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Analysis of fuelwood utilisation and existing reforestation strategy on local biodiversity in Northern Plateau State, Nigeria

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Unsustainable fuel wood utilisation and poorly articulated habitat reforestation strategy could pose serious threats to the survival of animal species. However, few areas have provided the opportunity to compare the twin effects of these factors on local biodiversity which may be useful for shaping conservation strategies at local levels. Thus, this study examined utilization patterns of plant species used for fuelwood in five Local Government Areas of Plateau State, Nigeria and the extent of avian and insect diversity that they support in natural habitats in comparison to the exotic *Eucalyptus camaldulensis* used in the reforestation of mined areas in the state. Pattern of fuel wood utilisation was obtained through direct survey of fuel wood markets. Biodiversity survey was also carried out to determine avian and insect visit rates, species richness and diversity on the three most utilised plant species (*Parkia biglobosa, Syzygium guineense* and *Terminalia macroptera*) and the exotic *E. camaldulensis*. Fuel wood utilisation appeared to involve a wide range of plant species. Most utilised plant species also supported higher local biodiversity as compared to the exotic *E. camaldulensis* suggesting that future reforestation in the area could achieve a wider ecological significance if some native plant species are considered.

Keywords: Fuel wood, reforestation, biodiversity, birds, insects.

INTRODUCTION

Unsustainable fuel wood utilisation and poorly articulated habitat reforestation strategy could pose serious threats to the survival of animal species. Fuel wood collection could lead to deforestation, landscape degradation as well as gradual local extinction of flora and possibly dependent fauna (Negi et al., 2018; Sambe et al., 2018; Madaki and Sayok, 2019). Poorly articulated reforestation project on the other hand, could distort ecosystem balance especially when candidate plant species is of little or no benefit to local fauna.

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However, examples that showcase specific ecological roles rendered by human threatened flora and examine candidate plant species utilised in reforestation projects at local levels are lacking despite their importance for shaping conservation and environmental management strategies. However, this is because few areas are available that gives the opportunity to exploit these two effects simultaneously.

Globally, fuel wood utilisation is occurring at an alarming rate with consumption reported to have grown from 1854 to 1860 million m^3 between 2012 and 2016 with at least one in three households globally depending on fuel wood for domestic energy needs either for cooking or heating (Singh et al., 2021). In Nigeria, fuel wood consumption rate is also quite high and widespread (Ekhuemelo et al., 2017; Salihu, 2019) even within protected areas (Chaskda and Fandip, 2017); annual consumption is estimated to reach about 156 million metric tons; Muazu and Ogujiuba (2020) reported that 72.2% of households in Nigeria use fuelwood up to thrice a day for domestic energy needs. Communal bushes and forests often constitute the major source of fuel wood for both urban and rural dwellers (Abdulrashid and Ibrahim, 2018; Abdul-Hamid et al., 2020). This is buttressed by a study on community patterns of fuelwood exploitation by Abdulrashid and Ibrahim (2018) which was collaborated by Abdul-Hamid et al. (2020) in a study that evaluated fuelwood consumption patterns in northern parts of Nigeria where both fuelwood supplied and consumed were shown to be sourced from the same local environment. These patterns could have attendant consequences on dependent local fauna as well as decrease plant diversity and lead to soil erosion (Madaki and Sayok, 2019).

This situation is compounded on the Jos-Plateau, Nigeria where the additional effects of fuel wood consumption and previous tin mining activities have left a widely degraded landscape. Thus, to reclaim mined areas, reforestation using the exotic *Eucalyptus camaldulensis* had been carried out till 1985 covering less than 1% of about 300 km^2 of mined area (Alexander, 1990). This was done without due consideration to the needs of local animal species existing in the area but mainly based on the fast growth rate of the plant.

Thus, this study examined plant species utilised for fuelwood in five Local Government Areas of northern Plateau State, Nigeria and the extent of avian and insect diversity that they support in natural habitats in comparison to the exotic *E. camaldulensis* used in the reforestation sites. This was with a view to recommend effective future reforestation strategy that may enhance the conservation of animal species in the area.

MATERIALS AND METHODS

Study site

This study was conducted in five Local Government Areas in the northern senatorial zone of Plateau State, Nigeria. These include: Jos-north, Jos-south, Jos-east, Barkin Ladi and Bassa Local Government Areas (Figure 1). These LGAs were chosen to obtain a representative sample of both rural and urban areas. The Jos environment has suffered environmental degradation as a result of tin mining activities in the past. This has left the landscape dotted with mining ponds (Alexander, 1990). Available natural habitats in this area are under pressure as a result of agricultural activities and fuelwood collection.

Determination of plant species utilised for fuelwood

This was carried out between August and December, 2006. It involved visit to twenty five (25) fuelwood markets, five each in the five selected LGAs. At each market, 10-bundles of fuelwood consisting of between 10 and 20 wood pieces (the form in which fuel wood was sold in the area) were randomly selected. From each bundle, five wood pieces (totalling 1250 wood pieces across the 25 markets) were further selected randomly and identified to species level using plant identification guide (Arbonnier, 2002).

Biodiversity survey

The top three plant species utilised for fuel-wood (that is, *Terminalia macroptera, Parkia biglobosa and Syzygium guineense,* based on survey conducted earlier) and *E. camaldulensis* (used previously to reclaim mined areas) were sampled for bird species visits and insect species presence. These were done between January and June, 2007. Twenty individual plants were sampled for each plant species; 10 individuals each at Amurum Forest Reserve (9° 53'N, 8° 59'E) and Kurra-Falls Forest (09° 23'N, 08° 42'E) to achieve a wider determination of the ecological functions of the study plants across available major natural habitats in the study area.

Bird sampling

Bird survey was carried out by positioning a telescope (Kamakura) within a range of 10 to 30 m to focal plant (depending on density of vegetation at the area). A period of 30 min was spent recording avian visits. Avian identification guide (Borrow and Demey, 2001) was used to confirm sighted individuals.

Insect sampling

Insect samples were obtained by enclosing plant branches (two randomly selected brances per plant) into a 25 × 65 cm net (diameter × length); this was shaken vigorously10-times and net content emptied into plastic bags, trapped insects were preserved in ethanol solution (70% ethanol, 10% glycerine and 20% distilled water). These were later identified and enumerated in the laboratory using insect identification keys (Borrer et al., 1989; Shattuck, 2000; Castner, 2000).

Analysis

The SPSS Statistical Package Version 17.0 was used for data analysis. Both descriptive and non-parametric statistics were used to analyse data obtained from the study. Kruskal Wallis test was used to test for any significant differences in the number of avian visitors to the four plant species studied. Both avian and insect diversity indices across plant species were determined using the Shannon-Weiner diversity index (H) with the formula:

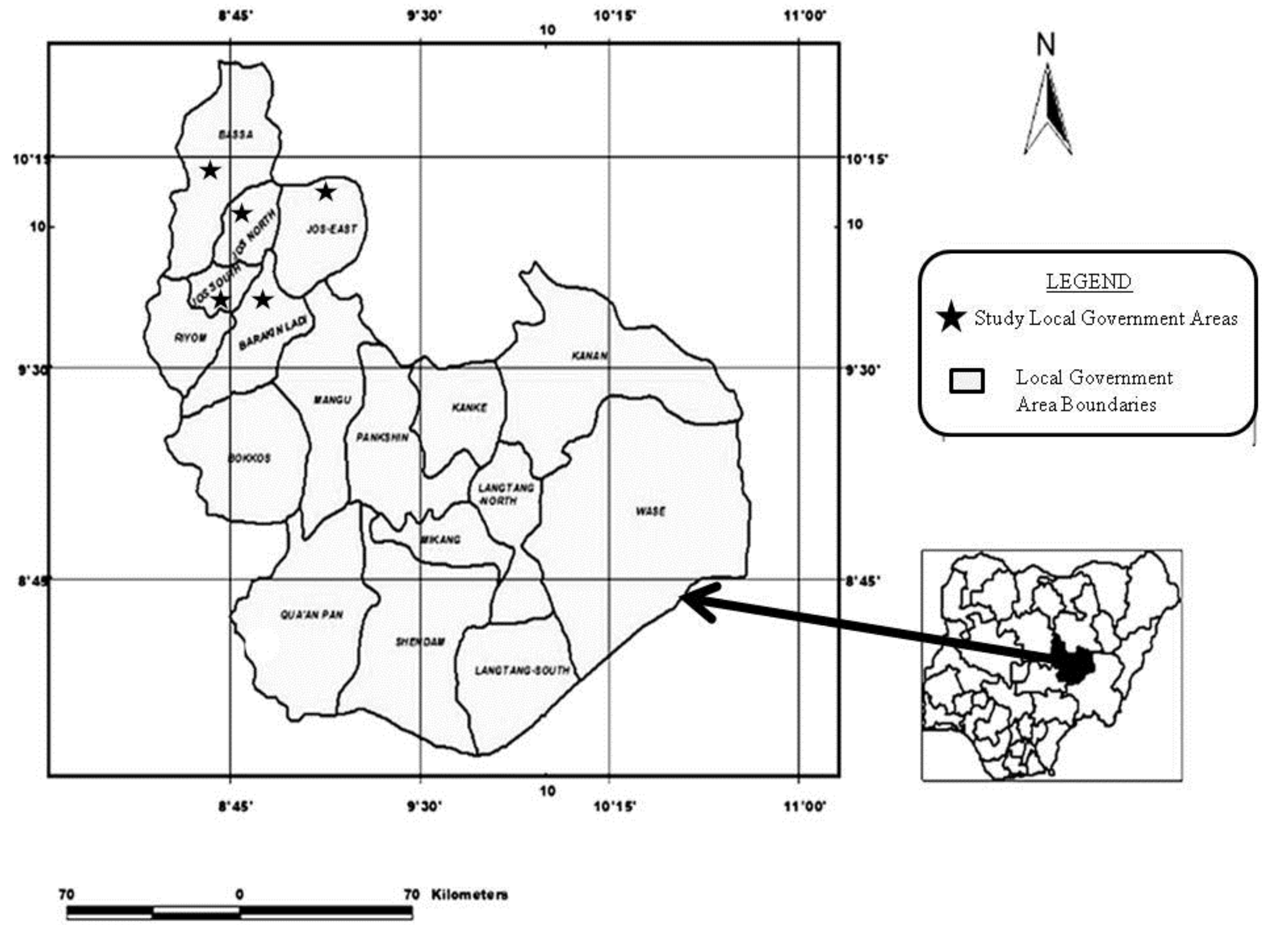

Figure 1. Map of Plateau State, Nigeria showing the location of Local Government Areas where study was conducted.

$H = \sum (pl) |\ln pl|$

where H= the Shannon diversity index, Pi= fraction of the entire population made up of species I, S= numbers of species encountered, and Σ=sum of species 1 to species S, where the index tend towards 0, indicates less diversity.

RESULTS

Plants species utilised for fuelwood

A total of 58 plant species divided across 23 plant families were recorded during market survey across the five study LGAs in Plateau State. The three most common fuelwood plant species were *Parkia biglobosa* (Mimosoideae), *Terminalia macroptera* (Combretaceae) and *Syzygium guineense guineense* (Myrtaceae), respectively (Table 1).

Bird species on fuel-wood plant species and *E. camaldulensis*

A total of 142 individual birds spread across 36 bird species and 11 families were recorded during this aspect of the study. Number of avian visitors to the four studied plant species varied significantly (Kruskal Wallis test; χ^2 = 46.157, df = 3, P < 0.001) with 87 individuals (that is, 61.3% of 142) recorded on *P. biglobosa*, 22 (15.5%) on *S. guineense guineense*, 17 (12.0%) on *T. macroptera* and 16 (11.3%) on *E. camaldulensis*. Bird species visit rates per plant, bird richness and diversity were the highest on indigenous fuelwood plant species in comparison to the exotic *E. camaldulensis* used in reforested mined areas (Tables 2 and 3).

Insect species on fuelwood plant species and *E. camaldulensis*

Individual insects (739) were sampled on the four studied plants. These were divided across 39 families of insects spread across 12 insect orders. *S. guineense guineense* had the highest number of insect families recorded (representing 35.1%), while *E. camaldulensis* supported the least number of insects (9.5%) during the period of this study (Tables 4 and 5).

Table 1. Fuel-wood plant species recorded at fuel-wood markets in Jos and its environment (August - December 2006).

S/N	Fuelwood plant species (scientific names)	Mean number/market (± SD)	n	Total (%)
1	*Acacia ataxacantha*	0.28 ± 0.50	7	0.6
2	*Acacia gourmaensis*	0.04 ± 0.00	1	0.1
3	*Acacia macrostachya*	0.80 ± 0.00	20	1.6
4	*Acacia mellifera*	0.08 ± 0.00	2	0.2
5	*Acacia sieberiana*	0.48 ± 1.14	12	1.0
6	*Albizia zygia*	1.8 ± 1.21	45	3.6
7	*Alchornea cordifolia*	0.08 ± 0.00	2	0.2
8	*Annona senegalensis*	1.88 ± 1.51	47	3.8
9	*Annona squamosa*	0.16 ± 0.58	4	0.3
10	*Anogeissus leiocarpus*	2.76 ± 1.32	69	5.5
11	*Bombax costatum*	0.44 ± 0.96	11	0.9
12	*Canarium* species	0.08 ± 0.00	2	0.2
13	*Canthium cornelia*	0.04 ± 0.00	1	0.1
14	*Carissa edulis*	0.44 ± 0.44	11	0.9
15	*Cola laurifolia*	0.08 ± 0.00	2	0.2
16	*Combretum fragrans*	2.32 ± 1.46	58	4.6
17	*Combretum molle*	0.64 ± 0.52	16	1.3
18	*Combretum tomentosum*	0.44 ± 0.75	11	0.9
19	*Dichrostachys cinerea*	0.76 ± 0.79	19	1.5
20	*Ekebergia senegalensis*	0.08 ± 0.00	2	0.2
21	*Erythrophleum suaveolens*	0.92 ± 1.83	23	1.8
22	*Euphorbia kamerunica*	0.08 ± 0.00	2	0.2
23	*Ficus asperifolia*	0.68 ± 0.55	17	1.4
24	*Ficus cordata*	0.20 ± 0.50	5	0.4
25	*Ficus ovate*	1.20 ± 1.33	30	2.4
26	*Ficus polita*	0.04 ± 0.00	1	0.1
27	*Flueggea virosa*	0.04 ± 0.00	1	0.1
28	*Guibourtia copallifera*	0.20 ± 0.58	5	0.4
29	*Harungana madagascariensis*	0.08 ± 0.00	2	0.2
30	*Holarrhena floribunda*	1.72 ± 1.21	43	3.4
31	*Hymenocardia acida*	0.44 ± 0.41	11	0.9
32	*Isoberlinia doka*	0.52 ± 1.47	13	1.0
33	*Jasminum dichotomum*	0.44 ± 0.96	11	0.9
34	*Khaya senegalensis*	0.08 ± 0.00	2	0.2
35	*Lantana camara*	0.32 ± 0.52	8	0.6
36	*Mangifera indica*	0.56 ± 1.91	14	1.1
37	*Manilkara multinervis*	0.32 ± 1.15	8	0.6
38	*Ochnella alba*	0.52 ± 0.67	13	1.0
39	*Pachystela pobeguiniana*	0.56 ± 1.00	14	1.1
40	*Parkia biglobosa*	5.92 ± 1.76	148	11.8
41	*Phyllanthus muellerianus*	0.12 ± 0.71	3	0.2
42	*Piliostigma thonningii*	0.60 ± 0.87	15	1.2
43	*Psidium guajava*	0.16 ± 1.41	4	0.3
44	*Rhus natalensis*	0.60 ± 0.71	15	1.2
45	*Santaloides afzelii*	0.08 ± 0.00	2	0.2
46	*Sarcocephalus latifolius*	0.92 ± 1.01	23	1.8
47	*Senna siamea*	0.16 ± 0.58	4	0.3
48	*Steganotaenia araliacea*	0.04 ± 0.00	1	0.1
49	*Swartzia madagascariensis*	0.08 ± 0.00	2	0.2
50	*Syzygium guineense guineense*	3.08 ± 0.89	77	6.2
51	*Tamarindus indica*	1.44 ± 1.48	36	2.9

Table 1. Contd.

52	*Tapinanthus dodoneifolius*	0.08 ± 0.00	2	0.2
53	*Terminalia brownii*	0.76 ± 1.80	19	1.5
54	*Terminalia macroptera*	3.80 ± 1.22	95	7.6
55	*Terminalia mollis*	1.40 ± 1.16	35	2.8
56	*Uvaria chamae*	0.44 ± 1.33	11	0.9
57	*Vitellaria paradoxa*	0.32 ± 0.82	6	0.5
58	*Vitex madiensis*	0.16 ± 0.58	4	0.3
59	*Eucalyptus camaldulensis*	5.92 ± 1.76	148	11.8
	Unknown	1.32 ± 1.36	35	2.8
	Total		1250	100

*Eucalyptus was treated separate from the other species being an exotic used in reforestation of mined areas and the subject of ecological comparison with the top three local plant species.

Table 2. Estimates of abundance, richness and diversity of bird species across fuel-wood plant species and *Eucalyptus camaldulensis*.

Plant species	Mean avian visit per half hour per plant (± SD)	Avian species richness	Simpson's diversity index
Parkia biglobosa	2.00 ± 0.391	14	10.00
Syzygium guineense guineense	1.00 ± 0.486	8	6.25
Terminalia macroptera	0.75 ± 0.509	9	11.11
Eucalyptus camaldulensis	0.80 ± 0.507	6	4.76

DISCUSSION

Previous studies have recognised the magnitude of anthropogenic tendencies on natural habitats (Chaskda and Fandip, 2017; Sambe et al., 2018; Madaki and Sayok, 2019). For example, rate of fuelwood utilization across different geographic regions globally and locally have been well documented (Ekhuemelo et al., 2017; Baqir et al., 2018; Negi et al., 2018; Gioda, 2019; Salihu, 2019). However, to gain a better understanding of the effects of man-made factors on natural habitats, the importance of integrated studies that explore community specific resource usage patterns and its implications on local fauna cannot be overemphasized. This is important as the nature and scale of habitat disturbance should vary from one community to another therefore suggesting community specific approach. Such a measure will provide conservation stakeholders with the knowledge of specific problem areas and therefore ways of tackling them.

This study, revealed a total of 58 plant species being utilized by communities in the northern senatorial zone of Plateau State as source of energy. This high number of utilised plant species suggests extraction as being random and possibly based on availability within the local environment. The top three plant species in order of utilisation (excluding the exotic *E. camaldulensis* which is the subject of ecological comparison in this study) include *P. biglobosa*, *T. macroptera* and *S. guineense guineense*. These plant species when compared with *E. camaldulensis* employed in the reforestation of mined areas in the state differed significantly in visit rates, species richness and diversity of birds and insects; avian visit rate, species richness and diversity favoured *P. biglobosa* while insect families and abundance were harboured more on *S. guineense guineense*. *E. camaldulensis* had the least faunal presence. The importance of *P. biglobosa* as an ecologically important resource for local wildlife particularly insects and bats has been previously acknowledged (Lassen et al., 2017). However, this study has in addition broadened this ecological importance to also include avian species. These findings have a wide range of implications, for example, though the aim of 'greening the environment' by planting *E. camaldulensis* might be achieved, in terms of sustenance of local fauna; however, the plant performed poorly as it was the least utilised by animals (birds and insects) in the study area. This situation is further being compounded by the gradual decimation in form of fuel wood usage of the most utilised local flora. These factors could distort ecological stability at local scale. For example, a number of the bird species recorded on indigenous plants are nectar feeding and pollinating birds; these include variable sunbird, scarlet-chested sunbird, pygmy sunbird and green headed sunbird which were actually observed to have shown their quest for nectar on the host plants. Other birds observed in this study were insectivores and dependent on the study

Table 3. Distribution of bird species across study plant species (√ = implies bird species recorded on plant species).

S/N	Common name	Scientific name	*Terminalia macroptera*	*Syzygium guineense guineense*	*Parkia biglobosa*	*Eucalyptus camaldulensis*
1	Adamawa turtle dove	*Streptopelia hypopyrrha*			√	√
2	Black crowned tchagra	*Tchagra senegalus*			√	
3	Black-billed wood dove	*Turtur abyssinicus*			√	
4	Bronze mannikin	*Lonchura cucullata*	√			
5	Cinnamon-breasted rock bunting	*Emberiza tahapisi*			√	
6	Common bulbul	*Pycnonotus barbatus*	√	√	√	√
7	Common white throat	*Sylvia communis*	√	√	√	
8	Familiar chat	*Cercomela familiaris*	√		√	
9	Green-headed sunbird	*Cyanomitra verticalis*		√		
10	Grey backed camaroptera	*Camaroptera brachyura*			√	
11	African Grey hornbill	*Tockus nasutus*			√	
12	Grey-headed sparrow	*Poicephalus suahelicus*	√			
13	Laughing dove	*Streptopelia senegalensis*			√	√
14	Little weaver	*Ploceus luteolus*	√		√	
15	Mocking cliff chat	*Thamnolaea cinnanomeiventris*			√	
16	Northern black flycatcher	*Melaenornis edolioides*			√	
17	Northern red bishop	*Euplectes franciscanus*	√	√	√	
18	Pale flycatcher	*Bradornis pallidus*			√	
19	Pied flycatcher	*Ficedula hypoleuca*	√			
20	Pygmy sunbird	*Muscicapella hodgsoni*		√		
21	Red billed hornbill	*Tockus erythrorhynchus*			√	
22	Yellow fronted tinkerbird	*Pogoniulus chrysoconus*			√	
23	Red throated bee-eater	*Merops bullocki*			√	
24	Red-cheeked cordon bleu	*Uraeginthus bengalus*	√	√	√	
25	Rock firefinch	*Lagonosticta sanguinodorsalis*			√	
26	Rock loving cisticola	*Cisticola aberrans*			√	
27	Scarlet-chested sunbird	*Chalcomitra senegalensis*			√	√
28	Short winged cisticola	*Cisticola brachypterus*			√	
29	Spotted flycatcher	*Muscicapa striata*			√	
30	Tawny flanked prinia	*Anthus campestris*			√	
31	Variable sunbird	*Cinnyris venustus*	√	√	√	√
32	Village weaver	*Ploceus cucullatus*			√	
33	Whinchat	*Saxicola rubetra*			√	
34	Wood warbler	*Phylloscopus sibilatrix*			√	
35	Yellow crowned gonolek	*Laniarius barbarus*			√	
36	Yellow fronted canary	*Serinus mozambicus*		√	√	

Table 4. Estimates of abundance, richness and diversity of insect species across fuel-wood plant species and *Eucalyptus camaldulensis.*

Plant species	Mean insect abundance/branch (± SD)	Number of insect families	Simpson's diversity index
Parkia biglobosa	10.78 ± 4.85	18	1.92
Syzygium guineense guineense	4.18 ± 1.78	26	12.50
Terminalia macroptera	3.00 ± 0.74	23	4.17
Eucalyptus camaldulensis	0.53 ± 1.08	7	0.40

Table 5. Distribution of insect families found on fuel wood plant species and *Eucalyptus camaldulensis* (√ = implies insect family recorded on plant species).

S/N	Insect families	*Parkia biglobosa*	*Syzygium guineense guineense*	*Terminalia macroptera*	*Eucalyptus camaldulensis*
1	Acanaloniidae				√
2	Acrididae	√	√	√	
3	Alydidae	√	√	√	
4	Apidae		√		
5	Aradidae				√
6	Blattidae		√	√	
7	Brachonidae		√	√	
8	Bruchidae	√		√	√
9	Buprestidae	√			
10	Calliphoridae	√	√	√	
11	Cercopidae	√	√	√	
12	Chalcididae		√	√	
13	Chrysididae		√	√	
14	Chrysopidae			√	
15	Cicadellidae	√	√	√	
16	Cicadidae	√	√	√	√
17	Coccinellidae		√		
18	Conopidae	√			
19	Curculionidae	√	√	√	√
20	Cynipidae	√	√	√	
21	Dermestidae			√	
22	Drosophilidae			√	
23	Formicidae	√	√	√	
24	Mantidae		√		
25	Meloidae		√		
26	Membracidae	√	√	√	
27	myrmeleontidae		√		
28	Nabidae	√		√	
29	Pentatomidae		√	√	
30	Perlodidae	√			
31	Polistinae				√
32	Pyrrhocoridae	√		√	
33	Reduviidae		√		
34	Scarabaeidae		√		
35	Scutelliridae	√	√	√	
36	Staphylinidae				√
37	Tenebrionidae	√	√	√	
38	Tephritidae		√		

Table 5. Contd.

39	Tingidae		√		
	Total (families)	18	26	23	7

plants as foraging substrate; these include birds like the northern black flycatcher, common bulbul and migratory passerines such as the common whitethroat and pied flycatcher.

The high numbers of *E. camaldulensis* recorded at fuelwood markets also suggest it to be one of the preferred fuel wood plants which thus points to a bleak future for areas where *E. camaldulensis* was used to reclaim mined areas particularly when utilisation becomes unsustainable. The use of the plant to reclaim mined areas has been attributed to its fast growth rates and drought resistance; therefore, reducing the long term cost of sustaining such projects (Alexander, 1990; Saadaoui et al., 2017; Zaiton et al., 2018). The plant's usage in reforestation is also attributable to its very valuable nature in the prompt solutions necessary for combating erosion and desertification (Zaiton et al., 2018). However despite these benefits, *E. camaldulensis* has also been shown to cause soil deterioration, thus, plants such as *Acacia albida* was previously suggested to have been used in its place in the reclaimed areas where this study was carried out (Alexander, 1990).

Conclusion

It is obvious from this study that if the needs of local fauna must be met effectively, then future reforestation strategy of the mined areas should incorporate indigenous plant species. This is because these plants apart from serving the energy demands of the populace are also a major support for the sustenance of local biodiversity as has been demonstrated in this study using both birds and insects.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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