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Abstract: Orchidaceae is one of the largest and most diverse families of flowering plants, comprising more than 450 species that span 107 genera in Nepal. Since orchids are facing an extinction risk from various anthropogenic factors at the regional and global level, we attempted to explore the diversity of orchid in two community managed forests – Karunabhumi Community Forest at Daman & Chandragiri Community Forest at Chitlang of Makawanpur District in central Nepal. We compiled a list of 58 species of orchids belonging to 23 genera, including 47 epiphytic and 11 terrestrial species, of which 29 species have medicinal value. Our result also revealed that epiphytic orchids are associated with particular host communities.

Keywords: Community forests, epiphyte, host association, medicinal value, Orchidaceae, threats.

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Author Contribution: BP, MRP and MBC wrote the manuscript and finalized it. BBR, SP and BBM reviewed the manuscript. All the authors visited the field for the study.

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INTRODUCTION

Orchidaceae is one of the largest and most diverse families of flowering plants, comprising of 736 genera worldwide with around 27,000 species (Chase et al. 2015; Govaerts et al. 2018). In Nepal, 450 orchid species are reported from 107 genera, among which 18 species have been known to be endemic (Rajbhandari 2014). Further systematic studies may reveal additional species of the family in Nepal, as new findings are still being reported every year (Raskoti & Ale 2011, 2013, 2014; Raskoti & Kurzweil 2015; Raskoti 2012, 2013, 2015; Gajurel et al. 2013; Raskoti et al. 2013; Rai et al. 2013, 2014; Rajbhandari 2015).

In the history of orchid exploration in Nepal, many plant collectors and naturalists collected and documented orchids. During 1820–1821, N. Wallich collected many orchid species around Kathmandu valley and other parts of Nepal. In 1825, D. Don published the description of 50 species of orchids collected from Nepal (Rajbhandari 1976). A comprehensive documentation of the Nepalese orchids given by Hara et al. (1978) enumerated 90 genera & 315 species. Later on, Banerjee & Thapa (1978) reported 55 genera & 196 species of orchids from the eastern part of Nepal. Banerjee & Pradhan (1984) described and illustrated 247 species in the book ‘The Orchids of Nepal Himalaya’. Press et al. (2000) reported 89 genera & 323 species of orchids in an annotated checklist of flowering plants of Nepal. Rajbhandari & Bhattarai (2001) published descriptions and images of 101 species of orchids of Nepal. Rajbhandari & Dahal (2004) enumerated 100 genera & 377 species in a checklist of orchids in Nepal. Raskoti (2009) enumerated 302 species of orchid along with their detailed descriptions. Similarly, Rokaya et al. (2013) published an annotated checklist of orchid species in Nepal with a list of 104 genera & 437 species. A recent study showed 450 species from 107 genera of orchids in Nepal (Rajbhandari 2014). Amongst the orchids of Nepal, however, only 98 species have been reported with medicinal value (Pant & Raskoti 2013; Chand et al. 2016; Paudel et al. 2017, 2018). As the floristic explorations and vegetation studies in Nepal has been the priority of botanical works, the number of orchid species and their new records are increasing with subsequent studies (Rajbhandari 2014; Rokaya et al. 2013). Numerous orchids, however, are becoming victims of population decline and threats due to various causes such as anthropogenic factors and some natural limitations on the propagation of orchids themselves (Pant 2013; Subedi et al. 2013).

Orchidaceae is considered to have the highest rate

of speciation, but also the highest rate of extinction (Gravendeel et al. 2004; Swarts & Dixon 2009). The rapid speciation and high species diversity within Orchidaceae are linked to the family’s specialized pollination syndromes, symbiotic associations with mycorrhizal fungi, and colonization of epiphytic habitats (Gravendeel et al. 2004; Pant et al. 2017). Because of their mycorrhizal specificity, pollinator specialization, and germination limitation, however, many species are only distributed in specific habitats (Gravendeel et al. 2004; Swarts & Dixon 2009; Liu et al. 2015). Moreover, due to their great economic importance in the floral and pharmaceutical industries, many species are over-collected, traded illegally, and becoming endangered (Swarts & Dixon 2009; Liu et al. 2015; Hinsley et al. 2017).

The abundance and diversity of orchids are decreasing throughout the world, beginning with genetic erosion and ending with local and global species loss. The main driving forces of orchid loss in community forests of Nepal are overgrazing, exploitation for ornamental and medicinal uses, construction projects in the forest, and massive collection and export to neighbouring countries (Subedi et al. 2013). The sustainable and speedy propagation of orchids by tissue culture technique and their reintroduction, however, can meet both biodiversity conservation and commercial propagation of valuable species (Pant 2013; Pradhan et al. 2014). Therefore, orchids need urgent conservation in their natural habitats. Conventionally, habitat and species protection are the two important strategies that can prevent a species from extinction. There should be a priority for exploring the diversity of orchid and their threats to apply these two strategies.

Since at the global level, only a few species are listed in Appendix I of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), all known orchid species are listed in Appendix II and categorized into different threat categories by the International Union for the Conservation of Nature (IUCN 2001). The prime objective of our study is to explore the diversity of orchid in two community forests of Makawanpur District, central Nepal, and to identify their major threats.

METHODS

Study area

Karunabhumi Community Forest (KCF) in Daman (KCF) & Chandragiri Community Forest (CCF) in Chitlang in Makawanpur District, central Nepal, in (KCF) were

selected for the study.

KCF (27.59–27.63 °N & 85.08–85.16 °E) occupies an area of 868ha. It is a hilly area rising from 1,800m to 2,550m. The adjoining forests of KCF that are habitats for orchids are Hrishweshwar Community Forest in the west & Jhirghari-Setoguransh Community Forest in the south. The climatic conditions of this site are in a transitional zone between sub-tropical and temperate. KCF has *Pinus wallichiana*, *Quercus semecarpifolia*, *Rhododendron arboreum*, *Castanopsis* sp. and *Pieris formosa* as dominant tree species while the understory of the forest is covered by bushes including *Daphne bholua*.

CCF (27.66–27.68 °N & 85.18–85.21 °E), with an area of 431.47ha, varies in altitude between 1,800m and 2,525m. The forest area is rich in biodiversity due to low human intervention. The adjoining areas of CCF are Falkhel in the east, Mahadevthan & Thankot in the north, and Gurjudhara Village in the west, and Siran-Pauwa in the south. The climatic conditions of these forests range from sub-tropical to temperate. Plants such as *Rhododendron arboreum*, *Castanopsis* sp. and *Quercus* sp. thrive as dominant trees. *Berberis aristata*, *Mahonia nepalensis*, *Prunus persica*, *Rubus ellipticus*, and *Viburnum* sp. grow as bushes covering the understory of the forest.

Field survey

Field survey for the exploration and diversity assessment of orchids was conducted by a simple random sampling method in the years 2014 and 2015. We recorded all the orchid species found during the field survey and identified the host tree species for the epiphytic species. The study area was visited in the months of March, May, July, September, November and January of each successive year with the forest guard of each forest or with members of the community forest user group in order to carry out the research with the participation of local people. Orchid genera and species were identified with their morphological and floristic characters in the field with standard references and literature and confirmed with the images taken from special references of the herbarium specimens available in National Herbarium (KATH) in Godavari and Tribhuvan University Central Herbarium (TUCH) in Kirtipur. The specimens were not collected for herbarium preparation as we were concerned about their in situ conservation.

RESULT AND DISCUSSION

The present research explored different species of

epiphytic and terrestrial orchids in the study area (Image 1). A total of 58 species were recorded from the two community forests; 49 species from 19 genera were recorded in KCF and 29 species from 15 genera in CCF (Table 1). *Dendrobium* was a genus frequently spotted among the study sites, followed by *Bulbophyllum*, *Otochilus*, *Pholidota*, *Gastrochilus*, *Pinalia*, *Coelogyne*, *Cymbidium*, *Goodyera* and *Calanthe*. *Bulbophyllum raskotii* is reported from its type locality in KCF (Raskoti & Ale 2011). Out of the 58 species recorded from the two community forests, 29 species have been recognized with medicinal values (Table 1) based on previous literature (Pant & Raskoti 2013) and information obtained from local people. Amongst the species recorded from the study sites, most of them are epiphytic (43 species in KCF & 22 species in CCF) and a few are terrestrial (6 species in KCF & seven species in CCF) (Fig. 1). This result also revealed that epiphytic orchid diversity is simply associated with host communities (Table 1), supporting the previous result analysed by Timsina et al. (2016).

Among the identified orchid species, *Gastrochilus calceolaris* is already known to be Critically Endangered (CR), and *Bulbophyllum leopardinum* & *Spiranthes sinensis* have been assessed as Least Concern (LC) (IUCN 2001). Although most of the orchids encountered in the selected forests have not been evaluated for their conservation status, they are equally threatened at least at the local and national level in Nepal by various anthropogenic factors such as deforestation, habitat destruction, and overexploitation of natural habitats. Since White & Sharma (2000) reported 175 species of orchids from these sites along Tribhuvan Rajpath, from Hetauda of Makawanpur to Naubise of Dhading and its adjoining areas, there is no available documentation on orchids from these study sites. Thus, this study gives the current insight that these areas still harbour good orchid

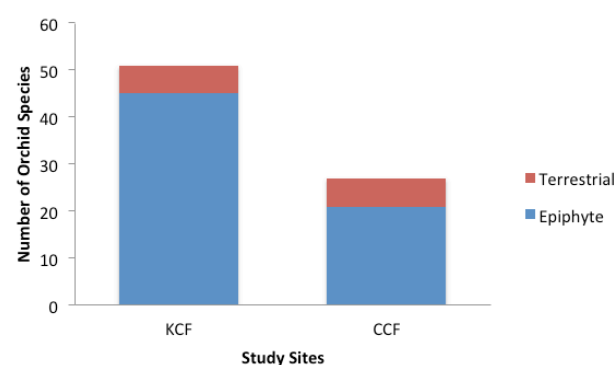


Figure 1. The total number of orchid species at the study sites Karunabhum Community Forest (KCF) & Chandragiri Community Forest (CCF) based on habitats



Image 1. Exploration of diversity and habitats of orchid. A, B, C - exploration of orchid species; epiphytic species D - *Otochilus lancilabius*, E - *Bulbophyllum reptans* & F - *Dendrobium fimbriatum*; terrestrial species G - *Satyrium nepalense*, H - *Goodyera schlechtendalana*, I - *Dienia cylindrostachya*

Table 1. The diversity of orchid species in Karunabhumi Community Forest (KCF) & Chandragiri Community Forest (CCF) of Makawanpur District, central Nepal

Species	Habitat/ Host/ Special Habitat	KCF	CCF	Medicinal use
<i>Agrostophyllum callosum</i> Rchb.f.	Epiphyte/ <i>Pinus wallichiana</i>	+	-	-
<i>Bulbophyllum careyanum</i> (Hook.) Spreng	Epiphyte/ <i>Quercus glauca</i> , <i>Rhododendron arboreum</i>	+	+	A paste made of pseudobulbs & leaves is used to treat burns.
<i>Bulbophyllum griffithii</i> (Lindl.) Rchb.f	Epiphyte/ <i>Quercus glauca</i> , <i>Schima wallichii</i> , <i>Rhododendron arboreum</i>	+	+	-
<i>Bulbophyllum leopardinum</i> (Wall.) Lindl.	Epiphyte/ <i>Quercus glauca</i> , <i>Schima wallichii</i>	+	-	A paste made from pseudobulbs is used to treat burns.
<i>Bulbophyllum muscicola</i> Rchb.f.	Epiphyte/ <i>Rhododendron arboreum</i> , <i>Quercus glauca</i>	+	-	-
<i>Bulbophyllum raskottii</i> J.J. Verm., Schuit. & de Vogel	Epiphyte/ <i>Schima wallichii</i> , <i>Quercus</i> sp.	+	-	-
<i>Bulbophyllum reptans</i> (Lindl.) Lindl. ex Wall.	Epiphyte/ <i>Rhododendron arboreum</i> , <i>Castanopsis indica</i>	+	-	-
<i>Bulbophyllum retusiusculum</i> Rchb.f.	Epiphyte/ <i>Quercus glauca</i> , <i>Schima wallichii</i> , <i>Rhododendron arboreum</i>	-	+	-
<i>Calanthe plantaginea</i> Lindl.	Terrestrial/ full shade	-	+	Dry powdered rhizomes are mixed with milk and taken as a tonic & an aphrodisiac.
<i>Calanthe puberula</i> Lindl.	Terrestrial/ light sun	-	+	Rhizomes are used as an antipyretic.
<i>Calanthe tricarinata</i> Lindl.	Terrestrial/ full shade	+	-	Leaves and pseudobulbs are thought to be aphrodisiacs and a paste of leaves is applied to treat sores & eczema.
<i>Coelogyne cristata</i> Lindl.	Epiphyte/ <i>Quercus glauca</i> , <i>Rhododendron arboreum</i>	+	+	Infusions of pseudobulbs are used as aphrodisiac and to treat constipation; their juice is applied to wounds & boils.
<i>Coelogyne nitida</i> (Wall. ex D. Don) Lindl.	Epiphyte/ <i>Castanopsis indica</i> , <i>Quercus glauca</i> & <i>Rhododendron arboreum</i>	+	+	The juice of pseudobulbs is used to treat stomachaches & other gastric ailments.
<i>Coelogyne stricta</i> (D. Don) Schltr.	Epiphyte/ <i>Quercus glauca</i>	+	-	A paste made from pseudobulbs is used to relieve headaches & fever.
<i>Cymbidium cyperifolium</i> Wall. ex Lindl.	Terrestrial/ light sun	+	+	-
<i>Cymbidium erythraeum</i> Lindl.	Epiphyte/ <i>Quercus glauca</i> , <i>Rhododendron arboreum</i>	+	-	-
<i>Cymbidium iridioides</i> D. Don	Epiphyte/ <i>Quercus glauca</i> , <i>Schima wallichii</i> , <i>Rhododendron arboreum</i>	+	-	Juice of fresh leaf is applied to deep wounds to stop bleeding.
<i>Dendrobium amoenum</i> Wall. ex Lindl	Epiphyte/ <i>Pinus wallichiana</i>	+	+	Stems are used as a tonic.
<i>Dendrobium bicameratum</i> Lindl.	Epiphyte/ <i>Schima wallichii</i>	+	-	-
<i>Dendrobium chrysanthum</i> Wall. ex Lindl.	Epiphyte/ <i>Schima wallichii</i> , <i>Quercus glauca</i>	+	-	-
<i>Dendrobium eriiflorum</i> Griff.	Epiphyte/ <i>Quercus glauca</i> , <i>Schima wallichii</i> , <i>Rhododendron arboreum</i> , <i>Pinus wallichiana</i>	+	-	The whole plant is taken as a tonic.
<i>Dendrobium fimbriatum</i> Hook.	Epiphyte/ <i>Quercus glauca</i> , <i>Schima wallichii</i> , <i>Rhododendron arboreum</i>	+	-	The whole plant is taken to treat liver ailments & nervous debility.
<i>Dendrobium heterocarpum</i> Wall. ex Lindl.	Epiphyte/ <i>Pinus roxburghii</i>	+	-	A paste of stems is applied to fractured & dislocated bones.
<i>Dendrobium longicornu</i> Lindl.	Epiphyte/ <i>Pinus roxburghii</i> , <i>Castanopsis indica</i> , <i>Quercus glauca</i>	+	+	Plant juice is used to relieve fever; boiled roots are fed to livestock suffering from coughs.
<i>Dendrobium moniliforme</i> (L.) Sw.	Epiphyte/ <i>Castanopsis indica</i>	+	-	Stems are used as a tonic.
<i>Dendrobium monticola</i> P.F.Hunt & Summerh.	Epiphyte/ <i>Quercus glauca</i> , <i>Rhododendron arboreum</i>	+	-	The pulp of stems is used to treat boils, pimples & other skin eruptions.
<i>Dienia cylindrostachya</i> Lindl.	Terrestrial/ Full shade	-	+	-
<i>Gastrochilus acutifolius</i> (Lindl.) Kuntze	Epiphyte/ <i>Quercus glauca</i>	+	+	-
<i>Gastrochilus calceolaris</i> (Buch.-Ham. ex Sm.) D. Don	Epiphyte/ <i>Quercus</i> sp.	+	+	-
<i>Gastrochilus distichus</i> (Lindl.) Kuntze	Epiphyte/ <i>Quercus glauca</i> , <i>Rhododendron arboreum</i>	+	-	-
<i>Gastrochilus pseudodisticus</i> (King & Pantl.) Schltr	Epiphyte/ <i>Quercus glauca</i> , <i>Rhododendron arboreum</i>	+	-	-
<i>Goodyera biflora</i> (Lindl.) Hook. f.	Terrestrial/ full shade, moist forest floor	+	+	-
<i>Goodyera foliosa</i> (Lindl.) Benth. ex C.B. Clarke	Terrestrial/ full shade, moist forest floor	+	-	-
<i>Goodyera schlechtendalana</i> Rchb.f.	Terrestrial/ full shade, moist forest floors	+	-	-
<i>Luisia brachystachys</i> (Lindl.) Blume	Epiphyte/ <i>Quercus glauca</i> , <i>Schima wallichii</i>	+	-	-

Species	Habitat/ Host/ Special Habitat	KCF	CCF	Medicinal use
<i>Oberonia caulescens</i> Lindl.	Epiphyte/ <i>Quercus glauca</i> , <i>Pieris</i> sp.	+	+	Tubers are used to treat liver ailments.
<i>Otochilus albus</i> Lindl.	Epiphyte/ <i>Quercus glauca</i> , <i>Schima wallichii</i>	+	+	Pseudobulbs are applied to bone fractures.
<i>Otochilus fuscus</i> Lindl.	Epiphyte/ <i>Schima wallichii</i>	+	-	Pseudobulbs are applied to bone fractures.
<i>Otochilus lancilabius</i> Seidenf.	Epiphyte/ <i>Castanopsis indica</i>	+	+	-
<i>Otochilus porrectus</i> Lindl.	Epiphyte/ <i>Castanopsis</i> sp., <i>Quercus glauca</i> , <i>Schima wallichii</i> , <i>Rhododendron arboreum</i> .	+	+	Pseudobulb is used in treating sinusitis & rheumatism and taken as a tonic.
<i>Papilionanthe uniflora</i> (Lindl.) Garay	Epiphyte/ <i>Prunus</i> sp.	-	+	-
<i>Phalaeonopsis taenialis</i> (Lindl.) Christenson & Pradhan	Epiphyte/ <i>Prunus</i> sp.	-	+	-
<i>Pholidota articulata</i> Lindl.	Epiphyte/ <i>Schima wallichii</i>	+	-	The whole plant is used as a tonic, root powder is used to treat cancer, and the plant's juice is applied to skin disorders.
<i>Pholidota pallida</i> Lindl.	Epiphyte/ <i>Schima wallichii</i> , <i>Pinus roxburghii</i>	-	+	Pseudobulbs are applied to relieve naval, abdominal & rheumatic pains. Powder made from pseudobulbs is used to induce sleep.
<i>Pholidota protracta</i> Hook.f.	Epiphyte/ <i>Schima wallichii</i>	+	+	-
<i>Pholidota recurva</i> Lindl.	Epiphyte/ <i>Schima wallichii</i>	+	+	-
<i>Pinalia bipunctata</i> (Lindl.) Kuntze	Epiphyte/ <i>Castanopsis</i> sp., <i>Quercus semecarpifolia</i> , <i>Rhododendron arboreum</i> .	+	+	-
<i>Pinalia excavata</i> (Lindl.) Kuntze	Epiphyte/ <i>Quercus glauca</i>	+	+	-
<i>Pinalia graminifolia</i> (Lindl.) Kuntze	Epiphyte/ <i>Quercus glauca</i>	+	+	-
<i>Pinalia spicata</i> (D. Don) S.C. Chen & J.J. Wood	Epiphyte/ <i>Schima wallichii</i> , <i>Castanopsis indica</i>	+	+	A paste of the stem is used to alleviate stomachaches & headaches.
<i>Pleione humilis</i> (Sm.) D. Don	Epiphyte/ <i>Quercus semecarpifolia</i>	+	-	A paste made from pseudobulbs is used to treat cuts & wounds.
<i>Pleione praecox</i> (Sm.) D. Don	Epiphyte/ <i>Quercus semecarpifolia</i>	+	-	-
<i>Rhynchostylis retusa</i> (L.) Blume	Epiphyte/ <i>Prunus</i> sp.	+	-	Leaves are used to treat rheumatism and the juice of roots is applied to cuts & wounds.
<i>Satyrium nepalense</i> D. Don	Terrestrial/ full sun, cool open grasslands.	+	-	Tubers are used as a tonic and to treat diarrhoea & malaria.
<i>Spiranthes sinensis</i> (Pers.) Ames	Terrestrial/ full sun, open wet meadows.	-	+	A decoction of plants is used to treat intermittent fever; tubers are used as a tonic.
<i>Spiranthes spiralis</i> (L.) Chevall	Terrestrial/ full sun, open wet meadows.	-	+	-
<i>Vanda cristata</i> Wall. ex.Lindl.	Epiphyte/ <i>Pinus roxburghii</i> , <i>Schima wallichii</i>	+	-	A paste of roots is applied to cuts, wounds, boils & dislocated bones.
<i>Vandopsis undulata</i> (Lindl.) J.J. Sm.	Epiphyte/ <i>Schima wallichii</i> , <i>Castanopsis indica</i>	+	-	-

Here, "+" = presence, "-" = absence

diversity despite various disturbing factors.

CONCLUSION

The present study documented 58 species of orchids including 29 medicinal, one Critically Endangered, and two Least Concern species within two community forests in central Nepal. Our study throws further light on studies of orchid flora in these areas persecuted by anthropogenic factors. More pressure occurs on the population of orchid species due to overexploitation and export in both community forests. Further, cutting down of host trees for use as fodder, firewood, and timber leads to a decrease in the population of orchids. Conservation of such economically and environmentally important group of plants, which are also important components of biodiversity, has been the matter of concern for the last

several decades. With the introduction of community forests in Nepal, some progress has been made in raising awareness for conserving these habitats among the locals, which has minimized unsystematic and illegal collection and cutting down of trees. Furthermore, as the local people were involved in the exploration and documentation process in our study, the stakeholders realized the necessity of conservation of orchids in their area. Finally, our study will provide more attention to the conservation of orchids among community leaders, members of community forests, and local people in general to national-level stakeholders.

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Image 2. Blossom of orchid species in the study area. A - *Bulbophyllum leopardinum*, B - *Cymbidium cyperifolium*, C - *Dendrobium heterocarpum*, D - *Gastrochilus calceolaris*, E - *Pinalia spicata* & F - *Spiranthes sinensis*

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