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Full Length Research Paper

Tamarinds' (*Tamarindus indica* L.) niche tree species diversity characterisation reveals conservation needs and strategies

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Recently, farmers in East Africa and some other African countries, with technical and research support from government, FAO and World Agroforestry Centre, prioritized tamarind conservation and product development to support livelihood diversification. Just like for most tropical trees; because of past low priority and research neglect, no conservation strategies were yet in place for tamarind. Knowledge on tamarind basic biology, including its niche-tree species diversity required to guide identification of appropriate holistic-economic-ecologically sound conservation strategies was lacking. The goal of this study was to generate East Africa tamarind-niche-tree species diversity knowledge. Specific objectives were to (1) determine tree species which grow in the same niche with tamarind on-farm and in wild (woodlands and riverbank) habitats and (2) assess species diversity in those niches. We therefore hypothesized similarity of species and diversity indices in tamarind-niches among habitats within and among countries in East Africa. The result show regional similarity of species but with significant variation of diversity indices among different habitats within and among similar habitats among countries; Shannon Wiener diversity index *H* is highest on-farm and poorest in riverbanks ($P < 0.05$). Evidently, farmer commitment to conservation of tamarind and its niche-tree species on-farm would cause sustainability and mitigate for poor diversity in wild habitats. However, diversity restoration in the wild habitats regionally and in all habitats in Uganda would be needed to ensure persistence and connectivity of species essential for long term conservation. Habitat type and country unique diversity indices observed also imply that localised habitat specific and not regional diversity restoration strategies will be applicable for tamarind-niche tree species conservation in East Africa. Wild habitat tree species diversity could be improved among others by enrichment planting with area specific-suitable tree species. Suitable tree species for conservation with tamarind in different habitats within and among countries are documented in this paper.

Key words: Conservation, tree species, tamarind niches, biodiversity hot spots, appraisal.

INTRODUCTION

Tamarindus indica L (*T. indica* or tamarind) belongs to the *legumnoseae* subfamily *Caesalpiniaceae,* tribe *Amherstieae* and genus *Tamarindus* (Leonard, 1957 in Diallo et al., 2007). It grows naturally widespread on-farm and in wild habitats in the topics (Gunasena and Hughes, 2000; Nyadoi, 2005; El-Sidig et al., 2006). Its products consumed domestically and used in industries include among others, soft drinks, drugs/drug additives, spices, jute, textile and timber (Gunasena and Hughes, 2000). Tamarind ornamental, shade, soil fertility improvement and boundary marker-environmental services are appre-

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ciated though management constraints are also reported (Nyadoi, 2005). Tamarind was recently prioritised for conservation and product development to support livelyhoods in East Africa and some other African countries (FAO, 2005; Jama et al., 2005). Until the recent prioritisation, tamarind utilisations have been largely upon wild populations, with no conservation strategies, the wild habitats are also threatened by increasing conversion to farm lands (Mouki et al., 2000; FAO, 2005; Nyadoi, 2005). In nature, plant species grow among others and or require the presence of other species in their niches in order to complete their own life cycles (Margules and Pressey, 2000; Fridley, 2001; Jefrey et al., 2004). Knowledge of tamarind–niche tree species was thus important to determine the species conservation needs and strategies.

The term niche in this study is used as defined by Meyer and his colleagues (Meyer- Martinez et al., 2006). Tamarind niche refers to areas where tamarind is found growing, and tamarind-niche-tree species refer to other tree species found within 18 metre radius of a tamarind tree. On-farm habitats include farm lands, settlements and administrative centres). The wild habitats refer to riverbanks and woodlands/forests. Considered a largely wild species until recently (Nyadoi et al., 2009), tamarind niche attributes such as niche-tree species were not yet uncharacterized in East Africa. The strategies required to ensure holistic economically optimum ecologically sound conservation of tamarind was thus unknown. Climate change adaptation researches have shown that tree resources will be needed not only for their economic values but also for maintaining resilience of agricultural production systems (Sinha et al. 1996; Tiffen and Mortimore, 2002; Dale, 2004). Tamarind enhancement of crop production through nitrogen fixation has been reported (Yoneyama, 1992). Conservation of tamarind with other ecologically compatible-economically important tree species within in its niches would also ensure sustainable raw material supply for planned tree products development industry.

In literature, spatial distribution of species and diversity within and among plant communities are the result of their shared or disparity evolutionary dynamics (Vellend and Geber, 2005; Ma, 2006; Kreft and Jetz, 2007). Diversity is in particular influenced by selection, drift, migrations, reproductive systems and mutations in interaction with each other and environment (Vellend and Gebber, 2005). Environment factors of species diversity includes habitats, climate, vegetation types, topography and others (Margules and Pressey, 2000; Vellend and Geber, 2005; Kreft and Jetz, 2007). Recently, a global study found that combined effect of a range of environment /climatic factors acting at regional and or local scales determine the spatial and temporal diversity of species (Allen, 2001; Ma, 2006; Kreft and Jetz, 2007). Detailed knowledge of species diversity in different habitats and niches of conservation targeted species is thus important for identification of conservation strategies (Kent and Cocker, 1992; Jefrey *et al*., 2004). For tamarind, a study on its niche tree species reported similarity in diversity in wild habitats and higher diversity on-farm, with *Ficus*, *Octea usambarensi, Terminalia brownie* as some of the common species. Given the dynamic, spatial-temporally heterogeneous nature of species diversity factors, it was questionable whether knowledge from one study site would be applicable for tamarind and its niche-tree species conservation regionally or even in other diverse local environments. There was thus need to carry out comprehensive assessment of species diversity in tamarind niches East Africa wide to generate reliable knowledge for conservation strategies design.

A number of analytical tools exist for species diversity assessments, for example, Shannon Weiner and Bray and Curtis diversity indices (Shannon, 1948; Bray and Curtis, 1957; Kent and Coker, 1992, 2000). Shannon Weiner species diversity index H *(*α diversity) provide information on species richness, relative abundance, rarity or commonness of different species and Evenness (H_E) measure how equal the numbers of individuals of different species are in a sample or community. Shannon H is derived as

$$H = -\sum_{i=1}^{S} p_i \ln p_i \qquad (1)$$

Where**,** H is the diversity in a sample of S species, S the number of species in the sample, P_i the relative abundance of i^{th} species or kinds measures = n_i/N, where N is the total number of individuals of all species/kinds, n_i the number of individuals of i_{th} species and l_n is the natural logarithm to the base ten. The value of *H* ranges from 0 meaning every species in the sample is the same i.e. no diversity to 4.6 signifying high species richness and that different species in the sample or community are equally abundant (Magurran, 2004). Shannon species evenness index H_E is given by

$$H_E=H/H_{max}=H/\ln S \qquad (2)$$

Its values range from 0 (complete unevenness) to 1 (the different species occur in equal numbers). These diversity indices can further statistically analysed for variance using for example the *t*-tests and inference used to guide management strategies. At least five individuals per community are needed to enable statistical analyses.

In other studies, it has been shown that knowledge of species diversity at community (β diversity) or ecological levels (γ diversity) are important for proper identification of landscape level conservation strategies (Kent and Cocker, 1992; Jefrey et al., 2004). Bray and Curtis similarity index (Sc), is widely used for species community studies because of its amenability to diverse ecological data and scale of comparisons or assessments (Bray and Curtis, 1957; Jefrey et al., 2004). It is derived from the distribution abundance of different species within or among communities as follows;

$$S_C = 2\sum_{i=1}^{m}\min(x_i; y_i) / \sum_{i=1}^{m} x_i + \sum_{i=1}^{m} y_i \quad 3$$

Where X_i, Y_i are the abundance of the i^{th} species, $\sum_{i=1}^{m}\min(x_i; y_i)$ are the sums of the less scores of the i^{th} species in the sample, m is total number of species in the sample. The dissimilarity coefficient (Dc) derived as

Dc=1–Sc. 4

The Sc/Dc matrix is used to generate dendrograms (clusters of species associations). The consistence of generated dendrograms are inferred using confidence intervals or boot strap analyses and this analytical tools are incorporated in most Soft Ware programmes, PAST (Hammer and Harper, 2005) being one of them. The paleontological statistical soft ware is also gives information on past species extinction if occurred in studied sites.

Sampling and data collection considerations for species diversity studies

Transects have been commonly applied to riparian habitats and circular plots in tropical forested landscapes (Kent and Coker, 1992, 2000). Standard circular plots of 0.1 hectares (18 m radius) are widely used for studying trees because it is easy to delineate plot boundary in the field and therefore minimise sampling error during inventories. Except for some analytical tools such as Shannon and Bray and Curtis diversity indices, unequal sample sizes and differences in plot shapes are sources of error (Bharati et al., 2004). In addition to plot and sample size considerations, different approaches exist for sampling individuals for population studies. In stratify-cation, populations under investigation are divided up into sub groups within which there is homogeneity and among which there are obvious differences (Rolf and Sokal, 1995). Randomization is another sampling technique where individuals are sampled at random but for tree species, randomisation can be rendered impossible by inaccessibility of selected random sample individuals in habitats. Systematic random sampling is where individuals are sampled at regular or systematic intervals as fixed by the researcher. In general, sampling strategy adopted depends on the objective of study, variables under study and statistical analysis requirements. For Shannon diversity indices, at least five species individuals per unit of comparisons are needed but numbers of samples do not have to equal (Manguran, 2004). Bray and Curtis diversity indices are also amenable to differences in sample sizes and or ecological scales of analysis (Jefrey et al., 2004).

Based on the literature above, it is clear that characterisation of tamarind-niche tree species diversity in East Africa was necessary to identify appropriate holistic conservation strategies to meet the planned objectives for the species conservation. It is also clear that Shannon Wiener and Bray and Curtis species diversity indices would help generate the required knowledge for identification and design of the conservation strategies. These indices particularly enabled comparative species diversity analysis for un-equal sample sizes among different habitats within and among countries in East Africa. Sample sizes were unequal as riverbanks and woodlands are fewer than on-farm habitats of tamarind in studied sites. However comparability was additionally enhanced by the constancy of sampling units among habitats across sites (0.1 hectare plots used in species enumeration for diversity analysis). As stated in abstract, the goal of the current study was to generate knowledge of tamarind niche-tree species diversity in order to elucidate conservation needs and guidelines for designing conservation strategies. Specific objectives addressed in the study were to;

(1) Determine tree species which grow in the same niches with tamarind in woodlands, on-farm and riverbank habitats in East Africa.
(2) Assess and compare tree species diversity in tamarind niches on-farm, in woodland and riverbank habitats in East Africa.

To achieve these objectives, a hypothesis that tamarind-niche-tree species and species diversity is similar East Africa wide due to shared evolutionary factors was evaluated.

MATERIALS AND METHODS

Study area and data collection

This study was restricted to East Africa tamarind populations in Kenya, Tanzania (Mainland and Zanzibar) and Uganda (Nyadoi et al., 2009). The units of comparison were on-farm, woodland and riverbank habitats but sites selection criteria was based on tamarind availability-sites being representative of tamarind niches in the Island- mainland, latitudes North above and South below equator, different vegetation types -phytocoria and climatic zones in East Africa. Tamarind trees sampling within habitats is described elsewhere (Nyadoi et al., 2009). For each sampled tamarind in a habitat, 18 m radius plot was established with the tamarind tree as centre of the plot. All tree species found in the plot were enumerated and recorded with the help of a botanist/plant collector and country specific Floras of East Africa (Mbuya et al., 1994; Katende et al., 1995, 1999; Mbuya et al., 1994). Geographic-GIS data were collected and used to generate study sites within the East African map (Nyadoi et al., 2009). The number-of sampled plots among habitats were different as riverbanks and woodlands are few compared to on-farm in all sampled sites. Exhaustive sampling of all riverbanks and woodlands found in study sites were done. Additionally, enumeration of tree species in tamarind niches was done in 18 m radius circular plots uniformly in all habitats. Thus comparison and species diversity indices analysis were based on uniform sample units among habitats as recommendable for biodiversity studies (Margules and Pressey, 2000). Where as Shannon and Bray and Curtis analytical tools for diversity indices amenable to comparative analyses of unequal sample size in vegetation studies (Jefrey et al., 2004) were used to enable comparative analyses for unequal sample sizes among different habitats within countries and among countries. Further more, sampling errors were minimized by adoption of 18 m radius circular plots. Species were enumerated in 117 plots in 117 farms of which 46 were from Uganda, 47 from Kenya an 34 from Tanzania (on-farm), 47 plots in woodlands of which 12 were from Uganda, 13 from Tanzania and the rest from Kenya and 23 in riverbanks of which four were from Uganda, nine from Tanzania and 14 from Kenya.

Data management and analysis

Each tree species recorded in tamarind niche plots was scored using binary approach - presence (1) and absence (0) in all the 187 plots inventoried. Each plot was grouped by its habitat type and country identity. A table of regional species list and their respective frequencies among all plots per habitat and country were generated. The binary data was loaded into PAST- Paleontological Statistical Package (Hammer and Harper, 2005). The means and lower and upper limit estimates of Shannon Wiener diversity indices; species richness S, relative abundance P_i, diversity indices (H, H_E,) for each habitat type in each country were generated using the standard approach (Equations 1 and 2) as implemented in PAST. The Shannon diversity index H generated for the different habitats within and similar habitats among countries were then comparatively analysed using the ANOVA *t*-test as implemented in PAST. Bray and Curtis similarity coefficients between species were calculated and used to generate their association dendrograms as implemented in PAST. The consistence (how robust the generated species association dendrogram is) was inferred using bootstrap and confidence interval (CI) analysis in PAST.

RESULTS

Species diversity in tamarind niches in East Africa

Based on 46 plots from Uganda, 47 from Kenya and 34 from Tanzania on-farm, 12 plots from Uganda, 13 from Tanzania and 22 from Kenya woodlands and 4 plots from Uganda, 9 from Tanzania and 14 from Kenya river banks (187 plots sampled in tamarind niches East Africa wide, Appendix 1); 725 individuals composed of 171 different species of 57 different families were found. Overall, species diversity was high but evenness low (H = 4.07 and H_E = 0.34, Table 1) and the common species were among others *Senna spectabilis*, *Cascabela thevetia* and *Mangifera indica* (Appendix 2). Species families diversity was low regionally (H = 3.67, H_E = 0.69, Table 1 and Appendix 2) and species distribution pattern were similar; few species dominant while majority have similar low abundances regionally and at country or habitat levels (Figures 1 - 13).

There were 129 tree species in tamarind niches on-farm regionally, among these, *Mangifera indica*, *Carica Papaya*, *Azadiracta indica*, *bananas*, *Cocos nucifera*, *Sena spectabilis*, *Cascabela thevetia*, *Acaccia tortolis* and *Psidium quajave* were common (H = 3.86, H_E = 0.36, Table 1 and Appendix 3). In the woodlands regionally 96 species were found, the *Acacias* and c*ommiphora* were dominant (H = 3.94, H_E =0.53, Table 1 and Appendix 4). In riverbanks regionally, the *Acaccias*, *Combretum* and *Terminalia* were common among 69 species found (H = 3.69, H_E = 0.55, Table 1, Appendix 5). Country wise, species richness was 45 (Uganda), 69 (Kenya) and 58 in Tanzania on-farms, in woodlands, species richness was 30 (Uganda), 51 (Kenya) and 41 in Tanzania and in riverbanks, species richness were 10 (Uganda), 42 (Kenya) and 30 in Tanzania (Table 1).

Analysis of variances frame work as implemented in PAST revealed that the mean of Shannon H on farm among the countries (Kenya, Uganda and Tanzania) was 3.37 (t = 19.26 and P = 0.003 for variation in Shannon H on-farm among the countries). Shannon H mean in woodlands among countries (Kenya, Uganda and Tanzania) was 3.31 (t = 24.42 and P = 0.002 for variation in Shannon H in woodlands among the countries). The mean of Shannon H in riverbanks among countries (Kenya, Uganda and Tanzania) was 3.85 (t = 8.57, P = 0.01 for variation in Shannon H in riverbanks among the countries). Among different habitats within countries, Shannon H mean was 2.76, t = 9.99 and P = 0.01 in Uganda, Shannon H mean was 3.31, t = 22.54 and P = 0.002 in Tanzania and Shannon H mean was 3.46, t = 45.66 and P = 0.001 in Kenya.

Groups of species association in tamarind niches include among others tamarind with *Mangifera indica*, *Carica papaya*, *Vernomia amygadeleine*, *Musa species* (banana), *Cafea robusta*, *Persea americana*, *Artocarpus heterophylum*, *Psidium quajave*, *Citrus cinensis* and *P. fragrani* (S_c = 1or 100%, at 95% CI, Figure 5). Rare species in tamain niches included *Albizia lebbeck*, *M. zanzibarica*, *T. catapa* and *P. Juliflora* (S_c < 0.1, 95% CI, Figure 14). Fabaceae was the most common family in tamarind niches, it associated with Euphorbiaceae among others (Sc = 100, 95% CI, Figure 15, Appendix 2).

DISCUSSIONS

Regionally, similar tree species occur in tamarind niches, the most common ones are *Mangifera indica* (Anarcadiaceae), *Carica papaya* (Caricacaceae), *Azadiracta indica* (Meliaceae) and *Cordia* species (Borignaceae). Below the regional scale, differences in diversity indices occur among habitats and among similar habitats among countries (species-habitat and or species-country relationship exhibited). Among countries, the diversity differences may have been the impact of differences in socio-economic-cultural valuation, exploitation and management of different tree species. Commonality of *Cocos nucifera* and *Azadiracta indica* in *tamarind niches* on farm in Kenya possibly mean they are valued and conserved by farmers. The same would hold for M*angifera indica and Citrus cinensis* in Uganda on-farm or *Carica papaya* in Tanzania. Generally poor species diversity in all habi-

Table 1. Species diversity in tamarind niches in East Africa.

Spatial scale of species study	Species richness (S)	Number of individuals (i)	Shannon H diversity index	Shannon Species evenness H_E
Overall regional	171 (130-148)*	725 (725-725)	4.07 (3.81-4.08)	0.34 (0.33-0.41)
On-farm regional	129 (92-108)	460 (460-460)	3.86 (3.55-3.85)	0.37 (0.36-0.46)
Woodlands regional	96 (65-79)	211(211-211)	3.94 (3.48-3.86)	0.54 (0.47-0.64)
Riverbank regional	69 (44-56)	140 (140-140)	3.64 (3.14-3.59)	0.55 (0.48-0.68)
Country level				
On-farm Uganda	45 (30-40)	146 (146-146)	3.02 (2.60-3.08)	0.46 (0.41-0.59)
On-farm Kenya	69 (47-58)	188 (188-188)	3.59 (3.18-3.56)	0.52 (0.48-0.64)
On-farm Tanzania	58 (38-48)	128 (128-128)	3.49 (3.01-3.46)	0.57 (0.49-0.70)
Woodlands Uganda	30 (18-26)	58 (58-58)	3.04 (2.46-2.99)	0.69 (0.60-0.83)
Woodlands Kenya	51 (32-42)	93 (93-93)	3.47 (2.91-3.39)	0.63(0.54-0.75)
Woodland-Tanzania	41(27-35)	82 (82-82)	3.42 (2.91-3.33)	0.75 (0.64-0.84)
Riverbanks Uganda	10 (5-9)	12 (12-12)	2.21 (1.35-2.4)	0.91 (0.73-0.96)
Riverbanks Kenya	42 (26-35)	78 (78-78)	3.32 (2.77-3.24)	0.66 (0.57-0.79)
Riverbank Tanzania	30(17-25)	53 (53-53)	3.02 (2.41-2.96)	0.67 (0.59-0.83)
Regional Species families	57 (41-51)	171 (171-171)	3.67 (3.33-3.61)	0.69 (0.64-0.77)

*(130-148) lower and upper limits estimates of diversity indices (S, i,H and H_E) calculated using Shannon Wiener diversity analytical tool as implemented in the Soft ware PAST by Hammer and Harper, (2005).

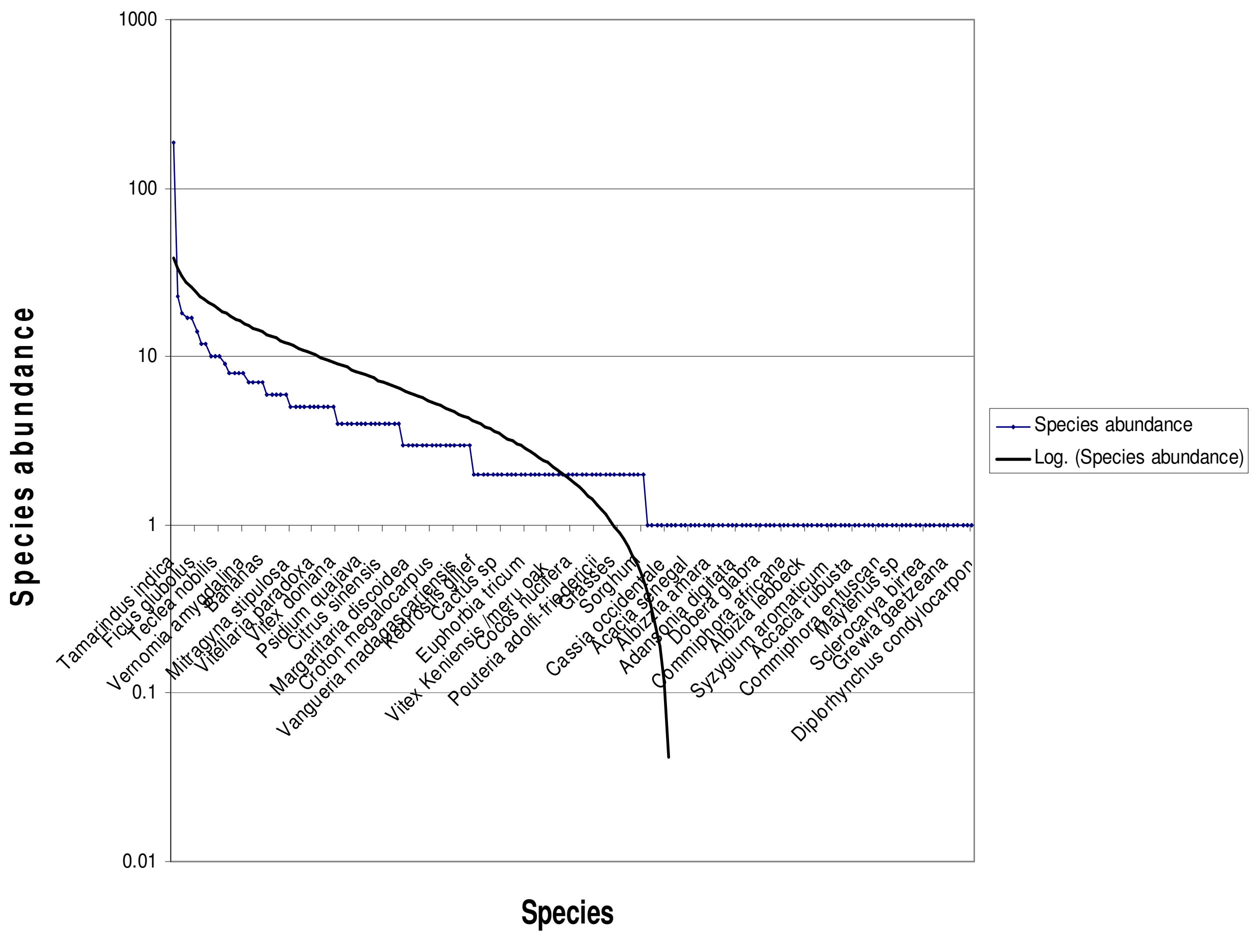

Figure 1. Abundance curve-tree species in tamarind niches in East Africa (N = 725 and S = 171 from 187 plots) generated using excel analysis tools of the Microsoft Excel computer soft ware programme.

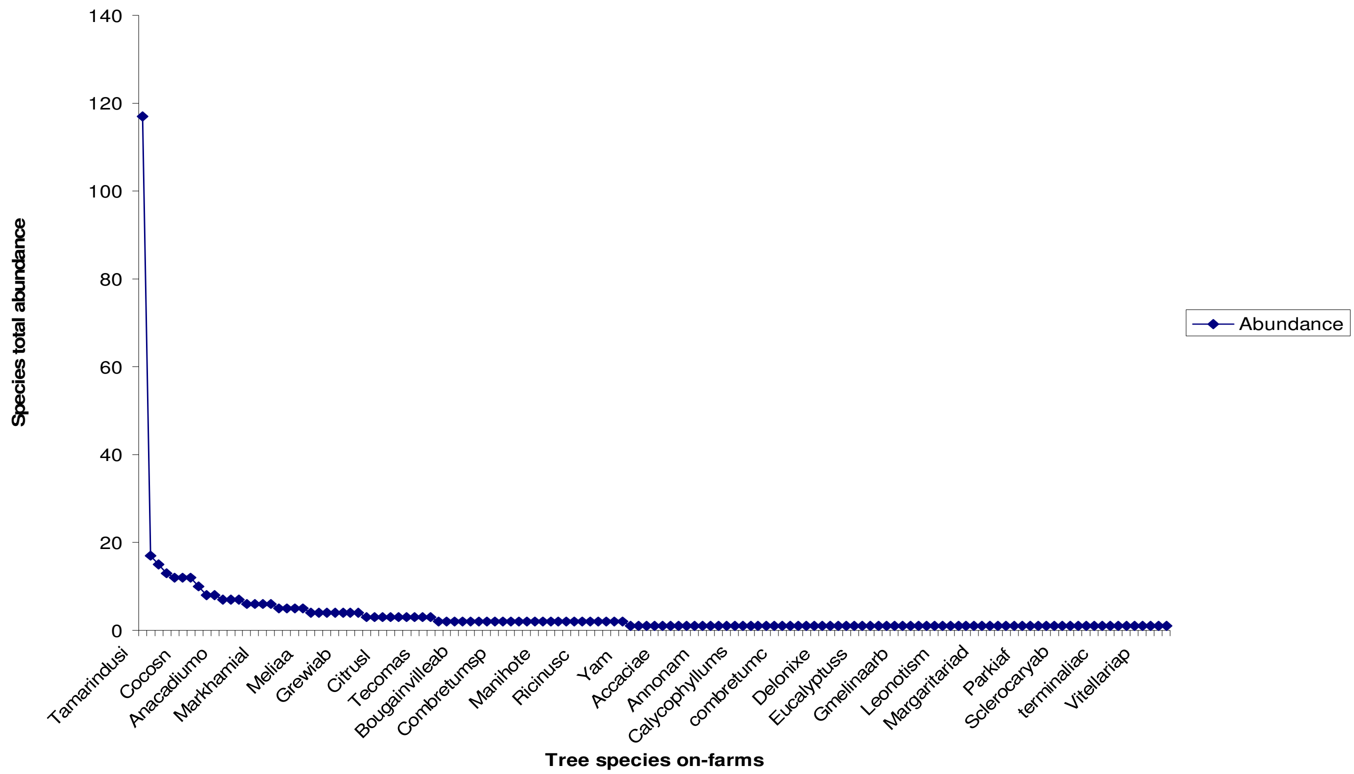

Figure 2. Abundance curve- tree species in tamarind niches on farms in East Africa (N = 460 and S = 129 from 117 plots).

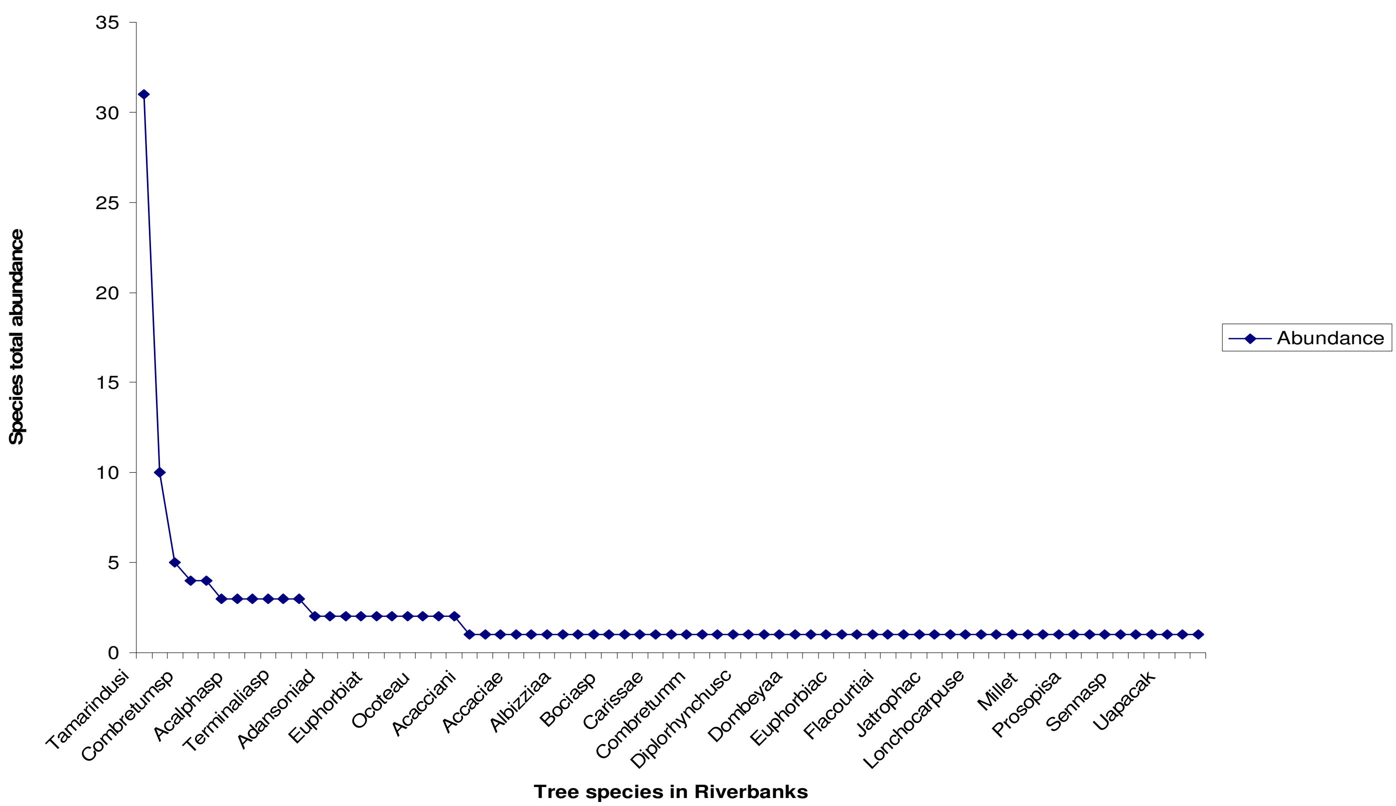

Figure 3. Abundance curve- tree species in tamarind niches in Riverbanks in East Africa.

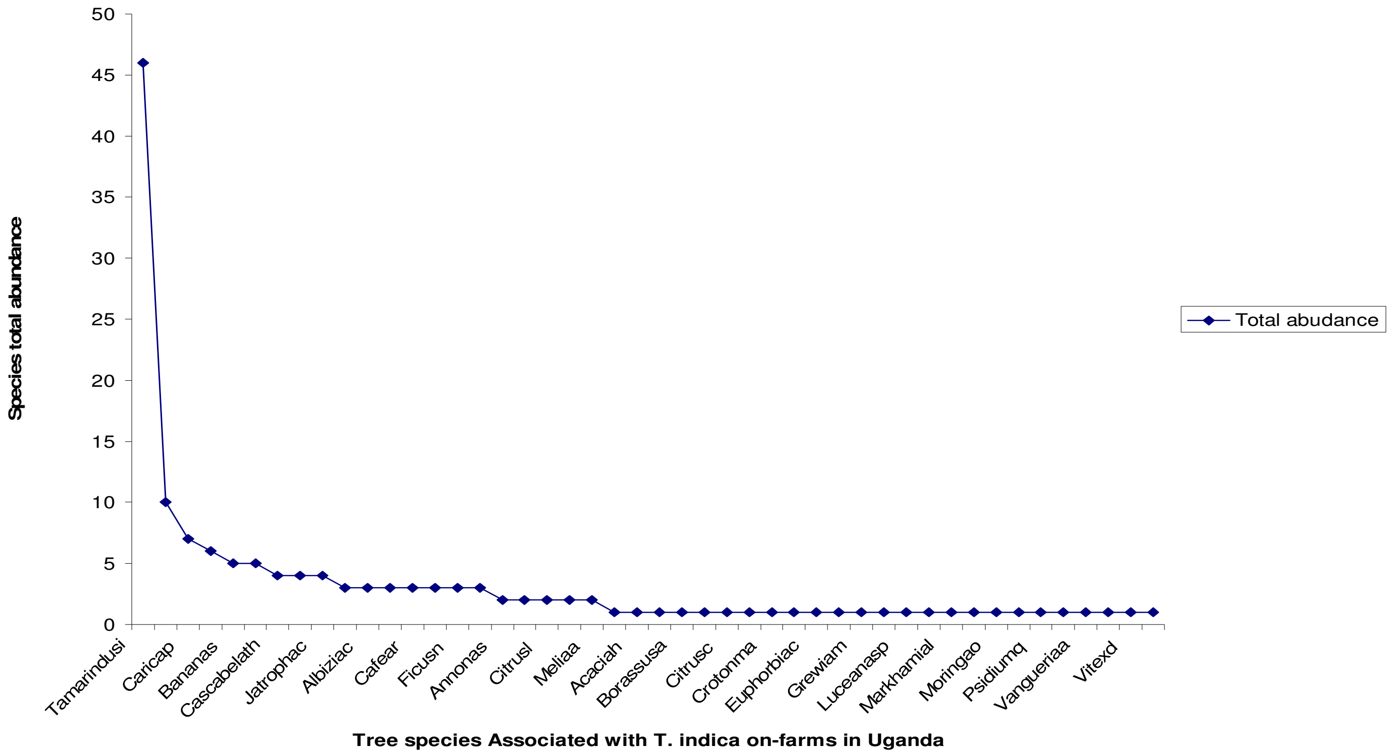

Figure 4. Abundance curve- tree species in tamarind niches on-farm in Uganda.

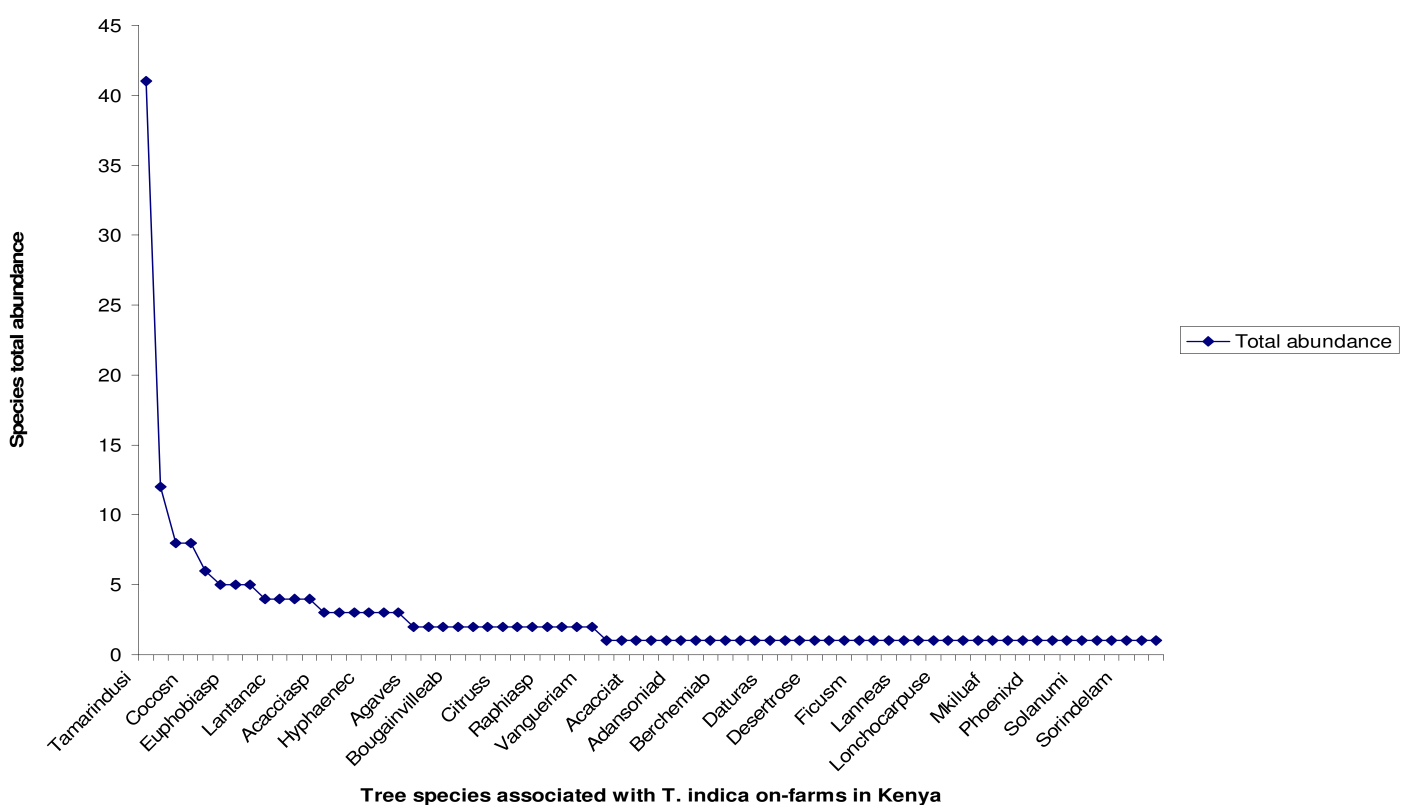

Figure 5. Abundance curve-tree species in tamarind niches on-farm in Kenya.

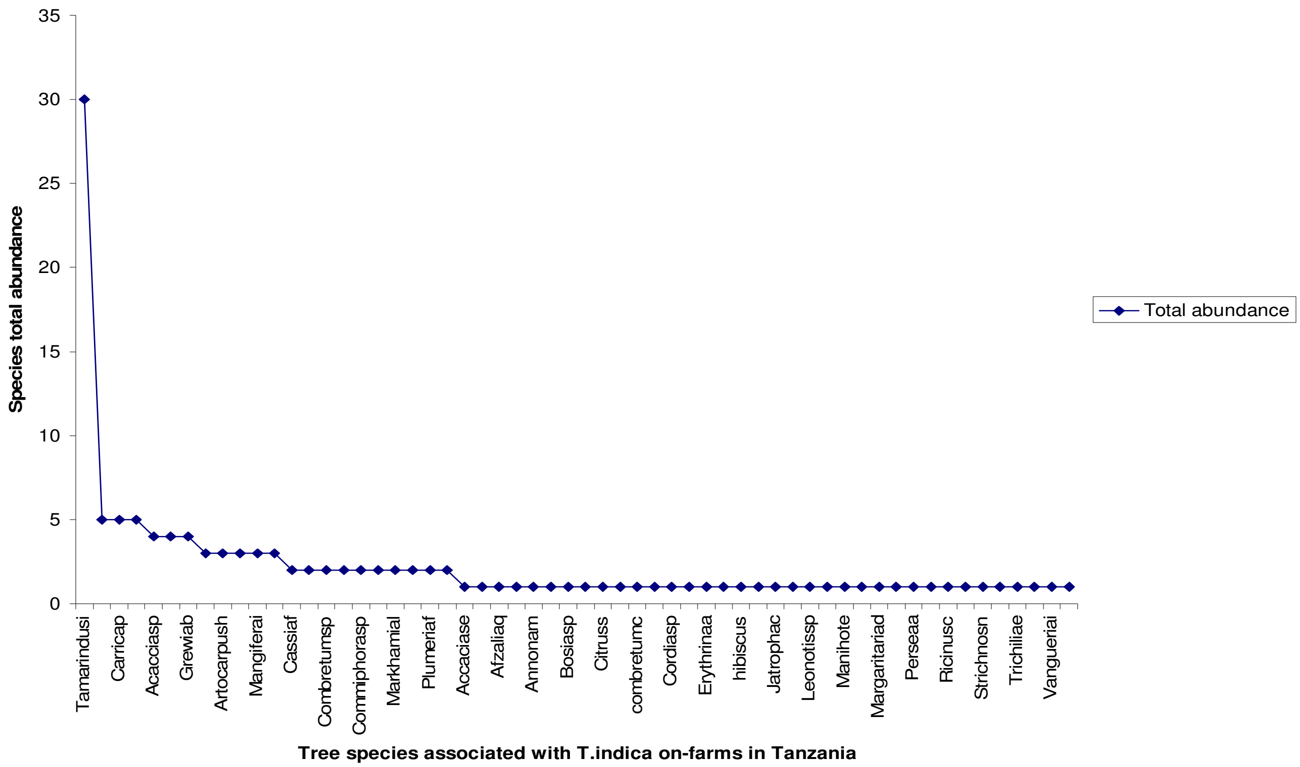

Figure 6. Abundance curve-tree species in tamarind niches on farms in Tanzania.

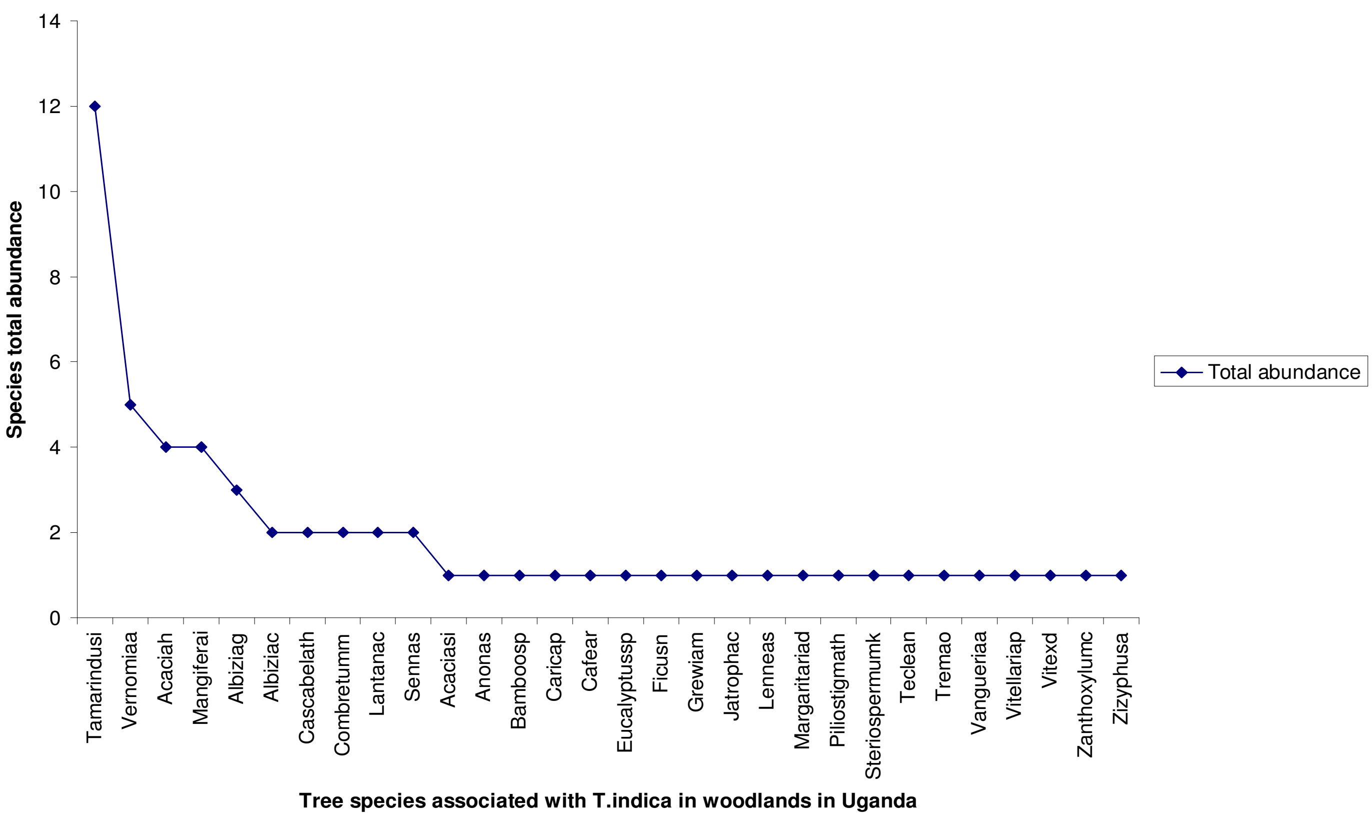

Figure 7. Abundance curve- tree species in tamarind niches in woodlands in Uganda.

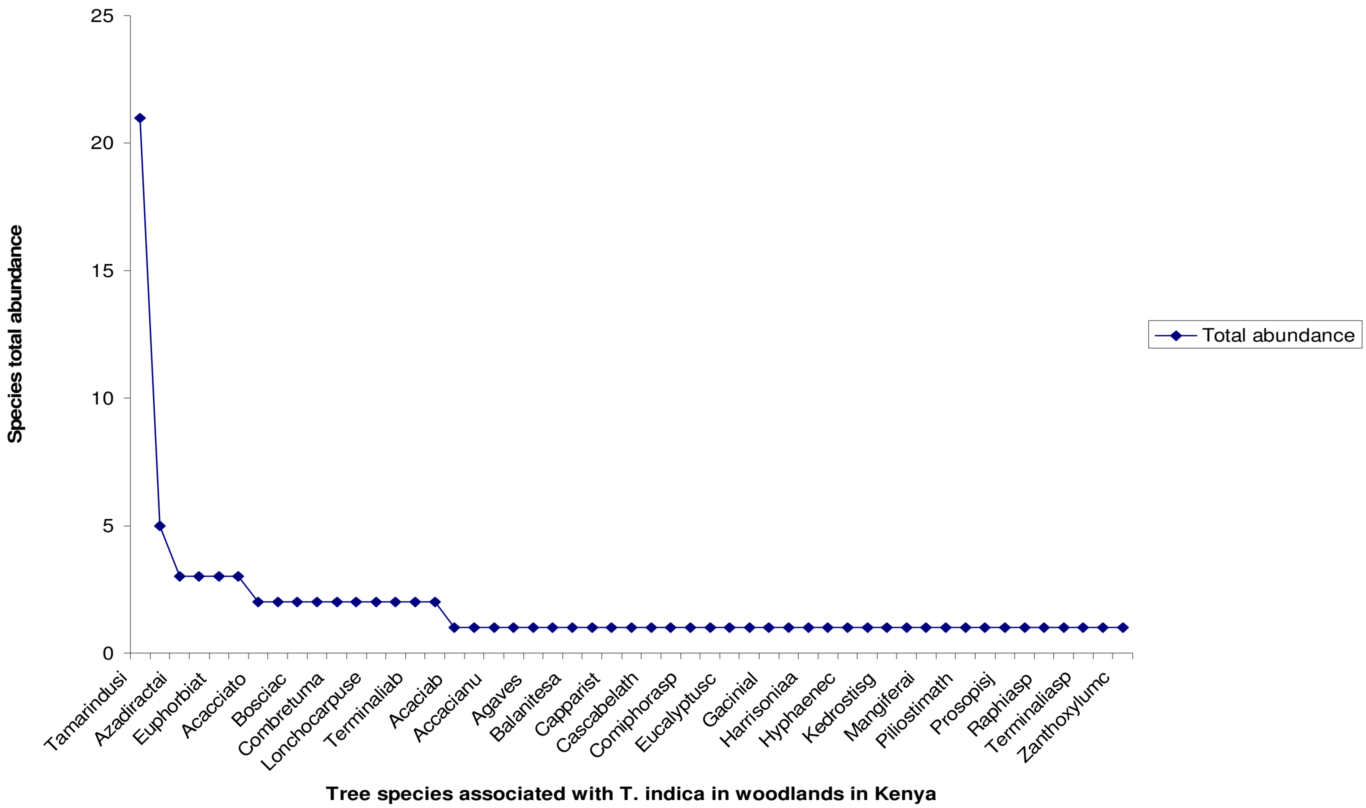

Figure 8. Abundance curve for tree species in tamarind niches in woodlands in Kenya.

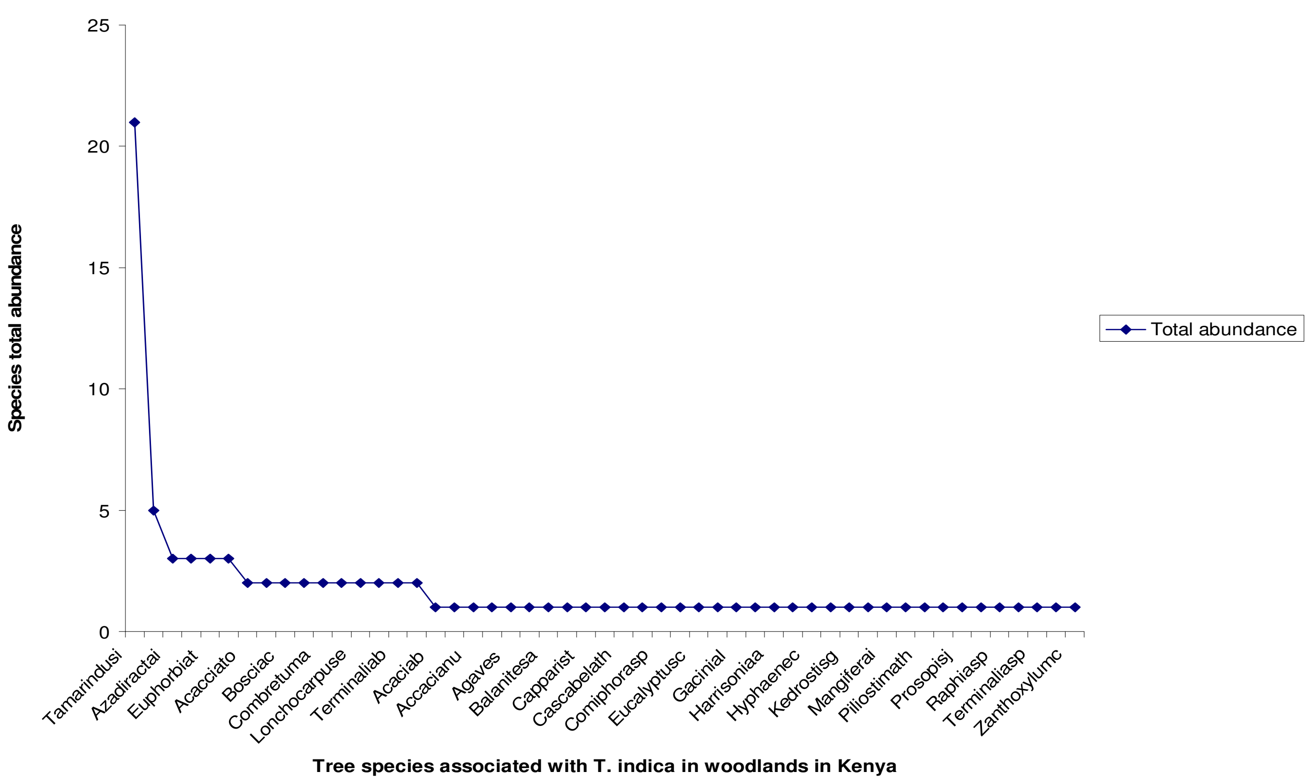

Figure 9. Abundance curve-tree species in tamarind niches in woodlands in Kenya.

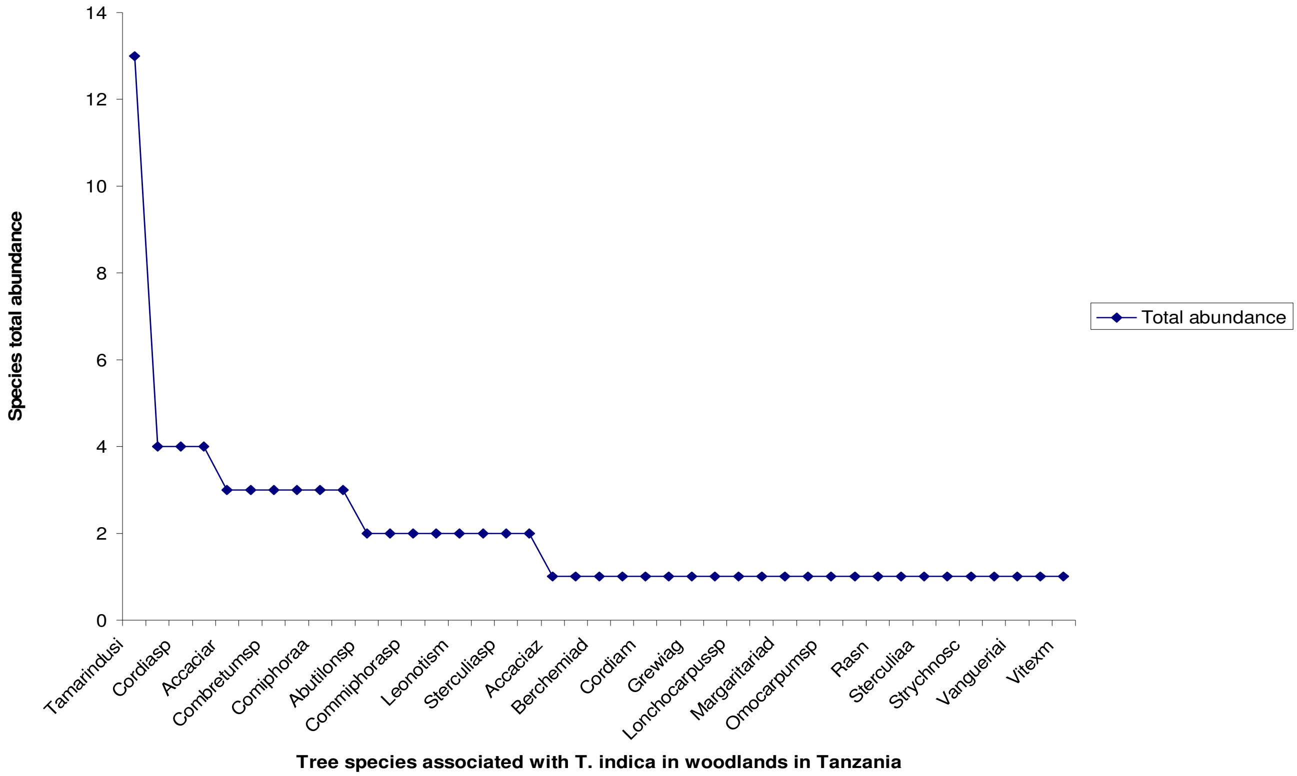

Figure 10. Abundance curve-tree species in tamarind niches in woodlands in Tanzania.

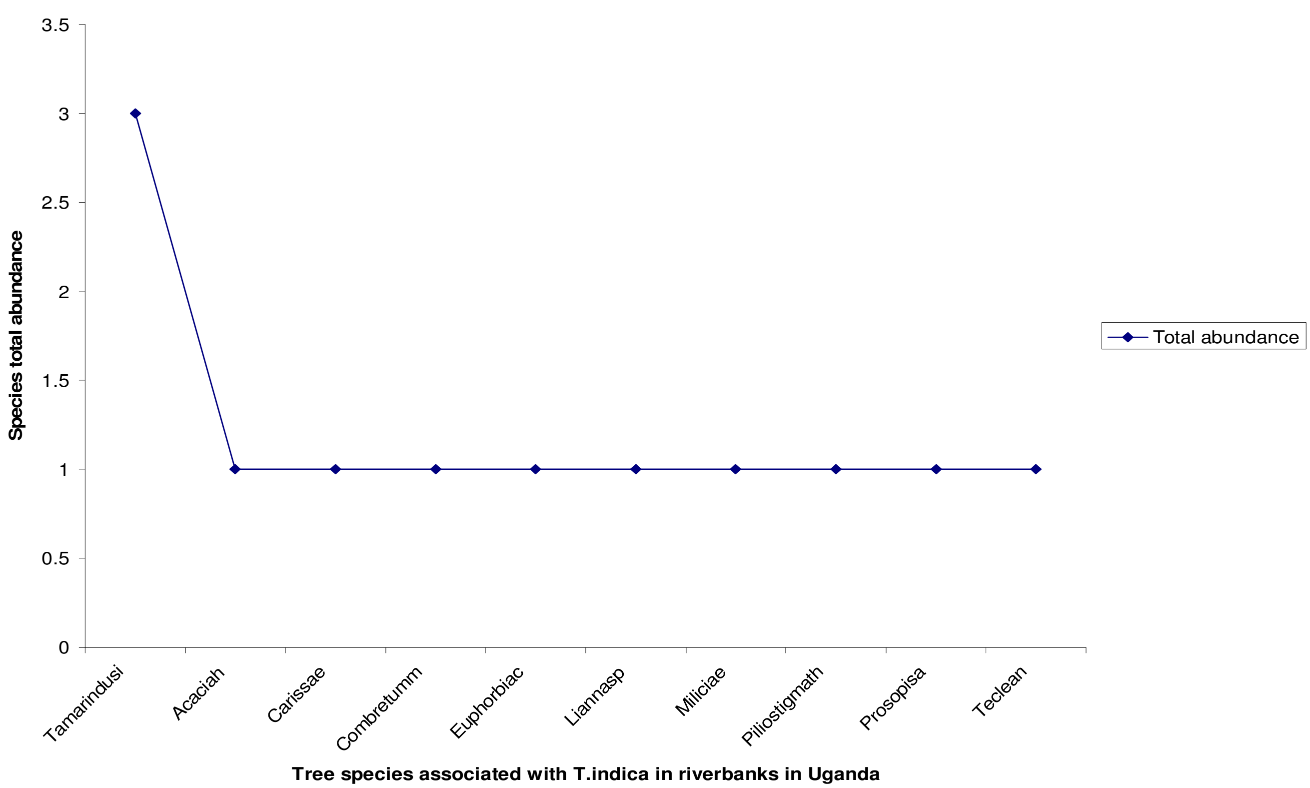

Figure 11. Abundance curve- tree species in tamarind niches in Riverbanks in Uganda.

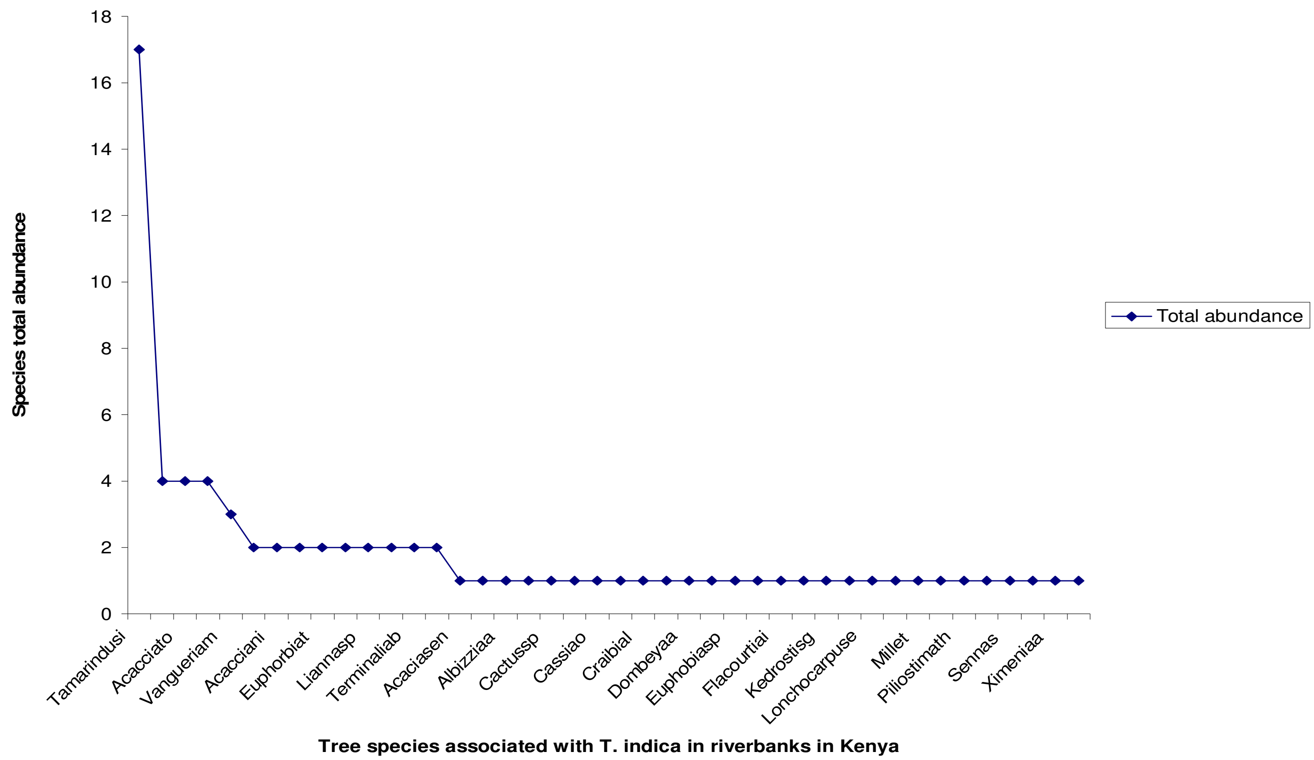

Figure 12. Abundance curve-tree species in tamarind niches in Riverbanks in Kenya.

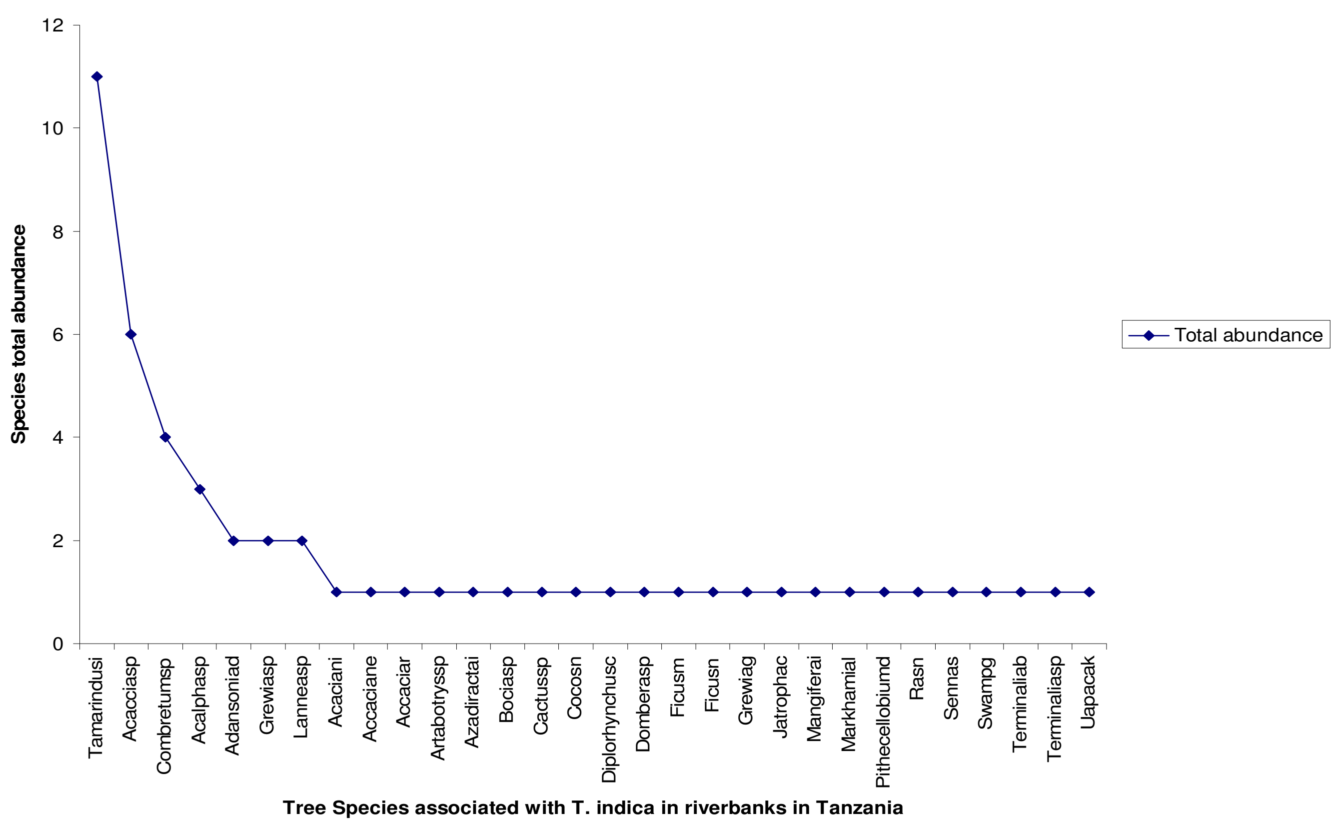

Figure 13. Abundance curve- tree species in tamarind niches in Riverbanks in Tanzania.

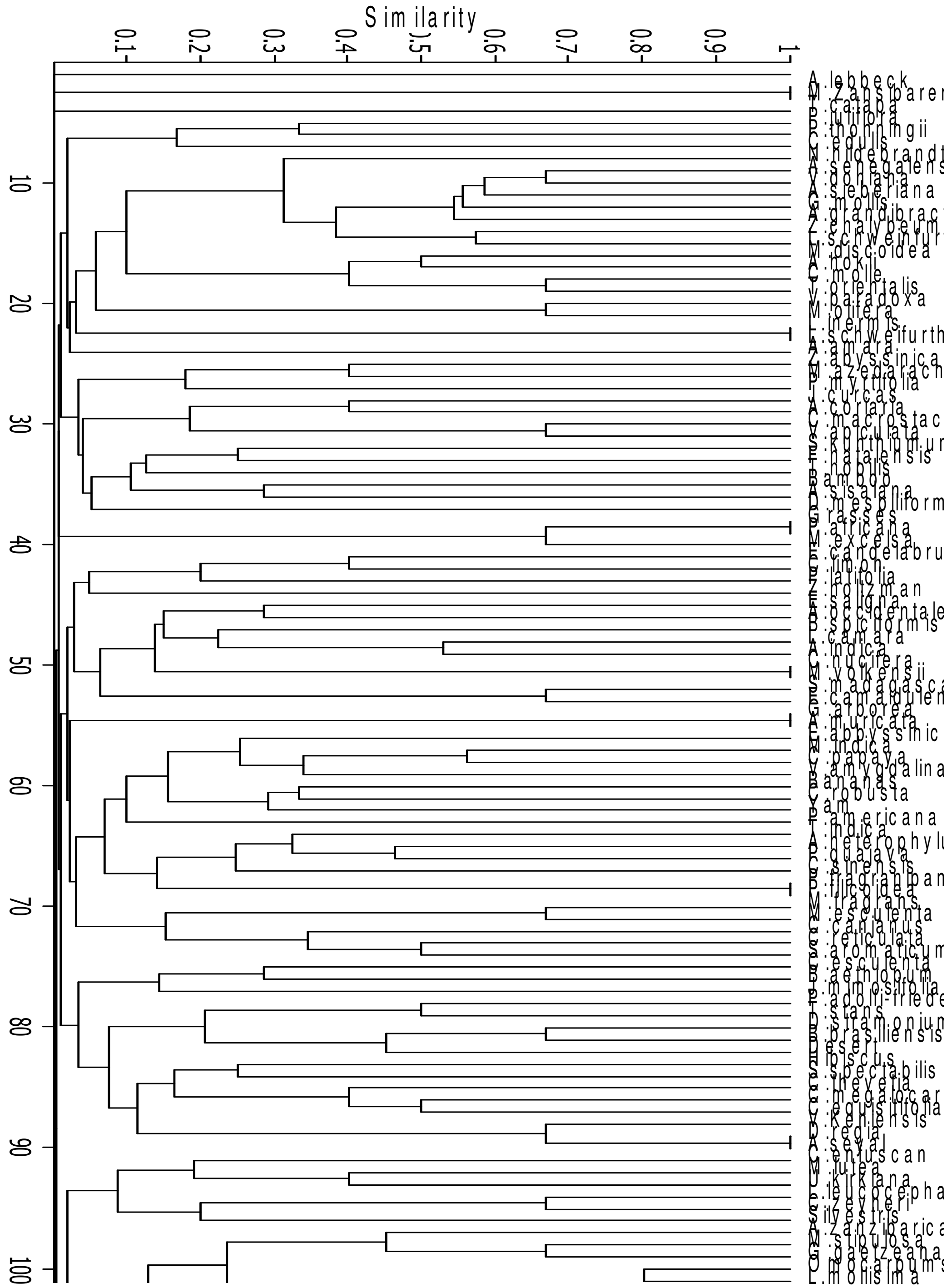

Figure 14. Bray Curtis - Regional similarity dendrograms for tree species found within tamarind niches in East Africa (N = 725 and S = 171 from 187 plots, Boot strap, 95% CI, associations derived based on similarity coefficients- similarity between species) species diversity analyses as implemented in PAST developed by Hammer and Harper, (2005).

*The figure is rotated for proper view, the X axis is up (0.1 - 1 indicating similarity coefficient between species, the basis of groups of association generated, 10 - 100 refer to scale of groups).

tats in Uganda could be due to general lack of conservation practice for trees. Implementation of Uganda's conservation/forestry policies has been limited to few and mostly commercial timber species (some of them exotics)

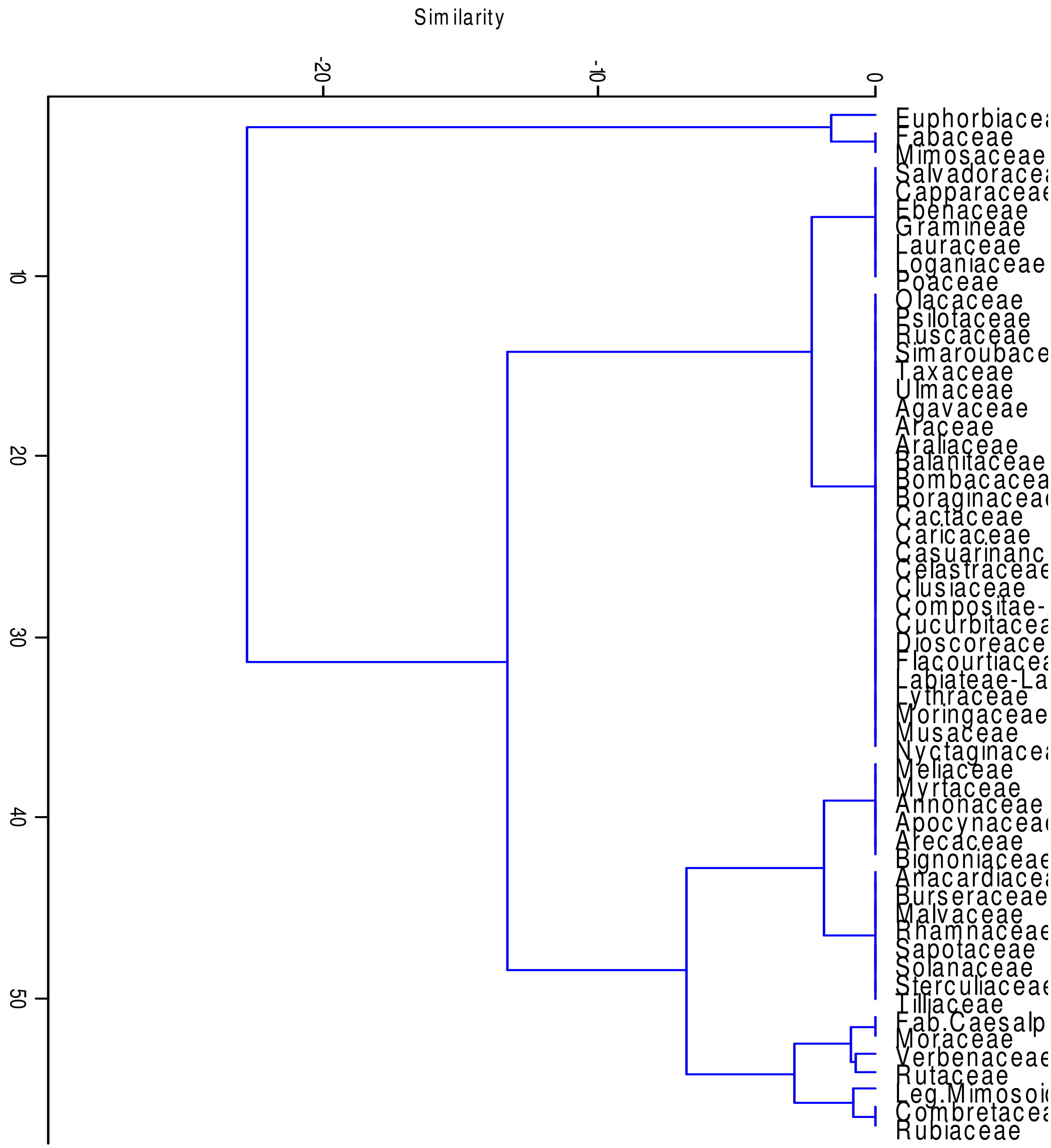

Figure 15. Similarity dendrograms -tree species families in tamarind niches in East Africa (N = 725 and S = 171 from 187 plots, Boot strap, 95% CI, Wards method, associations derived based on similarity coefficients-similarity between families) diversity analyses as implemented in PAST developed by Hammer and Harper, (2005).*The figure is rotated for proper view, the X axis is up (0.1 - 1 indicating similarity coefficient between families, 10 -100 refer to scale of group display).

in Central Forest Reserves and buffer zones. This is despite of good policies on on-farm and wild habitats biodiversity conservation (Republic of Uganda, 2001). The West Nile and Northern Uganda region where this study was carried out has been a war zone for the past 20 years. Insecurity may have led to removal or no planting of tree species. Tobacco and cotton are also the main cash crops in this region. Tree planting may have been fore gone and tobacco and or cotton grown on-farm. The trees may have been cut from wild and on-farm habitats to provide wood for tobacco processing.

High species diversity in Kenya may be the result of

Appendix 1. Table of tree species in tamarind niches in East Africa.

Species family	Species names	Total abundance	Proportional abundance	Rank
Fabaceae-Caesalpiniaceae	Tamarindus indica	188	0.259	1
Fabaceae-Caesalpiniaceae	Senna spectabilis(Cassia siamea)	23	0.032	2
Apocynaceae	Cascabela thevetia	18	0.025	3
Anacardiaceae	Mangifera indica	17	0.023	4
Meliaceae	Melia azedarach	17	0.023	4
Moraceae	Ficus glubolus	14	0.019	5
Euphorbiaceae	Manihot esculenta	12	0.017	6
Leguminosae-Mimosoideae	Albizia coriaria	12	0.017	6
Leguminosae-Caesalpinioideae	Piliostigma thonningii	10	0.014	7
Rubiaceae	Cafea robusta	10	0.014	7
Rutaceae	Teclea nobilis	10	0.014	7
Leguminosae-Mimosoideae	Prosopis Africana	9	0.012	8
Euphorbiaceae	Euphorbia candelabrum	8	0.011	9
Moraceae	Milicia excelsa	8	0.011	9
Caricaceae	Carica papaya	8	0.011	9
Compositae/Asteraceae	Vernomia amygdalina	8	0.011	9
Bignoniaceae	Markhamia lutea	7	0.010	10
Annonaceae	Annona senegalensis	7	0.010	10
Moraceae	Ficus natalensis	7	0.010	10
Gramineae (Poaceae)	Bamboo sp	7	0.010	10
Musaceae	Bananas	6	0.008	11
Lauraceae	Persea Americana	6	0.008	11
Dioscoreaceae	Yam	6	0.008	11
Moraceae	Artocarpus heterophylus	6	0.008	11
Rutaceae	Citrus limon	6	0.008	11
Rubiaceae	Mitragyna stipulosa	5	0.007	12
Rhamnaceae	Zizyphus abyssinica	5	0.007	12
Mimosaceae	Acaccia hokii	5	0.007	12
Ulmaceae	Trema orientalis	5	0.007	12
Combretaceae	Combretum molle	5	0.007	12
Sapotaceae	Vitellaria paradoxa	5	0.007	12
Euphorbiaceae	Jatropha curcas	5	0.007	12
Agavaceae	Agave sisalana	5	0.007	12
Ebenaceae	Diospyros mespiliformis	5	0.007	12
Apocynaceae	Carissa edulis	5	0.007	12
Verbenaceae	Vitex doniana	4	0.006	13
Taxaceae	Podocarpus latifolia	4	0.006	13
Anacardiaceae	Anacardium occidentale	4	0.006	13
Euphorbiaceae	Croton macrostachyus	4	0.006	13
Moringaceae	Moringa olifera	4	0.006	13
Myrtaceae	Psidium quajave	4	0.006	13
Bignoniaceae	Jacaranda mimosifolia	4	0.006	13
Arecaceae	Borassus aethiopum	4	0.006	13
Rubiaceae	Vangueria apiculata	4	0.006	13
Tilliaceae	Grewia mollis	4	0.006	13
Rutaceae	Citrus sinensis	4	0.006	13
Bignoniaceae	Steriospermum kunthiumum	4	0.006	13
Verbenaceae	Lantana camara	4	0.006	13

Appendix 1. Contd.

Leguminoseae-Mimosoidae	Albizia grandibracteata	4	0.006	13
Fabaceae	Lennea schweinfurthii	3	0.004	14
Euphorbiaceae	Margaritaria discoidea	3	0.004	14
Rutaceae	Zanthoxylum chalybeum	3	0.004	14
Mimosaceae	Acacia sieberiana	3	0.004	14
Rutaceae	Citrus reticulate	3	0.004	14
Solanaceae	Capsicum annuum	3	0.004	14
Euphorbiaceae	Croton megalocarpus	3	0.004	14
Mimosaceae	Acaccia tortolis	3	0.004	14
Bignoniaceae	Tecoma stans	3	0.004	14
Meliaceae	Azadiracta indica	3	0.004	14
Solanaceae	Datura stramonium	3	0.004	14
Rubiaceae	Vangueria madagascariensis	3	0.004	14
Leguminoseae-Mimosoidae	Leucaena leucocephala	3	0.004	14
Nyctaginaceae	Bougainvillea brasiliensis	3	0.004	14
Malvaceae	Desert rose	3	0.004	14
Malvaceae	Hibiscus sp	2	0.003	15
Cucurbitaceae	Kedrostis gijief	2	0.003	15
Salvadoraceae	Salvadora persica	2	0.003	15
Mimosaceae	Acaccia breviscens	2	0.003	15
Balanitaceae	Balanites egyptiaca	2	0.003	15
Mimosaceae	Acaccia nilotica	2	0.003	15
Cactaceae	Cactus sp	2	0.003	15
Rhamnaceae	Zizyphus macronata	2	0.003	15
Ficus mucuso	Moraceae	2	0.003	15
Fabaceae	Craibia laurentii	2	0.003	15
Sterculiaceae	Dombeya African	2	0.003	15
Euphorbiaceae	Euphorbia tricum	2	0.003	15
Flacourtiaceae	Flacourtia indica	2	0.003	15
Olacaceae	Ximenia Americana	2	0.003	15
Fabaceae	Delonix regia	2	0.003	15
Casuarinanceae	Casuarina equisitifolia	2	0.003	15
Verbenaceae	Vitex Keniensis /meru oak	2	0.003	15
Mimosaceae	Acaccia arepanolobium	2	0.003	15
Arecaceae	Phoenix dactylifera	2	0.003	15
Arecaceae	Hyphaene compressa	2	0.003	15
Rubiaceae	Calycophyllum spruceanum	2	0.003	15
Arecaceae	Cocos nucifera	2	0.003	15
Fabaceae	Parkia filicoidea	2	0.003	15
Annonaceae	Mkilua fragrans	2	0.003	15
Fabaceae	Brachystegia spiciformis	2	0.003	15
Leguminosae-Mimosoideae	Prosopis juliflora (mathenge)	2	0.003	15
Sapotaceae	Pouteria adolfi-friedericii	2	0.003	15
Lythraceae	Lawsonia inermis	2	0.003	15
Myrtaceae	Eucalyptus camaldulensis	2	0.003	15
Verbenaceae	Gmelina arborea	2	0.003	15
Myrtaceae	Eucalyptus saligna	2	0.003	15
Gramineae	Grasses	2	0.003	15
Rutaceae	Zanthoxylum holtzman	2	0.003	15
Meliaceae	Melia volkensii	2	0.003	15
Burseraceae	Sorindela madagascariensis	2	0.003	15
Mimosaceae	*Newtonia hildebrandtii*	2	0.003	15

Appendix 1. Contd.

Poaceae	Sorghum	2	0.003	15
Fabaceae	*Lonchocarpus eriocalyx*	1	0.001	16
Euphorbiaceae	*Flueggea virosa*	1	0.001	16
Simaroubaceae	Harrisonia abyssinica	1	0.001	16
Euphorbiaceae	Euphorbia tiriculli	1	0.001	16
Fabaceae - Caesalpiniaceae	*Cassia occidentale*	1	0.001	16
Lauraceae	Ocotea usambarensis	1	0.001	16
Combretaceae	*Terminalia brownie*	1	0.001	16
Capparaceae	*Boscia coriacea*	1	0.001	16
Araliaceae	Polyscias fulva	1	0.001	16
Mimosaceae	*Acacia senegal*	1	0.001	16
Combretaceae	*Combretum apiculatum*	1	0.001	16
Psilotaceae	Pteridophytes sp	1	0.001	16
Poaceae	Millet	1	0.001	16
Leguminoseae-Mimosoidae	Lanea schweifurthii	1	0.001	16
Leguminoseae-mimosoideae	Albizzia amara	1	0.001	16
Rhamnaceae	Berchemia bicolour	1	0.001	16
Fabaceae	Delonix elata	1	0.001	16
Euphorbiaceae	Ricinus communis	1	0.001	16
Fabaceae	Pterocarpus officinalis	1	0.001	16
Bombacaceae	Adansonia digitata	1	0.001	16
Ebenaceae	Ras natalensis/euclea natalensis	1	0.001	16
Mimosaceae	Acaccia elata	1	0.001	16
Mimosaceae	Acaccia nubica	1	0.001	16
Solanaceae	Solanum incutna/sp/laciniatum!	1	0.001	16
Salvadoraceae	Dobera glabra	1	0.001	16
Capparaceae	Capparis tomentosa	1	0.001	16
Rubiaceae	Vangueria infausta	1	0.001	16
Ruscaceae	Sansevieria ehrenbergii	1	0.001	16
Clusiaceae -Guttiferae	Gacinia livingstonei	1	0.001	16
Burseraceae	Commiphora Africana	1	0.001	16
Apocynaceae	Plumeria fragranipani	1	0.001	16
Sapotaceae	Manilkara Zansibarensis	1	0.001	16
Combretaceae	Terminalia catapa	1	0.001	16
Fabaceae	Pithecellobium dulce	1	0.001	16
Leguminoseae-mimosoideae	Albizia lebbeck	1	0.001	16
Fabaceae – Caesalpiniaceae	Cassia fistula	1	0.001	16
Combretaceae	combretum constrictum	1	0.001	16
Annonaceae	Annona muricata	1	0.001	16
Fabaceae	Erythrina abbyssinica	1	0.001	16
Myrtaceae	Syzygium aromaticum	1	0.001	16
Araceae	Colocasia esculenta	1	0.001	16
Fabaceae	Cajanus canjanus	1	0.001	16
Euphorbiaceae	Acalpha sp	1	0.001	16
Mimosaceae	Accacia negresse	1	0.001	16
Mimosaceae	Accacia rubusta	1	0.001	16
Loganiaceae	Strychnos cocculoides	1	0.001	16
Tilliaceae	Grewia bicolour	1	0.001	16
Verbenaceae	Vitex mombassae	1	0.001	16
Mimosaceae	Accacia seyal	1	0.001	16
Burseraceae	Commiphora enfuscan	1	0.001	16
Labiateae-Lamiaceae	Leonotis mollisima	1	0.001	16

Appendix 1. Contd.

Combretaceae	Pteleopsis myrtifolia	1	0.001	16
Euphorbiaceae	Uapaca kirkiana	1	0.001	16
Combretaceae	Combretum zeyheri	1	0.001	16
Celastraceae	Maytenus sp	1	0.001	16
Sterculiaceae	Silvestris	1	0.001	16
Fabaceae	Bauhinia varigata	1	0.001	16
Malvaceae	Abutilon sp	1	0.001	16
Boraginaceae	Cordia monoica/ovalis	1	0.001	16
Anacardiaceae	Sclerocarya birrea	1	0.001	16
Fabaceae	Afzalia quanzensis	1	0.001	16
Meliaceae	Trichilia emitica	1	0.001	16
Rubiaceae	Psychotria sp	1	0.001	16
Loganiaceae	Strichnos noqua	1	0.001	16
Tilliaceae	Grewia gaetzeana	1	0.001	16
Sterculiaceae	Sterculia Africana	1	0.001	16
Fabaceae	Omocarpum sp	1	0.001	16
Mimosaceae	Accacia zanzibarica	1	0.001	16
Annonanceae	Artabotrys sp	1	0.001	16
Apocynaceae	Diplorhynchus condylocarpon	1	0.001	16
	Total abundance of all species (N)	725	1	
	Number of species S = 171			

Appendix 2. Table of tree species families found in tamarind niches in East Africa.

Species family	Number of different species recorded in family
Fabaceae	14
Mimosaceae	14
Euphorbiaceae	12
Leg.Mimosoideae	8
Combretaceae	7
Rubiaceae	7
Rutaceae	6
Fab.Caesalpiniaceae	5
Moraceae	5
Verbenaceae	5
Annonaceae	4
Apocynaceae	4
Arecaceae	4
Bignoniaceae	4
Meliaceae	4
Myrtaceae	4
Anacardiaceae	3
Burseraceae	3
Malvaceae	3
Rhamnaceae	3
Sapotaceae	3
Solanaceae	3
Sterculiaceae	3
Tilliaceae	3
Capparaceae	2
Ebenaceae	2

Appendix 2. Contd.

Gramineae	2
Lauraceae	2
Loganiaceae	2
Poaceae	2
Salvadoraceae	2
Agavaceae	1
Araceae	1
Araliaceae	1
Balanitaceae	1
Bombacaceae	1
Boraginaceae	1
Cactaceae	1
Caricaceae	1
Casuarinanceae	1
Celastraceae	1
Clusiaceae -Guttiferae	1
Compositae-Asteraceae	1
Cucurbitaceae	1
Dioscoreaceae	1
Flacourtiaceae	1
Labiateae-Lamiaceae	1
Lythraceae	1
Moringaceae	1
Musaceae	1
Nyctaginaceae	1
Olacaceae	1
Psilotaceae	1
Ruscaceae	1
Simaroubaceae	1
Taxaceae	1
Ulmaceae	1

Appendix 3. Table of tree species in tamarind niches on-farm in East Africa.

Species	Total abundance	Proportional abundance	Rank
Tamarindusi	117	0.254348	1
Mangiferai	17	0.036957	2
Caricap	15	0.032609	3
Azadiractai	13	0.028261	4
Bananas	12	0.026087	5
Cocosn	12	0.026087	5
Sennas	12	0.026087	5
Cascabelath	10	0.021739	6
Acacciato	8	0.017391	7
Psidiumq	8	0.017391	7
Anacadiumo	7	0.015217	8
Artocarpush	7	0.015217	8
Jatrophac	7	0.015217	8
hibiscus	6	0.013043	9
Lantanac	6	0.013043	9
Markhamial	6	0.013043	9

Appendix 3. Contd.

Vernomiaa	6	0.013043	9
Agaves	5	0.01087	10
Euphobiasp	5	0.01087	10
Jacarandam	5	0.01087	10
Meliaa	5	0.01087	10
Annonas	4	0.008696	11
Citrusr	4	0.008696	11
Citruss	4	0.008696	11
Combretumm	4	0.008696	11
Grewiab	4	0.008696	11
Hyphaenec	4	0.008696	11
Perseaa	4	0.008696	11
Accaciar	3	0.006522	12
Albiziac	3	0.006522	12
Citrusl	3	0.006522	12
Comiphoraa	3	0.006522	12
Crotonm	3	0.006522	12
Eucalyptussp	3	0.006522	12
Ficusn	3	0.006522	12
Tecomas	3	0.006522	12
Ziziphusm	3	0.006522	12
Adansoniad	2	0.004348	13
Balanitesa	2	0.004348	13
Bamboosp	2	0.004348	13
Bougainvilleab	2	0.004348	13
Cafear	2	0.004348	13
Cassiaf	2	0.004348	13
Cassiasp	2	0.004348	13
Casuarinae	2	0.004348	13
Combretumsp	2	0.004348	13
Combretumz	2	0.004348	13
Commiphorasp	2	0.004348	13
Delonixr	2	0.004348	13
Leucaenal	2	0.004348	13
Manihote	2	0.004348	13
Moringao	2	0.004348	13
Plumeriaf	2	0.004348	13
Pterocarpuso	2	0.004348	13
Raphiasp	2	0.004348	13
Ricinusc	2	0.004348	13
Salvadorap	2	0.004348	13
Sorghum	2	0.004348	13
Syzygiuma	2	0.004348	13
Vangueriam	2	0.004348	13
Yam	2	0.004348	13
Acacciaa	1	0.007634	14
Acacciani	1	0.007634	14
Acacciat	1	0.007634	14
Acaciah	1	0.007634	14
Accaciae	1	0.007634	14
Accacianu	1	0.007634	14
Accaciase	1	0.007634	14

Appendix 3. Contd.

Afzaliaq	1	0.007634	14
Albizial	1	0.007634	14
Annonam	1	0.007634	14
Berchemiab	1	0.007634	14
Borassusa	1	0.007634	14
Bosiasp	1	0.007634	14
Cajanusc	1	0.007634	14
Calycophyllums	1	0.007634	14
Capsicuma	1	0.007634	14
Citrusc	1	0.007634	14
Cofear	1	0.007634	14
Colocasiae	1	0.007634	14
combretumc	1	0.007634	14
Commiphorae	1	0.007634	14
Cordiasp	1	0.007634	14
Crotonma	1	0.007634	14
Daturas	1	0.007634	14
Delonixe	1	0.007634	14
Desertrose	1	0.007634	14
Diospyrosm	1	0.007634	14
Erythrinaa	1	0.007634	14
Eucalyptusc	1	0.007634	14
Eucalyptuss	1	0.007634	14
Euphorbiac	1	0.007634	14
Ficusg	1	0.007634	14
Ficusm	1	0.007634	14
Ficussp	1	0.007634	14
Gmelinaarb	1	0.007634	14
Grasses	1	0.007634	14
Grewiam	1	0.007634	14
Lanneas	1	0.007634	14
Lawsoniai	1	0.007634	14
Leonotism	1	0.007634	14
Leonotissp	1	0.007634	14
Lonchocarpuse	1	0.007634	14
Luceanasp	1	0.007634	14
Manilkaraz	1	0.007634	14
Margaritariad	1	0.007634	14
Maytenussp	1	0.007634	14
Meliav	1	0.007634	14
Mitragynas	1	0.007634	14
Mkiluaf	1	0.007634	14
Parkiaf	1	0.007634	14
Phoenixd	1	0.007634	14
Piliostigmath	1	0.007634	14
Podocarpusl	1	0.007634	14
Pteleopsism	1	0.007634	14
Sclerocaryab	1	0.007634	14
Solanumi	1	0.007634	14
Sorindelam	1	0.007634	14
Strichnosn	1	0.007634	14
Teclean	1	0.007634	14

Appendix 3. Contd.

terminaliac	1	0.007634	14
Trichiliae	1	0.007634	14
Uapacak	1	0.007634	14
Vangueriaa	1	0.007634	14
Vangueriai	1	0.007634	14
Vitellariap	1	0.007634	14
Vitexd	1	0.007634	14
Vitexk	1	0.007634	14
Zanthoylumh	1	0.007634	14
	460	1	

Appendix 4. Table of tree species in tamarind niches in woodlands in East Africa.

Woodland species	Total abundance	Proportional abundance	Rank
Tamarindusi	46	0.218009	1
Acacciasp	9	0.042654	2
Mangiferai	5	0.023697	3
Acaciah	4	0.018957	4
Cocosn	4	0.018957	4
Comiphorasp	4	0.018957	4
Cordiasp	4	0.018957	4
Grewiab	4	0.018957	4
Lantanac	4	0.018957	4
Accaciar	3	0.014218	5
Albiziag	3	0.014218	5
Azadiractai	3	0.014218	5
Bauhiniav	3	0.014218	5
Cascabelath	3	0.014218	5
Combretumsp	3	0.014218	5
Combretumz	3	0.014218	5
Euphorbiat	3	0.014218	5
Grewiasp	3	0.014218	5
Lianasp	3	0.014218	5
Abutilonsp	2	0.009479	6
Acacciato	2	0.009479	6
Accaciae	2	0.009479	6
Albiziac	2	0.009479	6
Bociasp	2	0.009479	6
Bosciac	2	0.009479	6
Caricap	2	0.009479	6
Cassiasp	2	0.009479	6
Combretuma	2	0.009479	6
Combretumm	2	0.009479	6
Commiphoraa	2	0.009479	6
Lanneasp	2	0.009479	6
Leonotism	2	0.009479	6
Lonchocarpuse	2	0.009479	6
Margaritariad	2	0.009479	6
Mitragynasp	2	0.009479	6
Piliostigmath	2	0.009479	6
Polysciasf	2	0.009479	6

Appendix 4. Contd.

Sennas	2	0.009479	6
Sterculiasp	2	0.009479	6
Acaciab	1	0.004739	7
Acaciasen	1	0.004739	7
Acaciasi	1	0.004739	7
Accacianu	1	0.004739	7
Accaciat	1	0.004739	7
Accaciaz	1	0.004739	7
Adansoniad	1	0.004739	
Agaves	1	0.004739	7
Annacardiumo	1	0.004739	7
Anonas	1	0.004739	7
Balanitesa	1	0.004739	7
Bamboosp	1	0.004739	7
Berchemiad	1	0.004739	7
Brachystegias	1	0.004739	7
Capparist	1	0.004739	7
Citrusl	1	0.004739	7
Cofear	1	0.004739	7
Comiphoraa	1	0.004739	7
Cordiam	1	0.004739	7
Doberag	1	0.004739	7
Eucalyptusc	1	0.004739	7
Eucalyptussp	1	0.004739	7
Ficusn	1	0.004739	7
Ficuss	1	0.004739	7
Flueggeav	1	0.004739	7
Gacinial	1	0.004739	7
Grasses	1	0.004739	7
Grewiag	1	0.004739	7
Grewiam	1	0.004739	7
Harrisoniaa	1	0.004739	7
Hibiscussp	1	0.004739	7
Hyphaenec	1	0.004739	7
Jacarandam	1	0.004739	7
Jatrophac	1	0.004739	7
Kedrostisg	1	0.004739	7
Lenneas	1	0.004739	7
Leonotissp	1	0.004739	7
Leucaenal	1	0.004739	7
Lonchocarpussp	1	0.004739	7
Makhamial	1	0.004739	7
Maytenuss	1	0.004739	7
Mikulwaf	1	0.004739	7
Ocoteau	1	0.004739	7
Omocarpumsp	1	0.004739	7
Pouteriaa	1	0.004739	7
Prosopisj	1	0.004739	7
Psychotriasp	1	0.004739	7
Pterocarpuso	1	0.004739	7
Raphiasp	1	0.004739	7
Rasn	1	0.004739	7

Appendix 4. Contd.

Sansevieriae	1	0.004739	7
Sclerocaryab	1	0.004739	7
Sterculiaa	1	0.004739	7
Steriospermumk	1	0.004739	7
Strichnossp	1	0.004739	7
Strychnosc	1	0.004739	7
Syzygiuma	1	0.004739	7
	211	1	

Appendix 5. Table of tree species in tamarind niches in riverbanks in East Africa.

Species in riverbanks	Total abundance	Proportional abundance	Rank
Tamarindusi	31	0.221429	1
Acacciasp	10	0.071429	2
Lanneasp	5	0.035714	3
Combretumsp	4	0.028571	4
Salvadorap	4	0.028571	4
Acacciato	3	0.021429	5
Acalphasp	3	0.021429	5
Ficusm	3	0.021429	5
Terminaliab	3	0.021429	5
Terminaliasp	3	0.021429	5
Vangueriam	3	0.021429	5
Acacciab	2	0.014286	6
Adansoniad	2	0.014286	6
Balanitesa	2	0.014286	6
Cactussp	2	0.014286	6
Euphorbiat	2	0.014286	6
Grewiasp	2	0.014286	6
Mangiferai	2	0.014286	6
Ocoteau	2	0.014286	6
Piliostigmath	2	0.014286	6
Sennas	2	0.014286	6
Acacciani	1	0.007143	7
Acaciah	1	0.007143	7
Acaciasen	1	0.007143	7
Accaciae	1	0.007143	7
Accaciane	1	0.007143	7
Accaciar	1	0.007143	7
Albizziaa	1	0.007143	7
Artabotryssp	1	0.007143	7
Azadiractai	1	0.007143	7
Bociasp	1	0.007143	7
Bosciac	1	0.007143	7
Capparist	1	0.007143	7
Carissae	1	0.007143	7
Cassiao	1	0.007143	7
Cocosn	1	0.007143	7
Combretumm	1	0.007143	7
Commiphoraa	1	0.007143	7
Craibial	1	0.007143	7

Appendix 5. Contd.

Diplorhynchusc	1	0.007143	7
Doberag	1	0.007143	7
Domberasp	1	0.007143	7
Dombeyaa	1	0.007143	7
Eucalyptussp	1	0.007143	7
Euphobiasp	1	0.007143	7
Euphorbiac	1	0.007143	7
Euphorbiatri	1	0.007143	7
Ficusn	1	0.007143	7
Flacourtiai	1	0.007143	7
Flueggeav	1	0.007143	7
Grewiag	1	0.007143	7
Jatrophac	1	0.007143	7
Kedrostisg	1	0.007143	7
laneas	1	0.007143	7
Lonchocarpuse	1	0.007143	7
Markhamial	1	0.007143	7
Miliciae	1	0.007143	7
Millet	1	0.007143	7
Newtoniah	1	0.007143	7
Pithecellobiumd	1	0.007143	7
Prosopisa	1	0.007143	7
Pteridophytessp	1	0.007143	7
Rasn	1	0.007143	7
Sennasp	1	0.007143	7
swamp grass	1	0.007143	7
Teclean	1	0.007143	7
Uapacak	1	0.007143	7
Ximeniaa	1	0.007143	7
Zizyphusm	1	0.007143	7
	140	1	

more agroforestry outreach from the World Agroforestry Centre, which is based and more active in this country. Alternatively, Kenya farmers may have engaged more on tree species conservation than their Ugandan and Tanzanian counterparts, for purposes of climate amelio-ration, given that most of Kenya is arid and or semi arid. Currently, the Albertine Rift (where most of the studied area in Uganda is) is considered a biodiversity hot spot in East Africa (Eilu et al., 2004; Plumptre et al., 2004; Poulsen et al., 2005). Higher species diversity in Kenya is contrary to expectations but supports a recent study which revealed that combined effect of several climatic-environment factors influence diversity (Kreft and Jetz, 2007). Kreft and Jetzs' study reported that the effect of high annual energy inputs with constant water supply and high spatio topographic complexicities are particularly important. Comparatively, the mean annual temperature is higher in Kenya but number of wet days is fewer than in Uganda though both countries lie more in higher latitudes north. Tanzania is in lower latitudes south below equator and its studied area mean temperature is lower. Higher temperatures, topographic complexities and other environment factors in combination may have favoured diversity in Kenya. Kreft and Jetzs' study also revealed that historical factors like past differential dispersal, speciation and extinction rates do not influence species diversity. In other studies it has been shown that neighborhood effects and other evolutionary forces can homogenize diversity patterns at different spatial scale (Rosenzweig, 1995; Vellend and Gebber, 2005; Ma, 2006). Given that tamarind-niche-tree species study was conducted within the Great Rift Valley system, homogeneous regional evolutionary forces may have caused the observed regional species similarity. Diversity among different habitats within countries and among similar habitats among countries can be attributed to differential management, utilisation, and heterogeneous environment factors below the regional scale.

The current study also shows that species diversity is highest on-farm among habitats and this is consistent with findings of a previous study in one district in Kenya (Nyadoi, 2005). The consistencies qualify past collective ideas that the future of tree resources is on-farm (Temu et al., 2000). Higher diversity on-farm may be due to farmer planting and management of tree species while poor diversity in wild habitats may be the effect of unsustainable exploitation of species in absence of management. Unsustainable exploitation of tree species in wild habitats has been reported in different sites in East (Fitzgibbon et al., 1995; Klas, 1995; Neuman, 1996; Omeja et al., 2005). Given regional similarity of species, poor diversity in wild habitats in the current study means erosion taking place and therefore restoration needed in these habitats. Restoration of tree species diversity in the wild habitats will be particularly critical for maintenance of connectivity and persistence of biodiversity in East Africa landscapes. From the results, it is also evident that different habitats within countries and similar habitats among countries in East Africa will require different conservation investments. This results support localised area specific conservation strategies as reviewed elsewhere (Margules and Pressey, 2000). Cross border-regional conservation strategies being implemented in East Africa are challenged while the need for comprehensive re-inventory and appraisal of biodiversity hot spots and their management is also revealed by the current study. Restoration of wild habitat tamarind niche tree species diversity could be achieved among others by enrichment planting with specific area-habitat suited species, documented here. Further more, observed higher species diversity in tamarind niches on-farm regionally and within countries suggests anthropogenic interventions enhanced diversity. Tree species conservation on-farm will therefore be important for the achievement of representative and persistent diversity in East Africa landscapes. This finding implies that farmers have to be actively involved as major stakeholders in conservation programmes in East Africa. In general, effective biodiversity conservation policy implementation in all habitats is needed and this will require both government and farmers commitment to conservation of tree species in different habitats.

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