ecosystem landscapes observed along the river Cauvery of southern India. Riparian forest was sampled in a belt transect of size 100 × 50 m, at each of the 80 sampling plots scattered over a 318 km length along the river Cauvery. Total of 177 tree species belonging to 52 families, representing 2930 individuals, were recorded. Differences occurred between the forest and agro ecosystem landscape in terms of species richness, family richness and number of individuals observed, with a decrease in agro-ecosystem compared to forest landscape. Species similarity was low between the forest and agro-ecosystem landscapes. The Shannon-Wiener diversity index was higher for forest landscape (5.6) with more evenness in distribution. In the forest landscape, high importance value indices (IVI) were obtained for *Terminalia arjuna*, *Pongamia pinnata, Hopea parviflora*. In the agro-ecosystem, species *Pongamia pinnata, Ficus benghalensis, Salix tetraspermae* exhibited high IVI. Expansion of agricultural activities and other biotic pressures might have led to the variation in species composition between the forest and agro-ecosystem. Also, it has led to the decline in ripicole and evergreen species such as *Hydnocarpus pentandra, Elaeocarpus tuberculatus, Madhuca neriifolia, Palaquium ellipticum, Myristica dactyloides,* etc., consequently affecting the associated biodiversity of the river in the agro-ecosystem. Country needs to enact a permanent policy to protect and conserve riparian buffers to avoid further degradation and loss of biodiversity in the unregulated areas along the river.

Key words: Anthropogenic disturbance, biodiversity, diversity and similarity, riparian buffer, ripicole.

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Introduction

Riparian forests have received much attention in the recent years and attracted international concern (Scott *et al.* 2009), due to their role in providing many ecosystem services such as preventing soil erosion, minimizing floods, enhancing wildlife corridor, habitat for endemic species, etc. The riparian forest has been recognized as "keystone ecosystem", because it harbours certain unique habitats which are highly influenced by water (Goebel *et al.* 2003). Wildlife biologists recognize the riparian as a critically and functionally dominant component of a terrestrial landscape (Tabacchi *et al.* 1998).

Riparian landscapes across the world generally promote mechanized agriculture and animal husbandry (Burkhart *et al.* 1994; Dudgeon 2000).

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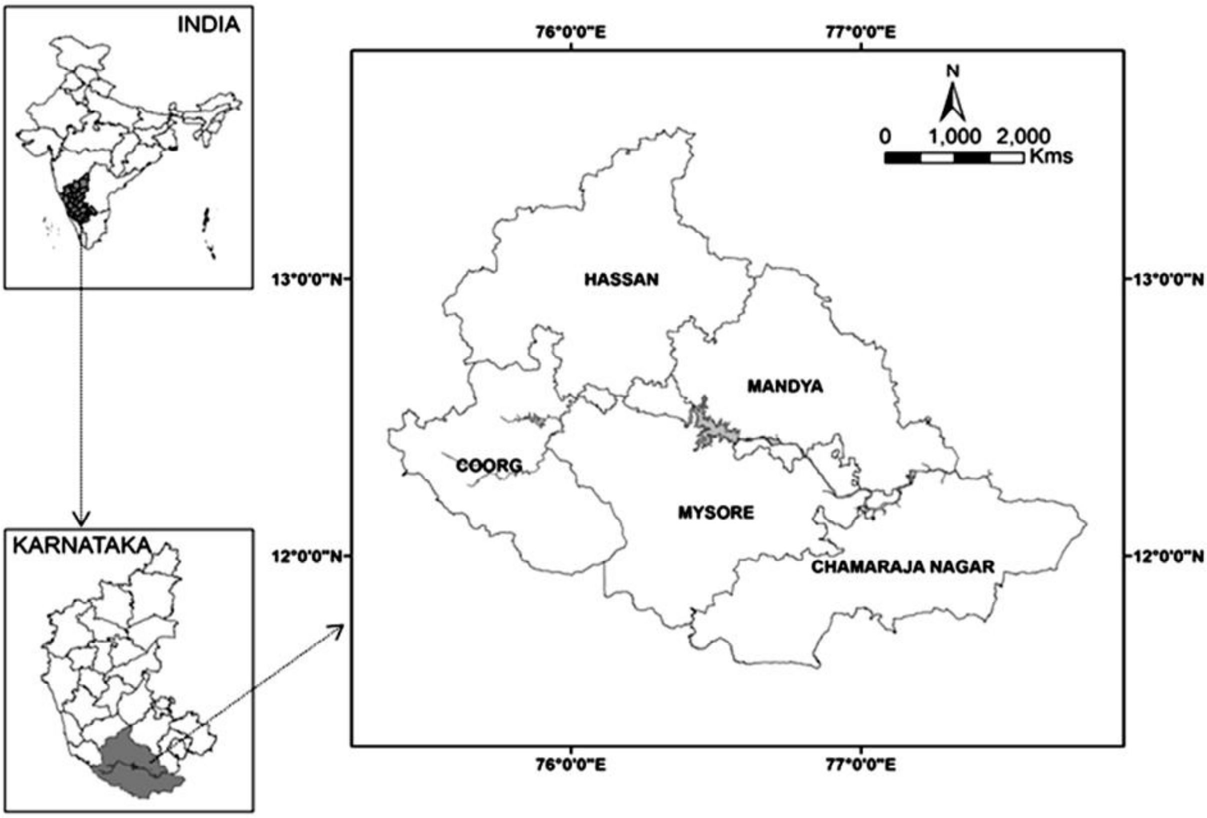

Fig. 1. Study area map.

The use of riparian zones for farming is a predominant activity along the banks of rivers that affects the riparian ecology and ecosystem services and interferes with the ecological functions of wetlands (Gopal *et al.* 2002). Disturbances caused by intense usage of riparian zone for agriculture activities have caused much spatial variation in the reported values of native species richness, composition and productivity (Aguiar & Ferreira 2005; An *et al.* 2002; Corbacho *et al.* 2003; Gopal *et al.* 2002; Smakhtin & Anputhas 2006). Besides affecting the community structure, these disturbances also lead to biodiversity loss (Sultana *et al.* 2014), polluting the streams (Bere & Mangadze 2014; Schultz *et al.* 2004) and could substantially affect the hydrological cycle which in turn impacts the human livelihood activities in the downstream by accelerating floods in the event of heavy rainfall and decreased water availability during summer (Barthelemy *et al.* 2015; Fualing *et al.* 2009; USAID 2008).

River Cauvery, the eighth largest river in tropical Asia, faces growing population pressures in its basin having the highest population density in the world of 350 people km^{-2} (Smakhtin *et al.* 2007). Consequently, it is experiencing serious anthropogenic pressures from agricultural expansion (Sunil *et al.* 2010), increased commercial plantations, mining, tourism, etc., that pose severe threat to the vast riparian ecosystem in the region (Cincotta & Engelman 2000; Smakhtin & Anputhas 2006). People from peripheral villages graze their cattle along the river bank of riparian zones due to shortage of land designated for grazing. In addition, the riparian ecosystem in Cauvery has become an integral part of cultural activities with many historic places for worship evident along the side of river bank. The riparian vegetation corridor in the Cauvery river plays a pivotal role in determining faunal communities such as Asian elephants (*Elephas maximus*), otter species (*Amblonyx cinereus*) (near threatened species), *Lutra perspicillata* (vulnerable, 2004 IUCN Red List) Nilgiri languar (*Trachypithecus johnii*), Small Indian civet, *Ratufa macroura* (Near Threatened, IUCN Red List), (Baskaran *et al.* 2011; Shenoy *et al.* 2006), fish species such as *Barbodes wynaadensis*, *Labio kontius, Silonia* *childreni* (White cat fish), *Tor putitora* (Mahseer) (Arunachalam 2004; Jayaram 2000; Lakra *et al.* 2010; Smakhtin *et al.* 2007) and invertebrates (Jayaram 2000; Sivaramakrishnan *et al.* 1995).

Realizing its importance, several developed countries worldwide have documented the vegetation dynamics and moved forward to restore their fragmented riparian landscapes by formulating relevant policies and legislation (Hansen *et al.* 2010; Moyle *et al.* 1996; NRC 2002). Studies on riparian vegetation in India are still in infancy, probably due to lack of awareness and also to complexities associated with riparian ecosystem. The Government of India, now, is contemplating to introduce "River Regulation Zone" to safeguard riparian habitat and to ensure that river beds remained safe from large-scale encroachment and developmental activities (Cullet *et al.* 2012; Gopal *et al.* 2002). Floristic patterns in the lower stretch of Cauvery River have been documented (Jayaram 2000). The tree species distribution, and structure and diversity of vegetation of riparian ecosystem are not well understood. Expansion of agricultural lands along the river banks has led to encroachment of riparian forests along the river Cauvery in Karnataka (Shenoy 2003). Increasing rate of population growth and agricultural practices are the major threats to the vast native forests in the river basin leading to its disappearance in the coming decades (Cincotta & Engelman 2000). Therefore, a comprehensive study of vegetation structure in the riparian landscapes was undertaken to evaluate patterns of species richness, species similarity, species diversity and dominance across different land use patterns *viz.* forest and agro-ecosystem landscapes along a 318 km stretch of river Cauvery in Karnataka.

Materials and methods

Study area

The study area (Fig. 1) lies along 318 km stretch of the Cauvery river in Karnataka. The study area covers five districts namely Chamarajanagar (77° 44' 83.0" E, 12° 25' 81.8" N), Mysore (76° 52' 21.2" E, 12° 16' 41.7" N), Mandya (76° 39' 18.1" E, 12° 25' 26.6" N), Hassan (76° 08' 23.5" E, 12° 35' 03.7"N) and Kodagu (Coorg)(75° 30' 09.5" E, 12° 22' 72.4" N). Its total drainage area accounts for nearly 2.5 % of the total geographical area of India (Arni & Henry 2009). Cauvery is one of the important interstate rivers of peninsular India acting as life-blood for two states namely, Karnataka and Tamil Nadu. Approximately 35 million people are dependent on this river (Hoekstra *et al.* 2012) and its water is used for irrigation, household consumption, industries and generation of electricity (Varunprasath & Daniel 2010). In the upstream region of Kodagu district, the river flows for ~102 km through forests, plantations, agricultural land and villages. Coffee plantations (dating back to 18th century), silver oak, rubber, cardamom, rice and areca nut are the major agricultural activities observed along the riparian zone (Sunil *et al.* 2012). In the middle reaches of Mandya and Mysore, rice and sugarcane cultivation is done on a large scale (Sunil *et al.* 2010). The study area is dominated by red and black soil.

The Cauvery river basin areas have a large floristic wealth and constitute a separate phytogeographic unit (Jayaram 2000). Four major forest types are found along the river viz. evergreen, semi evergreen and moist deciduous forests in Kodagu belt of Western Ghats; southern thorn scrub forest found in the middle reaches of river and southern tropical dry deciduous forest type occurring in Mysore and Mandya districts and southern moist deciduous forests found in the areas receiving less than 200 cm of rainfall (Champion & Seth 1968). The forest and agro-ecosystem are the two distinct landscapes along the river. The forest landscape (~50 km) occurs at two locations along the study area, one at river origin i.e. Kaveriammana sacred grove, covered under Karnataka Forest Rules, 1969 and the other at downstream portion of the river i.e. Cauvery Wildlife Sanctuary protected with a legal status under Indian Wildlife Protection Act 1972. The agro-ecosystem landscape is found in the middle stretch of river Cauvery, extending from Kollegala at Chamarajanagar District to Cherangala at Kodagu District covering ~268 km along the study area.

Sampling design

The plots were laid at every 8 km distance on both sides of the river bank. Total of 80 plots were sampled,15 from the forest landscape (area covered under Wildlife Protection Act 1972 and Karnataka Forest Rules, 1969) and 65 from agro-ecosystem (area used for plantations, crop cultivation and other farming activities). At each plot, a belt transect of 100 × 50 m was laid and subjected to floristic assessment using a quadrat of 20 m × 20 m (4 at each corner of a transect and 1 in the centre). The total area sampled amounts to 1.25 %. Total number of individuals (> 30 cm in girth at breast height or GBH) was recorded in each sampling plot. Tree species were identified using different floras (Gamble 1967; Keshavamurthy & Yoganarasimha 1990; Saldanha 1976) and cross-checked with the herbarium centre, at the Botanical Garden of Gandhi Krishi Vignyan Kendra (GKVK), University of Agriculture Science, Bangalore.

Data analysis

For vegetation analysis density, abundance, frequency, species richness and basal area per hectare were estimated to measure the structure and heterogeneity of the riparian vegetation. The relative frequency, relative density, relative dominance (relative basal area), and importance value index (IVI) (Curtis & McIntosh 1951) were derived for each of the two landscapes.

Species Richness: A measure of the number of species present for a given number of individuals is calculated by using Marglef's Index (Margalef 1958).

$$R = \frac{S-1}{Log\, N}$$

(S = Total number of species, N = Total number of individuals)

Shannon - Wiener Index (H') was used to calculate the species diversity (Shannon & Weaver 1949).

Diversity Index $H' = -\sum_{i=1}^{s} pi \ln pi$

where, $p_i = n_i / N$ (n_i = number of individuals of a species, N = total number of individuals of all the species).

Basal area was calculated as

$$Basal\ area = \frac{C^2}{4\pi}$$

where, C = gbh

To measure dominance, Simpson Index derived from probability theory is used (Simpson 1949). It gives relatively less weightage to rare species and more weightage to common species.

$$D = 1 - \sum (pi)^2$$

Equitability Index (Pielou 1969) is calculated as:

$$E = H'/H'_{max}$$

where, H′ is the Shannon-Wiener's Index

Rank abundance curves (Whittaker 1965), species rarefaction curve (Colwell *et al.* 2004), and species similarity (Bray-Curtis cluster analysis - single link) were performed using Biodiversity Pro software (McAleece 1996). The value of Bray-Curtis similarity index varies between 0 and 100 %, where 100 means the two sites have the same composition (that is they share all the species), and 0 means the two sites do not share any species (Hugh & Gauch 1973).

A two-tailed *t* test (XL stat software) was used to compare Shannon Wiener diversity Index and Simpson Dominance Index in the categorized landscapes. Whisker plots were calculated to compare the mean values for species richness, family richness and number of individuals between forest and agro-ecosystem landscapes.

Species area curve was prepared by plotting a graph between the number of quadrats sampled on the X axis versus cumulative number of species sampled on the Y axis. It determines whether the community is sufficiently sampled. A species based rarefaction curve was prepared to compare the species variation between the two categorized landscapes and provides a measure of species diversity which is robust to sample size effects, permitting comparison between communities. Steeper curves indicate more diversity.

Results

Vegetation characteristics

A total of 177 tree species was recorded from the riparian forest along the river Cauvery. Fifty two species (29.38 % of total number of species) were common to both the landscapes. 54 (30.51 %) species including *T. arjuna, Mitragyna parviflora, Garcinia xanthochymus, Myristica dactyloides, Olea dioca, Palaquium ellipticum, Pinanga dick-sonii*, etc.) and 71 (40.1 %) species including *Salix tetraspermae, Coffea arabica, Grevillea robusta, Cocus nucifera,* etc., were exclusive to forest and agro-ecosystem landscapes, respectively (complete data set is available from the authors on request). The Margalef's Index of species richness recorded for the forest (23.53) was higher than that for the agro-ecosystem (15.9) (Table 1). The basal area of riparian forest observed in the study area (19.17 m^2 ha^{-1}) was greater compared to the agro-ecosystem (6.50 m^2 ha^{-1}). Tree density in the forest was higher (118.6 trees ha^{-1}) than that of the agro-ecosystem landscape. Species richness, family richness and number of individuals were higher in forest landscape than in agro-ecosystem (Fig. 2).

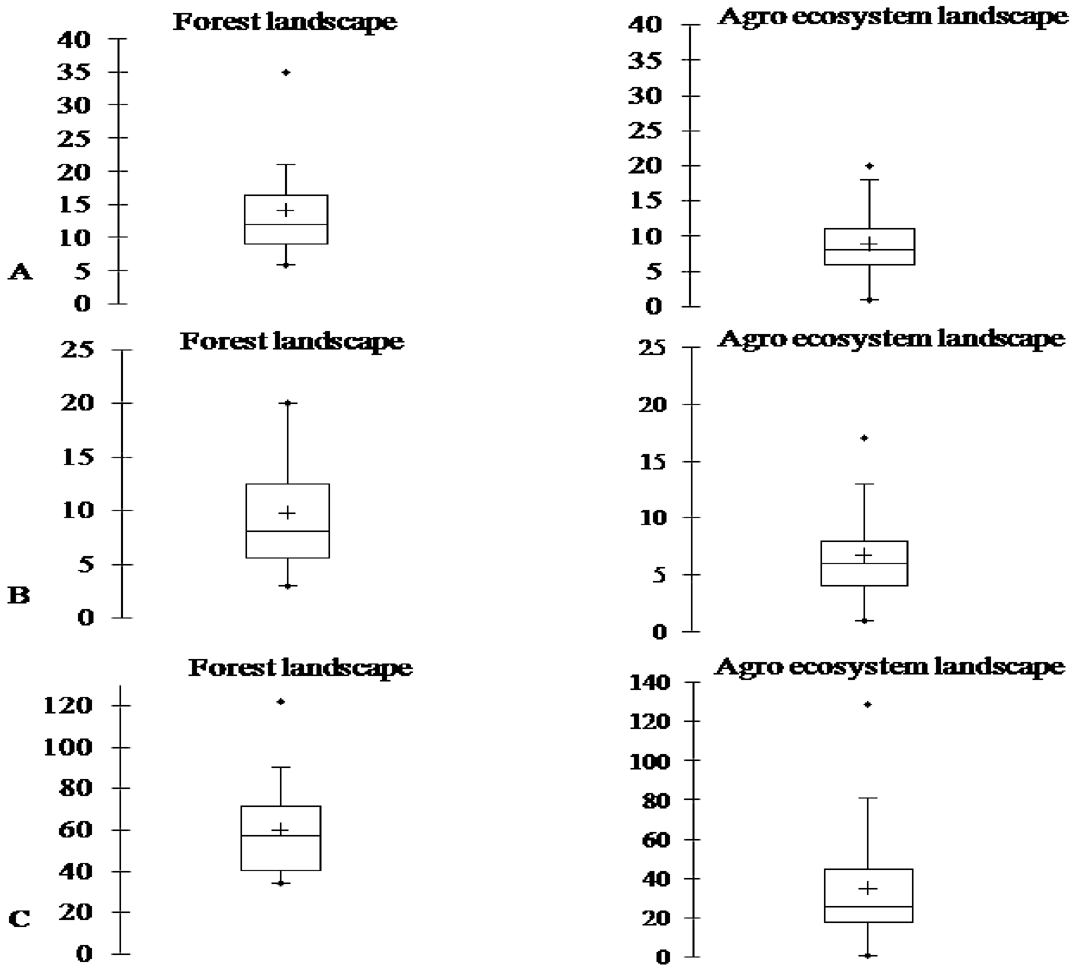

Fig. 2. Whisker plots for (A) Species richness, (B) Family richness and (C) Number of individuals across forest and agro-ecosystem landscapes. (Horizontal line through each box depicts the median, the + mark depicts mean, dot above represents the maximum and below represents minimum).

Table 1. Vegetation characteristics in the forest and agro-ecosystem.

Vegetation characteristics	Forest	Agro-ecosystem
Species richness (Margalef's index)	23.53	15.9
Number of families	36	46
Density (trees ha^{-1})	118.6	70.98
Basal area (m^2 ha^{-1})	19.17	6.50

The rarefaction curve showed less tree density in forest than the agro-ecosystem. However, rarefaction curve for the forest remained steeper than the agro-ecosystem, suggesting that the vegetation was more diverse (Fig. 3).

Species abundance

The rank abundance curve for the forest (Fig. 4a) showed that *Pongamia pinnata* (90) was the dominant species followed by *Terminalia arjuna* (58), *Tamarindus indica* (50) and *Hopea parviflora* (45). The first 13 ranked species included 488 individuals contributing to 53.80 % of the stand. The rank abundance curve for agro-ecosystem (Fig. 4b) indicated that *Pongamia pinnata* (297) was dominant followed by *Salix tetraspermae* (146), *Coffea arabica* (109) and *Mangifera indica* (94). *P. pinnata, S. tetraspermae* and *C. arabica* constituted 27 % of the stand occupying the topmost position in the agro-ecosystem.

Diversity and similarity: The species diversity in forest and agro-ecosystem landscapes were 5.6 and 5.2, respectively (Table 2). The t- test revealed a significant difference between the two land-

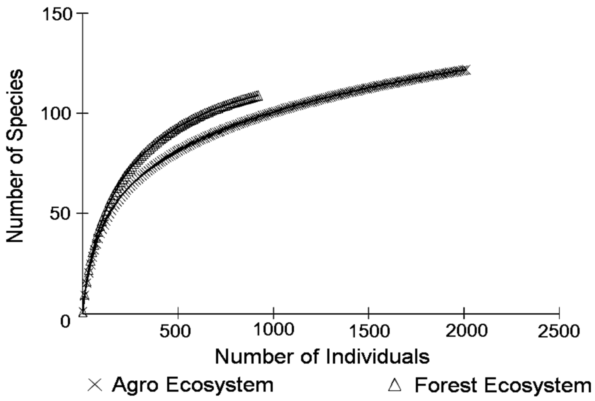

Fig. 3. Species rarefaction plot for the forest and agro ecosystem landscape.

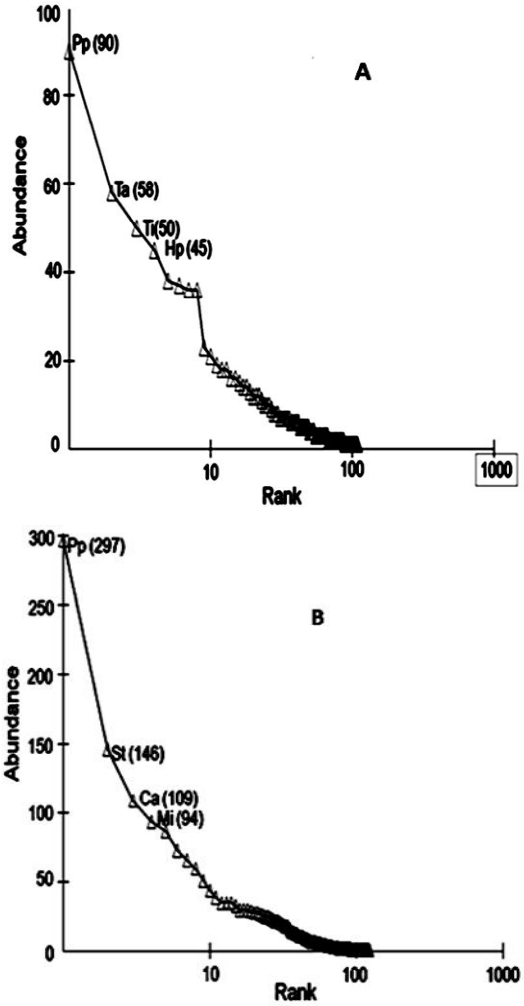

Fig. 4. Rank abundance plot for the species observed in (A) forest landscape and (B) agro-ecosystem landscape. *(Ta - Terminalia arjuna, Ti - Tamarindus indica, Hp - Hopea parviflora); (Pp - Pongamia pinnata, St - Salix tetraspermae, Ca - Coffea arabica, Mi – Mangifera indica).*

scapes. The Simpson Index indicates the presence of diverse tree species in the two landscapes with few dominant species. The equitability index indicated a more even distribution of species in the forest than the agro-ecosystem. However, the t-test revealed an insignificant relationship between the two landscapes at 0.05 % level for Simpson and Equitability indices. The similarity index for the riparian vegetation between the forest and agro-ecosystem is around 23.1 % (Fig. 5). The species area curve for the pooled data from all the 80 sampling sites revealed that further increase in transect size is needed for the sites located in the periphery area (Fig. 6).

According to the IVI values, of the total 106 species in forest landscape, *T. arjuna P. pinnata, Tamarindus indica, H. parviflora* exhibited values 44.1, 18.1, 16.8 and 16.5, respectively, contributing 32 % of the stand (Table 3). Whereas, in agro-ecosystem *P. pinnata* (30.9), *F. benghalensis* (19.5), *S. tetraspermae* (19.1) scored maximum IVI (Table 3).

Discussion

The species density in the forest (14.1 species ha^{-1}) and agro-ecosystem (4.35 species ha^{-1}) along the Cauvery river is relatively lower than the reported values for Nelliampathy region along the Chalakkudy river (30 species ha^{-1}) in Kerala (Amitha Bachan 2003). Though the local climatic factors between the two areas vary, anthropogenic activities have negatively affected the species density of the riparian forest of the Cauvery. However, minimal disturbance in the forest has favoured high species density in the forest compared to the agro-ecosystem because they are protected legally and traditionally by the protected area status and sacred grove category (Sunil *et al.* 2012). The tree basal area of the agro-ecosystem landscape with monospecific plantations is characterized by low representation of trees in higher girth classes. The appearance of big trees such as *T. arjuna, Dimocarpus longan, Elaeocarpus tuberculatus*, etc., added to the basal area of the forest. Chalakkudy river in Kerala state recorded 18.22 m^2 0.01 ha^{-1} (> 30 cm GBH) of basal area which is an indication that the basal area in the present study area is relatively low. Tree density of forest is higher (118.6 trees ha^{-1}) compared to 70.98 trees ha^{-1} recorded in the agro-ecosystem. However, the tree density observed in the present study is low, compared to 11.9 trees 0.01 ha^{-1} reported along the Chalakkudy river in

Table 2. Shannon-Wiener Diversity Index and Simpson's Dominance Index of the forest and agro-ecosystem.

Variable	Shannon-Wiener Diversity	Simpson Reciprocal Index	Evenness
Forest landscape (overall 15 plots) *Mean* (n = 15)	5.6	0.96	0.83
	2.1 ± 0.4	0.82 ± 0.07	0.66 + 0.08
Agr- ecosystem (overall 65 plots) *Mean* (n = 65)	5.2	0.95	0.75
	1.7 ± 0.5	0.74 ± 0.15	0.73 ± 0.16
Difference	0.384	0.08	-0.073
t (Observed value)	2.576	1.943	-1.667
|t| (Critical value)	1.994	1.994	1.994
DF	70	70	70
p-value (Two-tailed)	0.012	0.056	0.100
alpha	0.05	0.05	0.05

the neighboring state of Vazhachal (Amitha Bachan 2003).

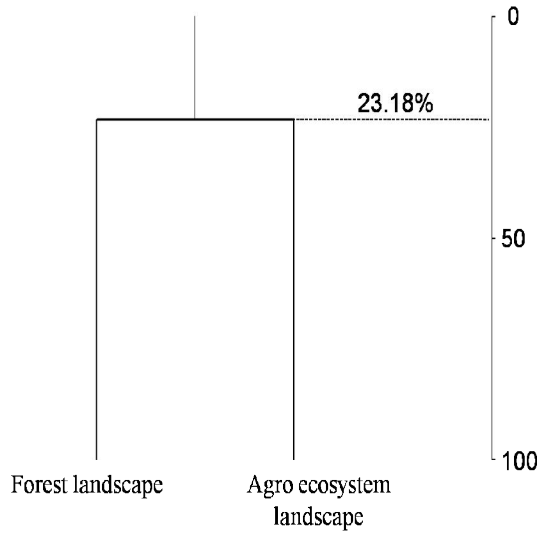

Fig. 5. Bray-Curtis Cluster Analysis (single link) for tree species similarity in forest and agro-ecosystem landscape.

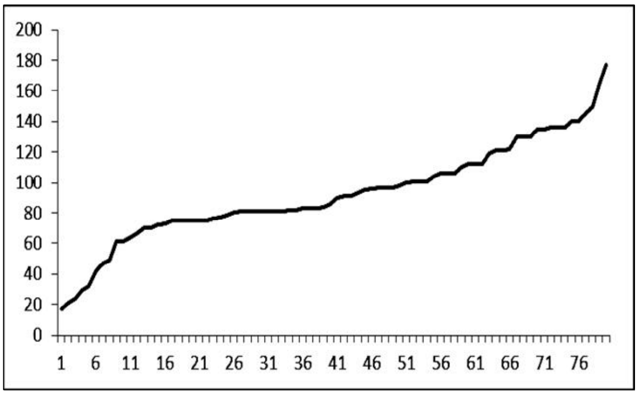

Fig. 6. Species area curve in the riparian forest.

P. pinnata, a deciduous tree is more dominant in the riparian forest than other riparian species such as *T. arjuna, Syzygium cumini, E. tubercualatus, H. parviflora*, etc. It is a pioneer species which often initiates a secondary succession in the riparian forest replacing the dominant native riparian species. With the availability of water, nutrients and successful hydrochory, the former species has rapidly invaded the riparian zones. In addition to natural events, livestock grazing also creates a suitable niche for *P. pinnata* to become dominant because it is less palatable to livestock (Daniel & Hegde 2007). The forest in the upper stretch of the river exhibited greater abundance of *H. parvilfora*, a native and endemic species, followed by *D. longan*. In the agro-ecosystem, plantation species such as *C. arabica, Salix tetraspermae,* etc. indicated the extent of utilization of the riparian zone for commercial agriculture. Species such as *Litsea floribunda, Terminalia bellerica, Syzygium* sp. and *Artocarpus integrifloia* recorded in agro-ecosystem landscape act as refugee to native biodiversity and are sparsely distributed. The rarefaction plot curve revealed a decreased tree density in forest probably because fewer individuals were sampled due to the low intensity of forest in the study area. However, the rarefaction curve for the forest was steeper than that for the agro-ecosystem, indicating that the vegetation was more diverse.

Species similarity between the forest and agro-ecosystem was low. The riparian vegetation in agro-ecosystem is found altered with small patches of single row tree cover (over < 10 m width) leading to severe loss of original habitat as observed by Zhu *et al.* (2004). Species such as *T. arjuna, Mitragyna parviflora, Garcinia xanthochymus, Myristica dactyloides, Olea dioca, Palaquium ellipticum*

Table 3. List of dominant species found in the riparian zone in forest and agroecosystem landscape, together with their density, basal area and IVI.

Forest ecosystem				Agro-ecosystem			
Species name	Density	Basal area	IVI	Species name	Density	Basal area	IVI
Terminalia arjuna Roxb.	3.8	49.1	44.1	*Pongamia pinnata* (L.) Pierre	5.2	19.4	30.9
Pongamia pinnata (L.) Pierre	6	7.14	18.4	*Ficus benghalensis* L.	1.2	24.2	19.5
Tamarindus indica L.	3.3	11.7	16.8	*Salix tetraspermae* Roxb.	2.5	13.3	19.1
Hopea parviflora Bedd.	3	14.6	16.5	*Ficus religiosa* L.	0.6	22.3	17.1
Elaeocarpus tuberculatus Roxb.	2.4	6.3	11.6	*Ficus glomerata* Roxb.	1.1	9.3	12.2
Mangifera indica L.	2.4	8.9	10.7	*Tamarindus indica* L.	0.3	13.6	10.4
Dimocarpus longan Lour.	2.5	0.02	8.6	*Mangifera indica* L.	1.6	5.8	10.4
Syzygium cumini (L.) Skeels	1.3	3.9	7.1	*Eucalyptus torticornis* Sm.	1	5.6	7.2
Diospyros malabarica Gaub.	2.4	1.07	5.6	*Pithecellobium dulce* Mart.	1.5	2.1	6.7
Madhuca latifolia Roxb.	1	3.6	5.5	*Coffea arabica* Lam.	1.9	0.8	6.6
Other species - 96 Nos.	31.6	37.1	155.2	Other species - 113 Nos.	18	68.9	159.4

dominating in the forest were not observed in the agro-ecosystem. In addition, ripicole species such as *P. ellipticum, Syzygium mundagum, M. dactyloides* and *Pinanga dicksonii* were not encountered in the agro-ecosystem. Besides grazing and sand mining, encroachments for agricultural activities along the riparian corridor have lead to a decline in these ripicole and evergreen species.

Both the forest and agro-ecosystem of the riparian zones had a good species diversity which corresponds to values reported for evergreen forests of south India (Ganesh 1996). The species diversity in the agro-ecosystem tends to decrease due to anthropogenic activities such as grazing, agricultural practices, and sand mining, similar to results of studies conducted elsewhere (Michael *et al*. 2009; Sagar *et al*. 2003).

Higher IVI of *T. arjuna* (44.1), a marshy habitat tree indicates its relative richness in forest landscape followed by *P. pinnata* (18.4), *T. indica* (16.8), *H. parviflora* (16.5) and *E. tuberculatus* (11.6). The dominance of *P. pinnata* is not a good sign of a naturally balanced riparian forest because it performs very few ecological functions than native riparian species and may increase in number and expand into new areas of the riparian zone. Riparian landscapes are susceptible to such species due to the frequency of natural disturbances which allow invasive species to propagate and establish along with the mobility provided by flowing water and the connectivity provided by riparian corridors (Verry *et al*. 2000).

Of the 123 species observed in the agro-ecosystem landscape, *P. pinnata* is the lone species with IVI > 20 indicating its dominance in terms of density and frequency in the riparian zone. Species endemic to the riparian zone such *S. cumini, S. jambose, T. arjuna, Madhuca neriifolia, Syzygium* sp., *Hydnocarpus pentandra, E. tuberculatus, M. neriifolia, P. ellipticum* and *M. dactyloides* exhibited an IVI of less than 5 showing their fragile nature in the agro-ecosystem landscape. Species such as *S. cumini, M. neriifolia, Vateria indica* and *H. pentandra* considered as true riparian (Amitha Bachan 2003) are sparsely distributed along the riparian zone of the present study area. These species are crucial for the riparian zone and their absence resulting from fragmentation could affect the composition, richness and structure of native species in the riparian corridor (Ramakrishnan *et al*. 2000), which may decline over a period of time (Tabarelli *et al*. 1999) and threaten the associated biodiversity (Nyelele *et al*. 2014).

Over-utilization of riparian zones for

agricultural activities including coffee plantation and paddy rice cultivation have led to a decline in ripicole and evergreen species such as *H. pentandra, E. tuberculatus, M. neriifolia, P. ellipticum, M. dactyloides*. Sand mining observed in the study area might also pose a threat to the existence of these native species, as it obstructs the flow of surface water, which is an essential requirement to retain soil moisture for their germination and establishment (Pamela *et al.* 2008). Several studies have demonstrated that a decline in native riparian species negatively affects the richness and diversity of avian species in the study area (Arizmendi *et al.* 2008; Edward *et al.* 2008; Hinojosa-Huerta 2006; Villasenor-Gomez 2006).

Importance of riparian buffer for river Cauvery

Of the total 318 km surveyed in the present study area, only 15.7 % of the riparian vegetation lies in protected areas. The riparian vegetation here exhibits remarkable habitat heterogeneity by supporting endangered fish species such as *Barbodes wynaadensis*, *Labio kontius, Silonia childreni* (White cat fish), and *Tor putitora* (Mahseer) (Lakra *et al.* 2010; Smakhtin *et al.* 2007); otter species (*Amblonyx cinereus*) (near threatened), smooth-coated otter (*Lutra perspicillata*) categorized as 'vulnerable' by *2004 IUCN Red List* (Shenoy *et al.* 2006); endangered Nilgiri languar (*Trachypithecus johnii*) (Sunderraj & Johnsingh 2001); Indian civet (*Viverricula indica*), Lion-tailed Macaque (*Macaca silenus*), etc. The forest landscape here acts as corridor for wildlife, specially the Asian elephants (*Elephas maximus*), as it is contiguous with large protected areas such as Nagarahole National Park, Talacauvery, Brahmagiri and Pushpagiri Wildlife Sanctuaries. In the lower stretch, riparian vegetation in the Cauvery Wildlife Sanctuary (CWS) assumes high significance for existing wildlife and rich biodiversity in these areas harbouring otters, crocodiles, grizzled giant squirrel (*Ratufa macroura*) and many varieties of fishes along with the famous Masheer. The CWS also contains the best habitat and populations for the elephants, as the study area provides connectivity to Biligiri Rangana hills Temple (BRT) Sanctuary and Mudumalai Tiger Reserve, which is in conjunction with Mysore Nilgiri corridor (largest population of Asian elephants found here) (Sukumar 1989).

Increase in population pressures and massive agricultural activities from the last few decades has put additional pressures on the river ecosystem which resulted in deteriorated water quality and soil loss in the study area (Kothyari 1996; Krishna Jayashankar 2012). Less than 10 m width of riparian vegetation is observed in agro-ecosystem landscape (84.3 % of the study area), which is far less than the minimum requirement of 30 m width (Bellows 2003) to maintain water quality and stability of the river bank besides trapping and redistributing sediments. Being a interstate river, increase in water scarcity during summer (Hoekstra *et al.* 2012) raises the problem of water allocation between the two major staking states of the southern part of India (Vanham *et al.* 2011) to most complex and contentious conditions, sometimes turned to violence and substantial loss of property (Babu *et al.* 2005; Ferdin *et al.* 2010). Hence, to avoid future disputes over water and to meet the growing demand in the region; conservation and restoration of riparian vegetation in the agricultural landscape is utmost important in this region.

Conclusions

The study confirms considerable variations in the two categorized landscapes of riparian stretch viz., forest and agro-ecosystem landscape in terms of species composition, tree density, basal area and species richness. Species similarity was low due to the shrinkage of endemic species in the agro-ecosystem landscape. Appearance of plantation species with top IVIs, confirmed a large extent of agricultural encroachment in the riparian landscape. Besides agricultural activities along the riparian landscapes, uncontrolled tourism activities are also exerting immense pressure on the riparian forests, leading to the decline in typical riparian species, consequently affecting the allied biodiversity of the river.

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