RESEARCH ARTICLE

Orchid Distribution along the Elevation Gradient in Panchase Forest Conservation Area of Gandaki Province, Nepal

Alisa Rai[1], Udhab R. Khadka[1*], Dil K. Limbu[2], Lokesh R. Shakya[3]

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Abstract

The vegetation composition and elevation play a key role in the distribution of plants. Among the flowering plants, orchids are widely distributed beautiful flowers having ornamental and medicinal values. The Panchase Forest Conservation Area is one of the hot spots for the orchids, a threatened group of the flowering plants. The preceding studies on orchids seem usually focused on documentation of the orchid species and their medicinal values showing no works on orchid species distribution along the elevation gradient and aspects. Therefore, this research was concentrated on assessing orchid distribution along the elevation in the forest of the Middle-mountain. The study was conducted in former Chapakot and Bhadaure-Tamagi Village Development Committees that lie in Pokhara Metropolitan City-23 and Annapurna Rural Municipality-4, Kaski District. Chapakot represents south-west (SW) aspect and Bhadaure-Tamagi represents north-west (NW) aspect. For this study, the belt-transect method with 20 m x 20 m quadrat size at an interval of 100 m elevation was used for assessing the orchid richness along elevation and aspects. Altogether, 61 orchid species, with *Eria, Dendrobium, Cymbidium* and *Bulbophyllum* as the most common genera, were found. Among the orchid species, *Dendrobium gibsonii* was not reported in earlier studies from Panchase area. The orchid richness varied along the elevation and aspect. The SW aspect showed fluctuation in orchid richness, whereas the NW aspect showed humped shaped pattern. Further detailed studies on factors causing distribution of orchids and their relationship with host species need to be conducted for the conservation of orchids in the Panchase Forest Conservation Area.

Keywords: Aspect, Elevation, Middle-Mountain, Orchid diversity, Pokhara.

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Introduction

The earth is not uniform and the organisms across its surface are also unevenly distributed (Groom *et al.*, 2006). The early naturalists Darwin, Wallace and Von Humboldt were the first to note the types of habitats and the number of species changes with increase in elevation (Lomolino, 2001). In the present days, the distribution pattern of individual species and communities has become the important topic in the ecological literatures (Jacquemyn *et al.*, 2005). There are different hypothesis to explain the variation in species richness along elevation gradients. According to Rapoport's rule, the latitudinal range of species increases with increase in latitude. Stevens (1992) have shown a positive correlation between elevation and the range of species. Then, Colwell and Hurt (1994) proposed a new hypothesis called 'hard boundary' or 'mid-domain effect' to explain the mid-elevation peaks in species richness. It suggests that mid-elevation peaks arise due to increasing overlap of species ranges towards the center that is bounded by the highest and the lowest elevations.

Elevation gradients in species richness offer many characteristics that make them suitable for finding the underlying reasons of spatial variation in ecosystems diversity (Sanders and Rahbek, 2012). Therefore, it has been used increasingly as a tool to find out the mechanisms that shape both biodiversity patterns and the functioning of ecosystems (Fukami and Wardle, 2005; Nogues-Bravo *et al.*, 2008). Species compositional turnover along elevation gradients are often related to temperature, differences in nutrient availability and plant speciation, or elevational declines in plant growth and habitat turnover (Jacquemyn *et al.*, 2005). But the lack of quality long-term data on climate factors like rainfall, humidity, cloud cover and productivity on the small-scaled elevation gradients have hampered the development of a quantitative theory (McCain, 2007).

Orchidaceae, the largest family of the angiosperm, comprises various attractive flowers that are not only important for their beauty, but also for their medicinal use and trade (Acharya and Rokaya, 2010). Geographically, Nepal is located on the subtropical zone with diverse climatic features providing habitats for variety of orchids of all bioclimatic zones (Milleville and Shrestha, 2004). In Nepal, 502 species of orchids belonging to 108 genera have been recorded (Rajbhandari and Rai, 2017). Rokaya *et al.* (2013) reported 115 orchid species endemics to the Himalayan region and 18 species endemic to Nepal. The orchid species are categorized under Appendix I and II in the CITES (Joshi *et al.*, 2017). The orchids are under threat due to their over exploitation, unawareness regarding conservation of their host-trees, illegal trading, overgrazing, forest fire, climate

[1]Central Department of Environmental Science, Tribhuvan University, Kathmandu, Nepal

[2]Central Campus of Technology, Tribhuvan University, Dharan, Nepal

[3]Department of Botany, Amrit Science Campus, Tribhuvan University, Kathmandu, Nepal

***Corresponding author:** Udhab R. Khadka, Central Department of Environmental Science, Tribhuvan University, Kathmandu, Nepal, Email: ukhadka@cdes.edu.np

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change and lack of implementation of the effective conservation strategy (Rokaya *et al.*, 2013). Among others, habitat destruction of the wild orchids, especially endemic orchids, has been attributed for the reduction of orchid's population (Rajbhandari, 2014).

Since the orchids are cosmopolitan in distribution, they are considered as one of the suitable indicator species for the study of species richness along elevations. The epiphytic orchids grow on the host-trees through symbiotic relationship. The most frequently documented elevational patterns of biodiversity ranges from 500 meters to above 8000 meters (Bhattarai *et al.*, 2004; Bhattarai and Vetaas, 2006). This suggests that biodiversity patterns along elevational gradient on the middle-mountain (1000 to 3,000 m) have not well covered in the preceding studies as in the Himalayas. Moreover, many preceding studies on species richness along elevational gradients of the Nepalese Himalaya have been conducted for the species like ferns (Bhattarai *et al.*, 2004), lichens (Baniya *et al.*, 2010), orchids (Acharya *et al.*, 2011), trees (Bhattarai and Vetaas, 2006), liverworts (Grau *et al.*, 2007) and birds (Acharya *et al.*, 2011). This also shows that previous researches have not focused on the Middle-mountain region. With respect to orchids, in the Middle-hill regions, the preceding studies have mostly focused on documentation of their types and medicinal values (Koirala *et al.*, 2010). In the present context of climate change, elevational gradient serves as baselines for the comparison of orchid population decline, range shift and extinction risk in future (Parmesan, 2006). Thus, the present research emphasized assessing orchid distribution along the elevation gradient in the middle-hill forest, Panchase Forest Conservation Area.

Materials and Methods

Study Area

Panchase Forest is a national forest declared as the 'Protected Forest' in 2012 by the Government of Nepal under the Forest Act-1993 (DoF, 2012). The Forest Act- 2019 has recognized the Panchase Forest as Panchase Forest Conservation Area. The forest is located at the juncture of Kaski, Parbat and Syangja districts covering 57.7 km^2 areas and is surrounded by 17 villages (the then Village Development Committees) (DoF, 2017; Kunwar and Upadhyay, 2013). The forest area lies in the warm temperate and cool temperate climatic zones with orographic rainfall pattern (IUCN, 2012). Out of the 35 forest types of Nepal (Stainton, 1972), Panchase Forest Conservation Area includes five forest types, namely Alder Forest, Chirpine-Broadleaved Forest, Oak-Laurel Forest, Lower Temperate Oak Forest and Schima-Castanopsis Forest (DoF, 2017). The forest harbors 589 species of plants, 262 species of birds and 24 species of mammals (DoF, 2012). The forest provides several important ecosystem services (Bhandari *et al.*, 2018a; Bhandari *et al.*, 2018b). The Panchase pond at the peak and several springs within the forest are playing key role in maintaining the flow of Harpan River, the major water source of Phewa Lake, one of the attractive tourist destinations and lake of the Ramsar site, Pokhara Valley Lake Cluster (Ramsar,

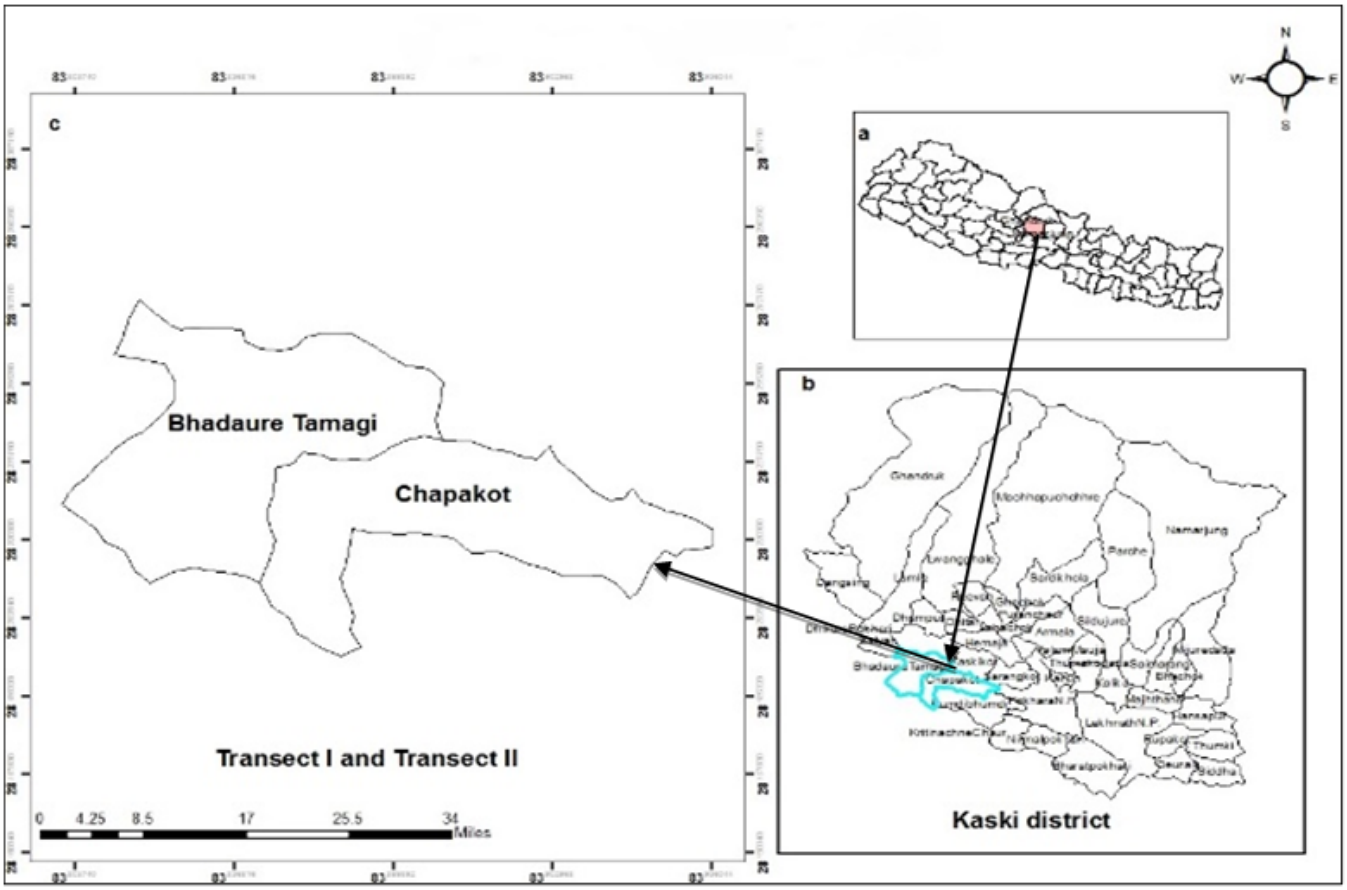

Fig. 1: Study area showing Kaski District (a), different VDCs in the district (b) and Chapakot and Bhadaure-Tamagi VDCs (c)

2016). In addition to other biodiversity, the forest is one of the well-known hotspots for orchid with having 113 orchid species including two endemic orchids (Kunwar and Upadhyay, 2013). To assess the orchid distribution along the elevation gradient and aspects of the forest, two belt transects along the NW and SW aspects were followed (Fig. 1).

Methods

In the present study, the observation of orchid species and collection of their data was accomplished through systematic sampling methods (belt transects). The field study was carried out from June to November, 2014 covering the monsoon and post-monsoon seasons. Orchid species richness was studied on 16 plots along the SW aspect (starting from Ghattichina to the Panchase peak) and 9 plots along the NW aspect (starting from Bhadaure-Tamagi to the Panchase peak) with the elevation interval of 100 m in the Panchase Forest. The plot size was kept 20 m x 20 m. The orchid species within the quadrat were recorded. The orchids were identified by observing their characteristics through photographs as referred in books that help in orchid identification (Jezek, 2003; Milleville and Shrestha, 2004). Herbarium visit and consultation with orchid experts was also done. Then the field data were analyzed using the Microsoft Excel 2010 and studied the distribution of orchids (richness) along the elevation.

Results and Discussion

Orchid richness by habitats

In the Panchase Forest Conservation Area, 61 orchid species were observed and documented in this study. Among the total observed orchids, 45 species belonging to 24 genera were identified and 12 species could not be identified (Annex I). Among the orchid species, 6 were terrestrial and 55 were epiphytic orchid (Table 1; Annex I). Kunwar and Upadhyay (2013) have reported 113 orchid species from the area. In the forest, *Eria, Dendrobium, Cymbidium* and *Bulbophyllum* were found to be the most common genera. Among the orchid species, *Eria pokharensis* and *Oberonia rufilabris* var. *nepalensis* are the endemic species (Rokaya *et al.*, 2013). The less prevalence of terrestrial orchids in the forest might be due to the anthropogenic disturbances like uncontrolled grazing, forest fire and illegal firewood collection (Sanders, 2002).

Orchid Distribution by Elevation and Aspects

In the Panchase Forest Conservation Area, the results showed variation in orchid richness along the elevational gradients. The orchid richness was found to be higher in the altitude between 2100 m and 2300 m (Figures 2 and 3). The elevational variation of orchid speices by aspect revealed fluctuation in orchid richness along the SW aspect (Fig. 2). However, in the NW aspect, the orchid distribution along the elevation's gradients showed "humped shaped" or "uni-modal" pattern with the mid-elevation peak (Fig. 3). This finding is in accordance with many preceding studies that have reported mid-elevation peak in species richness with altitude (Whittaker, 1960; Janzen, 1973; Whittaker and Niering, 1975; Shmida and Wilson, 1985; McCoy, 1990; Lieberman *et al.*, 1996; Gutie´rrez, 1997; Rahbek, 1997; Fleishman et al., 1998). Grytnes *et al.* (2006) have reported the uni-modal relationship between species richness and vertical gradient caused by the hard boundaries, which cause obstruction to the species and make them overlap at the mid-altitude.

With respect to aspect, the results revealed higher numbers of orchid in the SW aspect compared to the NW. This could be

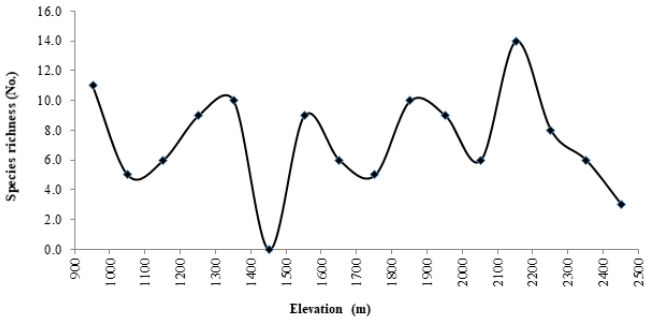

Fig. 2: Orchid richness along the elevation gradient in SW aspect (Jun-Nov, 2014)

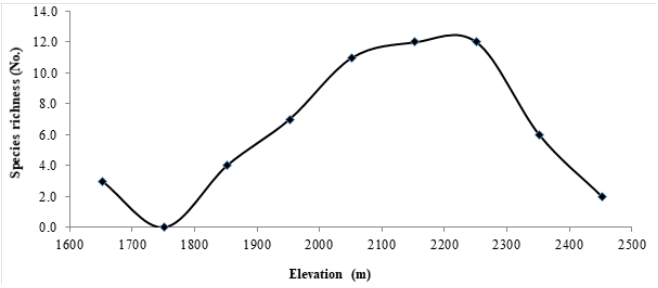

Fig. 3: Orchid richness along the elevation gradient in NW aspect (Jun-Nov, 2014)

Table 1 Distribution of orchid species by habitats

Habitats	*Orchid species*
Terrestrial	*Anthogonium gracile, Crepidium acuminatum, Goodyera vittata, Habenaria arietina, Satyrium nepalense, Spiranthes sinensis,*
Epiphytic	*Aerides odorata, Bulbophyllum* sp., *B. careyanum B. purpureofuscum, B. retusiusculum, B. roseopictum, Ceologyne nitida, C. fuscescens, C. prolifera, Cryptochilus luteus, Cymbidium* sp., *C. aloifolium, C. elegans*, *C. erythraeum*, *C. gamieanum*, *C. iridioides*, *Dendrobium amoenum*, *D. denudans, D. eriiflorum, D. gibsonii, D. longicornu, D. porphyrochilum, Eria*sp, *E. coronaria, E. graminifolia, E. paniculata, E. pokharensis, E. spicata*, *Gastrochilus pseudodistichus,*, *Oberonia* sp., *O. rufilabris, Otochilus albus, O. porrectus, Panisea demissa, Papilionanthe uniflora, Phalaenopsis difformis, Pholidota articulata, P. imbricata, Pleione humilis, P. praecox, Rhynchostylis retusa, Thunia alba, Vanda cristata* 12 unidentified species

due to the differences in elevation ranges. The SW aspect starts from 952 to 2452 m, whereas NW aspect starts from 1652 to 2452 m. In addition, the higher radiant energy input along the SW aspect might have supported the higher species richness (Hawkins *et al*., 2003). Holland and Steyne (1975), Gallardo-Cruz *et al*. (2009) have mentioned that topographic features such as slope orientation, elevation are very important factors influencing the vegetation composition in the mountainous region. The solar radiation distribution between the north and south slopes produces variation in the micro-climate like temperature, moisture, which causes the differences in species richness and their composition (Scherrer and Körner, 2010). In terms of distribution, the orchid richness pattern varied with the aspects and the orchid richness showed no fixed patterns such as uni-modal, linear and it did not coincide with the other common patterns.

Conclusion

The Panchase Forest Conservation Area is rich in orchid diversity reflecting the healthy ecosystem. In the forest, 61 orchid species were observed along the NW and SW aspects. By habitats, most of the orchid species are epiphytic. Among the orchid species, *Eria, Dendrobium, Cymbidium* and *Bulbophyllum* are the dominant genera present in the forest. The orchid richness varies with the elevation and aspects. The elevation between 2100 m and 2300 m which represents temperate bioclimatic zone in the Middle-mountain physiographic zone revealed higher orchid richness with no definite pattern as in the latitudinal gradients. At 2152 m elevation, orchid richness is highest showing mid-elevation peak. Below 2052 m elevation, anthropogenic disturbances are prominent affecting the orchid richness. As most of the preceding studies on vegetation diversity along the elevation gradient represent High-mountain, the present orchid richness pattern along the elevation gradient in the Middle-mountain is different. By aspect, the SW aspect is richer than the NW with peak diversity in the altitude range from 2100 to 2300 m. The SW aspect shows fluctuations in orchid richness with increasing elevations, whereas NW aspect shows humped shaped uni-modal pattern. This study will help as the baseline to study the changes in the distribution along different elevation and causes behind them. Thus, more detailed studies considering numerous factors are required to uncover the further reasons behind those patterns. And different conservation actions need to be implemented as per the identified reasons behind decline in the orchid richness as well as to protect them.

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Annex I: Orchid species in PanchaseForest Conservation Area during Monsoon and Post-monsoon (Jun-Nov)

S.N	*Name of species*	*Elevation (m)*	*Habitat*	*Aspects*
1	*Aerides odorata* Lour.	952	Epiphytic	SW
2	*Anthogonium gracile* Wall.exLindl	1552	Terrestrial	SW
3	*Bulbophyllum careyanum* (Hook.) Spreng.	1352	Epiphytic	SW
4	*Bulbophyllum purpureofuscum* J. J. Verm., Schuit. & de Vogel. (*Ione cirrhata* Lindl.)	2252	Epiphytic	NW
5	*Bulbophyllum retusiusculum* Rchb.f.	2152	Epiphytic	SW
6	*Bulbophyllum roseopictum*J.J.Verm., Schuit. & de Vogel (*Sunipia bicolor* Lindl.)	1352-1952	Epiphytic	SW/NW
7	*Bulbophyllum* sp.	1052	Epiphytic	SW
8	*Ceologyne nitida* (Wall ex.D. Don) Lindl.	1552-2052	Epiphytic	SW/NW
9	*Coelogyne fuscescens* Lindl.	1552-1652	Epiphytic	SW/NW
10	*Coelogyne prolifera* Lindl.	1052-1252	Epiphytic	SW
11	*Crepidium acuminatum* (D.Don) Szlach. *(Malaxis acuminata)*	1952	Terrestrial	SW
12	*Cryptochilus luteus Lindl.*	2252	Epiphytic	NW
13	*Cymbidium aloifolium* (L.)Sw.	952-1052	Epiphytic	SW
14	*Cymbidium elegans Lindl.*	1952-2452	Epiphytic	SW/NW
15	*Cymbidium erythraeum*Lindl.	1752-2352	Epiphytic	SW/NW
16	*Cymbidium gamieanum King and Prantl.*	1852-2352	Epiphytic	NW
17	*Cymbidium iridioides* D.Don*	1752-2352	Epiphytic	SW/NW
18	*Cymbidium* sp.	1952	Epiphytic	SW/NW
19	*Dendrobium amoenum* Wall. Ex Lindl.	1152-1752	Epiphytic	SW/NW

S.N	Name of species	Elevation (m)	Habitat	Aspects
20	*Dendrobium denudans* D.Don	1652	Epiphytic	SW
21	*Dendrobium eriiflorum* Griff.	1652	Epiphytic	SW/NW
22	*Dendrobium gibsonii* Lindl.	1552	Epiphytic	SW
23	*Dendrobium longicornu* Lindl.	1552-2052	Epiphytic	NW
24	*Dendrobium porphyrochilum* Lindl.	1552-1652	Epiphytic	SW
25	*Eriacoronaria* (Lindl) Rchb.f.	2052	Epiphytic	SW
26	*Eria graminifolia* Lindl.	952-1252	Epiphytic	SW/NW
27	*Eria paniculata* Lindl.	2252	Epiphytic	SW/NW
28	*Eria pokharensis* Bajrach., Subedi and K.K Shrestha	2152	Epiphytic	SW/NW
29	*Eria* sp.	2152	Epiphytic	SW/NW
30	*Eria spicata* (D.Don) Hand.-Mazz.	1852-1952	Epiphytic	SW
31	*Gastrochilus pseudodistichus* (King &Pantl.) Schltr	2452	Epiphytic	NW
32	*Goodyera vittata* (Lindl.) Benth. ex Hook.f. *(Georchis vittata Lindl.)*	2152-2252	Terrestrial	SW
33	*Habenaria arietina* Hook.f.	2152	Terrestrial	NW
34	*Oberonia rufilabris* var. nepalensis (L.R.Shakya & R.P.Chaudhary) Rajbh. & R.Chhetri	1152	Epiphytic	SW
35	*Oberonia* sp.*	1152	Epiphytic	SW
36	*Otochilus albus* Lindl.	2052	Epiphytic	NW
37	*Otochilus porrectus* Lindl.	1952	Epiphytic	SW
38	*Panisea demissa* (D. Don) Pfitzer.	1952-2152	Epiphytic	NW
39	*Papilionanthe uniflora* (Lindl.) Garay	1952-2152	Epiphytic	SW/NW
40	*Phalaenopsis difformis* (Wall. ex Lindl.) Kocyan & Schuit.	952	Epiphytic	SW
41	*Pholidota articulata* Lindl.	952-1352	Epiphytic	SW/NW
42	*Pholidota imbricata* Hook.	1552	Epiphytic	SW/NW
43	*Pleione humilis* (Smith) D. Don	2052-2352	Epiphytic	SW/NW
44	*Pleione praecox* (Smith) D. Don	2052-2352	Epiphytic	SW/NW
45	*Rhynchostylis retusa* (L.) Blume*	1100	Epiphytic	SW
46	*Satyrium nepalense* D. Don*	2052	Terrestrial	SW
47	*Spiranthes sinensis* (Pers.) Ames*	2152	Terrestrial	SW
48	*Thunia alba* (Lindl) Rchb. f.	1252	Epiphytic	SW/NW
49	*Vanda cristata* Wall. ex Lindl.	1252-1352	Epiphytic	SW
50	Unidentified 1	952	Epiphytic	SW
51	Unidentified 2	952	Epiphytic	SW
52	Unidentified 3	1852	Epiphytic	SW
53	Unidentified 4	1852	Epiphytic	SW
54	Unidentified 5	952	Epiphytic	SW
55	Unidentified 6	952	Epiphytic	SW
56	Unidentified 7	952	Epiphytic	NW
57	Unidentified 8	1952	Epiphytic	NW
58	Unidentified 9	2152	Epiphytic	NW
59	Unidentified 10	2452	Epiphytic	SW
60	Unidentified 11	2152	Epiphytic	NW
61	Unidentified 12	2252	Epiphytic	SW

*Orchid species observed outside the quadrats