



Additions to the Orchid Flora of the Anamalai Tiger Reserve, Western Ghats, Tamil Nadu, India

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

A study was conducted in the Anamalai Tiger Reserve (ATR), in the Southern Western Ghats of Tamil Nadu, to document the wide range of wild orchids in the area and evaluate their conservation status. The ATR, known for its high species diversity, is a protected region spanning a core area of 958.59 km² and a buffer area of 521.28 km². The main objective of the study was to investigate and assess the diversity of orchids within the reserve, providing essential information for their conservation. The present study revealed the presence of 137 orchid species belonging to 56 genera in the Anamalai Tiger Reserve. Among them, 37 species forms an addition to the orchid flora of the reserve. The dominant genus in ATR is *Dendrobium* followed by *Habenaria*, and *Oberonia*.

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1. INTRODUCTION

The Western Ghats, recognized as one of the 36 global hotspots along with Sri Lanka, boasts an incredibly rich biodiversity. However, the flora and fauna in this region face severe threats as a result of habitat loss, fragmentation, and escalating human population and activities. Situated in the Western Ghats mountain range in southwest India, the Anamalai Tiger Reserve is home to a remarkable array of flora and fauna that exemplify the region's diversity [27-31]. The reserve encompasses diverse habitat types, including moist evergreen forests, semi-evergreen forests, moist deciduous forests, dry deciduous forests, dry thorn forests, and shola forests. Unique habitats such as Montane grassland, Savanna, and Swampy grassland also can be seen within its boundaries [22-26].

The Orchidaceae family, around 28,000 orchid species worldwide [1], distributed among 736 genera (Christenhusz & Byng, 2016). In India, there are 1,256 orchid species belonging to 155 genera, with 388 species being endemic to the country (Paramjit Singh, 2019). Orchids not only aesthetically and medicinally significant but also serve as important ecological indicators. However, due to ongoing destruction of natural habitats, illicit trade, and indiscriminate collection by orchid enthusiasts, numerous orchid species are rapidly disappearing from the wild [32-36]. The high commercial demand for orchids [20,21,37,38] has further underscored the need for mass propagation and conservation efforts for key species. Successful conservation management of orchids requires knowledge of the ecological preferences and distribution patterns of plant species [2,3].

Therefore, it is crucial to conduct a comprehensive assessment of orchid diversity and update the data to safeguard and preserve orchid species in all biodiversity hotspots, including the Anamalai Tiger Reserve. The study was conducted to investigate the orchid diversity within the reserve and provide valuable insights into their conservation status.

2. MATERIALS AND METHODS

The study was conducted during March 2019 to March 2023 within the Anamalai Tiger Reserve

(ATR), located in the Anamalai Hills spanning Pollachi, Valparai, and Udumalpet taluks of Coimbatore District and Tiruppur District in the state of Tamil Nadu. As per the National Tiger Conservation Authority, the reserve comprises a core area of 958.59 km² and a buffer/peripheral area of 521.28 km², resulting in a total extent of 1479.87 km². Geographically, ATR lies between latitude 10° 25' 01" N and 10° 41' 70" N and longitude 77° 03' 24" E and 77° 05' 67" E, in the state of Tamil Nadu, with a minimum elevation of 175.86 meters above sea level (masl) and a maximum of 2514.51 masl.

The study specifically focused on seven forest ranges, Pollachi, Valparai, Manomboly, Ulandy, Udumalpet, Amaravathy, and Kodaikanal in Coimbatore, Thiruppur and Dindugul districts of Tamil Nadu respectively (Fig. 1).

The Anamalai Tiger Reserve consists of six distinct types of forests. These include:

1. Grassland vegetation: Found in low altitude and low rainfall areas such as Udumalpet, Pollachi, and Amaravathi.
2. Shola forest: Present in high altitude and high rainfall areas like Manamboly, Valparai plateau, and Grass hills.
3. Moist deciduous forest: Occurring in medium altitude and medium rainfall areas around the Topslip environs.
4. Tropical evergreen forest: A type of forest characterized by year-round greenery and found in varying altitudes and rainfall conditions within the reserve.
5. Teak dry deciduous forest: These forests consist of teak trees and are classified as dry deciduous due to the seasonal shedding of leaves. They are distributed across different parts of the Anamalai Tiger Reserve.
6. Thorn forest: This type of forest is characterized by thorny vegetation and is found in specific areas within the reserve.

The distribution of these forest types corresponds to the varying altitudes and rainfall patterns within the reserve, with different areas experiencing low, medium, or high levels of both.

2.1 Methodology

The present study primarily relied on an extensive and systematic field survey conducted in various explored and unexplored areas of the ATR. Field tours were carefully planned to cover the pre-monsoon, mid-monsoon, and post-monsoon periods, ensuring periodic surveys throughout. The survey areas within the reserve included wildlife regions in Pollachi, Valparai, Ulandy, Manambolly, Udumalpet, Amaravathy, and Kangeyam. The documentation of orchids was the specific focus of these field studies conducted from 2019 to 2023.

All collected orchid specimens were processed at the IFGTB herbarium (FRC) in Coimbatore. The major field explorations took place after the rainy season, spanning from July 2019 to March 2023. Monthly field visits were undertaken, covering different seasons and maximizing coverage across areas such as Grass hills, Chinnakallar, Periyakallar, Highforest, Urlikal, Anali, Manambolly, Shekalmudi, Topslip, Aliyar, Attakatti, Villonie, Gopalsamymalai, Varagaliyar, Poonachi, Upper Aliyar, Tanakkamalai, Iyerpadi, Kadampari, Itliyar, Valparai Estates, Kokkanamalai, Vandal, Thirumoothimalai, Kurumalai, Esalthittu, Thalinji, Keelanavayal, Manajampatti, Moongilpallam, Kookal, Kudirayar, Samikkanal, Kathirikai Odai, Pulavachiar, and Vandaravu.

To identify the orchid specimens, relevant literature sources such as Abraham and Vatsala [4], Joseph [5,6], Ansari and Balakrishnan [7], and Matthew [8] were consulted. Online databases including IPNI [9] (updated, 2015) at www.ipni.org, the Plant List (2013) at www.theplantlist.org, the Herbarium Catalogue at Kew (www.kew.org), and the IUCN Red List (www.iucnredlist.org) were utilized to ensure accurate nomenclature. The respective habitat and ecological patterns of the orchids were also observed in the field.

During the field surveys conducted within the Anamalai Tiger Reserve (ATR), various species of orchids were observed and documented. Photographs were taken as part of the documentation process [18]. Subsequently, each recorded orchid species was evaluated and classified according to its conservation status using the IUCN Red List of Threatened Species (IUCN, 2022) [10].

The IUCN Red List classifies species into different categories based on their risk of extinction. These categories include Extinct (EX), Critically Endangered (CR), Endangered (EN), Vulnerable (VU), Near Threatened (NT), Least Concern (LC), Data Deficient (DD), and Not Evaluated (NE). The classification of orchids was determined by assessing them against the criteria outlined in the 1994, 2000, and 2022 versions of the IUCN Red List [11].

Table 1. Forest types at the Anamalai Tiger Reserve

Sl. No.	Name of Forest type	Classification number
1.	Southern sub-tropical hill forest	8A/ C1
2.	Southern dry mixed deciduous forest	5A/ C3
3.	Southern moist mixed deciduous forest	3B/C2
4.	Secondary moist mixed deciduous forest	3B/2S1
5.	West coast Tropical evergreen forest	1A / C4
6.	Southern Montane Wet forest (Wet temperate)	11A /C1
7.	Southern Montane Wet temperate grassland	11A/C1/D S2
8.	Dry Grasslands Savanna (Rocky and vacant portions)	5B S4
9.	Moist bamboo Wet bamboo breaks	2B/ E3, 2B E3
10.	Thorn forest	6A C1
11.	Dry Deciduous forest	5/2S1

Source: Revised Survey of Forest Types of India - 1964

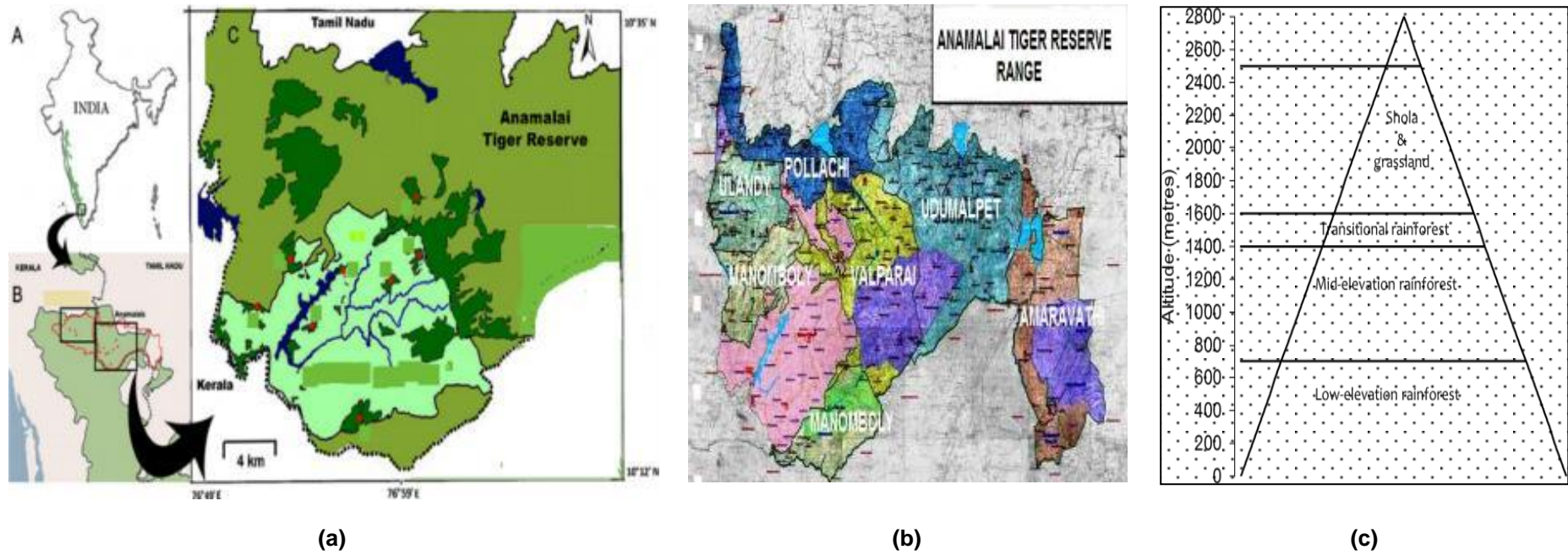


Fig. 1. a). Map of the Anamalai Tiger Reserve, b). ATR range, c). ATR Altitude (meters)

3. RESULTS AND DISCUSSION

The field surveys conducted in the Anamalai Tiger Reserve (ATR) have resulted in the documentation of 137 orchid species belonging to 56 genera (Table 1 and Fig. 2). Among these species, 100 orchids were identified and reported earlier (Ganesan et al.) [12] in 2019.

Orchids exhibit a wide distribution range, from tropical to alpine zones, and can be found on forest trees, secondary vegetation, riverbanks, bamboo and palm thickets, forest floors, grassy slopes, and rocky areas [13,14]. Arisdason [15] conducted a study on the flora of the Indira

Gandhi National Park, presently part of the ATR documented 30 orchid species belonging to 18 genera. Fischer & Gamble [16] reported 46 orchid species from 26 genera. Ahmedullah & Nayar (1987) documented 123 species from 33 genera in Peninsular India. More recently, Ganesan et al. [17] documented 100 orchid species from 18 genera.

In the Western Ghats, a Conservation Assessment and Management Plan (C.A.M.P) assessed [11] 98 endemic and threatened orchid species. Kiruthika et al. [19] reported *Vanilla walkeriae* Wight as a new addition to the flora of Coimbatore, Tamil Nadu, India.

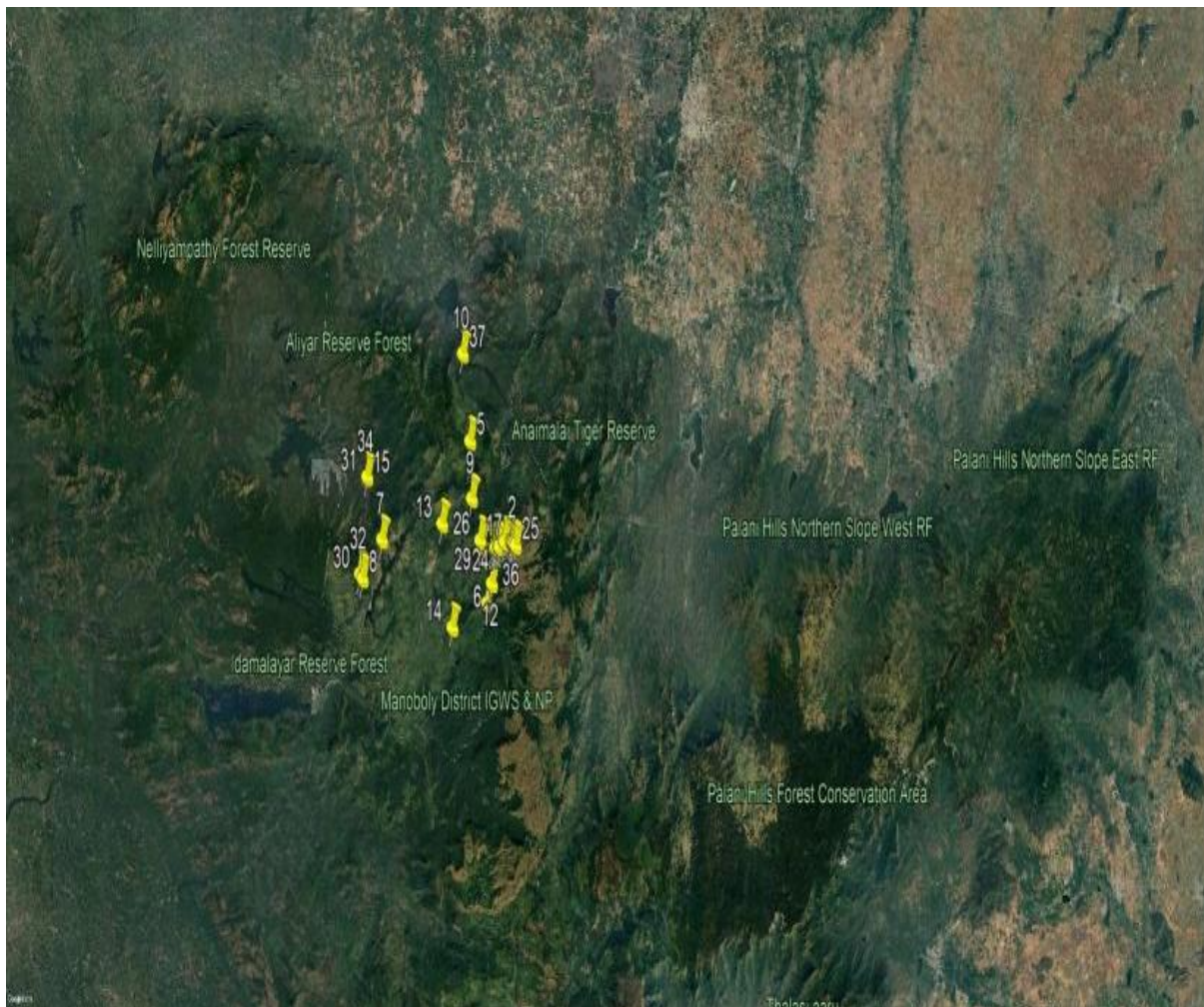


Fig. 2. GPS coordinates of additional new orchid species in the Anamalai Tiger Reserve, Western Ghats, Tamil Nadu

Table 2. IUCN status and Endemism and habitats of additional species to orchid diversity of the Anamalai Tiger Reserve

Sl. No	Species	IUCN Status	Endemism	Habitat	Lat	Long	Alt (masl)	Collection Place
1	<i>Bulbophyllum acutiflorum</i> A.Rich.		Endemic	E	N 10° 18'28.8"	E077°01'23.5"	1241	Valparai range, Chinnakallar falls
2	<i>Bulbophyllum keralensis</i> Muktesh & Stephen		Endemic	E	N 10° 19'53.3"	E077°02'55.0"	1949	Grass hills, Valparai
3	<i>Bulbophyllum mysorensense</i> (Rolfe)J.J.Sm	EN		E	N 10° 19'39.7"	E077°01'30.0"	1634	Marappalam river, Grass hills, Akkamalai
4	<i>Bulbophyllum orezii</i> Sathish	EN		E	N 10° 19'38.8"	E077°01'28.1"	1630	Before Marappalam river, Grass hills, Akkamalai
5	<i>Calanthe triplicata</i> (Willem.) Ames	NE		T	N 10° 23'07.7"	E076°59'46.5"	1462	Kavarkal, Valparai range
6	<i>Conchidium filliforme</i> (Wight) Rauschert		Endemic	E	N 10° 18'28.8"	E077°01'23.5"	1241	Chinnakallar falls, Valparai range
7	<i>Dendrobium barbatulum</i> Lindl.		Endemic	E	N 10° 19'42.5"	E 076°53'43.6"	1072	Valparai range, Urilikal
8	<i>Dendrobium wightii</i> A.D.Hawkes & A.H.Heller		Endemic	E	N 10° 18'23.4"	E 076°52'24.9"	944	Sheikalmudi, Kalyanapanthal bus stand near.
9	<i>Diplocentrum congestum</i> Wight		Endemic	E	N 10° 21'14.7"	E 076°59'56.3"	1206	After Iyerpadi, Valparai Range
10	<i>Eria exilis</i> Hook.f.	VU		E	N 10° 25'58.9"	E 076°59'10.0"	1063	Urilikal check post to Manampally, Valparai range
11	<i>Eria pauciflora</i> Wight		Endemic	E	N 10° 19'39.7"	E 077°01'23.1"	1542	Marappalam, Grass hills, Akkamalai
12	<i>Eria polystachya</i> (A.Rich.) Kuntze		Endemic	E	N 10° 18'28.5"	E077°01'23.0"	1242	Chinnakallar falls, Valparai range

Sl. No	Species	IUCN Status	Endemism	Habitat	Lat	Long	Alt (masl)	Collection Place
13	<i>Eulophia flava</i> (Lindl.)Hook.f.		Endemic	T	N 10°20'20.6"	E076°57'53.5"	1151	Puthuthottam, Valparai
14	<i>Flickingeria nodosa</i> (Dalzell) Seidenf.	VU		E	N 10°16'57.03"	E076°58'41.0"	1141	Chinhona tea estate, Valparai range
15	<i>Gastrochilus calceolaris</i> (Buch. To Ham.ex Sm.) D.Don	CR		E	N 10°21'40.1"	E076°52'34.2"	657	Manampally river area, Valparai range
16	<i>Gastrochilus flabelliformis</i> (Blatt. & McCann) C.J.Saldanha		Endemic	E	N 10°19'42.1"	E077°00'37.6"	1088	Pachamalai, Valparai range
17	<i>Habenaria acuminata</i> (Thwaites) Trimen	NE		T	N 10°19'54.8"	E 077°02'49.3"	1927	Edaisholai, Siriyakan, Grasshills
18	<i>Habenaria brachyphylla</i> (Lindl.)	NE		T	N 10°19'55.2"	E 077°02'16.7"	1841	5 Km bend, Grasshills
19	<i>Habenaria crinifera</i> Lindl.,	NE		T	N 10°19'45.7"	E 077°02'01.2"	1777	Aattupparai kurukku, Grasshills
20	<i>Habenaria digitata</i> Lindl.	NE	Endemic	T	N 10°19'43.3"	E 077°01'51.2"	1775	Before Rest Rock area, Grasshills, Akkamalai
21	<i>Habenaria furcifera</i> Lindl.	NE		T	N 10°19'42.3"	E 077°01'39.2"	1681	Before Aattupparai kurukku, Grasshills
22	<i>Habenaria marginata</i> Colebr. In Hook	NE		T	N 10°19'40.2"	E 077°01'33.1"	1656	Before Aattupparai kurukku, Grasshills

Sl. No	Species	IUCN Status	Endemism	Habitat	Lat	Long	Alt (masl)	Collection Place
23	<i>Habenaria multicaudata</i> Sedgw.	VU		T	N 10°19'39.7"	E 077°01'30.0"	1634	After Marapalam river area, Grass hills
24	<i>Habenaria richardiana</i> Wight		Endemic	T	N 10°19'44.2"	E 077°01'53.8"	1786	Rest Rock area, Grasshills, Akkamalai
25	<i>Habenaria roxburghii</i> Nicolson	NE		T	N 10°19'49.0"	E 077°03'02.1"	1950	Old camp, Grass hills
26	<i>Liparis atropurpurea</i> Lindl	NE		T	N 10°19'53.6"	E 077°00'34.8"	935	Shloayar Valparai range
27	<i>Liparis elliptica</i> Wight	NE		E	N 10°18'29.9"	E 077°01'24.8"	1249	Chinnakallar falls bridge, Valparai range
28	<i>Liparis walkeriae</i> Graham in Lindl	NE		T	N 10°19'39.7"	E 077°01'23.1"	1542	LTM after Marappalam, Grass hills, Valparai
29	<i>Malaxis rheedii</i> B. Heyne ex Wallace	NE		T	N 10°19'42.3"	E 077°00'37.4"	1447	Akkamalai post office near, Valparai range
30	<i>Nervilia crocifformis</i> (Zoll. & Moritzi) Seidenf.	NE		T	N 10°18'31.7"	E 076°52'13.4"	932	After Sheikalmudi top bunglow area
31	<i>Nervilia infundibulifolia</i> Blatt. & McCann	NE		T	N 10°21'44.3"	E 076°52'36.2"	634	Manampally powerhouse, Valparai range
32	<i>Oberonia brunoniana</i> Wight		Endemic	E	N 10°18'31.7"	E076°52'13.4"	932	Valparia range, Murukali,
33	<i>Oberonia sebastiana</i> B.V.Shetty & Vivek.	VU		E	N 10°17'49.1"	E077°01'05.1"	1077	Valparai range, Chinnakallar

Sl. No	Species	IUCN Status	Endemism	Habitat	Lat	Long	Alt (masl)	Collection Place
34	<i>Oberonia verticillata</i> Wight		Endemic	E	N 10°21'44.3"	E076°52'36.2"	617	Valparai range, Manompally
35	<i>Peristylus spiralis</i> A.Rich.	NE		T	N 10°19'56.9"	E077°02'44.3"	1905	Periyakaan Grasshills
36	<i>Spiranthes sinensis</i> (Pers.) Ames		Endemic	T	N 10°19'54.8"	E077°02'49.3"	1927	Sriyakaan Grasshills
37	<i>Vanda tessellata</i> (Roxb.) Hook. ex G.Don	LC		E	N 10°25'58.9"	E076°59'10.0"	1129	Valparai range, Attakatti to Valparai (24 Hairpin bend)

CR – Critically Endangered; EN – Endangered; VU – Vulnerable; LC – Least Concern; NE – Not Evaluated; E – Epiphytic; T – Terrestrial



Bulbophyllum acutiflorum
A.rich



Bulbophyllum keralensis
Muktesh & Stephen



Bulbophyllum mysorensense
(Rolfe) J.J.Sm.



Bulbophyllum orezii
Sathish



Calanthe triplicata
(Willem.) Ames



Conchidium filiforme
(Wight) Rauschert



Dendrobium barbatulum
Lindl.



Dendrobium wightii A.D.
Hawkes & A.H. Heller
Lindl.



Diplozentrum congestum
Wight



Eria exilis Hook.f.



Eria pauciflora Wight



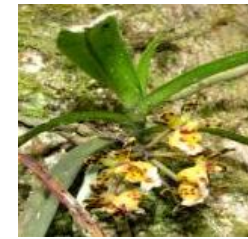
Eria polystachya (A.Rich.)
Kuntze



Eulophia flava (Lindl.)
Hook.f.



Flickingeria nodosa
(Dalzell) Seidenf.



Gastrochilus calceolaris
(Buch.-Ham. ex Sm.)
D.Don



Gastrochilus flabelliformis
(Blatt. & McCann)
C.J.Saldanha



Habenaria acuminata
(Thwaites) Trimen



Habenaria brachyphylla
(Lindl.)



Habenaria crinifera Lindl.



Habenaria digitata Lindl.



Habenaria furcifera Lindl.



Habenaria marginata
Colebr. In Hook



Habenaria multicaudata
Sedgw.



Habenaria richardiana
Wight



Habenaria roxburghii
Nicolson



Liparis atropurpurea Lindl.



Liparis elliptica Wight



Liparis walkeriae Graham



Malaxis rheedii B. Heyne
ex Wallace



Nervilia crocifformis (Zoll.
& Moritzi) Seidenf.



Nervilia infundibulifolia
Blatt. & McCann



Oberonia brunoniana
Wight



Oberonia sebastiana
B.V.Shetty & Vivek.



Oberonia verticillata Wight



Peristylus spiralis A.Rich.



Spiranthes sinensis (Pers.)
Ames



Vanda tessellata (Roxb.)
Hook. ex G.Don

Fig. 3. Images of additional orchids in the Anamalai Tiger Reserve

The present study conducted in ATR has recorded the highest number of orchid species compared to previous studies. It has documented 37 additional orchid species not previously recorded in the orchid flora of ATR, highlighting the area's significant biodiversity conservation value. Among these, 15 are endemic orchids, 1 critically endangered species, 2 endangered species, 4 vulnerable species, 1 least concern species, and 14 species that have not been evaluated according to the IUCN Red List criteria [11]. Based on literature and herbarium references, other areas surrounding ATR, such as Coimbatore District and the Pollachi region, likely harbor several other orchid species.

4. CONCLUSION

The primary aim of this study was to thoroughly document and record the extensive diversity of orchids found within the ATR. The research focused on gathering detailed information about the different species and varieties of orchids present in the reserve. The researchers recorded a total of 137 orchid species belonging to 56 genera within the reserve. Out of these, 37 species forms a new addition to the orchid flora of ATR, indicating an expanded distribution range for these orchids within the Western Ghats.

The conservation of orchid species is a crucial goal that requires the involvement of various sectors, including the government, private individuals, research institutions, non-governmental organizations, and breeders. International cooperation is also essential in achieving effective conservation efforts for orchids.

Conserving and managing the biodiversity of a specific area requires a thorough understanding of its biotic components, which can only be achieved through consistent exploration and systematic analysis. The conservation of orchid species can be facilitated through both in situ (on-site) and ex-situ (off-site) conservation approaches, coupled with domestication and the involvement of community-based organizations [14]. This is a critical issue that necessitates the engagement of various sectors, including the government, private individuals, research institutions, non-governmental organizations, and breeders.

Recognizing the significance of documenting and identifying the various biotic units of a specific

area or region, consistent exploration and systematic analysis are essential. The present study has recorded the highest number of orchid species in the ATR compared to previous studies conducted in this tiger reserve in Tamil Nadu. Furthermore, based on literature and herbarium references, areas surrounding the ATR, such as Coimbatore District and the Pollachi region, have the potential to harbor several additional species of orchids. Therefore, it is expected that the number of orchid species in the ATR will continue to increase with further studies in these areas.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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