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**Study on Species richness and Conservation status of
Myanmar Orchid Biodiversity**



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Contents

Abstract	i
စာတမ်းအကျဉ်း	ii
1. Introduction	1
1.1. Orchid Flora of Myanmar	1
1.2. Orchid Conservation in Myanmar	1
2. Objectives	2
3. Materials and Methods	2
3.1. Study Areas	2
3.2. Specimen Collection and Identification	2
3.3. Herbarium specimen examination	3
3.4. Dataset Preparation for Conservation Assessment	4
3.5. Conservation Assessment of Myanmar orchid flora	4
4. Results	7
4.1. Orchid Biodiversity Richness in Myanmar	7
4.2. Conservation Assessment	10
5. Discussion	13
6. Conclusion	13
7. Acknowledgements	13
8. References	15
Appendix 1	18
Appendix 2	18
Supporting Information	18

မြန်မာ့သစ်ခွမျိုးစုံမျိုးကွဲများ၏ မျိုးစိတ်ကြွယ်ဝမှုနှင့် ထိန်းသိမ်းကာကွယ်ထားရှိမှု အခြေအနေအား လေ့လာခြင်း

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နွယ်နွယ်ဝင်း၊ သုတေသနလက်ထောက်-၂
အောင်ဇော်မိုး၊ သုတေသနအရာရှိ

စာတမ်းအကျဉ်း

ဇီဝပထဝီအရ မြန်မာနိုင်ငံသည် ဇီဝမျိုးစုံမျိုးကွဲကြွယ်ဝသည့် အရှေ့တောင်အာရှ၏ ပင်မကုန်းမြေထုပေါ်တွင် တည်ရှိပါသည်။ ဇီဝမျိုးစုံမျိုးကွဲကြွယ်ဝမှုအား ပိုမိုနားလည် သိရှိနိုင်ရန်နှင့် ထိန်းသိမ်းကာကွယ်ရေးလုပ်ငန်းများ ထိရောက်စွာ လုပ်ဆောင်နိုင်ရန်အတွက် ဇီဝမျိုးစုံမျိုးကွဲ ကြွယ်ဝမှုအား ပိုမိုအရှိန်အဟုန်မြှင့်ပြီး သုတေသနပြုလေ့လာရန် လိုအပ်ပါသည်။ အလားတူစွာဖြင့် မြန်မာနိုင်ငံတစ်ဝန်းရှိ ဂေဟစနစ်မျိုးစုံတွင် မြန်မာ့သစ်ခွ မျိုးစုံမျိုးကွဲများသည် အထူးကြွယ်ဝစွာ ပေါက်ရောက်လျက်ရှိပါသည်။ လတ်တလောကာလအတွင်း မြန်မာ့သစ်ခွမျိုးစုံမျိုးကွဲများအား ရုက္ခဗေဒဆိုင်ရာ သုတေသနပြုလေ့လာရေးလုပ်ငန်းများ လုပ်ဆောင်လာနိုင်ခြင်းဖြင့် မြန်မာနိုင်ငံတစ်ဝန်း၌ သစ်ခွမျိုးစိတ်သစ် များစွာအား လေ့လာတွေ့ရှိရပါသည်။ ဤသစ်ခွ သုတေသနပြုလေ့လာရေး လုပ်ငန်းတွင် ကွင်းဆင်းလေ့လာ၍ ပန်းပုံစံနမူနာများ စုဆောင်းခြင်း၊ ပန်းပုံစံနမူနာများအား လေ့လာခြင်း၊ သက်ဆိုင်ရာစာပေအထောက်အထားများအား လေ့လာခြင်းနှင့် အွန်လိုင်း ဒေတာဘေ့ခ်များအား လေ့လာခြင်းစသည့် အချက်အလက်မျိုးစုံအား လေ့လာခြင်းဖြင့် မြန်မာ့သစ်ခွမျိုးစိတ်စာရင်းအား အသစ်ပြုပြင်မွမ်းမံခဲ့ရာ လက်ရှိအချိန်ထိ မြန်မာနိုင်ငံတွင် ပေါက်ရောက်လျက်ရှိသည့် သစ်ခွမျိုးစိတ် စုစုပေါင်း(၁,၀၈၃)မျိုးရှိပါသည်။ ထို့အပြင် IUCN Red List Categories and Criteria နှင့်အညီ ConR R Package အား အသုံးပြု၍ မြန်မာ့သစ်ခွမျိုးစိတ်များ၏ ထိန်းသိမ်းကာကွယ်ထား ရှိမှုအား အကဲဖြတ်လေ့လာခဲ့ရာ မြန်မာ့သစ်ခွမျိုးစိတ် စုစုပေါင်း၏ (၃၀)ရာခိုင်နှုန်းခန့်သည် အထူး ကာကွယ်ထိန်းသိမ်းရေးလုပ်ဆောင်ရန် လိုအပ်ပါသည်။ မြန်မာ့သစ်ခွ မျိုးစိတ်ကြွယ်ဝမှုအား ပိုမိုနားလည်နိုင်ရန်နှင့် ထိရောက်စွာ ကာကွယ်ထိန်းသိမ်းနိုင်ရန် သုတေသနလုပ်ငန်းများ ဆက်လက် ပြုလုပ်ရန် လိုအပ်ပါသည်။

Study on Species richness and Conservation status of Myanmar Orchid Biodiversity

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Abstract

Biogeographically, Myanmar is situated in mainland Southeast Asia with high biodiversity richness. Biodiversity research needs to be accelerated to better understand the biodiversity richness as well as to make effective conservation actions. In this regard, orchid flora of Myanmar is very rich all over the different ecosystems of Myanmar. Over recent years, botanical explorations into orchid flora of Myanmar results in discoveries of many new species to science as well as new records for Myanmar. In the present study, the checklist of Myanmar orchid flora was updated based on the field collections, herbarium specimens examined, relevant literature and online databases, resulting in a checklist of 1,083 species of Orchidaceae currently known from Myanmar. In addition, the conservation status of Myanmar orchid flora was also assessed based on the available data by using ConR R Package in compliance with IUCN Red List Categories and Criteria. As a result, about 30 % of Myanmar orchid flora needs special conservation actions. Further studies are needed to better understand the orchid flora of Myanmar and to make effective conservation actions in Myanmar.

Key Words: checklist, herbarium specimens, conservation status, Myanmar, Orchidaceae

Study on Species richness and Conservation status of Myanmar Orchid Biodiversity

1. Introduction

1.1. Orchid Flora of Myanmar

Myanmar is one of the Southeast Asian countries, with high richness of natural resources. In terms of biodiversity richness, Myanmar is one of the countries which are included in the Indo-Burma biodiversity hotspot, with high species richness and endemism (Myers et al. 2000, Mittermeier et al. 2011). Due to its broad latitudinal range (tropical to subtropical), topographical (mostly mountainous) and climatic (monsoonal) factors, there are various types of ecosystems in Myanmar, from southern tropical evergreen rainforest ecosystem to northern subtropical montane forest ecosystem through central dry deciduous forests.

In this regard, biodiversity research plays an important role in effective conservation actions and it needs to be accelerated as many species of fauna and flora still remain undescribed in Myanmar. Therefore, biodiversity research and biodiversity conservation go hand in hand and they are in urgent need to secure the sustainability of existing biodiversity resources in Myanmar (Giam et al. 2010, Webb et al. 2010, Forest Department 2015).

Myanmar orchid biodiversity is very rich but still needs to be explored more and more in order to better understand the species richness and distribution patterns. According to the recent checklists of Aung et al. 2020 and Ormerod et al. 2021, there are more than 1,000 species of Orchidaceae in Myanmar, with potential increase in the number of species due to high discovery rate of new species and new records. Further botanical explorations are still needed to fully cover the whole richness and diversity of orchid flora in different ecosystems of Myanmar.

1.2. Orchid Conservation in Myanmar

Orchid family has already received the global conservation attention and then all species of orchid family have been enlisted in the appendices of CITES (the Convention on International Trade in Endangered Species of Wild Fauna and Flora) for the conservation of orchid species survival across the globe (<https://cites.org/eng>). In this regard, all species of Myanmar orchid flora have also been protected under the management of CITES authority of Myanmar Forest Department. In Myanmar, the major approach of biodiversity conservation is the establishment of Protected Area System (PAS) across the country, currently having established 59 protected areas (6.44 % of country's total area).

Orchid conservation is under the main theme of biodiversity conservation program in Myanmar. Some locally or globally endangered plant species including orchid species are legally protected by national legislation across the country. The ornamental use of orchids is very common in Myanmar, while medicinal use and other kinds of uses of orchids are very rare. The practices of trade in wild-collected orchids have been found in various reports and papers on (possibly illegal) trade of wildlife and wild plants in borderland areas of Myanmar. Some practice of domestic orchid market via social media such as Facebook can be easily observed on the social media platform. However, the major threat to orchid species survival is the habitat loss due to deforestation and land use change in Myanmar. Although there are various challenges for effective conservation of biodiversity in Myanmar, the conservation efforts are still being made across the country.

In this regard, the present study is conducted to investigate the orchid species richness and its conservation status in Myanmar. The present study will bridge the gap of knowledge

on orchid flora of Myanmar and it will highlight the conservation awareness for orchid conservation in Myanmar.

2. Objectives

The main objectives of the present study are as follows;

- To explore the species richness of Myanmar orchid flora,
- To assess the conservation status of Myanmar orchid flora in accordance with IUCN Red List Categories & Criteria,
- To contribute the plant diversity and distribution data to the biodiversity conservation program of Myanmar.

3. Materials and Methods

3.1. Study Areas

In order to investigate species richness of Myanmar orchid flora, a program of fieldwork has been conducted in various ecosystems across Myanmar. Popa Mountain Park of Mandalay Region, Nat Ma Taung National Park of Chin State and Kalaw Township of Shan State (**Figure 1**), had been investigated two to three times in each study area during 2019-2022. The general landscape ecosystems of study areas can be described as follows;

- Nat Ma Taung National Park (713 km²) is tropical montane forest ecosystem extensively situated in Kanpatlet, Mindat and Matupi Townships, Mindat District, Chin State, **Northwest Myanmar**.
- Popa Mountain Park (129 km²) is oasis of dry zone area surrounded by dry scrub forests and situated in Kyaukpadaung Township, Nyaung-Oo District, Mandalay Region, **Central Myanmar**.
- Natural forestland in Kalaw Township, Taunggyi District, Shan State of **Eastern Myanmar**.

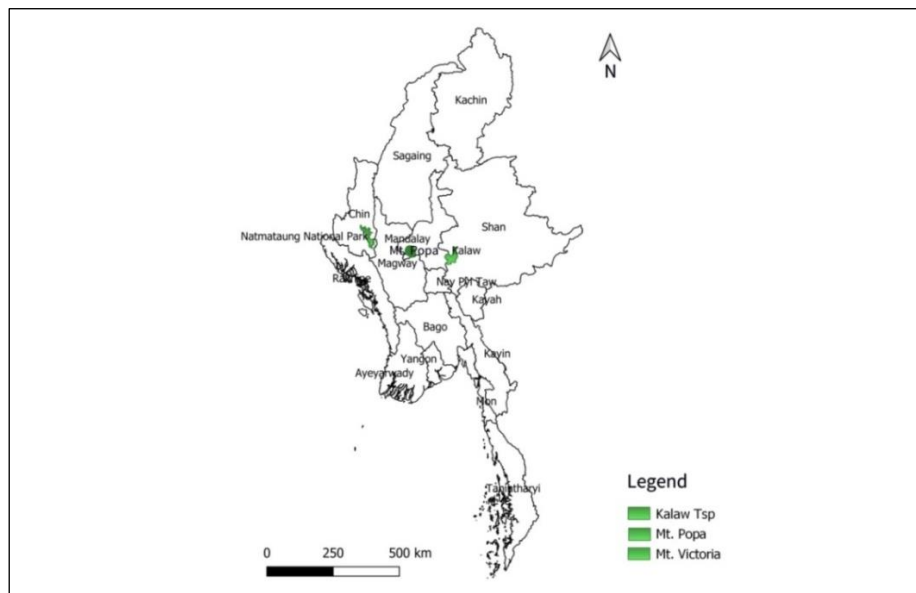


Figure 1. Map of Myanmar, showing the study areas for orchid survey

3.2. Specimen Collection and Identification

In total, approximately 111 specimens of orchid species were collected for vouchers, kept in RAF (Thiers 2019, <http://sweetgum.nybg.org/ih/>). In the collections, most species are

species of *Dendrobium*, *Bulbophyllum*, *Coelogyne*, *Eria*, *Liparis* and *Oberonia*. *Dendrobium* species and *Bulbophyllum* species are widespread and collected from different study areas. *Coelogyne* species and *Eria* species are also widespread across Myanmar. In tropical deciduous dipterocarp forest, species of *Dendrobium* and *Vanda* are widespread and can be found in flower during April-May. In subtropical montane forest, most orchid species are in flower during rainy seasons of June-August.

All collected specimens were taxonomically identified based on relevant literature, field notes, photographs taken during fieldwork, herbarium specimens (RAF) and online herbarium specimens such as Kew Herbarium Catalogue and Chinese Virtual Herbarium (Seidenfaden 1992, Dressler 1993, Kress et al. 2003, Chen et al. 2009, Pridgeon et al. 2005 & 2014, Pedersen et al. 2011 & 2014, Kurzweil and Lwin 2014, Chase et al. 2015, Aung et al. 2020, Ormerod et al. 2021, Aung et al. 2021). For verification of taxonomic status of all species, all relevant literature and online databases such as POWO are reviewed to confirm its respective taxonomic status (Chen et al. 2009, Gardiner 2012, Gardiner et al. 2013, Jin et al. 2014, Pridgeon et al. 2005 & 2014, Vermeulen et al. 2014, Chase et al. 2015, Raskoti et al. 2016, Raskoti et al. 2017, Ng et al. 2018, POWO 2023).

It is obvious that specimens having flowers are more convinced for identification because identification keys of Orchidaceae are mainly based on floral morphology and its related distinct features. In some species, vegetative morphology is very similar to each other so that floral morphology is the set of key features for identification. Most species of *Bulbophyllum* and *Dendrobium* can be readily identified based on its flowers collected and photographs taken during fieldwork. Some species can be readily identified by its vegetative morphology, e.g., *Appendicula cornuta* and *Podochilus khasianus*.

3.3. Herbarium specimen examination

Examination of herbarium specimens was conducted at the herbarium (RAF) of Forest Research Institute in Yezin, Nay Pyi Taw. In total, ca. 3,100 herbarium specimens were examined, including specimens of our present collections (RAF), previous collections (kept at both RAF and PE) and specimen records (both datasets and specimen photographs) downloaded from online herbaria: AMES, BM, E, GH, K, L, NY, P, US and W (Thiers 2019, <http://sweetgum.nybg.org/ih/>).

The followings are specimen records downloaded from each online herbarium, AMES (12 records), BM (420 records), E (496 records), GH (3 records), K (324 records), L (39 records), NY (116 records), P (87 records), US (81 records) and W (11 records), amounting 1,589 records in total (Natural History Museum 2014, Royal Botanic Gardens Kew 2018, The BioPortal of Naturalis Biodiversity Center 2019, Smithsonian National Museum of Natural History 2019, New York Botanical Garden 2019, Royal Botanic Garden Edinburgh 2019, The Index of Botanical Specimens, Harvard University Herbaria and Libraries 2019, The Vascular Plants, Muséum National d'Histoire Naturelle 2019, The Virtual Herbaria, Naturhistorisches Museum Wien 2019).

In addition, some literature provides information on specimens collected from Myanmar so that it can be cited as specimen-based species occurrences in Myanmar (Aung et al. 2017, Jin and Kyaw 2017, Liu et al. 2017, Yang et al. 2017, Aung and Jin 2018, Aung et al. 2018, Kurzweil and Ormerod 2018, Liu et al. 2018, Tanaka et al. 2018, Zhou et al. 2018, Aung et al. 2020, Latt et al. 2021, Ormerod et al. 2021, Kurzweil et al. 2022, Naïve et al. 2022, Yukawa et al. 2022).

3.4. Dataset Preparation for Conservation Assessment

In order to conduct conservation assessments of Myanmar orchid flora by using ConR R package (Dauby et al. 2017) in compliance with the IUCN Red List Categories and Criteria, the dataset was developed based on the herbarium specimens (ca. 3,100 specimens) and species occurrence data (251 occurrence records) from GBIF (Global Biodiversity Information Facility: <https://www.gbif.org/>).

The species distribution data of Orchidaceae will be used for assessment of their respective conservation status in accordance with IUCN Red List Criterion B. In this regard, specimens which consist of coordinate points and taxonomic verification will be used for conservation assessment. Therefore, the datasets of herbarium specimens and species occurrence data (GBIF) were revised and verified accordingly. In addition, taxonomic name standardization of orchid species was conducted by using WorldFlora R package (Kindt 2020) in R (R Core Team 2022).

As a result, the dataset of 1,004 species occurrence records (which belongs to 418 species of Orchidaceae) was obtained in order to make conservation assessment by using ConR R package (Dauby et al. 2017). The distribution of species occurrence records (coordinate points) can be plotted in the map of Myanmar (see **Figure 2**).

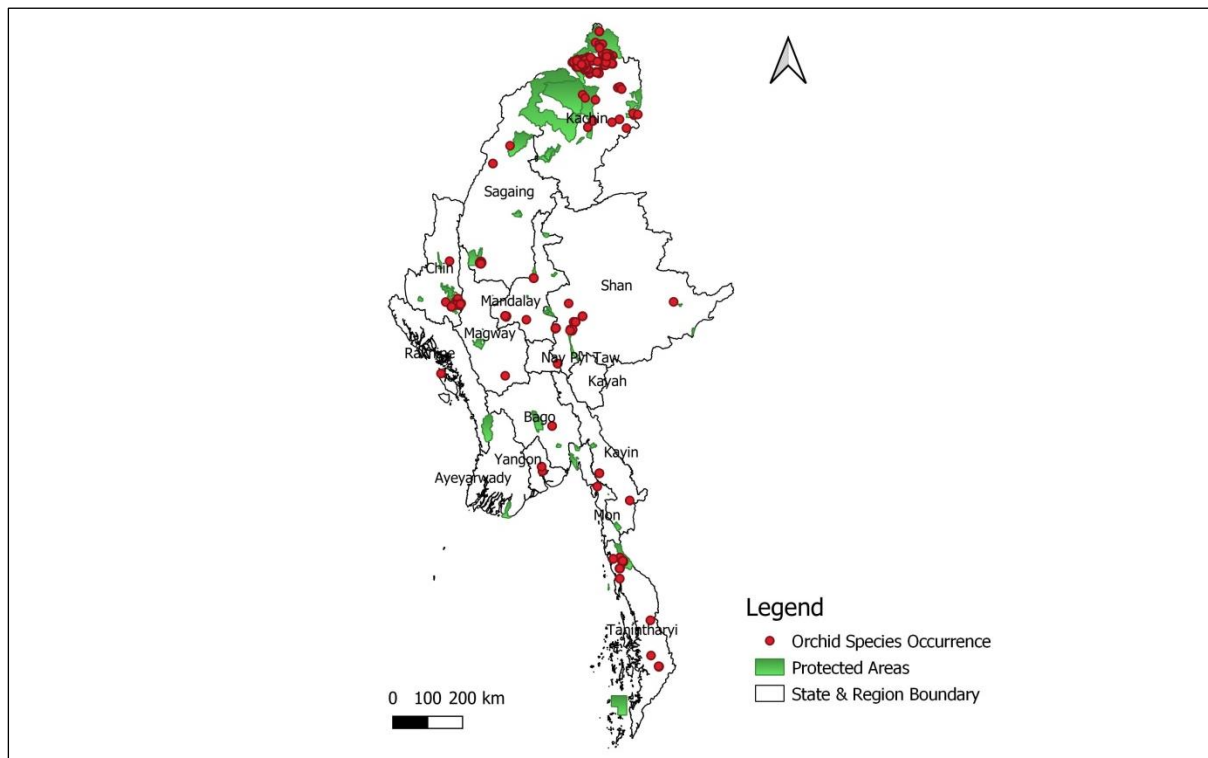


Figure 2. Plotting the coordinate points from the dataset of 1,004 species occurrence records (which belongs to 418 species) in the map of Myanmar

3.5. Conservation Assessment of Myanmar orchid flora

Globally, there are ca. 28,000 species of Orchidaceae, whereas there are only 1,970 orchid species which have been assessed their respective conservation status according to the IUCN Red List of Threatened Species database (<https://www.iucnredlist.org/>) (Chase et al. 2015, Willis 2017). In Myanmar, there are more than 1,000 species of Orchidaceae (Aung et al. 2020, Ormerod et al. 2021). Myanmar orchid biodiversity is very rich so that many new species and new records are increasingly discovered during the botanical explorations across

different ecosystems of Myanmar, making the number of orchid species continuously increased (Aung et al. 2020, Latt et al. 2021, Ormerod et al. 2021, Kurzweil et al. 2022, Naïve et al. 2022, Yukawa et al. 2022).

Based on the recent checklists of Myanmar orchid flora and relevant papers, there are 1,083 species of Orchidaceae in Myanmar. Based on the herbarium specimens (present and previous collections) and species occurrence data (GBIF), the dataset of 1,004 species occurrence records (which belongs to 418 species of Orchidaceae) was obtained for conservation assessment. There are different automated conservation assessment methods for the orchid family and they have their own advantages as well as limitations (Zizka et al. 2021). Among these different automated conservation assessment methods, ConR R package method was chosen to use for orchid conservation assessment. Therefore, 418 species out of total 1,083 species were assessed their respective conservation status by using ConR R package (Dauby et al. 2017) in compliance with the IUCN Red List Categories and Criteria (see **Table 1** and **Figure 3**).

In the present study, the conservation assessment was conducted at national level assessment and it follows the IUCN guidelines for regional and national levels (IUCN 2012b). We performed all analyses in R (R Core Team 2022). All maps were created in QGIS 3.16.3 (<http://www.qgis.org>).

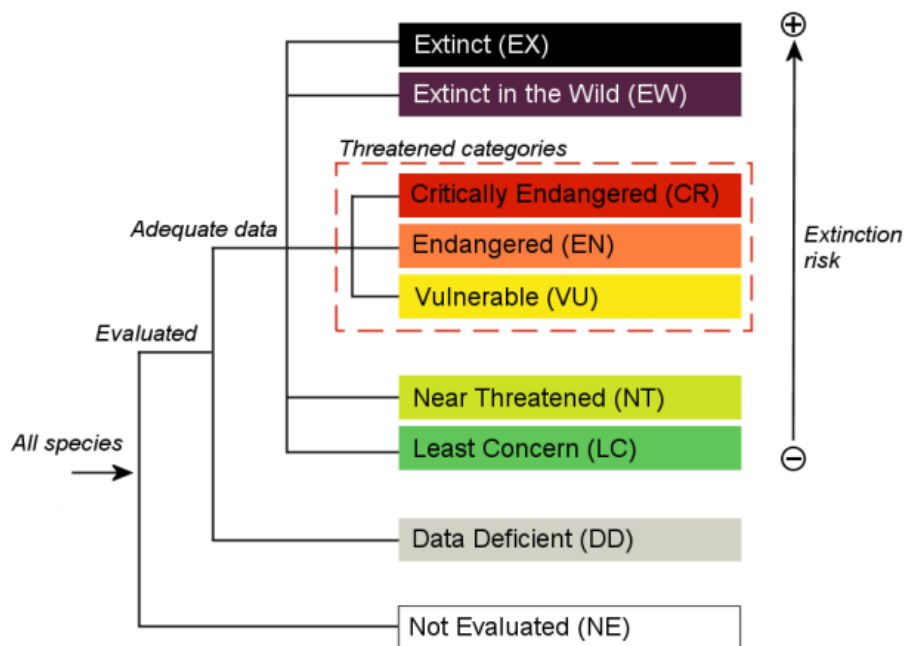


Figure 3. Structure of the IUCN Red List Categories (IUCN 2012a)

Table 1. Summary of the five criteria (A-E) used to evaluate if a taxon belongs in a threatened category (Critically Endangered, Endangered or Vulnerable) (IUCN Standards and Petitions Committee 2022)

A. Population size reduction. Population reduction (measured over the longer of 10 years or 3 generations) based on any of A1 to A4			
	Critically Endangered	Endangered	Vulnerable
A1	≥ 90%	≥ 70%	≥ 50%
A2, A3 & A4	≥ 80%	≥ 50%	≥ 30%
A1 Population reduction observed, estimated, inferred, or suspected in the past where the causes of the reduction are clearly reversible AND understood AND have ceased.	based on any of the following:	(a) direct observation [except A3]	
A2 Population reduction observed, estimated, inferred, or suspected in the past where the causes of reduction may not have ceased OR may not be understood OR may not be reversible.		(b) an index of abundance appropriate to the taxon	
A3 Population reduction projected, inferred or suspected to be met in the future (up to a maximum of 100 years) [(a) cannot be used for A3].		(c) a decline in area of occupancy (AOO), extent of occurrence (EOO) and/or habitat quality	
A4 An observed, estimated, inferred, projected or suspected population reduction where the time period must include both the past and the future (up to a max. of 100 years in future), and where the causes of reduction may not have ceased OR may not be understood OR may not be reversible.		(d) actual or potential levels of exploitation	
		(e) effects of introduced taxa, hybridization, pathogens, pollutants, competitors or parasites.	
B. Geographic range in the form of either B1 (extent of occurrence) AND/OR B2 (area of occupancy)			
	Critically Endangered	Endangered	Vulnerable
B1. Extent of occurrence (EOO)	< 100 km ²	< 5,000 km ²	< 20,000 km ²
B2. Area of occupancy (AOO)	< 10 km ²	< 500 km ²	< 2,000 km ²
AND at least 2 of the following 3 conditions:			
(a) Severely fragmented OR Number of locations	= 1	≤ 5	≤ 10
(b) Continuing decline observed, estimated, inferred or projected in any of: (i) extent of occurrence; (ii) area of occupancy; (iii) area, extent and/or quality of habitat; (iv) number of locations or subpopulations; (v) number of mature individuals			
(c) Extreme fluctuations in any of: (i) extent of occurrence; (ii) area of occupancy; (iii) number of locations or subpopulations; (iv) number of mature individuals			
C. Small population size and decline			
	Critically Endangered	Endangered	Vulnerable
Number of mature individuals	< 250	< 2,500	< 10,000
AND at least one of C1 or C2			
C1. An observed, estimated or projected continuing decline of at least (up to a max. of 100 years in future):	25% in 3 years or 1 generation (whichever is longer)	20% in 5 years or 2 generations (whichever is longer)	10% in 10 years or 3 generations (whichever is longer)
C2. An observed, estimated, projected or inferred continuing decline AND at least 1 of the following 3 conditions:			
(a) (i) Number of mature individuals in each subpopulation	≤ 50	≤ 250	≤ 1,000
(ii) % of mature individuals in one subpopulation =	90–100%	95–100%	100%
(b) Extreme fluctuations in the number of mature individuals			
D. Very small or restricted population			
	Critically Endangered	Endangered	Vulnerable
D. Number of mature individuals	< 50	< 250	D1. < 1,000
D2. Only applies to the VU category Restricted area of occupancy or number of locations with a plausible future threat that could drive the taxon to CR or EX in a very short time.	-	-	D2. typically: AOO < 20 km ² or number of locations ≤ 5
E. Quantitative Analysis			
	Critically Endangered	Endangered	Vulnerable
Indicating the probability of extinction in the wild to be:	≥ 50% in 10 years or 3 generations, whichever is longer (100 years max.)	≥ 20% in 20 years or 5 generations, whichever is longer (100 years max.)	≥ 10% in 100 years

4. Results

4.1. Orchid Biodiversity Richness in Myanmar

In the present study, the checklist of Myanmar orchid flora has been revised and updated mainly based on the literature of recently published papers and field observations (Aung et al. 2020, Kurzweil 2020, Kurzweil et al. 2020, Liu et al. 2020, Mu et al. 2020, Ormerod and Kurzweil 2020, Aung and Jin 2021, Aung et al. 2021, Latt et al. 2021, Ormerod et al. 2021, Kurzweil et al. 2022, Naïve et al. 2022, Yukawa et al. 2022). Some species or taxa are currently set aside if they need to be re-examined later due to lack of voucher specimen citations or lack of taxonomic or occurrence evidences even though they were listed in the checklists of Kress et al. 2003, Kurzweil and Lwin 2014, Aung et al. 2020 and Ormerod et al. 2021. These species or taxa are still under taxonomic review to make their taxonomic statuses confirmed.

As a result, there are 1,083 species in 150 genera of Orchidaceae currently known from Myanmar. The updated checklist consists of all species of Orchidaceae which are taxonomically accepted and currently known from Myanmar, mainly based on the checklists of Aung et al. 2020 and Ormerod et al. 2021 and all relevant papers of new species or new records (**Figure 4-6**). In terms of endemism, there are ca. 80 species endemic to Myanmar.

In the updated checklist, the genus *Dendrobium* is the largest genus of Orchidaceae in Myanmar, having more than 100 species currently known from Myanmar. The genus *Bulbophyllum* follows the second position after *Dendrobium* in terms of number of species per genus. The number of species in each genus of Myanmar orchid flora is shown in **Table 2**. The updated checklist of Myanmar orchid flora can be seen in **Appendix 1**.

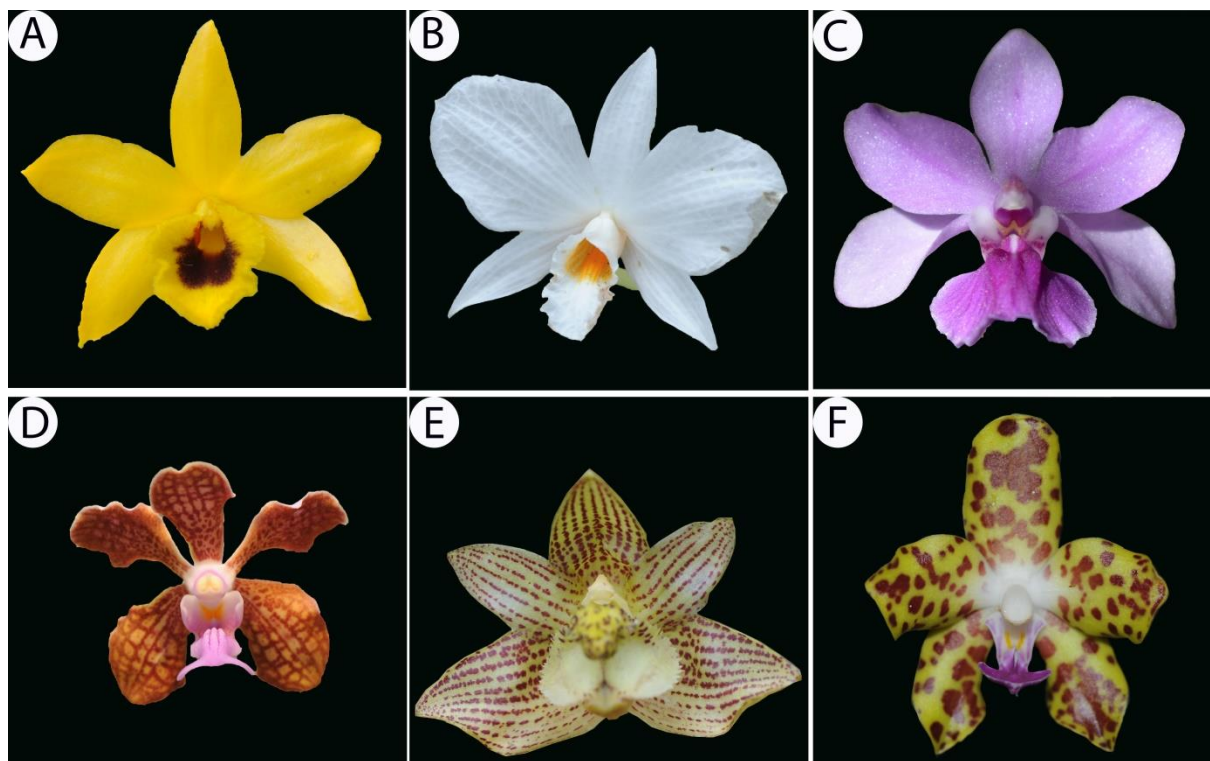


Figure 4. Orchid Biodiversity of Myanmar (A) *Dendrobium ochreatum* Lindl. (B) *Dendrobium infundibulum* Lindl. (C) *Holcoglossum amesianum* (Rchb. f.) Christenson (D) *Vanda bensonii* Bateman (E) *Bulbophyllum pectinatum* Finet (F) *Phalaenopsis hygrochila* J.M.H.Shaw. Photos by Ye Lwin Aung.

Table 2. Number of species per genus of Orchidaceae in Myanmar

No.	Genera	Number of Species	No.	Genera	Number of Species	No.	Genera	Number of Species
1	<i>Acampe</i>	6	51	<i>Diplomeris</i>	2	101	<i>Phaius</i>	6
2	<i>Acanthephippium</i>	2	52	<i>Diploprora</i>	2	102	<i>Phalaenopsis</i>	15
3	<i>Acropsis</i>	2	53	<i>Disperis</i>	1	103	<i>Pholidota</i>	11
4	<i>Aerides</i>	5	54	<i>Epipactis</i>	4	104	<i>Pinalia</i>	34
5	<i>Aeridostachya</i>	1	55	<i>Epipogium</i>	2	105	<i>Platanthera</i>	16
6	<i>Agrostophyllum</i>	5	56	<i>Eria</i>	6	106	<i>Pleione</i>	10
7	<i>Ania</i>	2	57	<i>Eriodes</i>	1	107	<i>Podochilus</i>	4
8	<i>Anoectochilus</i>	5	58	<i>Erythrodes</i>	2	108	<i>Pogonia</i>	1
9	<i>Anthogonium</i>	1	59	<i>Erythrorchis</i>	1	109	<i>Polystachya</i>	1
10	<i>Aphyllorchis</i>	1	60	<i>Eulophia</i>	16	110	<i>Pomatocalpa</i>	2
11	<i>Apostasia</i>	3	61	<i>Galearis</i>	3	111	<i>Ponerorchis</i>	5
12	<i>Appendicula</i>	2	62	<i>Galeola</i>	2	112	<i>Porpax</i>	13
13	<i>Arachnis</i>	4	63	<i>Gastrochilus</i>	14	113	<i>Pteroceras</i>	3
14	<i>Arundina</i>	1	64	<i>Gastrodia</i>	2	114	<i>Renanthera</i>	5
15	<i>Bambuseria</i>	2	65	<i>Geodorum</i>	8	115	<i>Rhomboda</i>	3
16	<i>Biermannia</i>	2	66	<i>Goodyera</i>	11	116	<i>Rhynchostylis</i>	2
17	<i>Bletilla</i>	4	67	<i>Grammatophyllum</i>	1	117	<i>Risleya</i>	1
18	<i>Brachycorythis</i>	6	68	<i>Grosourdia</i>	1	118	<i>Robiquetia</i>	3
19	<i>Bromheadia</i>	2	69	<i>Gymnadenia</i>	1	119	<i>Saccolabiopsis</i>	1
20	<i>Bryobium</i>	1	70	<i>Habenaria</i>	54	120	<i>Sarcoglyphis</i>	3
21	<i>Bulbophyllum</i>	126	71	<i>Hemipilia</i>	3	121	<i>Satyrium</i>	1
22	<i>Bulleyia</i>	1	72	<i>Herminium</i>	12	122	<i>Schoenorchis</i>	2
23	<i>Calanthe</i>	28	73	<i>Herpysma</i>	1	123	<i>Seidenfadenia</i>	1
24	<i>Callostylis</i>	3	74	<i>Hetaeria</i>	4	124	<i>Sirindhornia</i>	1
25	<i>Cephalanthera</i>	2	75	<i>Holcoglossum</i>	4	125	<i>Smitinandia</i>	2
26	<i>Cephalantheropsis</i>	3	76	<i>Lecanorchis</i>	4	126	<i>Spathoglottis</i>	4
27	<i>Ceratostylis</i>	4	77	<i>Liparis</i>	29	127	<i>Spiranthes</i>	1
28	<i>Cheirostylis</i>	7	78	<i>Ludisia</i>	1	128	<i>Stereochilus</i>	3
29	<i>Chiloschista</i>	3	79	<i>Luisia</i>	16	129	<i>Stereosandra</i>	1
30	<i>Chrysoglossum</i>	2	80	<i>Malaxis</i>	3	130	<i>Stichorkis</i>	1
31	<i>Cleisomeria</i>	2	81	<i>Micropera</i>	6	131	<i>Strongyleria</i>	1
32	<i>Cleisostoma</i>	17	82	<i>Microsaccus</i>	1	132	<i>Taeniophyllum</i>	1
33	<i>Coelogyne</i>	45	83	<i>Mycaranthes</i>	2	133	<i>Tainia</i>	4
34	<i>Collabium</i>	3	84	<i>Myrmechis</i>	2	134	<i>Thecostele</i>	1
35	<i>Corymborkis</i>	1	85	<i>Neogyna</i>	1	135	<i>Thelasis</i>	5
36	<i>Cremastra</i>	1	86	<i>Neottia</i>	7	136	<i>Thrixspermum</i>	5
37	<i>Crepidium</i>	10	87	<i>Nephelaphyllum</i>	3	137	<i>Thunia</i>	5
38	<i>Cryptochilus</i>	4	88	<i>Nervilia</i>	9	138	<i>Thuniopsis</i>	1
39	<i>Cryptostylis</i>	2	89	<i>Oberonia</i>	28	139	<i>Tipularia</i>	1
40	<i>Cylindrolobus</i>	7	90	<i>Odontochilus</i>	8	140	<i>Trachoma</i>	1
41	<i>Cymbidium</i>	25	91	<i>Oreorchis</i>	5	141	<i>Trichoglottis</i>	7
42	<i>Cymbilabia</i>	2	92	<i>Otochilus</i>	4	142	<i>Trichotosia</i>	7
43	<i>Cypripedium</i>	5	93	<i>Oxystophyllum</i>	1	143	<i>Tropidia</i>	2
44	<i>Cyrtosia</i>	1	94	<i>Pachystoma</i>	1	144	<i>Tuberolabium</i>	1
45	<i>Dendrobium</i>	149	95	<i>Panisea</i>	5	145	<i>Uncifera</i>	2
46	<i>Dendrochilum</i>	2	96	<i>Paphiopedilum</i>	14	146	<i>Vanda</i>	17
47	<i>Dendrolirium</i>	4	97	<i>Papilionanthe</i>	5	147	<i>Vandopsis</i>	2
48	<i>Dicksonia</i>	1	98	<i>Pecteilis</i>	4	148	<i>Vanilla</i>	3
49	<i>Didymoplexis</i>	1	99	<i>Pelatantheria</i>	3	149	<i>Vrydagzynea</i>	2
50	<i>Diglyphosa</i>	1	100	<i>Peristylus</i>	11	150	<i>Zeuxine</i>	9
						Total	1083	

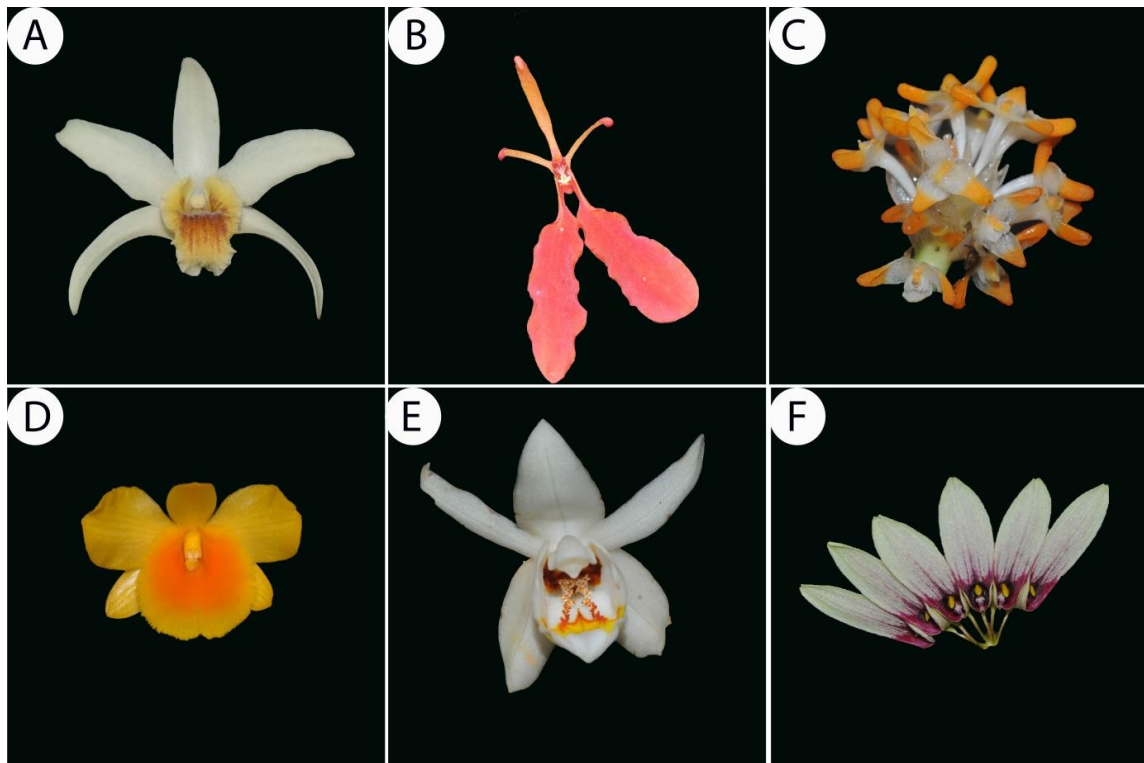


Figure 5. Orchid Biodiversity of Myanmar (A) *Dendrobium heterocarpum* Wall (B) *Renanthera coccinea* Lour. (C) *Bulbophyllum odoratissimum* Lindl. (D) *Dendrobium lindleyi* Steud. (E) *Coelogyne holochila* P.F. Hunt & Summerh. (F) *Bulbophyllum lepidum* (Blume) J.J.Sm. Photos by Ye Lwin Aung.

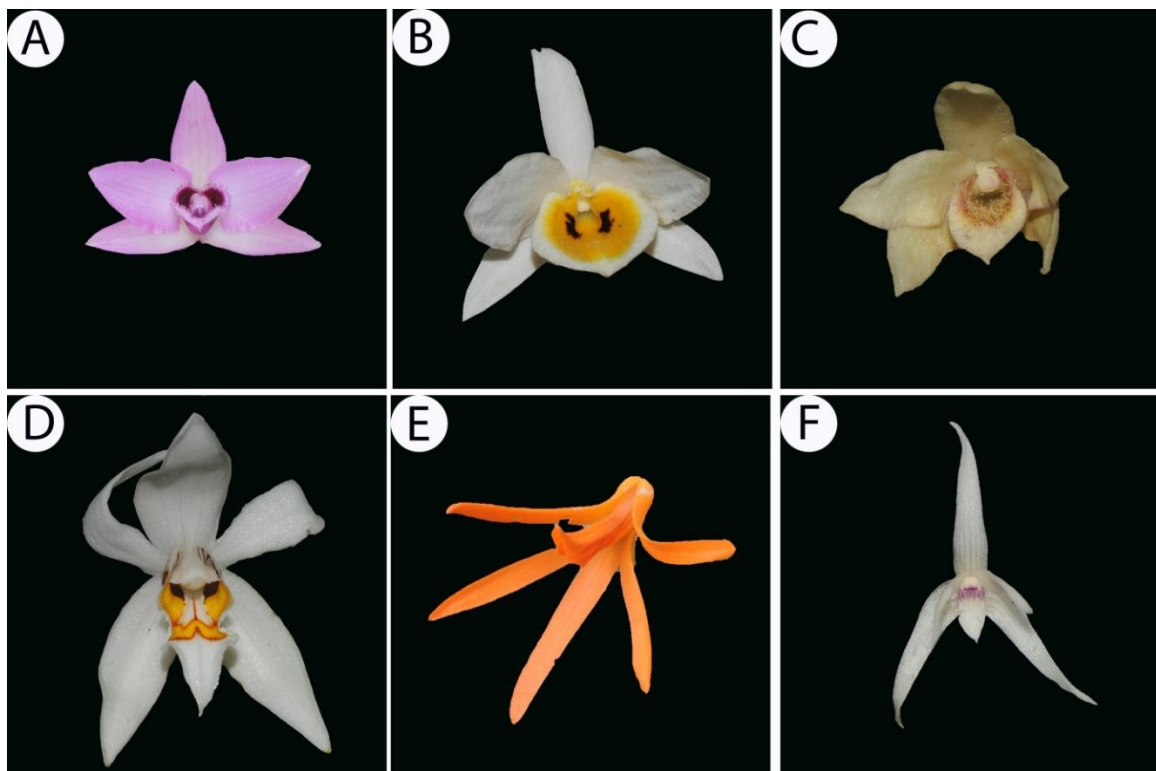


Figure 6. Orchid Biodiversity of Myanmar (A) *Dendrobium parishii* Rchb. f. (B) *Dendrobium bensoniae* Rchb. f. (C) *Dendrobium moniliforme* (L.) Sw. (D) *Coelogyne corymbosa* Lindl. (E) *Dendrobium dickasonii* L.O. Williams (F) *Eria javanica* (Sw.) Blume Photos by Ye Lwin Aung.

4.2. Conservation Assessment

According to the IUCN Red List of Threatened Species (<https://www.iucnredlist.org/>), there are only 1,970 orchid species (out of total species ca. 28,000 species) which have been assessed their respective conservation status. There are 1,083 species of Orchidaceae currently known from Myanmar. Based on the herbarium specimens and GBIF dataset, the dataset of 1,004 species occurrence records (which belongs to 418 species of Orchidaceae) is developed and used to evaluate the conservation status of Myanmar orchid flora in compliance with IUCN Red List Criterion B. The data analysis was conducted by using ConR R package (Dauby et al. 2017) in the R (R Core Team 2022). In the present study, the conservation assessment was conducted at national level assessment and it follows the IUCN guidelines for regional and national levels (IUCN 2012b).

As a result, the preliminary conservation status of 418 orchid species was obtained (see **Appendix 2** for detailed results). The summary of conservation assessment of 418 orchid species is shown in **Figure 7**. Among 418 orchid species assessed, EOO (Extent of Occurrence) of 127 species can be calculated and developed into their respective EOO Polygons, depending on their unique occurrence records (i.e., EOO can be calculated only for the species which have at least three unique occurrence records if EOO calculation is based on species distribution data). The EOO Polygons of some species can be seen in **Figure 8-9** and the remaining ones can also be seen in **Supporting Information**. In brief, about 30 % of total orchid species (1,083 species) shall need special conservation actions.

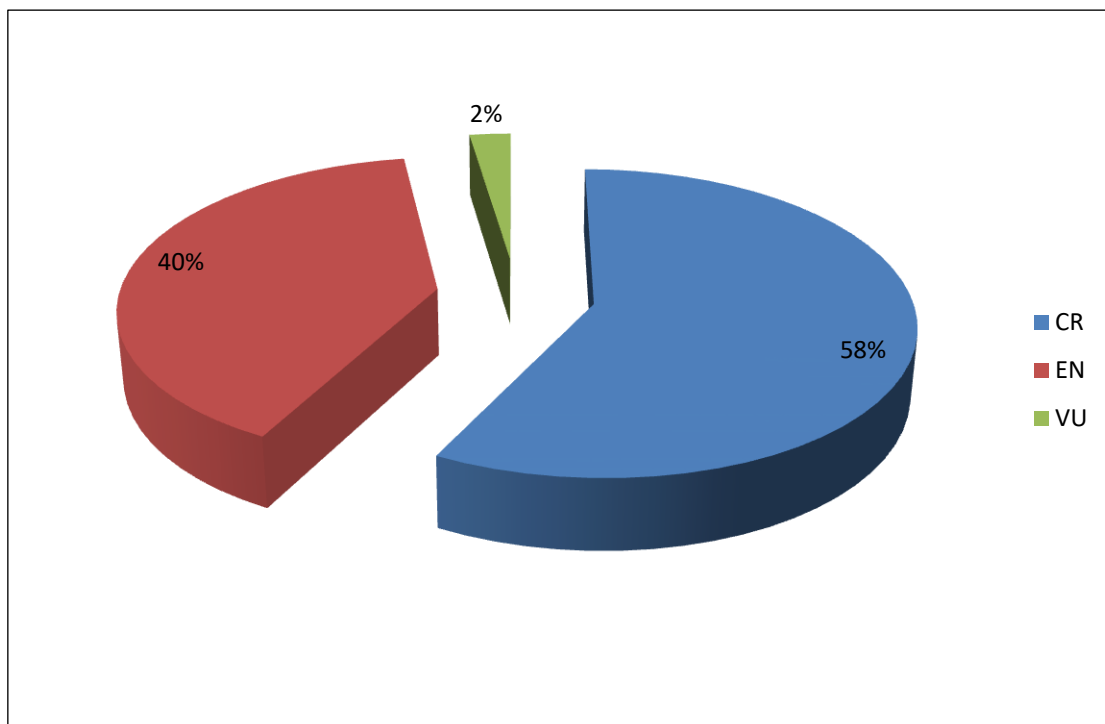


Figure 7. Number of species assigned in their respective IUCN Red List Categories, assessed in accordance with IUCN Red List Criterion B

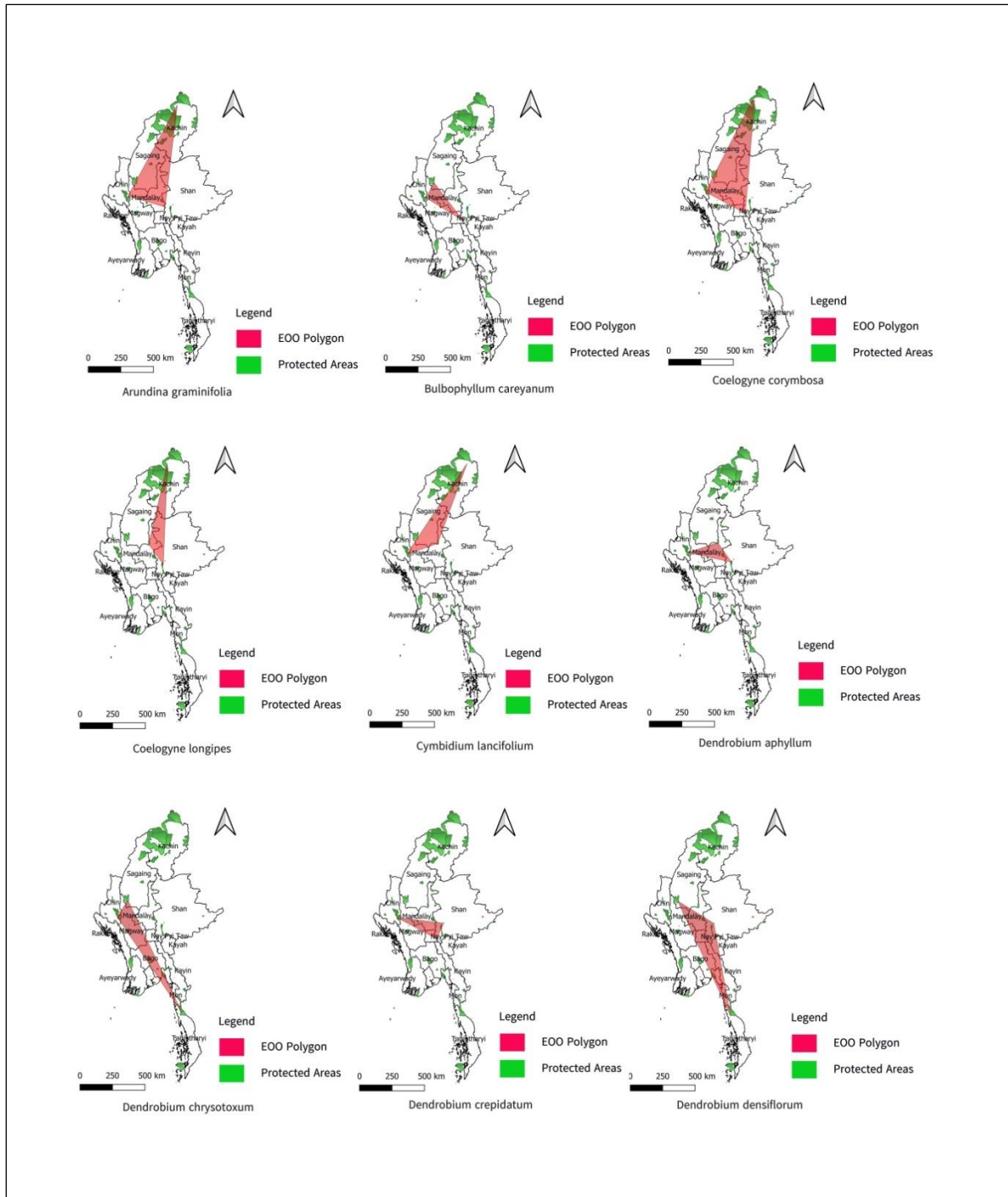


Figure 8. EOO (Extent of Occurrence) Polygons of orchid species in Myanmar; *Arundina graminifolia*, *Bulbophyllum careyanum*, *Coelogyne corymbosa*, *Coelogyne longipes*, *Cymbidium lancifolium*, *Dendrobium aphyllum*, *Dendrobium chrysotoxum*, *Dendrobium crepidatum*, *Dendrobium densiflorum*, calculated based on their respective unique occurrence records in Myanmar.

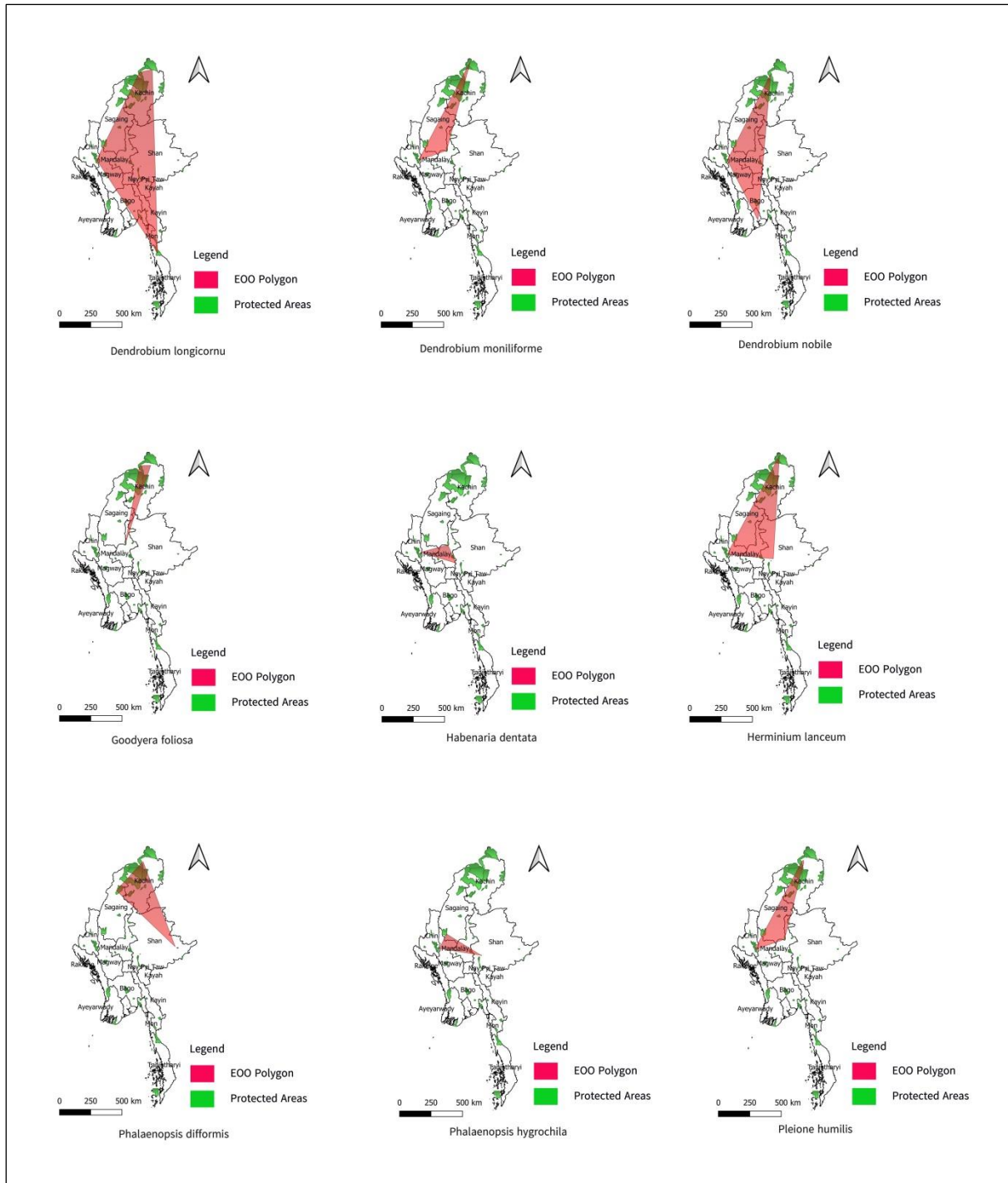


Figure 9. EOO (Extent of Occurrence) Polygons of orchid species in Myanmar; *Dendrobium longicornu*, *Dendrobium moniliforme*, *Dendrobium nobile*, *Goodyera foliosa*, *Habenaria dentate*, *Herminium lanceum*, *Phalaenopsis difformis*, *Phalaenopsis hygrochila*, *Pleione humilis*, calculated based on their respective unique occurrence records in Myanmar.

5. Discussion

Myanmar orchid flora is very diverse and rich while the botanical explorations are still needed to fully cover the different ecosystems of Myanmar. Over recent years, discoveries of many new species and new records make the number of orchid species in Myanmar continuously increased. Research cooperation with international organizations mainly contributes to the recent discoveries of many new species and new records. With regard to new species description, most new species are described from recent botanical collections of Myanmar orchid flora while some new species are described from old botanical collections of Myanmar orchid flora. In this regard, the current status of species occurrences can be easily tracked for recent collection-based description but maybe more efforts are needed to track for old collection-based description because species occurrence data is very useful for conservation assessment.

The botanical explorations still remain under-represented to cover the whole diversity of Myanmar orchid flora. In consequence, at least 150 species might remain unexplored and are expected to be discovered in further studies. But there are some major threats to species survival such as habitat loss due to deforestation and land use change. Under such threats, some species might be locally extinct before recorded their occurrences and distribution in Myanmar. In order to counteract such threats, botanical explorations are urgently needed to better understand orchid biodiversity of Myanmar and to take proactive conservation measures. With more botanical explorations, orchid studies will contribute to better understanding of Myanmar orchid flora and also contribute to the biodiversity conservation and research in Myanmar.

As for orchid conservation, there are various conservation actions and approaches all over the world. Habitat status is directly linked to orchid species survival and conservation. On the other hand, societal needs or perceptions on orchid and its conservation play an important role in orchid conservation. In this regard, socio-economic assessment on public perceptions on orchids and its conservation shall be needed for effective orchid conservation. In terms of socio-economic dimension, alternative approaches for livelihood sustainability and innovative approaches for development of orchid industry will become key factors for effective orchid conservation.

6. Conclusion

The present study is one of the contributions to both floristic studies of Myanmar and biodiversity conservation of Myanmar. The present study is mainly based on our own collections of specimens, herbarium specimen sheets available, relevant literature and online databases. The present study will highlight the species richness and preliminary conservation status of Myanmar orchid flora by providing the species checklist as well as conservation assessment results obtained based on the distribution data (IUCN Red List Criterion B).

7. Acknowledgements

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Appendix 1

Orchid checklist can be seen from the link:

https://docs.google.com/spreadsheets/d/1dPOPsnQJ0ZF4A6exK1BT_SYc8RdZRYQY/edit?usp=share_link&ouid=116376168682763602539&rtpof=true&sd=true

Appendix 2

Conservation assessment results can be seen from the link:

https://docs.google.com/spreadsheets/d/1rnF14uSotpIgU6geLwLvlSaXyi8Xu-Bq/edit?usp=share_link&ouid=116376168682763602539&rtpof=true&sd=true

Supporting Information

EOO Polygons of orchid species can be seen from the link:

<https://drive.google.com/drive/folders/1WHgKKCYl1Sox6lDMzosISdf5sgppDbiA?usp=sharing>