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COMMUNICATION

Characterisation of breeding habitat of Grizzled Giant Squirrel *Ratufa macroura* (Mammalia: Sciuridae) in Chinnar Wildlife Sanctuary, Western Ghats, India

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Abstract: The Grizzled Giant Squirrel (GGS) *Ratufa macroura* (Pennant, 1769) is a 'Near Threatened' and endemic giant squirrel distributed in southern India and Sri Lanka. In India, the species is distributed in more than 10 locations between Cauvery Wildlife Sanctuary in Karnataka in the north and Srivilliputhur Grizzled Squirrel Wildlife Sanctuary in Tamil Nadu in the south. A study was conducted in the riparian habitats of Chinnar Wildlife Sanctuary in Kerala to understand the habitat characteristics, including the drey site use of GGS. The vegetation of the GGS habitat was studied using the quadrat method, and the dreys were counted using the transects. A total of 95 species of trees were identified from the riverine vegetation, and the GGS used 36 species of trees for drey construction. Most of the dreys were found on *Mangifera indica, Terminalia arjuna, Ficus microcarpa, Diospyros ebenum*, and *Pongamia pinnata*. However, the GGS may prefer trees such as *Mitragyna parviflora, Diospyros ebenum, Ficus microcarpa, Albizia procera, Acacia nilotica*, and *Acacia leucophloea* for drey construction. The study also highlights the usage of large trees with extensive crown by the GGS for various activities such as feeding, resting, moving, and nesting, thus signifying the necessity for protecting the remaining riverine habitat at Chinnar Wildlife Sanctuary to ensure the long-term conservation of GGS. We recommend an urgent restoration by restocking with already existing, native tree species of the riverine habitat due to the extremely poor regeneration of trees in the riverine habitat that support the only population of the GGS in Kerala.

Keywords: Conservation, drey construction, Kerala, large trees, population, riverine habitat, vegetation.

Malayalam: പശ്ചിമഘട്ടത്തിലും ശ്രീലങ്കയിലും മാത്രം കാണപ്പെടുന്ന ഒരിനം അണ്ണാനാണ് ചാമ്പൽ മലയണ്ണാൻ. ഇത് IUCNന്റെ വിശകലനത്തിൽ വംശനാശ ഭീഷണി നേരിടുന്ന ഒരിനം മലയണ്ണാൻ ആണ്. തെക്കേ ഇന്ത്യയിൽ, കർണാടകത്തിലെ കാവേരി വന്യജീവിസങ്കേതത്തിന്റെയും തെക്കു ശ്രീവില്ലിപുത്തൂർ ചാമ്പൽ മലയണ്ണാൻ വന്യജീവി സങ്കേതത്തിന്റെയും ഇടയിലായി പത്തിടങ്ങളിൽ ഇവയെ കാണപ്പെടുന്നുണ്ട്. കേരളത്തിലെ ചിന്നാർ വന്യജീവി സങ്കേതത്തിൽ നടത്തിയ ഒരു പഠനത്തിന്റെ അടിസ്ഥാനത്തിൽ, ചിന്നാറിലെ പുഴയോര കാടുകളിൽ 95ഇനം മരങ്ങൾ ഉണ്ടെന്നും, അതിൽ 36ഇനം മരങ്ങളിൽ ചാമ്പൽ മലയണ്ണാൻ കൂട് കൂട്ടുന്നതായും കണ്ടെത്തി. ഇതിൽ തന്നെ കൂടുതൽ കൂടുകളും മാവ്, അർജുൻ, ആൽമരം, കരി മരം, ഉങ്ങു എന്നിവയിലായിരുന്നു. കൂടാതെ മഞ്ഞക്കടമ്പ്, ഇത്തി, വെള്ളവാക, കരിവേലം, വെള്ളവേലം എന്നിവയും മലയണ്ണാൻ കൂടു കൂട്ടുവാൻ ഉപയോഗിക്കുന്നതായി കാണുന്നു. വലുതും വിശാലമായശാഖകളും മേലാപ്പും ഉള്ള മേൽപറഞ്ഞഗണത്തിൽപെട്ട വൃക്ഷങ്ങളാണ് ഇവ ഭക്ഷണത്തിനും, വിശ്രമത്തിനും, സഞ്ചാരത്തിനും, മറ്റുമായി കൂടുതലായി ആശ്രയിക്കുന്നത്. ഈ വൃക്ഷങ്ങളുടെ തൈകളുടെ പുനരുജ്ജീവന നിരക്ക് ചിന്നാർ വന്യജീവി സങ്കേതത്തിൽ വളരെ കുറവാണെന്ന് ഈ പഠനത്തിൽ ഞങ്ങൾക്കു കാണാൻ കഴിഞ്ഞു. ആയതിനാൽ മേൽ സൂചിപ്പിച്ച മരങ്ങളുടെ പുനരുജ്ജീവനപ്രക്രിയ അടിയന്തരമായി ചിന്നാറിലെ പുഴക്കാടുകളിൽ നടപ്പാക്കേണ്ടതായിട്ടുണ്ട്. ഇത് കേരളത്തിലെ ചാമ്പൽ മലയണ്ണാനെ കാണപ്പെടുന്ന ഏക ആവാസവ്യവസ്ഥയുടെയും, ചാമ്പൽ മലയണ്ണാണിന്റെയും നിലനിൽപ്പിനു അത്യന്താപേക്ഷിതമാണ്.

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INTRODUCTION

The Grizzled Giant Squirrel (GGS) is endemic to southern India (Kerala, Karnataka, and Tamil Nadu) and Sri Lanka (Image 1). GGS shows one of the most important paradigms of isolated populations. In India, it is known to occur in severely fragmented locations, and a few with connections including Srivilliputhur Grizzled Squirrel Wildlife Sanctuary (Joshua & Johnsingh 1994), Theni Forest Division (Babu et al. 2013), Palani Hills (Davidar 1989), Anamalai Tiger Reserve (Kumar et al. 2002), Sirumalai (Sathasivam et al. 2008), Thiruvannamalai Forest Division (Babu & Kalaimani 2014), Hosur Forest Division (Baskaran et al. 2011), Athur & Dharmapuri (Paulraj 1991; Paulraj & Kasinathan 1993), Pakkamalai Reserve Forest, Gingee (Vimalraj et al. 2018), Cauvery Wildlife Sanctuary-Shivanasamudra Falls and Mekedatu on the Cauvery river basin (Karthikeyan et al. 1992; Kumara & Singh 2006); and Chinnar Wildlife Sanctuary (Chinnar WS) in Kerala (Ramachandran 1989; 1993, Senthilkumar et al. 2007; Thomas & Nameer 2018).

The GGS has three subspecies, with one present in southern India while all the three subspecies present in Sri Lanka (Ellerman 1961; Moore & Tate 1965; Phillips 1984; Corbet & Hill 1992; Menon 2014). *Ratufa macroura dandolena* is the smallest among the three races of GGS globally and is seen in southern India and Sri Lanka. In comparison, the other two races, *Ratufa macroura macroura* and *Ratufa macroura melanochra*, are endemic to Sri Lanka. The home range of the GGS is between 0.197 ha and 0.611 ha (Joshua 1992). There are less than 500 mature individuals of GGS in India (Joshua et al. 2008; Goonatilake 2019). However, a recent study estimated the population of the GGS and found a considerably low population in Chinnar WS than the previous estimate (Thomas & Nameer 2018).

Though the Chinnar WS has an extent of 90.44 km^2, the distribution of GGS is confined to a narrow stretch of riparian vegetation along the Chinnar and Pambar rivers and their tributaries. Either side of this riparian vegetation is surrounded by scrub jungle to dry deciduous forests not used by GGS. The actual extent of the riverine habitat preferred by GGS comes to only 2 km^2 which is around 2% of the total area of the sanctuary. The previous studies on GGS in Chinnar WS (Ramachandran 1989, 1993; Senthilkumar et al. 2007; Thomas & Nameer 2018) revealed that the animal's habitat is patchy in distribution and limited by the treeless areas in Chinnar WS (Ramachandran 1993). However, in Srivilliputhur WS and Sri Lanka, the GGS exploits the plantations of mango, coconut, and tamarind (Joshua 1992; Phillips 1984). The significant conservation challenges being faced by the GGS in Chinnar are increased predation risk due to opening up of the canopy due to natural and anthropogenic effects (Thomas et al. 2017), hybridisation between GGS and Indian Giant Squirrel (Thomas et al. 2018), disturbance in the habitat because of tourism and road kills (Ramachandran 1993).

Image 1. Grizzled Giant Squirrel *Ratufa macroura* at Chinnar Wildlife Sanctuary.

Although there are some studies on the habitat and nesting behaviour of this species (Joshua & Johnsingh 1994; Senthilkumar et al. 2007), a detailed study on the drey site usage of the species is not available. The information about drey site usage will be helpful for the long-term conservation of GGS.

MATERIALS AND METHODS

Study area

The study was conducted between April 2013 to May 2014 in the Chinnar WS, Kerala, southern India. It is located between Lat- 10.250–10.350, Long- 77.083–77.266 in the Kerala part of southern Western Ghats, in Idukki district (Figure 1). Though the Chinnar WS supports the only known population of GGS in Kerala, the GGS is seen in the Anamalai Tiger Reserve, in Tamil Nadu too, which is adjacent to the Chinnar WS. The terrain of Chinnar is undulating, with altitudes ranging 440–2,372 m. Chinnar supports different vegetation

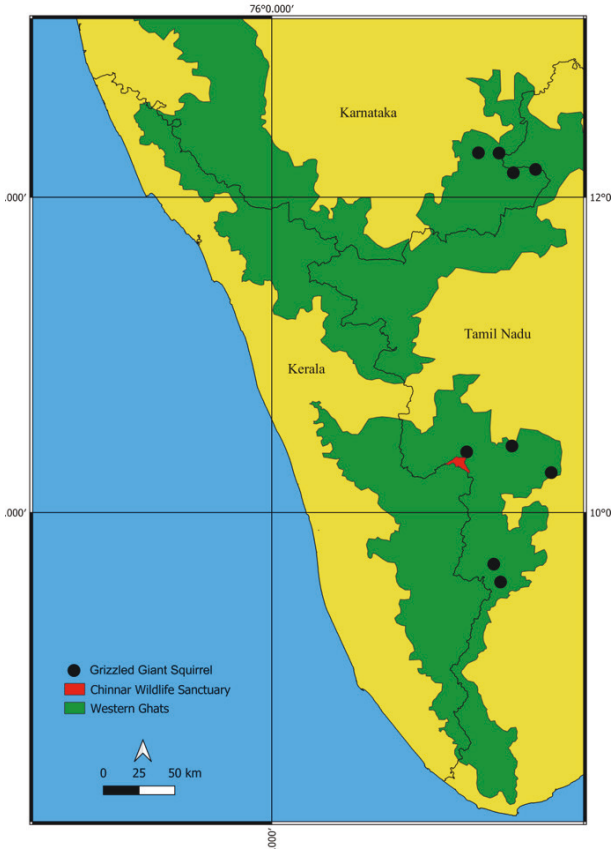

Figure 1. Location map of Chinnar Wildlife Sanctuary and other nearby populations of Grizzled Giant Squirrel in southern Western Ghats, India.

types such as southern tropical thorn forest (scrub jungle), southern dry mixed deciduous forest (dry deciduous forest), southern moist mixed deciduous forest (moist deciduous forest), tropical riparian fringing forest (riparian forest), southern montane wet temperate forest (shola forests), and southern montane wet grassland (grasslands) (Anonymous 2012; Champion & Seth 1968). The dominant vegetation among these is the dry deciduous forest followed by scrub jungle, mainly found in the plains and lower altitudes. The dry deciduous and scrub jungle together constitute about 70% of the total forest area in Chinnar (Thomas et al. 2017). However, the GGS in Chinnar WS are primarily seen only in the riverine forests along the Chinnar and Pambar rivers and tributaries which account for only about 2% of the Chinnar WS (Ramachandran 1993; Thomas & Nameer 2018).

Sampling of the Grizzled Giant Squirrel dreys

Eight, 1,000 m long transects were laid randomly after the reconnaissance survey done in the riparian habitats of Chinnar WS. These transects were walked twice a month for 12 months and recorded details of all the sighted dreys such as the number of dreys, tree species, tree height, and drey height.

Vegetation sampling

A total of 100, 10 x 10 m, quadrats were sampled for studying the vegetation in the riverine habitats in Chinnar WS. The 100m^2 (10 x 10 m) quadrats were laid at every 100m on five transects in the riverine habitats. In each quadrat, all trees with >10 cm GBH were enumerated, where the name of each tree species, the height of the tree in meters and girth at breast height in meters were recorded. The vegetation characters of tree species were quantified by calculating the following eight parameters as detailed below (after Pascal 1988).

1. Density (D) = Number of individuals/hectare

2. $$\text{Relative Density (RD)} = \frac{\text{Number of individuals of the species}}{\text{Number of individuals of all species}} \times 100$$

3. $$\text{Abundance (A)} = \frac{\text{Total Number of individuals of the species}}{\text{Number of quadrats of occurrence}}$$

4. $$\text{Percentage Frequency (PF)} = \frac{\text{Number of quadrats of occurrence}}{\text{Total Number of quadrats studied}} X\ 100$$

5. $$\text{Relative Frequency (RF)} = \frac{\text{Percentage frequency of individuals species}}{\text{Sum Percentage Frequency of all species}} \times 100$$

6. $$\text{Basal Area (BA)} = \frac{GBH^2}{4\Pi}$$

7. $$\text{Relative Basal Area (RBA)} = \frac{\text{Basal area of the species}}{\text{Basal area of all species}} X\ 100$$

8. Important Value Index (IVI) = RD + RF + RBA

Statistical analysis

We calculated the selectivity index (Ivlev 1961) to find out the relationship between the vegetation and the drey site preference by the GGS. We also performed a linear regression model to find out the relationship between the height of the tree species and the drey height.

RESULTS

Tree species composition and diversity in riparian habitat at Chinnar Wildlife Sanctuary

A total of 95 tree species were recorded from the riparian habitats of Chinnar WS. The ten most dominant

Table 1. Vegetation characteristics of riparian habitat of Chinnar Wildlife Sanctuary, Western Ghats, India.

Tree species@	D	RD	A	PF	RF	BA	RBA	IVI	RIVI
Pongamia pinnata	182	21.11	2.60	3.50	12.99	0.03	0.45	34.55	11.52
Terminalia arjuna	74	8.58	1.45	2.55	9.46	0.23	3.28	21.33	7.11
Mangifera indica	48	5.57	1.45	1.65	6.12	0.21	2.91	14.60	4.87
Pterocarpus marsupium	1	0.12	1.00	0.05	0.19	0.87	12.22	12.52	4.17
Alphonsea sclerocarpa	53	6.15	3.12	0.85	3.15	0.04	0.52	9.82	3.27
Ficus benghalensis	4	0.46	1.00	0.20	0.74	0.56	7.88	9.09	3.03
Syzygium cumini	26	3.02	1.53	0.85	3.15	0.17	2.46	8.63	2.88
Ficus microcarpa	25	2.90	1.32	0.95	3.53	0.09	1.31	7.73	2.58
Sapindus tetraphylla	22	2.55	1.38	0.80	2.97	0.02	0.32	5.84	1.95
Spondias pinnata	1	0.12	1.00	0.05	0.19	0.38	5.33	5.63	1.88
Lepisanthes senegalensis	19	2.20	1.46	0.65	2.41	0.07	0.95	5.57	1.86
Diospyros ebenum	23	2.67	1.92	0.60	2.23	0.04	0.61	5.51	1.84
Melia dubia	7	0.81	1.40	0.25	0.93	0.27	3.76	5.50	1.83
Psychoteris subintegra	23	2.67	1.77	0.65	2.41	0.01	0.08	5.16	1.72
Ficus racemosa	2	0.23	1.00	0.10	0.37	0.30	4.22	4.83	1.61
Mallotus philippensis	14	1.62	1.27	0.55	2.04	0.04	0.53	4.20	1.40
Jatropha sp.	18	2.09	1.64	0.55	2.04	0.00	0.06	4.19	1.40
Emblica officinalis	1	0.12	1.00	0.05	0.19	0.28	3.88	4.18	1.39
Gyrocarpus asiaticus	13	1.51	1.44	0.45	1.67	0.05	0.77	3.95	1.32
Calophyllum inophyllum	5	0.58	1.67	0.15	0.56	0.19	2.70	3.83	1.28
Albizia odoratissima	6	0.70	1.50	0.20	0.74	0.17	2.36	3.80	1.27
Schleichera oleosa	11	1.28	1.10	0.50	1.86	0.04	0.60	3.73	1.24
Albizia lebbeck	3	0.35	1.50	0.10	0.37	0.20	2.84	3.56	1.19
Manilkara hexandra	1	0.12	1.00	0.05	0.19	0.22	3.06	3.36	1.12
Artocarpus hirsutus	10	1.16	1.25	0.40	1.48	0.04	0.57	3.21	1.07
Euphorbia sp.	14	1.62	1.75	0.40	1.48	0.01	0.08	3.19	1.06
Tamarindus indica	11	1.28	1.10	0.50	1.86	0.01	0.00	3.13	1.04
Hopea parviflora	7	0.81	1.00	0.35	1.30	0.07	0.97	3.08	1.03
Dalbergia latifolia	10	1.16	2.00	0.25	0.93	0.05	0.75	2.84	0.95
Garuga floribunda	5	0.58	1.00	0.25	0.93	0.09	1.33	2.84	0.95
Cassia fistula	9	1.04	1.50	0.30	1.11	0.05	0.67	2.82	0.94
Chloroxylon swietenia	2	0.23	1.00	0.10	0.37	0.15	2.08	2.68	0.89
Commiphora caudata	10	1.16	1.67	0.30	1.11	0.03	0.39	2.66	0.89
Gmelina arborea	10	1.16	2.00	0.25	0.93	0.04	0.57	2.65	0.88
Garcinia gummi-gutta	7	0.81	1.17	0.30	1.11	0.05	0.65	2.57	0.86
Ceiba pentandra	2	0.23	2.00	0.05	0.19	0.15	2.08	2.49	0.83
Bauhinia racemosa	6	0.70	1.50	0.20	0.74	0.06	0.87	2.31	0.77
Stereospermum chelonoides	5	0.58	1.25	0.20	0.74	0.07	0.97	2.29	0.76
Albizia procera	6	0.70	1.20	0.25	0.93	0.04	0.58	2.21	0.74
Canarium strictum	5	0.58	1.00	0.25	0.93	0.05	0.67	2.17	0.72
Vitex altissima	3	0.35	3.00	0.05	0.19	0.11	1.59	2.12	0.71
Cassine paniculata	6	0.70	1.50	0.20	0.74	0.05	0.68	2.12	0.71
Anthocephalus cadamba	1	0.12	1.00	0.05	0.19	0.13	1.78	2.08	0.69
unidentified sp.2	4	0.46	1.00	0.20	0.74	0.06	0.87	2.08	0.69
Santalum album	7	0.81	1.17	0.30	1.11	0.01	0.15	2.07	0.69
Olea dioica	5	0.58	1.25	0.20	0.74	0.05	0.67	1.99	0.66
Phyllanthus emblica	5	0.58	1.25	0.20	0.74	0.04	0.61	1.94	0.65
Garuga pinnata	8	0.93	2.00	0.20	0.74	0.02	0.26	1.93	0.64
Randia dumetorum	6	0.70	1.00	0.30	1.11	0.01	0.08	1.89	0.63

Tree species@	D	RD	A	PF	RF	BA	RBA	IVI	RIVI
Acacia leucophloea	6	0.70	2.00	0.15	0.56	0.04	0.63	1.88	0.63
Strychnus nux-vomica	5	0.58	1.25	0.20	0.74	0.04	0.53	1.86	0.62
Drypetes sepiaria	5	0.58	1.25	0.20	0.74	0.04	0.50	1.83	0.61
Strychnos potatorum	5	0.58	1.25	0.20	0.74	0.03	0.45	1.77	0.59
Ficus albiphyla	1	0.12	1.00	0.05	0.19	0.10	1.46	1.76	0.59
Anogeissus latifolia	6	0.70	2.00	0.15	0.56	0.03	0.38	1.63	0.54
Azadirachta indica	4	0.46	1.00	0.20	0.74	0.02	0.30	1.51	0.50
Ixora brachiata	4	0.46	1.00	0.20	0.74	0.02	0.25	1.45	0.48
Mitragyna parvifolia	3	0.35	1.00	0.15	0.56	0.03	0.47	1.38	0.46
Memecylon umbellatum	2	0.23	1.00	0.10	0.37	0.05	0.77	1.38	0.46
Ficus sp.	2	0.23	1.00	0.10	0.37	0.05	0.74	1.34	0.45
unidentified sp.8	5	0.58	1.25	0.20	0.74	0.03	0.01	1.33	0.44
Excoecaria oppositifolia	2	0.23	1.00	0.10	0.37	0.05	0.70	1.30	0.43
Mallottus alba	5	0.58	2.50	0.10	0.37	0.02	0.34	1.29	0.43
Streblus asper	4	0.46	1.33	0.15	0.56	0.01	0.18	1.20	0.40
Aporosa cardiosperma	1	0.12	1.00	0.05	0.19	0.06	0.85	1.15	0.38
Acacia nilotica	2	0.23	1.00	0.10	0.37	0.04	0.52	1.12	0.37
Ziziphus oenoplia	4	0.46	1.33	0.15	0.56	0.01	0.09	1.11	0.37
Canthium umbellatum	5	0.58	2.50	0.10	0.37	0.01	0.15	1.10	0.37
Crotalaria pellida	2	0.23	1.00	0.10	0.37	0.03	0.47	1.08	0.36
Holigarna arnotiana	1	0.12	1.00	0.05	0.19	0.05	0.75	1.06	0.35
unidentified sp.4	4	0.46	2.00	0.10	0.37	0.01	0.20	1.03	0.34
Ziziphus xylopyrus	1	0.12	1.00	0.05	0.19	0.05	0.70	1.00	0.33
Manilkara roxburghiana	2	0.23	1.00	0.10	0.37	0.02	0.35	0.95	0.32
Grewia tiliifolia	1	0.12	1.00	0.05	0.19	0.04	0.63	0.93	0.31
Alseodaphnae semecarpifolia	2	0.23	1.00	0.10	0.37	0.02	0.32	0.92	0.31
Miliusa tomentosa	1	0.12	1.00	0.05	0.19	0.04	0.58	0.88	0.29
unidentified sp.6	3	0.35	1.50	0.10	0.37	0.01	0.14	0.86	0.29
Canthium dicoccum	2	0.23	1.00	0.10	0.37	0.02	0.25	0.85	0.28
unidentified sp.1	1	0.12	1.00	0.05	0.19	0.03	0.47	0.78	0.26
Plumeria alba	1	0.12	1.00	0.05	0.19	0.03	0.47	0.78	0.26
Sapindus trifoliatus	2	0.23	1.00	0.10	0.37	0.01	0.17	0.77	0.26
Ziziphus mauritiana	2	0.23	1.00	0.10	0.37	0.01	0.15	0.76	0.25
Helicteres isora	3	0.35	1.50	0.10	0.37	0.002	0.03	0.75	0.25
Lepisanthes tetraphylla	2	0.23	1.00	0.10	0.37	0.01	0.14	0.74	0.25
Bamboo sp.	2	0.23	1.00	0.10	0.37	0.01	0.12	0.73	0.24
Euphorbia trigona	2	0.23	1.00	0.10	0.37	0.01	0.12	0.73	0.24
unidentified sp.3	3	0.35	3.00	0.05	0.19	0.01	0.17	0.70	0.23
Terminalia paniculata	1	0.12	1.00	0.05	0.19	0.03	0.38	0.68	0.23
unidentified sp.5	1	0.12	1.00	0.05	0.19	0.03	0.38	0.68	0.23
Ailanthus triphysa	1	0.12	1.00	0.05	0.19	0.02	0.23	0.53	0.18
Acacia intsia	1	0.12	1.00	0.05	0.19	0.01	0.15	0.46	0.15
Ficus hispida	1	0.12	1.00	0.05	0.19	0.01	0.14	0.44	0.15
Acacia catechu	1	0.12	1.00	0.05	0.19	0.01	0.09	0.39	0.13
unidentified sp.7	1	0.12	1.00	0.05	0.19	0.006	0.06	0.37	0.12
Chukrasia tabularis	1	0.12	1.00	0.05	0.19	0.001	0.02	0.32	0.11
Total	862	100	127.74	26.95	100	7.13	100	300	100

@—arranged in the descending order of the IVI index value | D—density (trees/ha) | RD—relative density | A—abundance | PF—percentage frequency | RF—relative frequency | BA—basal area (m^2/ha.) | RBA—relative basal area | IVI—important value index | RIVI—relative important value index.

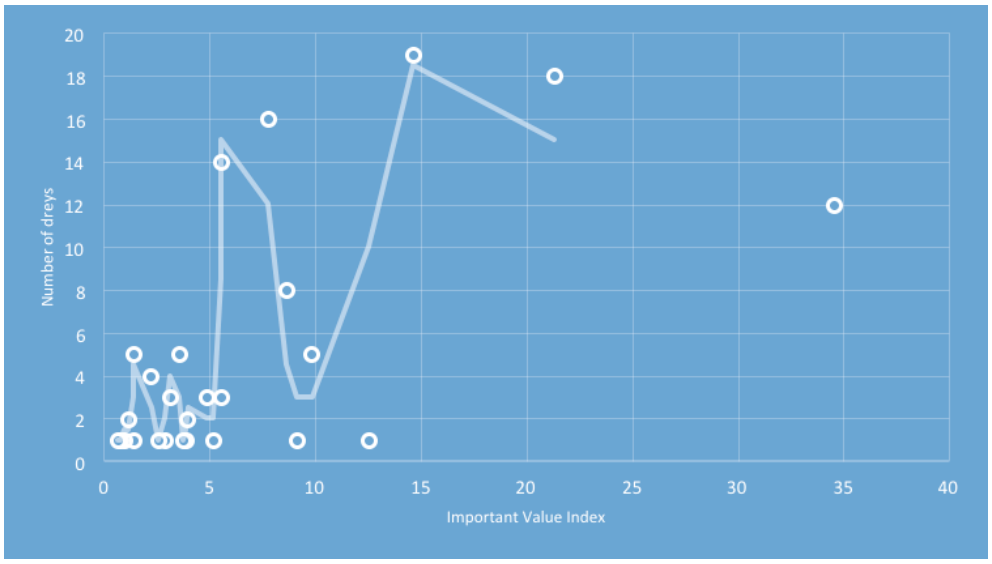

Figure 2. Relationship between the Important Value Index of the riparian vegetation and the number of dreys of Grizzled Giant squirrels at Chinnar Wildlife Sanctuary.

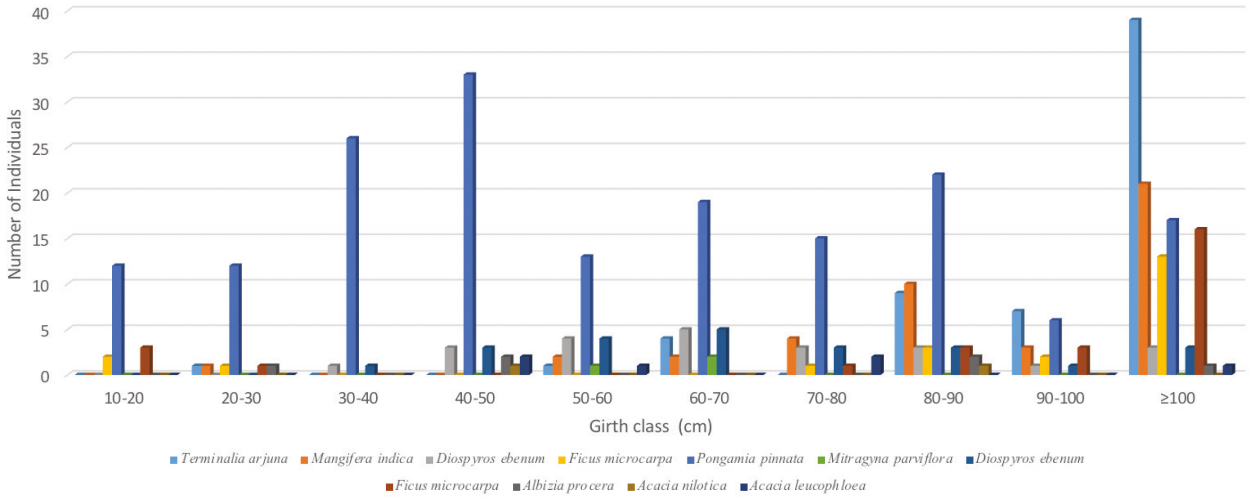

Figure 3. The girth class distribution of selected tree species used by the Grizzled Giant Squirrel for drey construction at Chinnar Wildlife Sanctuary.

tree species in the GGS habitat were *Pongamia pinnata, Terminalia arjuna, Mangifera indica, Pterocarpus marsupium, Alphonsea sclerocarpa, Ficus benghalensis, Syzygium cumini, Ficus microcarpa, Sapindus tetraphylla*, and *Spondias pinnata* (Table 1). The riparian habitat of the GGS is also characterised by a tree density of 862 trees per hectare and a tree basal area of 7.13 m^2/ha.

Characterising of the drey site occurrence of Grizzled Giant Squirrels

The GGSs were found to be using about 36 trees in Chinnar WS for drey construction (Table 2), and a total of 144 dreys were recorded. The following five species were found holding 54.86 % of the total dreys. The five species were *Mangifera indica* (n= 19) *Terminalia arjuna* (n= 18), *Ficus microcarpa* (n= 16), *Diospyros ebenum* (n= 14), and *Pongamia pinnata* (n= 12). The correlation studies between the important value index (IVI) of the trees and drey numbers showed (Figure 2) that there is no correlation between the dominant trees and the drey selection. This also suggests that the choice of nesting trees by the GGS is not random, and going by the ranks of the Ivlev index indicate that the GGS may have a preference for the trees such as *Mitragyna*

Table 2. Tree use preference by Grizzled Giant Squirrel for drey construction at Chinnar Wildlife Sanctuary, Western Ghats, India.

Tree species@	Family	Number of dreys	Habit	IVI	Ivlev index
Mitragyna parviflora	Rubiaceae	5	Deciduous	1.38	0.567
Diospyros ebenum	Ebenaceae	14	Evergreen	5.51	0.435
Ficus microcarpa	Moraceae	16	Evergreen	7.73	0.349
Albizia procera	Fabaceae	4	Deciduous	2.21	0.288
Acacia nilotica	Fabaceae	2	Deciduous	1.12	0.282
Acacia leucophloea	Fabaceae	1	Deciduous	0.63	0.227
Albizia lebbeck	Fabaceae	5	Deciduous	3.56	0.168
Mangifera indica	Anacardiaceae	19	Evergreen	14.6	0.131
Sapindus trifoliatus	Sapindaceae	1	Evergreen	0.77	0.130
Hopea parviflora	Dipterocarpaceae	1	Evergreen	0.97	0.015
Tamarindus indica	Fabaceae	3	Evergreen	3.13	-0.021
Syzygium cumini	Myrtaceae	8	Evergreen	8.63	-0.038
Terminalia arjuna	Combretaceae	18	Evergreen	21.33	-0.085
Memecylon grande	Melastomataceae	1	Evergreen	1.38	-0.160
Ficus racemosa	Moraceae	3	Evergreen	4.83	-0.234
Melia dubia	Meliaceae	3	Deciduous	5.5	-0.294
Alphonsea sclerocarpa	Annonaceae	5	Deciduous	9.82	-0.325
Gyrocarpus asiaticus	Hernandiaceae	2	Deciduous	3.95	-0.328
Garcinia gummi-gutta	Guttiferae	1	Evergreen	2.57	-0.440
Dalbergia latifolia	Fabaceae	1	Deciduous	2.85	-0.481
Pongamia pinnata	Leguminosae	12	Evergreen	34.55	-0.484
Schleichera oleosa	Sapindaceae	1	Deciduous	3.73	-0.577
Calophyllum inophyllum	Guttiferae	1	Evergreen	3.83	-0.586
Psychotria subintegra	Rubiaceae	1	Evergreen	5.16	-0.675
Ficus benghalensis	Moraceae	1	Evergreen	9.09	-0.802
Pterocarpus marsupium	Fabaceae	1	Deciduous	12.52	-0.852

@—arranged in the descending order of Ivlev index

parviflora, Diospyros ebenum, Ficus microcarpa, Albizia procera, Acacia nilotica, and *Acacia leucophloea* for drey construction.

Regeneration of the trees in the riverine habitat in Chinnar WS

The regeneration of the trees used by the GGS for drey construction was extremely low in Chinnar WS (Figure 3), as evidenced by the absence of individuals in the lower girth classes for most tree species. Ideally, the girth class distribution of the tree species in an undisturbed forest should have been showing an inverse 'J' pattern (Pascal 1988). In contrast, at Chinnar riverine patch, the plants with lower girth classes were more or less completely absent for most of the trees except *Pongamia pinnata*.

Relationship between the tree height and the drey height

The linear regression model analysis clearly showed a strong correlation between the height of the tree and the height at which the drey was constructed (R= 0.9483, P <0.0001) (Figure 4). It can also be deduced from this graph that the GGSs showed more significant variation in the height of the trees used to construct the dreys, which varied from 5 m to 30 m (Figure 4), with most of the drey height being between 15 to 20 m. However, it is interesting to note that the tree height influences the drey height in the respective habitat (Figure 5a,b).

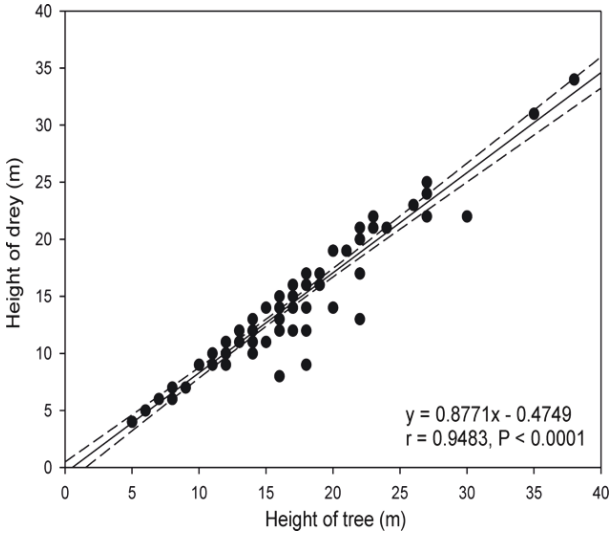

Figure 4. Relationship between drey height and tree height in Chinnar Wildlife Sanctuary, Western Ghats, India. Dashed line is 95% confidence interval of regression line.

DISCUSSION

The GGS were found using large, mature trees for the drey construction in the riverine habitat at Chinnar WS. The dreys were built just below the canopy of the trees. GGS's usually prefer significantly larger trees with greater girth and taller trees with multiple branches for drey construction (Senthilkumar et al. 2007). The selection of mature trees with greater canopy continuity could facilitate easy movement to and from the drey in all directions, equip the animal by providing a significant advantage to escape from predators and to move to other parts of the home range for foraging and other activities. The extent to which GGS is using a habitat depends on the composition of tree species and structural attributes of the forests canopy, predominantly the canopy continuum. Discontinuous forests are known to restrict their movement and dispersal because of their arboreal habit. Most of the arboreal dwellers and GGS prefer those habitats that provide dense canopy cover and higher canopy height (Baskaran et al. 2011; Nagarajan et al. 2011).

The observations in this study corroborate the findings of previous studies that giant squirrels prefer areas with canopy connectivity to live and build their dreys (Baskaran et al. 2011). The first branching height of the tree increases with its total height; hence the drey would have to be higher on taller trees. This may be helping the animal to escape from predation and effective utilisation of its entire home range for resources.

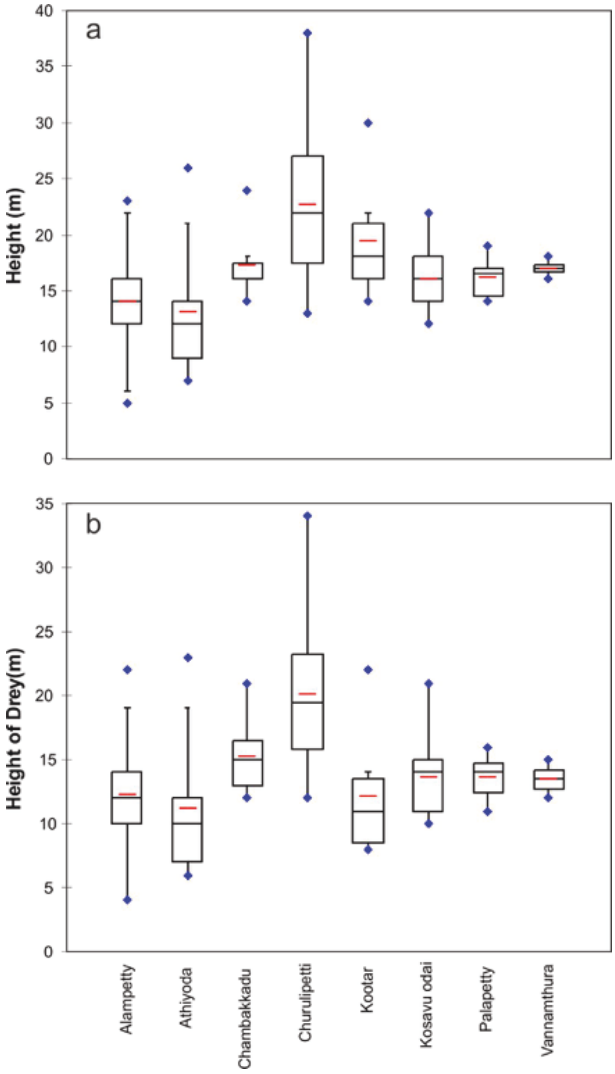

Figure 5. Height of the tree (a) and height at which the drey was constructed (b) in eight riparian locations of Chinnar Wildlife Sanctuary.

The GGS in Chinnar WS was found to construct globular dreys using leaves and twigs. One pair of GGS makes multiple dreys within their home range, similar to other giant squirrels (Prater 1971; Srinivas et al. 2008). The GGS was found to construct multiple dreys at a time. The construction and use of multiple dreys might provide conveniently placed insulated nesting places throughout the territory or reduce drey predation (Borges 2015). Drey rotation may also help to avoid extremes of weather conditions like temperature and rainfall. The rotation of the drey will also reduce ectoparasite load.

In the Sitanadi WS, 77.68% of the dreys of giant squirrels were found on deciduous trees, while 22.32 % were located on the evergreen trees (Kanoje 2008). However, in the present study, 73.61 % of nesting trees

were evergreen.

The extremely poor regeneration of the tree species used by the GGS for the drey construction at Chinnar WS is a matter of concern. It warrants urgent restoration programmes at Chinnar riverine habitat with the most suitable native tree species.

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