

Tourism and recreation a global threat to orchids

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Abstract

Orchidaceae is a mega diverse family accounting for 10% of the world's flowering plants. Due to factors such as small dispersed populations, specific symbiosis with fungi and with pollinators and their desirability for collecting, many orchids are threatened with extinction. Tourism and recreation is increasingly recognised as a global threat for plants, but is it an issue for orchids? When data on orchids from the International Union for Nature Conservation (IUCN) Red List was reviewed, we found that 149 (40%) of the 442 orchid species with threat data were at risk from tourism and recreation. This included: 98 (22%) species threatened by residential and commercial development for tourism and recreation, 75 (17%) by intentional collecting within protected areas, and 90 (20%) by human intrusions and disturbance from recreational activities. The three threats often co-occurred and hence can be treated as a threat syndrome. The proportion of species threatened varied among locations with 80% of the 65 species in East Asia, 32% of 68 species in South and Southeast Asia and 94% of 16 orchid species in Europe threatened by tourism and recreation. Terrestrial orchids and those growing in forests were more likely to be at risk from these threats. With so many species at risk, increased awareness and recognition of these threats combined with improved management to reduce impacts is needed. Gaps and inconsistencies in the IUCN Red List must also be addressed to obtain a better understanding of the extent of this, and other threats to plants.

Keywords

Orchidaceae, conservation, global biodiversity, International Union for the Conservation of Nature

Introduction

Global biodiversity is under threat from a range of human activities contributing to a sixth wave of mass extinction (Pimm and Raven 2000; Swarts and Dixon 2009a; Ceballos et al. 2015). This includes over 11,500 species of plants that are listed as threatened with extinction on the International Union for the Conservation of Nature (IUCN) Red List, 94% of which are flowering plants (IUCN 2016a). Figures of this magnitude highlight the need to better understand the type and severity of the different threats that are driving the loss of so many flowering plants, including numerous orchids.

Orchids are charismatic and highly speciate, accounting for 10% of the world's flowering plants (Cribb et al. 2003; Newman et al. 2007). They occur on all continents, except Antarctica, with 26,567 species within 850-1000 genera in the Orchidaceae (Jones and Bolger 2006; WCSP 2016). Although seemingly abundant, many orchids rely on specific associations with mycorrhizal endophytic fungi for nutrients, germination and growth and hence can be limited by the distribution and abundance of specific fungal species (Swarts and Dixon 2009a). Some orchids also have elaborate systems for attracting pollinators which can also restrict where they occur to the distribution of the specific pollinators (Nilsson 1992; Cozzolino and Widmer 2005 Swarts and Dixon 2009a). The diversity in the structure and colour of orchid flowers makes them highly prized by humans with collecting from the wild a major threat to orchids (Ballantyne and Pickering 2012; Swarts et al. 2010). Unfortunately, low densities and isolated populations of many orchids amplifies the impacts of threats such as habitat loss, climate change and illegal collection, resulting in orchids having the highest proportion of threatened genera and species of all flowering plants (Cribb et al. 2003, Swarts and Dixon 2009a, IUCN 2016a).

One increasingly common threat to plants, including orchids, is the impacts of tourism and recreation (Ballantyne and Pickering 2012; Ballantyne and Pickering 2013; Rankin et al. 2015). Tourism is one of the fastest growing industries globally, accounting for 9% of the global gross domestic product (Huybers and Bennett 2003; Balmford et al. 2009; UNWTO 2015a). Although a significant contributor to the global economy, tourism and recreation have a wide range of impacts on the environment contributing to species declines and extinctions (Balmford et al. 2009; Newsome et al. 2012; Leung 2012; Monz et al. 2013). Impacts from tourism and recreation on plants include those associated with the construction and use of tourism facilities for transport and accommodation, as well as those due to specific tourism activities (Pickering et al. 2007; Holden 2016). The construction and use of tourism facilities, for example, can involve major habitat alteration including the complete removal of existing natural vegetation and its replacement by either artificial surfaces such as tarmac,

pavers, and buildings, or revegetation with cultivated species introduced to the site such as those used in formal gardens and lawns (Holden 2016). It can also alter the structure of soils and hydrology of sites, as well as contributing to the introduction and spread of pathogens and weeds. Even nature based tourism and recreation has a wide range of impacts on plants increasing their risk of extinction (Liddle 1997; Kelly et al. 2003; Pickering and Hill 2007; Pickering et al. 2007; Pickering 2010).

The extent to which tourism and recreation threatens plants is increasingly being recognised. For instance, outdoor recreation was the single most common threat to the 2733 rare and vulnerable plants currently listed as at risk of extinction within the United States, impacting 35% of the species (Hernández-Yáñez et al. 2016). In Europe, tourism and recreation threatens 42% of 194 vascular plants on the IUCN Red List (Ballantyne and Pickering 2013), while in Australia, tourism and recreation threatens 42% of the 659 vascular plants listed as at risk of extinction by the Australian Government (Rankin et al. 2015). Both in Australia and Europe, a wide range of orchids are threatened, many by tourism and recreation: but how common is tourism and recreation a threat globally to orchids?

The aim of this study was to assess the extent to which tourism and recreation threatens orchids globally using data from the IUCN Red List. Specifically, it assesses: 1) the number of orchid species directly under threat by tourism and recreation, 2) which specific tourism and recreation threats are impacting orchids, 3) where these species occur, 4) which habitats contain orchids threatened by tourism and recreation, 5) which orchid genera are threatened by tourism and recreation, and 6) what is the relationship between plant traits such as life forms (e.g. terrestrial, epiphytic or lithophytic), and threats from tourism and recreation.

Methods

To assess the extent to which recreation and tourism threatens orchids, we used data from the IUCN Red List as it is the most comprehensive global database of threatened species, and it has a standardized set of criteria for listing species and types of threats (Rodrigues et al. 2006; Kull et al 2016). The Red List currently contains information about the timing, scope, severity and an overall impact score for all types of threats grouped into 12 categories (IUCN 2016a; IUCN 2016b). An initial assessment of the current academic literature on tourism and recreation as a threat to orchids identified only three papers specifically assessing tourism and recreation impacts on orchids (Hernández-Yáñez et al. 2016; Rankin et al. 2015; Ballantyne and Pickering 2013). Hence, it is not possible to use the academic literature to assess the extent of the threat of tourism and recreation on orchids. We focused on orchids specifically in this review, as the Orchidaceae had more species at risk of

extinction that other collectable plant families (e.g. *Cactaceae*, *Bromeliaceae* and *Aloaceae*) based on an initial review of the total listings, and tourism threat data on the IUCN Red List.

We obtained data from the IUCN Red List for all orchid species listed as Critically Endangered (CR), Endangered (EN) or Vulnerable (VU) up until October 2016. Although 519 Orchidaceae species were listed, threat information was only available for 442 species. Therefore, the information for these 442 species was exported from the Red List to a personal database. This included the species name, synonyms, common name, IUCN status, population trend, date listing published, habitat, presence in protected areas (PA), and where it occurs (e.g. land region, native countries and endemism) along with threat data, including tourism and recreation threats.

To determine which species were threatened by recreation and tourism, we focused on three tourism-related threat categories in the IUCN Red List. These were: 1) development (Threat 1.3 in the IUCN database = Residential and commercial development for tourism and recreation areas), 2) plant collecting in protected areas (Threat 5.2.1 = gathering terrestrial plants for intentional use, but as per Ballantyne & Pickering (2013) methodology, we only considered it a tourism and recreation related threat if the species occurred within protected areas, so collecting involved visitors to the protected area), and, 3) recreational activities (Threat 6.1 = human intrusions and disturbances from recreational activities). There were details on the timing, scope, severity and an overall impact score for each of the tourism and recreation threats, which was also transferred to the personal database. Additional data about the growth form of the orchids (e.g. if it was terrestrial, epiphytic or lithophytic) was included in the personal database using data from sources such as Kew monocots (WCSP 2016).

Data Analysis

The total number and proportion of orchid species listed by land region, habitat, genera and growth form that were threatened by tourism and recreation were calculated using the personal database. Overall, the number of species at risk from each type of threat were calculated to assess the relative impact of tourism and recreation compared to other listed threats. Chi-square tests were performed using statistical package SPSS (IBM 2016) to determine whether there were significant differences in the three tourism and recreation related threats depending on land regions, genera and plant traits, including if the species was terrestrial, epiphytic, or lithophytic.

Results

Tourism and recreation

Tourism and recreation was a common threat to orchids globally. Of the 442 orchid species with threat data, 149 (33.9%) were threatened by at least one tourism and recreation threat. This included 98 (22%) species by development for tourism and recreation (Threat 1.3), 75 (17%) by plant collecting in protected areas (Threat 5.2.1, and the species occurs within a protected area), and 90 (20%) by recreational activities (Threat 6.1). The three tourism and recreation threats are among the most common threat to orchids, when compared to all threats listed on the IUCN Red List (Table 1).

Table 1. The most common threats to orchids globally, with tourism and recreation threats in bold, for all species listed as threatened on the IUCN Red List

Threat	Threat code	Number of species threatened
Plant collecting	5.2.1	219
Residential development	1.1	125
Subsistence/small scale logging	5.3.3	128
Work & other activities	6.3	124
Development for tourism & recreation areas	1.3	98
Recreational activities	6.1	90
Plant collecting in protected areas	5.2.1	78
Transportation of roads & railroads	4.1	76
Climate change (habitat shifting & alteration)	11.1	73

The severity data showed the three tourism and recreation threats have substantial impacts (Figure 1).

Development for tourism and recreation was classified as an ongoing threat for all 98 species. It was affecting most populations of 77% of the species, it was causing or is likely to cause very rapid declines in 51% of the species, and it had a high impact score overall for 49% of the species (Figure 1). Plant collecting in protected areas (Threat 5.2.1 in protected areas) was an ongoing threat for 97% of the 75 species, was affecting the whole population of 67% of species, causing or likely to cause very rapid declines in 70% of species, and had a high impact score for 72% of species (Figure 1). Of the listed species threatened by recreational activities (Threat 6.1), 99% were classified as ongoing, 74% as affecting the majority of species, 47% caused very rapid declines, 47% caused rapid declines, and 52% had a high impact score (Figure 1).

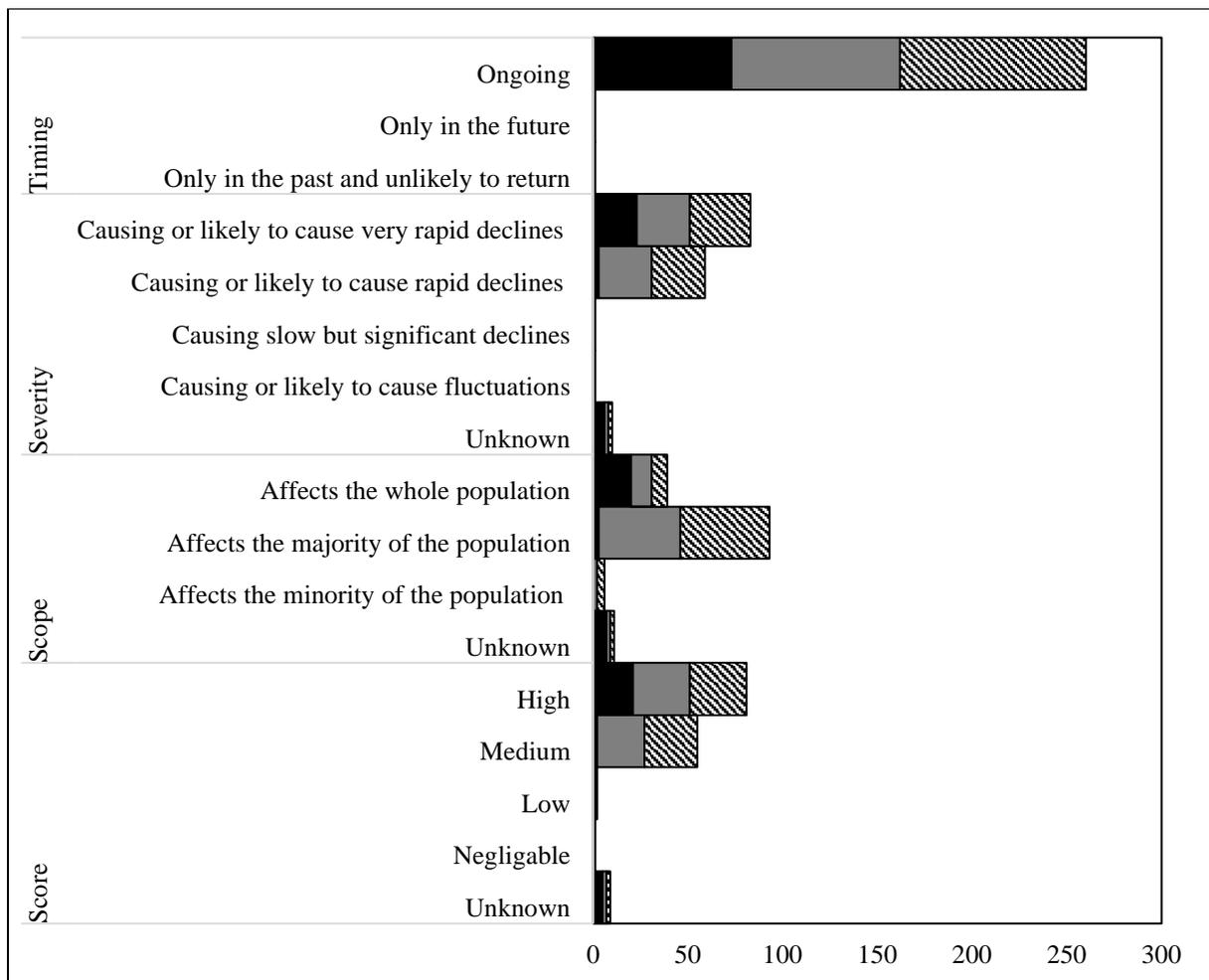


Fig. 1 Details on the timing, severity, score and scope for each of the three tourism and recreation threats to orchid species. Diagonal lines represent the number of orchid species threatened by development for tourism and recreation (Threat 1.3), plain grey represent the number of orchid species threatened by recreational activities (Threat 6.1) and plain black represents the number of orchid species threatened by collecting in a protected area (Threat 5.2.1 in protected areas)

The three tourism-related threats were not only common, they often co-occurred indicating that they could be seen as a threat syndrome. For example, 67 of the species threatened by tourism and recreation development were also threatened by recreational activities. Similarly, 39 of the species threatened by tourism and recreation development were also threatened by plant collecting in a protected area. Finally, 33 of the species threatened by recreational activities were also threatened by plant collecting in protected areas.

There has been a dramatic rise in the number of orchid species on the IUCN Red List, particularly since 2012. Paralleling this is an increase in the number of those species listed as threatened by tourism and recreation

(Figure 2), although less so in the last two years (2015 and 2016). This demonstrates that as orchid listings on the IUCN Red List increase, so does the recognition of tourism and recreation as a threat.

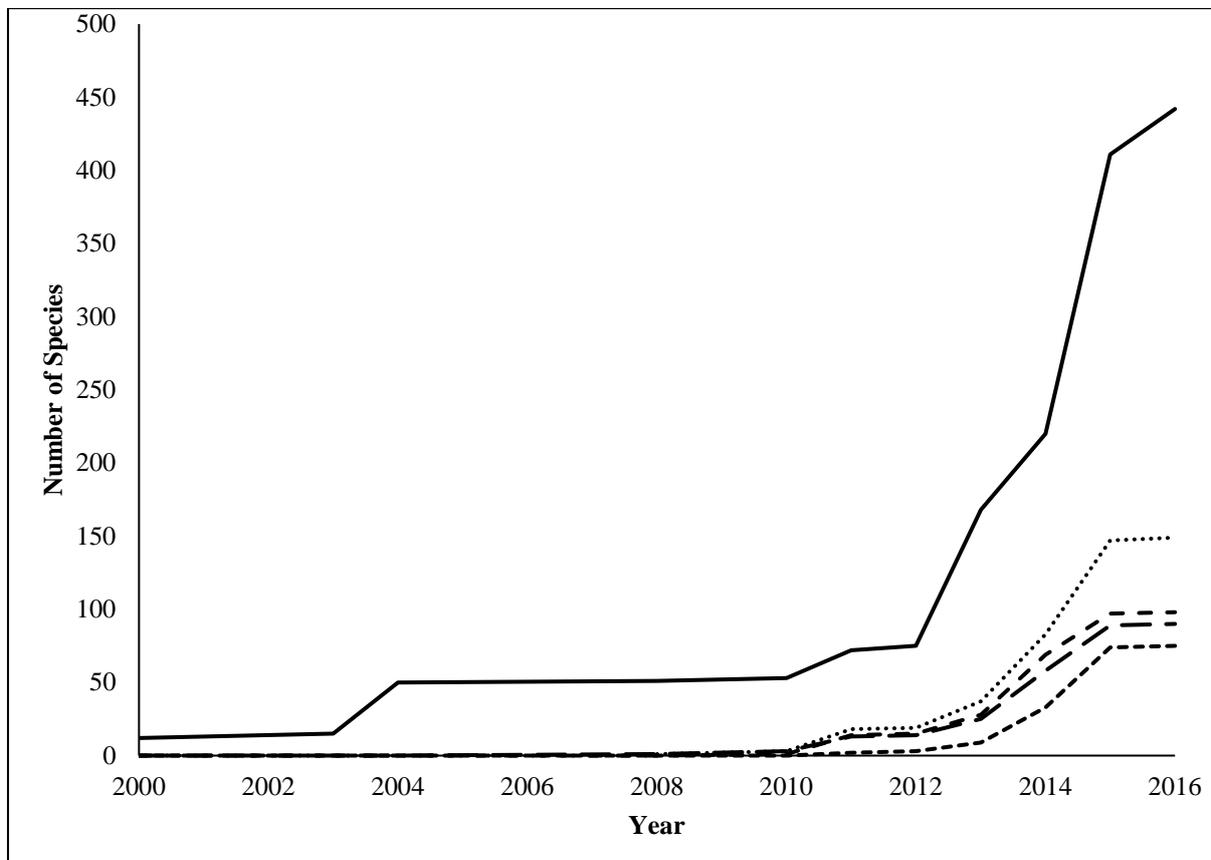


Fig.2 Cumulative number of orchid species (solid line) on the IUCN Red list, species threatened by at least one type of tourism (round dot), threatened by residential and commercial development for tourism and recreation areas (Threat 1.3) (dash), intentionally gathering terrestrial plants within a protected area (Threat 5.2.1 in PA) (square dot), human intrusions and disturbance by recreational activities (Threat 6.1) (long dash)

The extent to which tourism and recreation threatens orchids varies among locations (Chi-square test $p < 0.001$). (Table 2). For instance, in East Asia 80% of the 65 orchid species on the IUCN Red List are threatened by at least one type of tourism and recreation threat while for Europe, it is 94% of the 16 and for North America it is 68% of the 19 species listed. In contrast, there were very few orchids in North Africa, Oceania and West and Central Africa threatened by tourism and recreation (Table 2). Although Sub-Saharan Africa has the largest number of orchids on the Red List (194), only 10% of them were threatened by tourism and recreation, mostly those in Madagascar (19 species).

Table 2. Number of orchid species threatened by tourism and recreation on the IUCN Red List. T&R = tourism and recreation, PA = protected area, Threat 1.3 = residential and commercial development for tourism and recreation areas, Threat 5.2.1 = intentionally gathering terrestrial plants within a protected area, Threat 6.1 = human intrusions and disturbance by recreational activities and end = endangered

Assessment and land region	Species with data	Species threatened by T&R	Development (Threat 1.3)	Collecting (Threat 5.2.1 in PA)	Recreational activities (Threat 6.1)
Total	442	149	98	75	90
Critically end.	156	37	19	21	26
Endangered	205	79	55	38	42
Vulnerable	80	33	24	16	22
Extinct	1				
Caribbean Islands	194	20		18	3
East Asia	68	22	12	9	10
Europe	65	52	45	26	44
Mesoamerica	47	11	10	4	5
North Africa	19	13	8	10	8
North America	16	15	13	2	10
Oceania	12	7	3	4	5
South America	11	3	2	1	1
South and Southeast Asia	8	4	4	2	1
Sub Saharan Africa	2	2	1		2
West and Central Asia					

The number of orchids threatened by tourism and recreation varied among habitats (Figure 3). Forests had the highest number of orchids in the IUCN Red list (391 species), of which 130 were threatened by tourism and recreation (Figure 3). Within forests, development was the most common tourism and recreation related threat (90 species). There were also many orchids in shrublands threatened by tourism and recreation (56 species) including 49 species threatened by development for tourism and recreation (Figure 3). There were also a few orchid species in rocky areas, grasslands and wetland threatened by tourism and recreation.

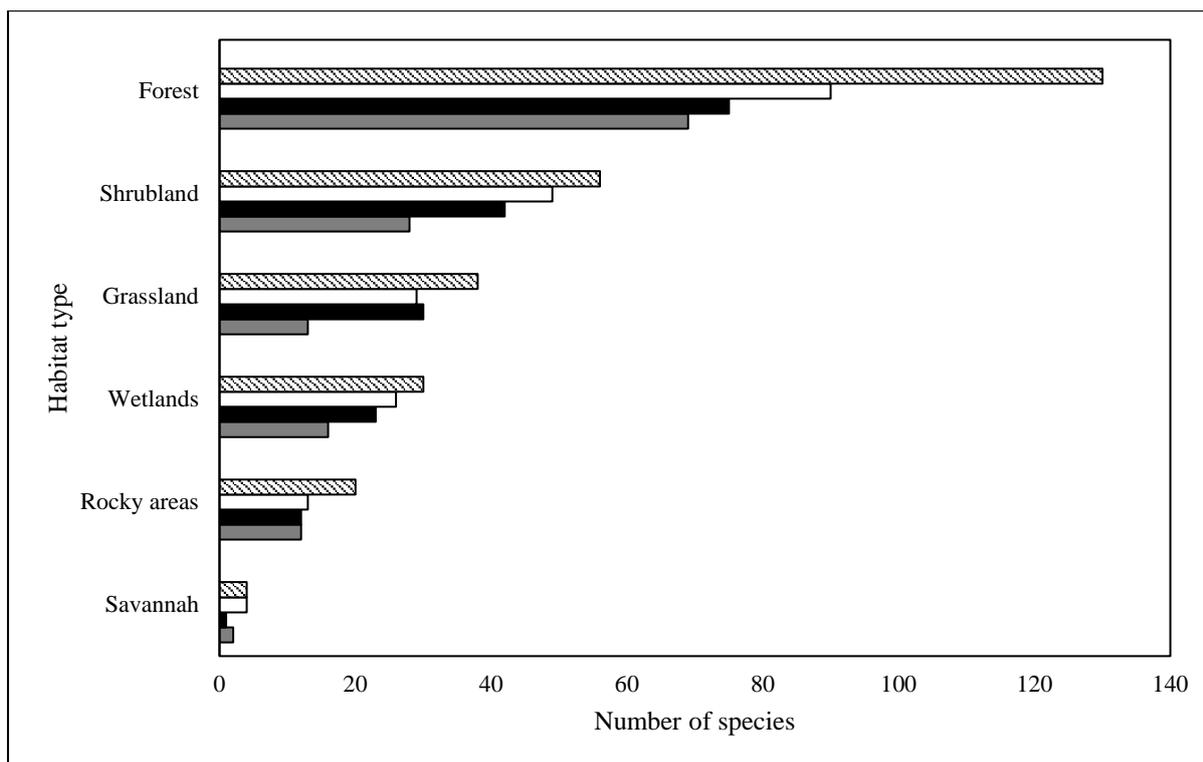


Fig. 3 The number of orchid species within different habitats threatened by tourism and recreation on the IUCN Red List (diagonal line), residential and commercial development for tourism and recreation (Threat 1.3) (plain white), intentionally gathering plants from protected areas (Threat 5.2.1 PA) (plain grey) and human intrusions and disturbance by recreational activities (Threat 6.1) (plain black)

Most of the orchids in the IUCN Red List are terrestrial (324 species) of which 38% were threatened by tourism and recreation (Table 3). The most common threats were development (26% of all species), and recreational activities (25%). Epiphytic orchids accounted for 20% of the species threatened by tourism and recreation, with collecting the most common threat (Table 3). There was a significant difference between the three life forms, terrestrial, epiphytic and lithophytic, and the likelihood that tourism and recreation is a threat among IUCN Red Listed orchid species (Chi square test, $p < 0.001$).

Table 3. Tourism threats listed by form. T&R = tourism and recreation, PA = protected area, Threat 1.3 = residential and commercial development for tourism and recreation areas, Threat 5.2.1 = intentionally gathering terrestrial plants within a protected area, and Threat 6.1 = human intrusions and disturbance by recreational activities

Form	With threat data	At least one T&R threat	Development (Threat 1.3)	Collecting (Threat 5.2.1 in PA)	Recreational activities (Threat 6.1)
Terrestrial	324	122	85	58	82
Epiphytic	162	32	14	22	7
Lithophyte	37	10	6	5	8

The threat of tourism and recreation was not evenly dispersed within the Orchidaceae, with some genera more likely to be threatened by these activities (Chi-square test $p < 0.001$). Two genera *Paphiopedilum* (37 species) and *Cypripedium* (41 species) included many species threatened by tourism and recreation while there were 48 orchid genera on the Red List with no species threatened by tourism and recreation, and 31 genera with only one species threatened by tourism and recreation.

Discussion

Tourism and recreation threats

Tourism and recreation is a common threat to orchids globally, including species threatened by development, activities, and collecting plants in areas associated with tourism and recreation. The impacts of tourism and recreation were high, showing that the threats are ongoing, impacting whole populations and causing, or likely to cause, rapid declines. The number of orchid species threatened by tourism and recreation is only likely to increase. This is due in part to the backlog of species to be added to the Red List, tourism and recreation becoming more widely recognised as a threatening process, but also because tourism and recreation impacts continue to spread globally (UNWTO 2015b). The three tourism and recreation threats often co-occurred indicating a potential threat syndrome and in some situations, will need to be managed as such. For instance, in areas where there is infrastructure for tourism, there will be an increase in visitors and therefore potentially greater environmental impacts from recreation activities and an increased risk of people collecting orchids from the wild.

Due to high specificity and localised populations of orchids, habitat alteration contributes to declines in local populations and for some, extinctions (Duncan et al. 2005; Swarts and Dixon 2009a; Swarts et al. 2010; Ballantyne and Pickering 2012). The most common tourism and recreation threat to orchids was development. This includes developments in areas such as ski areas, golf courses, resorts, county parks, campgrounds, coastal and estuarine tourist resorts (IUCN 2016b; Hall 2001). Tourism and recreation developments in such areas often involve land clearing, leaving a substantial environmental footprint (IUCN 2016b). Larger scale tourism

developments in areas of high biodiversity will also increase the severity and number of species threatened by extinction including orchids, such as mega resorts in the Canary Islands (Ballantyne and Pickering 2013).

Tourism and recreation activities threaten native orchids including damage to plants from trampling (Buckley and Pannell 1990; Duncan et al. 2005; Light and MacConaill 2007; Ballantyne and Pickering 2012). Terrestrial orchids are often sensitive to trampling as they tend to be low growing, easily crushed and can often have limited capacity to recover from this type of disturbance (Light and MacConaill 2007, 2011; Ballantyne and Pickering 2012). This makes them particularly susceptible to damage from activities such as hiking, mountain biking, horse riding, trail bikes and other recreational vehicles. Human intrusions and disturbance by recreational activities was a common threat to orchid species in the Red List. These disturbances are defined by the IUCN as people spending time in nature or traveling in vehicles outside of established transport corridors, usually for recreational reasons. They include activities such as off-road vehicles, motorcycles, snowmobiles, mountain bikes, hikers, cross-country skiers, birdwatchers, pets brought into recreation areas, temporary campsites, caving and rock-climbing among others (IUCN 2016b). Minimising the impacts of these activities on orchids can involve spatial and temporal restrictions on some of these activities in areas where orchids are growing, particularly when they are flowering, as well as improving infrastructure such as the use of raised boardwalks or other facilities that can limit impacts of trampling when the activities are permitted.

The illegal collection of plants from the wild contributes to declines in orchid populations and in some cases, threatens species with extinction (Swartz and Dixon 2009a; Cribb et al. 2003). Orchids are taken from the wild for ethnobotanical reasons, such as medicinal properties, food sources, illegal trade for horticulture and for personal collections (Subedi et al. 2013; Seaton et al. 2013). For example, more than 53,000 wild collected orchids were exported from both Vietnam and Central America in 1999 (Broad et al. 2003) and an estimated 6.1 million orchids were harvested in Iran in 2014 (Ghorbani et al. 2014). Plant collecting is devastating whole populations of orchids, with the over-exploitation threatening 98% of Indonesian orchid species (Budiharta et al. 2011).

Tourism and recreation in protected areas can facilitate orchid collecting. Visitors to protected areas may come deliberately with the intent to collect orchids ('orchid thieves'), or may only form this intent once they see orchids within a protected area. In either case, attractive and/or rare orchids close to tourism facilities such as hiking trails, camp grounds, viewpoints and climbing routes in protected areas are known to be at risk from plant collecting (Pickering & Ballantyne 2012). We found that 17% of IUCN Red Listed orchids that occurred

in protected areas were under threat from collecting. Due to the high demand for orchids, all orchid species are listed on the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), however, the illegal trade continues (Roberts and Dixon 2008). Regulating, monitoring and educating visitors to protected areas along with better enforcement of penalties can help reduce orchid collecting in these locations (Phelps and Webb 2015).

Geographic patterns

There were clear geographic patterns in where tourism and recreation threatens orchids, which could be indicative of the threat itself or of variability in regional reporting. East Asia, for instance, had a high proportion of orchid species threatened by tourism and recreation (80%, 65 species). All of these species occur in China, which is likely a reflection of the high diversity of orchids in the region (around 750 species, WCSP 2016), but also the popularity of tourism in the region, with China the fourth leading tourist destination in the world with 57 million visitors in 2015 (UNWTO 2015c; Zhong et al. 2008).

The region with the most threatened orchids on the Red List, Sub-Saharan Africa, had few species threatened by tourism and recreation. Much of the tourism and recreation development in Africa is in savannahs and grasslands where fewer orchids are found compared to African tropical forests. Many of the threatened African orchids were in Madagascar, with the 98 Red Listed species accounting for nearly 10% of the approximately 1000 orchid species found in the country (Cribb and Hermans 2007). Madagascar is renowned for the popularity of its nature based tourism, but also high levels of plant endemism and large numbers of threatened plants (Cribb and Hermans 2007; Fidelity and Yan 2008). As a result, increasing conservation efforts in Madagascar is particularly important, including expanding the currently relatively limited protected area system (Mittermeier et al. 2005) and minimising the impacts of expanding tourism and recreation industries.

For Oceania, which includes Australia (home to >1300 orchid species), there were only 11 species of orchid on the Red List with threat data (IUCN 2016b; Jones and Bolger 2006). This underestimates the number of threatened orchids within the region including those threatened by tourism and recreation. For example, there are 200 orchid species currently listed as threatened by the Australian Government (Australian Government 2016), of which 90 were threatened by tourism and recreation (Rankin et al. 2015). This discrepancy highlights one of the limitations of using databases such as the Red List where there can be delays in listing species from certain regions.

Habitat, growth form and genera

Tourism and recreation threatened orchids in many habitats, but particularly orchids in forests. Deforestation, including for tourism and recreation developments, is a major threat to forests globally and hence to the high diversity of orchids, particularly epiphytic orchids in forests (Swarts and Dixon 2009a). The recovery of epiphytic orchids often depends on the regrowth of the host trees and hence can be slow. For example, in Bolivia, there was a 90% reduction in epiphytic orchids in secondary forest compared to primary forest. Similar results were found in Ecuador (Gradstein 2008). Limiting deforestation, including for tourism and recreation developments, will help protect epiphytic orchids and other forest-dependent species.

Orchids are diverse with between 850-1000 genera. Of these, 93 genera were on the IUCN Red List with threat data. Within the Red List, two genera *Paphiopedilum* and *Cypripedium* were dominant and contained many species threatened by tourism and recreation (37 and 41 species, respectively). Both of these genera are ornamental favourites and as a result, illegal collecting has contributed to rapid declines in several of the species of *Paphiopedilum* and *Cypripedium* (Cribb and Sandison 1998; Luo et al. 2002; Liu et al. 2006). The propagation of varieties of popular orchids, such as taxa from these two genera, can help minimise the need for people to collect orchids from the wild (Swarts and Dixon 2009b; Giri and Tamta 2012).

There were differences in the number and proportion of orchids threatened by tourism and recreation among epiphytic, terrestrial and lithophytic orchids. Many terrestrial orchids were threatened by tourism and recreation (38%). This includes species threatened by development and recreational activities, threats which are likely to directly affect ground orchids. In contrast, plant collecting was a more common threat for epiphytic orchids including intentional collecting in protected areas (44%). This was not surprising considering the competitive nature of orchid collecting and the relative ease of cultivating epiphytic versus terrestrial orchids (Jones and Bolger 2006). The illegal collection and trade in epiphytic orchids is a global issue and studies have shown epiphytic orchids are the most common plant group sold (Flores-Palacios and Valencia-Díaz 2007).

Limitations

The IUCN Red List is a valuable tool for research and conservation and is used extensively for the management of threatened species (Rodrigues et al. 2006). There are, however, important limitations associated with using the database for research (Possingham et al. 2002). The underrepresentation of threatened species from specific regions is a major limitation and potentially stems from the Red List relying on different government bodies and research institutions to provide data. This results in data gaps for some regions renowned for high biodiversity. For instance, less than half of the national threatened orchid listings in China are also represented on the IUCN

Red List (Wang et al. 2016). Similarly, of the 200 species considered threatened in Australia by the Australian Government (Rankin et al. 2015, Australian Government 2016), only five are also on the Red List (IUCN 2016b). Even within Australia there are important gaps, with Western Australia a global biodiversity hotspot, having approximately 400 species of terrestrial orchids, 76 of which are considered threatened and almost all are endemic (Brundrett 2007). However, only one of the orchids from the region, *Caladenia dundasiae*, was on the IUCN Red List (IUCN 2016b).

For species that have made it onto the Red List, there are also important gaps in the data available. This includes 77 orchid species on the Red List with no threat data. When there is threat data available, it not always comprehensive, with many species missing data on the severity of the threat. Even when there is severity data, it needs to be treated with some caution as there are often issues with the underlying trend, geographic range and population size data for species in the Red List within and among regions and among taxonomic groups (Maes et al. 2015). These limitations of the Red List concomitantly limited our capacity to assess the full range of orchid species threatened by tourism and recreation, and also the relative importance of tourism and recreation as a threatening process compared to other threats to orchids. Adding more species, and more complete data, will make the Red List a more robust source of information on global threats to plants including the threat of tourism and recreation to orchids.

Conclusions

Tourism and recreation are common threats to orchids globally. This study has provided evidence that tourism and recreation pose a threat to 33% of IUCN listed threatened orchids, and the number of orchids threatened by these factors will continue to increase. Development was the most common of the three tourism and recreation threats, followed closely by recreational activities and plant collecting in protected areas. Each threat often co-occurred and hence can often be treated and managed as a threat syndrome. Tourism and recreation threatens all forms of orchids in diverse habitats, particularly those in forests and shrublands. Research on the extent, severity and ways to ameliorate tourism and recreation impacts will help improve conservation and management strategies, particularly in protected areas.

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