

**OPEN ACCESS**

The Journal of Threatened Taxa (JoTT) is dedicated to building evidence for conservation globally by publishing peer-reviewed articles online every month at a reasonably rapid rate at [www.threatenedtaxa.org](http://www.threatenedtaxa.org). All articles published in JoTT are registered under [Creative Commons Attribution 4.0 International License](https://creativecommons.org/licenses/by/4.0/) unless otherwise mentioned. JoTT allows unrestricted use, reproduction, and distribution of articles in any medium by providing adequate credit to the author(s) and the source of publication.

# Journal of Threatened Taxa

Building evidence for conservation globally

[www.threatenedtaxa.org](http://www.threatenedtaxa.org)

ISSN 0974-7907 (Online) | ISSN 0974-7893 (Print)

## COMMUNICATION

### SPECIES DIVERSITY AND ABUNDANCE PATTERNS OF EPIPHYTIC ORCHIDS IN ARALAM WILDLIFE SANCTUARY IN KERALA, INDIA

Jis Sebastian, Durairaj Kathiresan & Giby Kuriakose

26 July 2021 | Vol. 13 | No. 8 | Pages: 19060–19069

DOI: [10.11609/jott.4852.13.8.19060-19069](https://doi.org/10.11609/jott.4852.13.8.19060-19069)



For Focus, Scope, Aims, and Policies, visit [https://threatenedtaxa.org/index.php/JoTT/aims\\_scope](https://threatenedtaxa.org/index.php/JoTT/aims_scope)

For Article Submission Guidelines, visit <https://threatenedtaxa.org/index.php/JoTT/about/submissions>

For Policies against Scientific Misconduct, visit [https://threatenedtaxa.org/index.php/JoTT/policies\\_various](https://threatenedtaxa.org/index.php/JoTT/policies_various)

For reprints, contact [<ravi@threatenedtaxa.org>](mailto:ravi@threatenedtaxa.org)

The opinions expressed by the authors do not reflect the views of the Journal of Threatened Taxa, Wildlife Information Liaison Development Society, Zoo Outreach Organization, or any of the partners. The journal, the publisher, the host, and the partners are not responsible for the accuracy of the political boundaries shown in the maps by the authors.

**Publisher & Host**





## Species diversity and abundance patterns of epiphytic orchids in Aralam Wildlife Sanctuary in Kerala, India

Jis Sebastian<sup>1</sup> , Durairaj Kathiresan<sup>2</sup> & Giby Kuriakose<sup>3</sup>

<sup>1,2</sup>Department of Botany, Saraswathi Narayanan College, Perungudi, Madurai, Tamil Nadu 625022, India.

<sup>3</sup>Department of Botany, Sacred Heart College, Thevara P.O, Ernakulam, Kerala 682013, India.

<sup>1</sup>alkaeliza@gmail.com, <sup>2</sup>kathiresansnc@gmail.com (corresponding author), <sup>3</sup>giby.kuriakose@shcollege.ac.in

**Abstract:** Species diversity and abundance patterns of epiphytic orchids were studied in Aralam Wildlife Sanctuary, in the Western Ghats of northern Kerala. Habitats sampled were wet evergreen (EVEG), montane wet evergreen (MEVG), moist deciduous (MDEC), and semi evergreen (SEVG), on a gradient of altitude from 60 to 1,589 m. Selective tree scanning on linear line transects was deployed (n= 40) across spatial units. A total of 39 orchid species were recorded. Rarefied species richness was maximum in the EVEG (20) habitat. Best suited rank abundance models were analysed for epiphytic orchids in each habitat and checked for significant differences. Bootstrap and Jackknife-1 estimators and species accumulation curves suggested higher species richness than observed, therefore more effort in sampling was needed in order to record all epiphytic orchids of the area. The difference in species richness between habitat types was not statistically significant (ANOVA). 38% of recorded epiphytic orchid species were endemic.

**Keywords:** Endemic, Orchidaceae, terrestrials, Western Ghats.

**Editor:** Pankaj Kumar, Kadoorie Farm and Botanic Garden, Tai Po, Hong Kong S.A.R., China.

**Date of publication:** 26 July 2021 (online & print)

**Citation:** Sebastian, J., D. Kathiresan & G. Kuriakose (2021). Species diversity and abundance patterns of epiphytic orchids in Aralam Wildlife Sanctuary in Kerala, India. *Journal of Threatened Taxa* 13(8): 19060–19069. <https://doi.org/10.11609/jott.4852.13.8.19060-19069>

**Copyright:** © Sebastian et al 2021. Creative Commons Attribution 4.0 International License. JoTT allows unrestricted use, reproduction, and distribution of this article in any medium by providing adequate credit to the author(s) and the source of publication.

**Funding:** SERB- DST India (Reg.No. SR/FT/LS-176/2010) under the scheme SERB-DST Fast Track Young Scientist Program and UGC Minor Research Project (MRP(S)-1130/11-12/KAMY013/UGC-SWRO).

**Competing interests:** The authors declare no competing interests.

**Author details:** JIS SEBASTIAN—Independent researcher in the Western Ghats. Her interest lies in orchid science and climate resilient community conservation models. DURAIRAJ KATHIRESAN—Associate professor at PG department & Research Centre in Botany, Saraswathi Narayanan College, Perungudi, Madurai. GIBY KURIAKOSE—Assistant professor and Head of the Department at Department of Botany, Sacred Heart College, Cochin, Kerala.

**Author contributions:** JS—data collection-compilation-analysis and writing of the manuscript; DK—guiding the data compilation- analysis and writing of the manuscript; GK—conceptualisation of the study, executing the study and fund management, guiding data collection-compilation-analysis and writing of the manuscript.

**Acknowledgements:** This research work was possible due to the permission granted by the PCCF & CWW, Kerala. We thank the Department of Science and Technology and UGC Minor Research Project for the financial support. We acknowledge Saraswathi Narayanan College, Madurai, Tamil Nadu and Sacred Heart College, Thevara, Cochin, Kerala for guidance and support. SJ thanks Dr Abin Varghese, Co-ordinator, Dr R Satheesh Centre for Remote Sensing and GIS, School of Environmental Sciences, Mahatma Gandhi University, Kottayam; WWF Prince Bernhard Nature Fund, Switzerland and Idea Wild, USA.



## INTRODUCTION

Epiphytes, a significant group of slow growing plants (Benzing 1990), are more associated with tropical rain forests compared to temperate forests (Webb 1959; Richards et al. 1996). Orchidaceae are dominant among tropical rainforest epiphytes, possibly due to adaptations to temporary water stress in different climates and microclimates (Benzing 2004). Orchids make major contributions to the forest communities they inhabit (Nadkarni 1994) and they are also valued for their horticultural, medicinal, ethical, and edible prospects.

The Western Ghats is home to 310 orchid species, of which 123 are not found elsewhere (Jalal & Jayanthi 2012), and in Silent Valley National Park 50% of total epiphytes recorded are orchids (Kumar 1999). The Western Ghats are now inhabited by almost 50 million people, which has resulted in extensive transformation of landscapes, over exploitation of natural resources, habitat degradation, habitat loss, and encroachment. Selective removal of orchids for ornamental and medicinal purposes without considering their ecological attributes is globally identified as a threat to orchids (Huang 2011). In order to have a conservation strategy for specific species or groups in a region, it is important to know their ecology. However, taxonomic confusion persists in the region over endemic orchid species and sub species. In a moist lowland forest in the eastern Himalaya, selective logging was found to affect structural complexity of trees and hence associated microclimates, gradually threatening pteridophytes, non-orchids, and orchids (Padmawathe et al. 2004). The extensive forests of the Western Ghats become a challenge for an ecologist when groups such as orchids with random distribution is in focus. Epiphytes have been associated with trunk size in tropical evergreen forest in the Western Ghats (Annaselvam & Parthasarathy 2001). Apart from taxonomic explorations, diversity and ecology of *Dendrobium* in Chotanagpur plateau (Kumar et al. 2011), epiphytic orchid diversity from farmer managed forests in the Western Ghats (Sinu et al. 2011), habitat studies of medicinal orchids (Jalal & Rawat 2009), and conservation strategies for orchids of western Himalaya (Jalal 2012) are the only existing ecological works on orchids from India.

In order to fill this gap, the authors have examined ecological aspects of epiphytic orchids in the Western Ghats of Kerala. This study deals with the epiphytic orchids in Aralam Wildlife Sanctuary (WS) in Kannur district of northern Kerala. Aralam WS falls in Wayanad Plateau in the southern Western Ghats. The objectives

of this study were to assess patterns of species diversity, abundance, and endemism among epiphytic orchids in Aralam WS.

## STUDY AREA

The Aralam WS is situated between 11.900–11.983 °N 75.783–78.950 °E spanning around 55 km<sup>2</sup> (Figure 1). The elevation varies from 60m to ca. 1,589m from mean sea level with two major peaks, the Katti Betta (1,145 m) and the Ambalapara (1,589 m). The temperature varies from 21°C to 40°C in the lower altitudes and 8 °C to 25 °C at the higher reaches. The south-west and the north-east monsoons together give annual rainfall between 3,745 mm and 5,052mm. The Sanctuary land slopes from the east to the west, is drained by the Cheenkannipuzha, which flows to the west. Aralam WS is known for the west coast tropical evergreen forest where the unique *Dipterocarpus-Mesua-Palaquim* sub-type is seen (Nair 1991). There are about 490 ha of Teak and Eucalyptus plantations within the forest area (Manju et al. 2009). Apart from this, the vegetation of the Sanctuary can be classified into low (0–800 m) and medium (801–1,450 m) elevation types of wet evergreen, semi evergreen, moist deciduous, and high elevation (>1,450m) montane wet evergreen or hilltop evergreen forest (Champion & Seth 1968; Ramesh 2001). The floristic composition of Ambalapara region differs considerably from shola forests (Menon 1999; KFD 2009; Manju et al. 2009). The trees of this part are stunted, usually below 20m, belonging to Laurales and Myrtales, with trunks of heavy loads of epiphytic plants. Therefore, the vegetation from 1,450 to 1,700 m elevation is treated as high elevation/montane wet evergreen forest (MEVG).

The animal diversity of the Sanctuary was comparatively well studied (Radhakrishnan 1996; Abraham & Easa 1999; Nair 2001, 2003; Sreekumar & Balakrishnan 2001 etc), but reports on plant diversity are very few (Menon 1999) and mostly limited to bryophytes and pteridophytes (Manju et al. 2009; Dantas et al. 2016; Rajesh & Vijisha 2016). So far, 47 orchid species have been reported from the Sanctuary of which 20 are endemic to India (KFD 2009).

## METHODS

### Field sampling

Field sampling was done from September to November in 2015. Selective tree scanning (to ensure

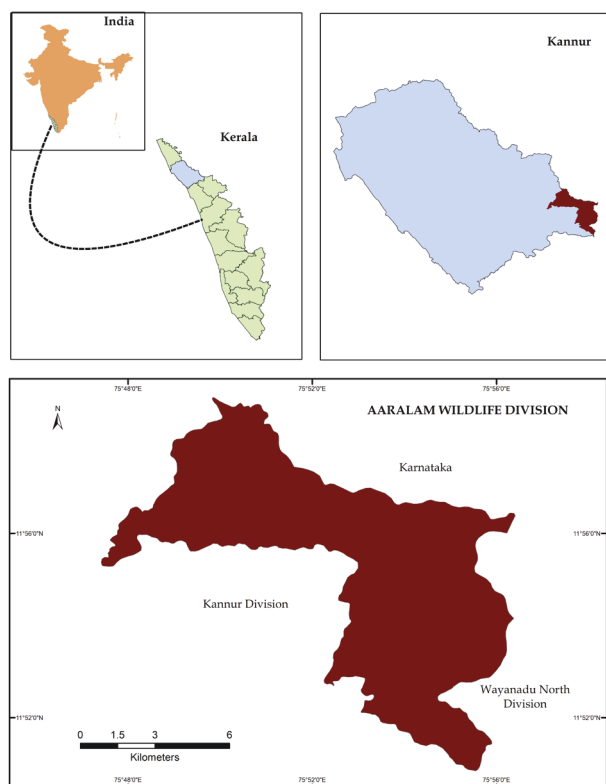


Figure 1. Aralam Wildlife Division in Kannur District, Kerala, India.

representation of vertical distribution and diversity of orchids) on linear line transects (to enable spatial scaling of orchids in heterogeneous habitats) was developed (Sebastian et al. 2017) through trial and error integrating sampling of vascular epiphyte richness and abundance (SVERA, Wolf et al. 2009) and line transects (Jacquemin et al. 2007). Transects were laid 100 m from each other in linear direction in different habitat types based on the presence of epiphytic orchids (see Table 1). A line transect was laid after finding a host tree with at least three individuals of orchids on it. Then, the next neighbouring tree was selected at the 10<sup>th</sup> meter point from the first individual and this was repeated until data collected from a total of 10 individual trees from each line transect. Data on three levels of sampling were taken from each transect. Data on characteristics of habitat, host tree, and the substrate (immediate surrounding) of orchids were recorded. Due to limitations in canopy access, orchid species were identified with a pair of binoculars (VORTEX 8X42) from ground, using the field key (Pradhan 1976, 1979; Abraham & Vatsala 1981; Joseph 1982; Kumar & Manilal 1994, 2004).

### Statistical analysis

Statistical analysis of data from 40 transects was

Table 1. Habitat types used for the study.

Habitat types (following Ramesh 2001)	
EVEG	Wet evergreen (low-mid elevation)
MDEC	Moist deciduous
SEVG	Semi evergreen
MEVG	Montane wet evergreen (high elevation)

performed using statistical software R (version 3.5.0) and PAST 3.19. Orchids were ranked based on their abundance to check on singletons and doubletons. Due to the difference in the number of transects in different spatial units, rarefied diversity indices were estimated. Different habitats were compared using graphical representation of diversity indices and dominance indices in point plots to focus on difference with the help of error bars from bootstrap sampling. Rank abundance model (rad) for habitats was prepared using the best suited model (with lowest Akaike Information Criteria, AIC) to visualise the site diversity/dominance. In order to understand total species richness of epiphytic orchids in Aralam, total species was estimated based on incidence-based estimators. Species accumulation curve was prepared for species across transects in habitats using random accumulator function based on individual accumulation model. The rarefied species richness was compared across habitats. The significance of difference was tested using ANOVA and Welch T-test. The proportion of endemic species richness and abundance in the sample was plotted as a bar diagram and has been compared with a previous research paper.

## RESULTS AND DISCUSSION

### Patterns in species diversity and abundance

In total, we found 2,831 individuals belonging to 39 species of epiphytic orchids (a complete species list is given in Table 2) from 400 individual trees (of >10cm GBH) spread across 40 transects. Also, 29 terrestrial orchids (of which, nine were unconfirmed species but morphologically distinct) were recorded from the study area. *Bulbophyllum fischeri* and *B. fuscopurpureum* were found growing both as epiphyte and terrestrial forms. The host trees sampled were grouped into 96 species and 15 unidentified species that were morphologically distinct. Among orchids, *Gastrochilus acaulis* was present in all habitats followed by *Cleisostoma tenuifolium*, *Cottonia peduncularis*, and *Liparis viridiflora* in three habitats each. The common species with the highest abundance was *Cleisostoma tenuifolium*. Two species





were recorded with single individuals (singletons) and another six species were represented by two individuals (doubleton) each.

Species Abundance Distribution (SAD) model, based on rank abundance of species for each habitat (Figure 2), explained the diversity of respective habitats with the help of basic models Null, Pre-emption, and Lognormal. Rank abundance models with least AIC values suggested an abundance model for each vegetation (habitat) type (Table 3). The relative abundance of species against their rank in EVEG habitat, best explained by the Null model, indicates that individuals are randomly distributed among observed species. Whereas, the Log normal model explained ranking based on relative abundance in MDEC and SEVG habitats as the abundance of species are in normal distribution with high evenness among species. Pre-emption model fitted to MEVG habitat describes least evenness among species with respect to the distribution of individuals. Interestingly, MEVG habitat had four dominant species: *Bulbophyllum fischeri*, *Sirhookera lanceolata*, *Coelogyne nervosa*, and *Conchidium microchilos*, while other species were barely represented.

EVEG habitat recorded 20 species with just 579 individuals, whereas SEVG habitat recorded 12 species with the highest abundance of 1,253 (Table 4). Biodiversity indices such as Shannon-Weiner index, Margalef & Fisher alpha showed variations with high diversity in EVEG, and the lowest was in SEVG habitat (Figure 3). Meanwhile, in a comparison of Simpson 1-D values (Figure 4), a dominance index that accounts for diversity and evenness between habitats, only EVEG and MEVG were significantly different from each other (Mann-Whitney pairwise test,  $df=3$ , at  $p=0.05$ ). MEVG habitat had only one species in common with other habitats. Six species were found shared between MEVG and EVEG habitat with more or less equal individuals. MEVG significantly differed from EVEG with the presence of five unique species, and of which species, *Bulbophyllum fischeri* was well represented in number of individuals. Furthermore, higher abundance of species, *Dendrobium nutans* in MEVG from that of EVEG habitat could have also contributed to it. EVEG habitat with Simpson 1-D value 0.92 indicated highest diversity amongst and SEVG habitat the lowest with 0.74. SEVG habitat showed maximum abundance per species and the abundance distribution across species was found to be in normal distribution with high evenness.

The transects were standardised and rarefied species richness was estimated for minimum and maximum abundances. Total species richness was estimated for

Aralam WS based on this rarefied data. One species per transect was added on average in accumulation of species for total species richness. The species observed, Sobs, was close to the bootstrap estimator which predicted a total of 46 species whereas, Chao estimator provided the highest predicted richness, 74 for the WS. This indicates the need of more transects to get a better picture about the distribution pattern of species and abundance of epiphytic orchids of Aralam WS. The relationship between species and individuals in each habitat was plotted (Figure 5). The number of species initially increased in a strong and steady manner along with the addition of individuals in habitats such as EVEG and MDEC. This clearly indicated the spacing of species in these habitats were not too far from each other. At the same time, the pattern of species accumulation was very gradual in MEVG and SEVG habitats in the beginning as a result of larger spacing between species in a wider area when compared to shorter spacing in EVEG and MDEC. Then the addition of individuals to species in SEVG reached an asymptote indicating that epiphyte assemblage in SEVG is not as diverse as other habitats but represented by high abundance. A comparison between rarefied species richness for minimum and maximum abundances in habitat types was tested (Figure 6). However, they were not statistically significantly different from each other (ANOVA at  $p=0.05$ ,  $df=3$ ). MEVG shared only one common species between SEVG and MDEC. However, MDEC and SEVG had nine common species. Lastly, EVEG shared six species with MDEC; seven species with MEVG; seven species with SEVG. Four habitats shared only one species in common.

The total extent of the study area is just 55 km<sup>2</sup> and it contains at least four major habitat types, other than plantations and riparian forests. The distribution of different habitats within the study area is highly contiguous and not continuous that creates several ecotones at places. Although the present study covered maximum area in each habitat the present results clearly shows the diversity in microhabitats and microclimates within each habitat type as the estimated species richness (74 species) differed greatly to that of observed species richness (39 species). Therefore, an approach involving identification of different microhabitat and microclimate zones should be deployed to maximise the likelihood of recording maximum species in the study area. Further, species abundance pattern (Figure 2) across different habitats varies greatly and different habitats fit in with different SAD models with different patterns of distribution of species.

**Table 2. The list of identified epiphytic and terrestrial orchids from Aralam Wildlife Sanctuary, Kannur.**

	Species	Epiphytic	Terrestrial	Endemic**
1	<i>Aerides crispa</i>	+	-	-
2	<i>Aerides ringens</i>	+	-	-
3	<i>Bulbophyllum fischeri</i>	+	+	-
4	<i>Bulbophyllum fuscopurpureum</i>	+	+	+
5	<i>Bulbophyllum neilgherrense</i>	+	-	-
6	<i>Bulbophyllum tremulum</i>	+	-	-
7	<i>Chiloschista pusilla</i>	+	-	-
8	<i>Cleisostoma tenuifolium</i>	+	-	-
9	<i>Coelogyne mossiae</i>	+	-	+
10	<i>Coelogyne nervosa</i>	+	+	+
11	<i>Conchidium exile</i>	+	+	+
12	<i>Conchidium microchilos</i>	+	+	+
13	<i>Cottonia peduncularis</i>	+	-	-
14	<i>Cymbidium aloifolium</i>	+	-	-
15	<i>Dendrobium aquem</i>	+	-	+
16	<i>Dendrobium macrostachyum</i>	+	-	-
17	<i>Dendrobium microbulbon</i>	+	-	+
18	<i>Dendrobium jerdonianum</i>	+	-	-
19	<i>Dendrobium ovatum</i>	+	-	+
20	<i>Dendrobium panduratum</i>	+	-	-
21	<i>Eria reticosa</i>	+	+	-
22	<i>Gastrochilus acaulis</i>	+	-	-
23	<i>Gastrochilus flabelliformis</i>	+	-	+
24	<i>Phalaenopsis deliciosa</i>	+	-	-
25	<i>Liparis elliptica</i>	+	-	-
26	<i>Liparis viridiflora</i>	+	-	-
27	<i>Oberonia brunoniana</i>	+	-	+
28	<i>Oberonia santapaui</i>	+	-	+
29	<i>Oberonia tenuis</i>	+	-	-
30	<i>Papilionanthe subulata</i>	+	-	-
31	<i>Pholidota imbricata</i>	+	-	-

	Species	Epiphytic	Terrestrial	Endemic**
32	<i>Pomatocalpa spicata</i>	+	-	-
33	<i>Porpax jerdoniana</i>	+	-	+
34	<i>Porpax reticulata</i>	+	-	-
35	<i>Rhyncostylis retusa</i>	+	-	-
36	<i>Seidenfadeniella rosea</i>	+	-	+
37	<i>Sirhookera lanceolata</i>	+	+	-
38	<i>Smithsonia straminea</i>	+	-	+
39	<i>Bulbophyllum stocksii</i>	+	-	+
40	<i>Calanthe sylvatica</i>	-	+	-
41	<i>Cheirostylis flabellata</i>	-	+	-
42	<i>Disperis neilgherrensis</i>	-	+	-
43	<i>Eria albiflora</i>	-	+	+
44	<i>Habenaria gibsonii</i> var. <i>gibsonii</i>	-	+	-
45	<i>Habenaria longicorniculata</i>	-	+	-
46	<i>Habenaria perrottetiana</i>	-	+	+
47	<i>Malleola gracilis</i>	-	+	-
48	<i>Pecteilis gigantea</i>	-	+	-
49	<i>Satyrium nepalense</i>	-	+	-
50	<i>Sirhookera latifolia</i>	-	+	-
51	<i>Tainia bicornis</i>	-	+	-
52	<i>Tropidia angulosa</i>	-	+	-
53	<i>Brachycorythis iantha</i>	-	+	+
54	<i>Liparis</i> sp.*	-	+	-
55	<i>Liparis</i> sp.2*	-	+	-
56	<i>Bulbophyllum</i> sp.*	-	+	-
57	<i>Bulbophyllum</i> sp. 2*	-	+	-
58	<i>Cheirostylis</i> sp.*	-	+	-
59	<i>Oberonia</i> sp.*	-	+	-
60	<i>Spiranthes</i> sp.*	-	+	-
61	<i>Zeuxine</i> sp.*	-	+	-

\*genus with unconfirmed species. \*\* Endemics (Jalal 2012; Kumar et al. 2000; Jayalakshmi 2016).

## Endemism

Endemism among epiphytic orchids of Aralam WS deserves further attention, as 29% of total orchids (N= 62) and 38% of epiphytic orchids (N= 39) from the area were endemic to the Western Ghats (Figure 7). Abundance of endemic orchids alone made up 28% of total abundance. However, the difference in endemic species richness and abundance between habitats was not significant (Kruskal Wallis test,  $p= 0.8$ ). Interestingly, of these endemic orchids, eight species were seen only in one habitat and five species in two habitats each. However, associations amongst species with respect to

**Table 3. RAD models for habitats with the least AIC value marked in red.**

	EVEG	MDEC	MEVG	SEVG
Null	117.9956	168.7757	128.51493	491.0734
Pre-emption	125.6122	197.9680	77.26034	125.5718
Lognormal	129.4657	151.8832	99.69576	102.5774

habitat could not be identified with sample size as low as 40 transects. Furthermore, three terrestrial endemics were also recorded. These terrestrial endemics such

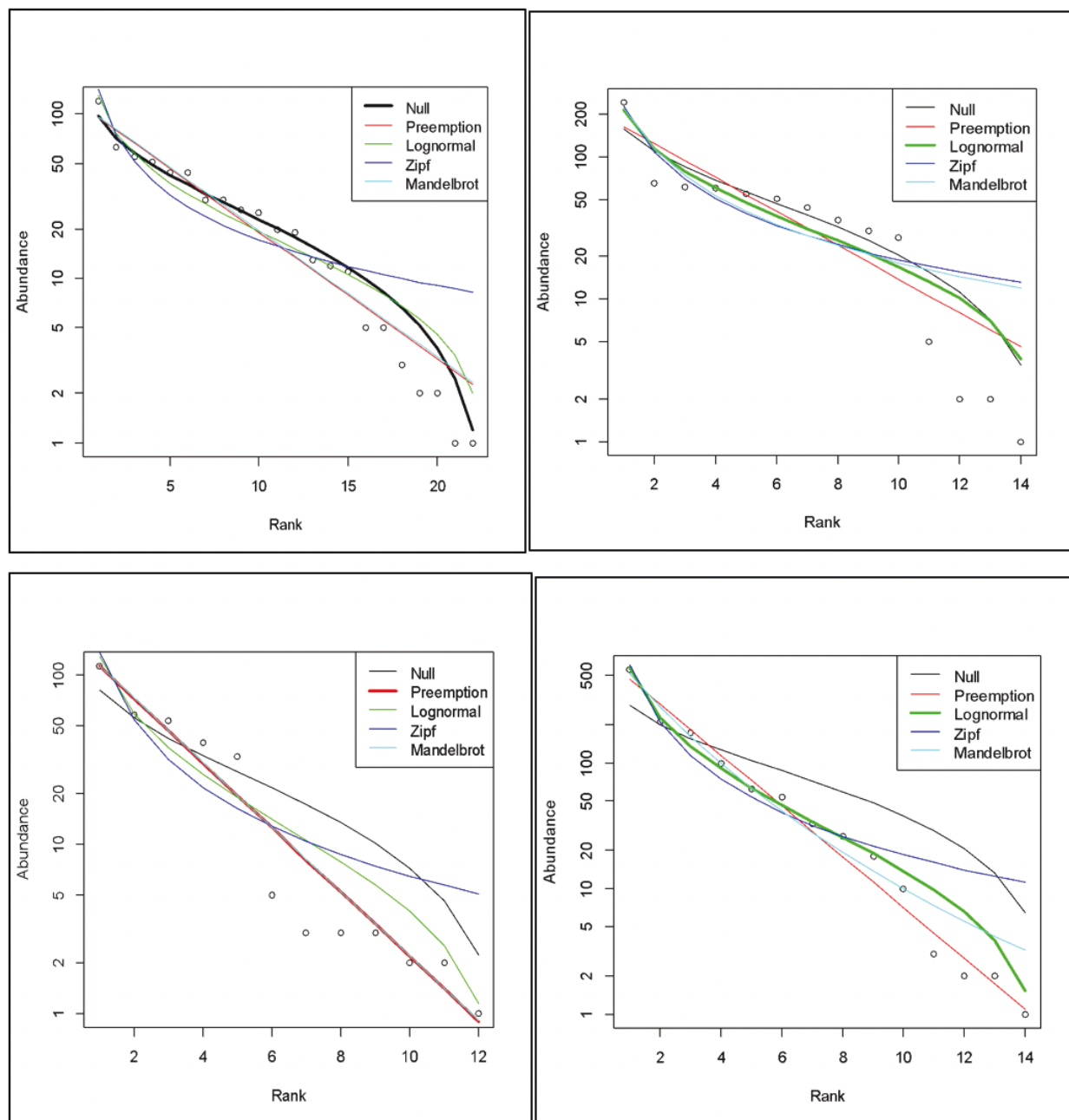


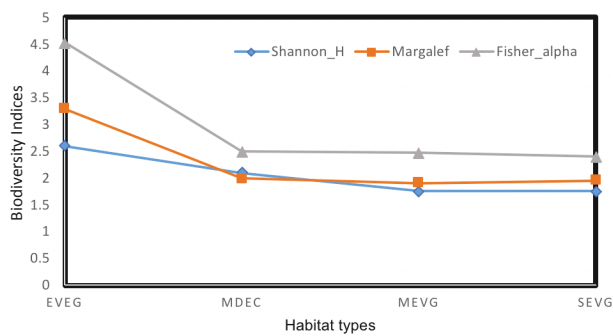
Figure 2. RAD models for habitats (clockwise) EVEG, MDEC, SEVG and MEVG.

as *Eria albiflora*, *Brachycorythis iantha* and *Habenaria perrottettiana* belonged to MEVG habitat but data was not sufficient to check if relationships existed with the habitat. Chao and ACE estimators suggested all endemic epiphytes of Aralam had been obtained through sampling from 40 transects. Species estimation for endemic epiphytes in Aralam WS was compared with that of entire southern western Ghats in Kerala (Figure 8). Species accumulation curve was almost stabilized at 181<sup>th</sup> transect for data on endemic epiphytic orchids

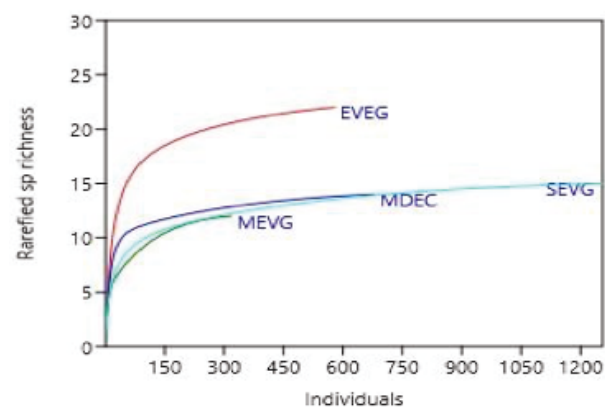
from entire southern Western Ghats in Kerala (Refer Sebastian et al. 2017). Further, high endemic epiphytic species diversity and abundance was observed in EVEG habitat followed by MEVG in Aralam WS.

## CONCLUSION

The total number of epiphytic orchid species recorded in this study was 62, higher than noted



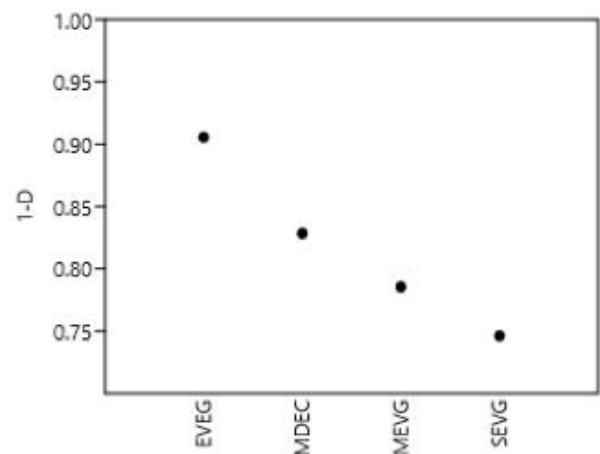
**Figure 3.** Graph showing diversity indices indicating epiphytic orchid diversity across habitats.



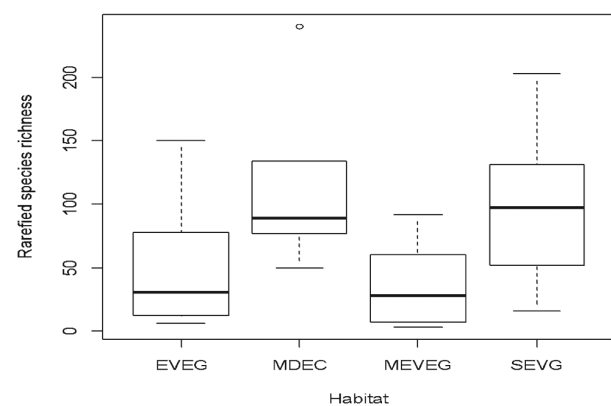
**Figure 5.** Species accumulation curves for habitats based on an individual accumulation model (rarefaction).

previously by KFD (2009). Species accumulation curves suggest that there are species that are yet to be sampled from Aralam WS (Figure 5). It is also possible that the exempted Teak plantations in the WS could have added a few more species into the list.

It is remarkable that all four habitat types possessed distinct epiphytic orchid diversity, and that sharing occurred mostly along transition zones. Based on different diversity indices explored, EVEG was the most diverse habitat for epiphytic orchids. Next, MDEC, MEVG, and SEVG habitats shared a more or less equal number of species. As Annaselvam & Parthasarathy (2001) discussed, sometimes epiphytic orchids that preferred deciduous trees in low wet evergreen forests contributed largely to abundance. As per the rate of species accumulation in response to individuals, EVEG habitat clearly varied from other habitats as was also indicated by the dominance index. Nonetheless, with few more transects all habitats could have added new species. In MEVG habitat the best explained rad model pre-emption was rather steep compared to suggested



**Figure 4.** Simpson 1-D (difference from 1) values across habitat types.



**Figure 6.** Comparison between rarefied species richness for minimum and maximum abundance across habitat types. The stripe shows median richness, the boxes are interquartile range and whiskers max-min.

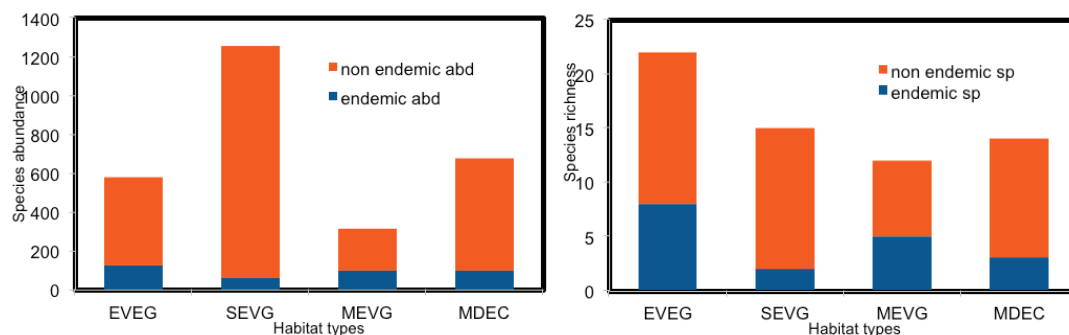
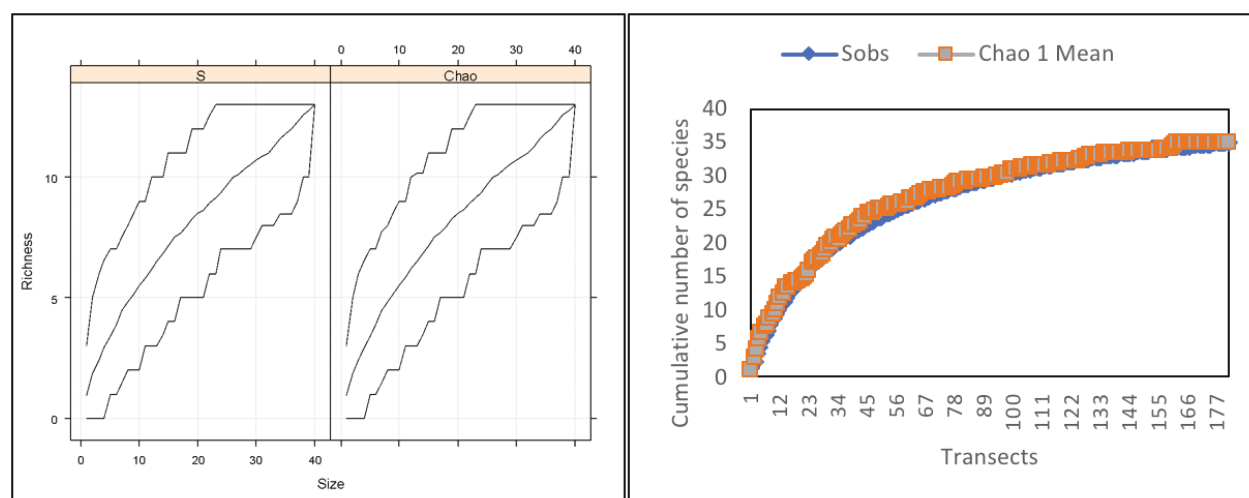
models for other habitats. This indicated less species evenness in MEVG habitat. Generally, log-normal models indicate habitats that are at equilibrium or perturbation is maintained, here for SEVG and MDEC. Whereas undisturbed forest such as EVEG and MEVG, however, may not necessarily be at equilibrium and do not fit log normal, a model for undisturbed habitat. A hierarchy based on dominance was evident in MEVG with less species evenness and therefore best explained by dominance pre-emption model. Null model for EVEG indicated a more neutral community with no species interactions among them and species equivalence or in other words more random. This might be because of the random distant presence of species or individuals in EVEG when compared with MDEC, where the species distribution was rather closer. Because of the absence of distinct patterns in composition from sampled data there



**Table 4. Orchid diversity across habitat types.**

Orchid Diversity	Habitat			
	EVEG (N= 12)	MDEC (N= 6)	MEVG (N= 9)	SEVG (N= 13)
Rarefied species richness*	20	13	12	12
Individuals	579	679	317	1253

\*rarefied at 301 individuals

**Figure 7. Pattern of (left) abundance (abd) and (right) species diversity (sp) of endemic epiphytic orchids in total sampled orchids from Aralam WS.****Figure 8. (left) Species richness and estimated richness using Chao in Aralam WS (right) species accumulation of endemic epiphytic orchids from 181 transects in the southern Western Ghats of Kerala, showing the observed and the estimated Chao-1 means (Refer: Sebastian et al. 2017).**

was no significant difference between species richness across habitats. The trend of results suggested a possible preference of epiphytic orchids towards evergreen habitats. The two habitats of evergreen nature gathered 27 epiphytic orchid species of a total 39 species.

Wet evergreen and montane wet evergreen habitats from low to high elevations also supported both epiphytic and terrestrial endemic orchids in Aralam WS. It is suggested that long term research in these habitats

could throw light on new perspectives on distribution of Endemic orchids. This area is located in Nilgiris-Silent valley-Wayanad-Kodagu region, a centre of endemism in the Western Ghats. This probably contributed to the high rate of endemism. Of 62 orchid species, 18 represented endemic orchids of the Western Ghats. Endemic orchids obtained from Aralam WS exhibited similar distribution patterns in as other studies (Sebastian et al. 2017).

The results obtained shows that all studied habitat


*Bulbophyllum fischeri*

*Conchidium exile*

*Dendrobium aquem*

Image 1 . Some epiphytic orchids recorded from Aralam Wildlife Sanctuary. © Arun TR.

types contribute to epiphytic orchid diversity and abundance in Aralam WS. An integrated approach to address both epiphytic and terrestrial orchids might pave the way to understanding the pattern of endemism among orchids. The location, size and diversity of the Aralam WS provides an opportunity for scientists to do a full-fledged experimental study on the mechanisms behind its floral and faunal diversity.

## REFERENCES

- Abraham, S. & P.S. Easa (1999). Additions to the amphibian fauna of Aralam Wildlife Sanctuary. *Cobra* 38: 12–13.
- Abraham, A. & P. Vatsala (1981). *Introduction to Orchids with Illustrations and Descriptions of 150 South Indian Orchids*. Tropical Botanical Garden and Research Institute, Trivandrum, India, 533pp.
- Annaselvam, J. & N. Parthasarathy (2001). Diversity and distribution of vascular epiphytes in a tropical evergreen forest at Varagalaia, Western Ghats, India. *Biodiversity and Conservation* 10(3): 317–329. <https://doi.org/10.1023/A:1016670621331>
- Benzing, D.H. (1990). *Vascular Epiphytes General biology and related Biota*. Cambridge University Press, Cambridge, United Kingdom, 354pp.
- Benzing, D.H. (2004). Vascular epiphytes, pp. 175–211. In: Lowman, M.D. & H.B. Rinker (eds.). *Forest Canopies*. Elsevier Academic Press, San Diego, California, USA, 501pp.
- Champion, H.G. & S.K. Seth (1968). *A Revised Survey of the Forest Types of India*. Natraj Publishers, Dehradun, India, 404pp.
- Dantas, K.J., N. Sasidharan & K.V. Binu (2016). Additions to the angiosperms of the flora of Kannur district, Kerala, India from Aralam Wildlife Sanctuary. *Annals of Plant Sciences* 5(7): 1381–1388. <https://doi.org/10.21746/aps.2016.07.003>
- Huang, H.W. (2011). Plant diversity and conservation in China: planning a strategic bio resource for a sustainable future. *Botanical Journal of the Linnean Society* 166(3): 282–300. <https://doi.org/10.1111/j.1095-8339.2011.01157.x>
- Jacquemyn, H., O. Honnay & T. Pailler (2007). Range size variation, nestedness and species turnover of orchid species along an altitudinal gradient on Reunion Island: Implications for conservation. *Biological Conservation* 136: 388–397. <https://doi.org/10.1016/j.biocon.2006.12.008>
- Jalal, J.S. & G.S. Rawat (2009). Habitat studies for conservation of medicinal orchids of Uttarakhand, Western Himalaya. *African Journal of Plant Science* 3(9): 200–204.
- Jalal, J.S. & J. Jayanthi (2012). Endemic orchids of peninsular India: a review. *Journal of Threatened Taxa* 4(15): 3415–3425. <https://doi.org/10.11609/JoTT.o3091.3415-25>
- Jalal, J.S. (2012). Status, threats and conservation strategies for orchids of the western Himalaya, India. *Journal of Threatened Taxa* 4(15): 3401–3409. <https://doi.org/10.11609/JoTT.o3062.3401-9>
- Jayalakshmi, P.S. (2016). Are the existing publications enough to study the endemic orchids of the Western Ghats?: A case study by using three major orchid publications from Kerala. MSc Thesis submitted to MG University, Kottayam, Kerala, 40pp.
- Joseph, J. (1982). *Orchids of Nilgiris*. Records of the Botanical Survey of India, Howrah, Calcutta, 144pp.
- KFD (2009). Aralam Wildlife Sanctuary Lifeline of Kannur. Kerala



- Forests and Wildlife Department. On the Silver Jubilee of Aralam Wildlife Sanctuary, Kannur, 73pp.
- Kumar, C.S. (1999).** Orchids of Silent Valley, pp. 191–216. In: Manoharan, T.M., S.D. Biju, T.S. Nayar & P.S. Easa (eds.). *Silent Valley Whispers of Reason*. Kerala Forest Department, Thiruvananthapuram, Kerala, 456pp.
- Kumar, C.S. & K.S. Manilal (1994).** *A Catalogue of Indian Orchids*. Bishen Singh Mahendra Pal Singh, Dehradun, India, 162pp.
- Kumar, C.S. & K.S. Manilal (2004).** Orchids of Kerala, India, pp. 155–252. In: Manilal, K.S. & C.S. Kumar (eds.). *Orchid Memories: A Tribute to Gunnar Seidenfaden*. Mentor Books & IAAT, Calicut, Kerala, 265pp.
- Kumar, P., Rawat G.S. & H.P. Wood (2011).** Diversity and ecology of *Dendrobiums* (Orchidaceae) in Chotanagpur Plateau, India. *Taiwania* 56(1): 23–36. [https://doi.org/10.6165/tai.2011.56\(1\).23](https://doi.org/10.6165/tai.2011.56(1).23)
- Kumar, S., B.V. Shetty, D. Bennett & S. Molur (2000).** Report of the Conservation Assessment and Management Plan Workshop on Endemic Orchids of the Western Ghats. Zoo Outreach Organisation & CBSG South Asia, Coimbatore, India, 150pp.
- Manju, C.N., Rajesh, K.P. & P.V. Madhusoodanan (2009).** Contribution to the bryophyte flora of India: the Aralam Wildlife Sanctuary in the Western Ghats. *Archive for Bryology* 42: 1–12.
- Menon, A.R.R. (1999).** Vegetation mapping and analysis of Aralam Wildlife Sanctuary using remote sensing techniques. KFRI Research Report 168, Kerala Forest Research Institute, Peechi, Kerala, 20pp.
- Nadkarni, N.M. (1994).** Diversity of species and interactions in the upper tree canopy of forest ecosystems. *American Zoologist* 34(1): 70–78.
- Nair, V.P. (2001).** Butterflies attracted to light at Aralam Wildlife Sanctuary, Kerala. *Zoos' Print* 16(12): 670.
- Nair, V.P. (2003).** Congregations of Common Crow butterflies *Euploea core* (Cramer) at Aralam Wildlife Sanctuary, Kerala. *Journal of the Bombay Natural History Society* 100(2/3): 632–633.
- Nair, S.C. (1991).** *The southern Western Ghats: a biodiversity conservation plan*. Indian National Trust for Art and Cultural Heritage, In Monographic series: Studies in Ecology and sustainable development no.4, New Delhi, 92pp.
- Padmawathe, R., Q. Qureshi & G.S. Rawat (2004).** Effects of selective logging on vascular epiphyte diversity in a moist lowland forest of Eastern Himalaya, India. *Biological Conservation* 119(1): 81–92. <https://doi.org/10.1016/j.biocon.2003.10.024>
- Pradhan, U.C. (1976).** *Indian Orchids: Guide to Identification and Culture Vol I*. Premulaceae Books, Kalimpong, India, 188pp.
- Pradhan, U.C. (1979).** *Indian Orchids: Guide to Identification and Culture Vol II*. Premulaceae Books, Kalimpong, India, 189–747pp.
- Radhakrishnan, C. (1996).** Amphibians from Aralam Wildlife Sanctuary, Western Ghats, Kerala. *Zoos' Print* 11(8): 5–6.
- Rajesh, K.P. & P. Vijisha (2016).** Pteridophyte flora of Aralam Wildlife Sanctuary, Kerala-A preliminary analysis. *Cryptogam Biodiversity and Assessment* 1(1): 71–74. <https://doi.org/10.21756/cba.v1i1.11020>
- Ramesh, B.R. (2001).** Patterns of Vegetation, Biodiversity and Endemism in the Western Ghats. In Y. Gunnell & B. Radhakrishna, *Sahyadri-The great escarpment of the Indian Subcontinent*. Kolkata: Geological Survey of India, 1053pp.
- Richards, P.W., R.P.D. Walsh, I.C. Baillie & P. Greig-Smith (1996).** *The Tropical Rainforest: An Ecological Study*. Cambridge University Press, Cambridge, UK, 575pp.
- Sebastian, J., S.R. Rathinavel, P.S. Jayalakshmi & G. Kuriakose (2017).** An Experimental Approach to Study the Distribution of Endemic Orchids In The Southern Western Ghats, pp. 217–243. In: *Proceedings of Ecology 2017 International Symposium*, Turkey.
- Sinu, P.A., G. Kuriakose & K. Chandrashekara (2011).** Epiphytic orchid diversity in farmer managed Soppinabetta forests of the Western Ghats: implications for conservation. *Current Science* 101(10): 1337–1346.
- Sreekumar, P.G. & M. Balakrishnan (2001).** Habitat and altitude preferences of butterflies in Aralam Wildlife Sanctuary, Kerala. *Tropical Ecology* 42(2): 277–281.
- Webb, L.J. (1959).** A Physiognomic classification of Australian rainforests. *Journal of Ecology* 47(3): 551–570.
- Wolf, J.H.D., S.R. Gradstein & N.M. Nadkarni (2009).** A protocol for sampling vascular epiphyte richness and abundance. *Journal of Tropical Ecology* 25: 107–121. <https://doi.org/10.1017/S0266467408005786>





www.threatenedtaxa.org

OPEN ACCESS



The Journal of Threatened Taxa (JoTT) is dedicated to building evidence for conservation globally by publishing peer-reviewed articles online every month at a reasonably rapid rate at [www.threatenedtaxa.org](http://www.threatenedtaxa.org). All articles published in JoTT are registered under [Creative Commons Attribution 4.0 International License](https://creativecommons.org/licenses/by/4.0/) unless otherwise mentioned. JoTT allows unrestricted use, reproduction, and distribution of articles in any medium by providing adequate credit to the author(s) and the source of publication.

ISSN 0974-7907 (Online) | ISSN 0974-7893 (Print)

July 2021 | Vol. 13 | No. 8 | Pages: 18959–19190

Date of Publication: 26 July 2021 (Online & Print)

DOI: 10.11609/jott.2021.13.8.18959-19190

#### Communications

**Distribution and habitat preferences of the Chinese Pangolin *Manis pentadactyla* (Mammalia: Manidae) in the mid-hills of Nepal**

– Suman Acharya, Hari Prasad Sharma, Rajeev Bhattarai, Beeju Poudyal, Sonia Sharma & Suraj Upadhaya, Pp. 18959–18966

**On the occurrence of the Himalayan Wolf *Canis lupus*, L. 1758 (Mammalia: Carnivora: Canidae) in the Gaurishankar Conservation Area, Nepal; its existence confirmed through sign and visual evidence in Rolwaling Valley**

– Bishnu Prasad Pandey, Shankar Man Thami, Rabin Shrestha & Mukesh Kumar Chalise, Pp. 18967–18974

**Group size, crowding, and age class composition of the threatened Sambar *Rusa unicolor* (Kerr, 1792) (Mammalia: Cetartiodactyla: Cervidae) in the semi-arid regions of northeastern Rajasthan, India**

– Deepak Rai & Kalpana, Pp. 18975–18985

**Study on the impacts of LULC change on the wildlife habitat and the livelihood of people in and around Dampa Tiger Reserve, Mizoram, India**

– Sushanto Gouda, Janmejaya Sethy, Netrapal Singh Chauhan & Harendra Singh Bargali, Pp. 18986–18992

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

– Kiran Thomas & P.O. Nameer, Pp. 18993–19001

**Seasonal prey availability and diet composition of Lesser Asiatic Yellow House Bat *Scotophilus kuhlii* Leach, 1821**

– Shani Kumar Bharti & Vadmalai Elangovan, Pp. 19002–19010

**Bird composition, diversity and foraging guilds in agricultural landscapes: a case study from eastern Uttar Pradesh, India**

– Yashmita-Ulman & Manoj Singh, Pp. 19011–19028

**Identification of a unique barb from the dorsal body contour feathers of the Indian Pitta *Pitta brachyura* (Aves: Passeriformes: Pittidae)**

– Prateek Dey, Swapna Devi Ray, Sanjeev Kumar Sharma, Padmanabhan Pramod & Ram Pratap Singh, Pp. 19029–19039

**Moths of the superfamily Gelechioidea (Microlepidoptera) from the Western Ghats of India**

– Amit Katewa & Prakash Chand Pathania, Pp. 19040–19052

**On the diversity and abundance of riparian odonate fauna (Insecta) of the midstream Chalakkudy River, Kerala, India**

– C. Nitha Bose, C.F. Binoy & Franci K. Kakkassery, Pp. 19053–19059

**Species diversity and abundance patterns of epiphytic orchids in Aralam Wildlife Sanctuary in Kerala, India**

– Jis Sebastian, Durairaj Kathiresan & Giby Kuriakose, Pp. 19060–19069

**Status and conservation needs of *Cycas pectinata* Buch.-Ham. in its natural habitat at Baroiyadhala National Park, Bangladesh**

– M.K. Hossain, M.A. Hossain, S. Hossen, M.R. Rahman, M.I. Hossain, S.K. Nath & M.B.N. Siddiqui, Pp. 19070–19078

#### Review

**Limitations of current knowledge about the ecology of Grey Foxes hamper conservation efforts**

– Maximilian L. Allen, Alexandra C. Avrin, Morgan J. Farmer, Laura S. Whipple, Emmarie P. Alexander, Alyson M. Cervantes & Javan M. Bauder, Pp. 19079–19092

#### Short Communications

**On the freshwater fish fauna of Krishna River, Sangli District, Maharashtra, India**

– Suresh M. Kumbhar, Shrikant S. Jadhav, Swapnali B. Lad, Abhijit B. Ghadage, Satyawar S. Patil & C. Shiva Shankar, Pp. 19093–19101

**Diversity and distribution of the large centipedes (Chilopoda: Scolopendromorpha) in the Phia Oac - Phia Den National Park, Vietnam**

– Le Xuan Son, Nguyen Thi Tu Anh, Tran Thi Thanh Binh, Thu Anh T. Nguyen & Anh D. Nguyen, Pp. 19102–19107

**Diversity of ants in Aarey Milk Colony, Mumbai, India**

– Akshay Gawade & Amol P. Patwardhan, Pp. 19108–19117

**First record of ghost shrimp *Corallianassa coutierei* (Nobili, 1904) (Decapoda: Axiidea: Callichiridae) from Indian waters**

– Piyush Vadher, Hitesh Kardani, Prakash Bambhaniya & Imtiaz Beleem, Pp. 19118–19124

**A preliminary checklist of dragonflies and damselflies (Insecta: Odonata) of Vakkom Grama Panchayath, Thiruvananthapuram District, Kerala, India**

– J. Arunima & P.O. Nameer, Pp. 19125–19136

**Diversity pattern of butterfly communities (Lepidoptera) in different habitat types of Nahan, Himachal Pradesh, India**

– Suveena Thakur, Suneet Bahrdwaj & Amar Paul Singh, Pp. 19137–19143

**Descriptions of the early stages of *Vagrans egista sinha* (Lepidoptera: Nymphalidae) with notes on its host plant *Xylosma longifolia* Clos from the western Himalaya of India**

– Pranav Gokhale & M.A. Yathumon, Pp. 19144–19148

#### Notes

**First photographic record of Mishmi Takin *Budorcus taxicolor taxicolor* and Red Goral *Nemorhaedus baileyi* from Kamlang Tiger Reserve, Arunachal Pradesh, India**

– Cheshta Singh & Deepti Gupta, Pp. 19149–19152

**Utilisation of honey trap method to ensnare a dispersing sub-adult Bengal Tiger *Panthera tigris tigris* L. in a human dominated landscape**

– Gobind Sagar Bhardwaj, Balaji Kari & Arvind Mathur, Pp. 19153–19155

**First camera trap photographs of Indian Pangolin *Manis crassicaudata* (Mammalia: Pholidota: Manidae) from Pakistan**

– Misbah Bint Riaz, Faraz Akrim, Siddiq Qasim, Syed Afaq Bukhari, Asad Aslam, Muhammad Waseem, Rizwana Imtiaz & Tariq Mahmood, Pp. 19156–19158

**Photographic record of Lesser Flamingo *Phoeniconaias minor* (Aves: Phoenicopteridae) in Ramganga river, Bareilly, India**

– Pichaimuthu Gangaikaran, Aftab A. Usmani, G.V. Gopi, S.A. Hussain & Khursid A. Khan, Pp. 19159–19161

**Total length and head length relationship in Mugger Crocodiles *Crocodylus palustris* (Reptilia: Crocodylia: Crocodylidae) in Iran**

– Asghar Mobaraki, Elham Abtin, Malihe Erfani & Colin Stevenson, Pp. 19162–19164

**First record of the hoverfly genus *Spilomyia* Meigen (Diptera: Syrphidae) for Pakistan**

– Muhammad Asghar Hassan, Imran Bodlah, Riaz Hussain, Azan Karam, Fazlullah & Azaz Ahmad, Pp. 19165–19167

**Rediscovery of Watson's Demon *Stimula swinhoei swinhoei* (Elwes & Edwards, 1897) (Lepidoptera: Hesperidae: Hesperinae) in Meghalaya, India after 60 years**

– Suman Bhowmik & Atanu Bora, Pp. 19168–19170

**A record of *Ourapteryx dierli* Inoue, 1994 (Lepidoptera: Geometridae: Ennominae) from the Garhwal Himalaya, India**

– Arun P. Singh & Lekhendra, Pp. 19171–19172

**Report of *Bradinopyga konkanensis* Joshi & Sawant, 2020 (Insecta: Odonata) from Kerala, India**

– Muhammed Haneef, B. Raju Stiven Crasta & A. Vivek Chandran, Pp. 19173–19176

**A new distribution record of *Bianor angulosus* (Karsch, 1879) (Araneae: Salticidae) from Kerala, India**

– Nishi Babu, John T.D. Caleb & G. Prasad, Pp. 19177–19180

**Notes on lectotypification of the Assam Ironwood *Mesua assamica* (King & Prain) Kosterm. (Calophyllaceae)**

– Prantik Sharma Baruah, Sachin Kumar Borthakur & Bhoben Tanti, Pp. 19181–19184

**On the rediscovery of a rare root parasite *Gleadovia ruborum* Gamble & Prain (Orobanchaceae) from Uttarakhand, western Himalaya, India**

– Amit Kumar, Navendu V. Page, Bhupendra S. Adhikari, Manoj V. Nair & Gopal S. Rawat, Pp. 19185–19188

**Occurrence of vivipary in *Ophiorrhiza rugosa* Wall. (Rubiaceae)**

– Birina Bhuyan & Sanjib Baruah, Pp. 19189–19190

Publisher & Host

