Hinsley, Amy Elizabeth (2016) ***Characterising the structure and function of international wildlife trade networks in the age of online communication.*** **Doctor of Philosophy (PhD) thesis, University of Kent,.**

Characterising the structure and function of international wildlife trade networks in the age of online communication

Amy Elizabeth Hinsley

Durrell Institute of Conservation and Ecology

School of Anthropology and Conservation

University of Kent

A thesis submitted for the degree of Doctor of Philosophy in Biodiversity Management

March 2016

“You can get off alcohol, drugs, women, food and cars but once you're hooked on orchids you're finished."

Joe Kunisch, professional orchid grower,

(quoted in Hansen. 2000, p 29)

Acknowledgements

I would like to thank Dr David Roberts, who encouraged me to do this PhD and was a source of constant ideas, advice and support throughout. Also to my other supervisors: Professor Martin Ridout for his patience and very useful stats advice, and Professor Mike Fischer. I would also like to thank some excellent collaborators, who confirmed my belief that conservation benefits greatly from interdisciplinarity. In particular: Freya St John, Ana Nuno and Diogo Verissimo for insights in to consumer behaviour; Tamsin Lee for all of the maths help; and Joe Harrison for the coding that Chapter 5. Also to my research assistants and orchid guides, in particular: Destario Metusala who took me to some interesting orchid nurseries in Indonesia; Anita Wan who translated discussions with traders in Taiwan; and my research assistants and translators in Japan, Michi and Tomoko Okabe, Tomoko Ashida, Sayaka Hoshino, Julia Schumanm-Mudrick and Hiro Shimai.

I would like to thank my funders, the Natural Environment Research Council (NERC) for supporting my work. I would also like to thank the Royal Horticultural Society (RHS) Coke Trust Bursary, John Garner, and the World Orchid Congress's Sponsored Speaker Award for funding research, conference attendance and orchid trips.

This PhD would have been completely impossible without the cooperation of the orchid community, who taught me a lot about the realities of legal and illegal trade, put up with my persistent and strange questions, and were not (too) suspicious of a conservationist in their midst. In particular I would like to thank Johan and Clare Hermans of the RHS Orchid Committee for their advice and the introductions to their contacts around the world, and Ian Chalmers for all of the interesting information. For permission and support to collect data at orchid shows: Chris and Jean Barker and all at the Malvern International Orchid Show; Emiko Maehara and the APOC team in Okinawa; and Nanako Terakubo, Ryoichi Oba and the Japanese Orchid Growers Association in Tokyo A sincere thank you to all orchid societies who allowed me to survey their members in return for an acknowledgment: Bournemouth Orchid Society (OS), (for all of their help), American OS, Australian Orchid Council, OS of Southeast Asia, Bristol OS, Cambridge OS, Cardiff & Vale of Glamorgan OS, Cheshire and North Wales OS, Fenland OS, NE England OS, North Hampshire OS, Essex, Hardy OS, North of England OS, Sheffield & District OS, Wessex OS, York OS, Cayman Islands OS, Jamaica OS, Asociacion De Orquideologia de Quito, Asociacion De Orquideologia de Costa Rica, Alabama OS, Denver OS, Platinum Coast OS, Eastern Airlines Orchid Club, OS of Minnesota, Tip of Texas OS, Twin State OS, Wisconsin OS and many more who did not want to be named.

DICE has provided an interesting, fun and supportive environment for this work in the past few years and I want to thank everybody here for being part of that. In particular I thank Susanne for the plant facts and companionship on orchid travels, Gail and Chris for introducing me to Krav Maga, and the support from Hazel, Emma, Tristan, Debbie, Janna, Bob, Tolly, Rob and everybody else in the department. Finally I thank PJ for being patient and keeping me grounded by telling me orchids are boring, and my parents and my nan for supporting me throughout my academic career (maybe now I have a PhD they will finally stop telling everybody they meet that I went to Oxford?)

Declaration of originality

Amy Hinsley wrote all of the chapters in this thesis with the editorial advice of David Roberts. Additional input for specific chapters is as follows:

Chapter 1 benefitted from minor proofreading suggestions from Rob Harris.

Chapter 2 originated during discussions between Amy Hinsley and David Roberts. All data were collected by Amy Hinsley and a team of research assistants. Diogo Verissimo produced the statistically efficient choice set design, whilst Anita Wan and Iain Fraser provided training and a code template for NLogit analysis. Amy Hinsley carried out all analysis and wrote the final text with comments and feedback from both co-authors and two anonymous reviewers at Biological Conservation, where it was published in 2015.

Chapter 3 was developed by Amy Hinsley after discussions with David Roberts and Freya St John. Amy Hinsley designed both surveys and collected all data. Ana Nuno, Freya St John and Martin Ridout gave advice on analysis. Ana Nuno provided R scripts for the multivariate analysis and for Figure 3.1. Amy Hinsley carried out all analysis except the UCT multivariate analysis, which was done by Ana Nuno. The final text was written by Amy Hinsley with comments and feedback from all authors. It is in prep for submission to Conservation Letters.

Chapter 4 originated during discussions about trade and access and benefit sharing between Amy Hinsley, David Roberts and Bob Smith. The final research was designed by Amy Hinsley, who also collected and analysed all online trade data. The final text was written by Amy Hinsley with comments and feedback from David Roberts and two anonymous reviewers.

Chapter 5 was designed by Amy Hinsley, who also collected all data. Tamsin Lee provided training and advice on network analysis. She also produced Figures 5.1, 5.2 and S1-S4 based on data provided by Amy Hinsley. Joe Harrison wrote computer script to download all notifications to a spreadsheet for analysis. The final text was written by Amy Hinsley with comments and feedback from Tamsin Lee, David Roberts, and one editor and three reviewers from Conservation Biology, where it is in review.

Chapter 6 benefitted from minor proofreading suggestions from Susanne Masters.

Abstract

The international wildlife trade supports livelihoods but can seriously threaten species if not controlled. The Convention on the International Trade in Endangered Species (CITES) monitors and controls trade in over 35,000 at risk species, over 70% of which are orchids. Mitigating the negative effects of illegal wildlife trade is difficult as traders are motivated by the large potential profits (an estimated $7-10 billion per year in total) to frequently adopt new methods to avoid detection, such as the increasing use of the internet as a marketplace. In this thesis I use the international orchid horticultural trade as a case study in which to explore issues relating to the structure and function of online wildlife trade networks.

I start by investigating consumer behaviour, one of the major gaps in knowledge relating to the function of wildlife trade networks. First, I test the use of choice experiments to reveal information about consumer preferences and identify particular orchid attributes that may drive demand. I also identify specific groups of consumers who may be buying from the illegal market, with a particular focus on those buying online. I then extend this focus on behaviour to explore non-compliance with CITES rules amongst an international group of orchid growers. I test the use of a specialized questioning method known as the Unmatched Count Technique alongside direct questions to identify which types of growers are breaking the rules and why.

I then move on to focus on the structure of trade networks currently operating online, beginning with a gap analysis of access and benefit sharing from the online orchid trade in Southeast Asia, to identify countries that are not selling their own species. The region is a centre of orchid diversity and export but the lower income countries are not currently benefitting from the widespread online trade in their own species. Following the study of formal online trade I switch to the informal trade operating within orchid themed groups on an international social media website. I use social network analysis to identify closely linked communities within the wider network and make recommendations for how best to communicate with these networks. I also assess the prevalence of both legal and illegal trade taking place via posts within these groups.

The findings of this thesis have the potential for application to the conservation of species threatened by wildlife trade and the methods used provide new potential approaches to studying the structure and function of online trade networks in particular. My findings address key gaps in conservation knowledge relating to consumer behaviour, online trade networks and the efficacy of current regulations. For policy makers and practitioners it emphasises the importance of a coordinated and adaptive approach to tackling illegal online wildlife trade and strengthening the legal trade. It also highlights the current status of the orchid trade and emphasises the ongoing lack of conservation attention being given to the trade in plants.

Contents

Tables

Figures

Chapter 1. Introduction

1.1 Background

Overharvesting of wildlife for human use is a key driver of biodiversity loss (Novacek & Cleland 2001). The majority of animals and plants collected from the wild are taken for subsistence use but a significant proportion is traded on a local, national or international scale (Roe et al. 2002). This trade is for a range of purposes and in both legal and illegal markets but the shift from subsistence to commercialisation often leads to unsustainable exploitation (Milner-Gulland & Leader-Williams 1992). One reason for this is the value of many wildlife products. The legal wildlife trade is estimated to be worth $249 billion per year, the majority of which are the high value fish and timber markets totalling $222 billion (Engler & Parry-Jones 2007). The remaining $27 billion is the value of a diverse range of products including live animals for the pet trade, wild-sourced plants and fungi used as food, and derivatives of hundreds of species for the medicinal market (Broad et al. 2003). Of particularly high value is the market for ornamental plants, which in 2005 was valued at $11 billion, more than all non-fisheries animal products combined (Engler & Parry-Jones 2007).

1.2 Legal wildlife trade

This legal trade in wild-collected products can bring significant benefits to the economies of whole countries, and to rural communities in particular (Roe et al. 2002; OECD 2012). For example, in 2002 around 60% of people in the Peruvian Amazon town of Puerto Maldonado gained income from the wild-collected brazil nut trade, through a fair trade scheme aiming to improve quality of exports to access markets in the EU (Nelson et al. 2002). As the volume of trade in a product increases, benefits can often shift away from these rural communities to urban traders and businesspeople (Roe et al. 2002). However, these larger national and international trade chains may also support satellite industries: the Indonesian songbird market is supplied by a network of collectors, birdfeed producers and traders, contributing an estimated $78.8 million to the economy of six large cities (Jepson et al. 2011). In addition to wild collection, wild mother stock can form the basis of captive breeding and artificial propagation operations, which can supply consumer demand for animal and plant products and create separate markets based on hybrid or domestic breeds.

The potential benefits that trade can bring mean that protecting the sovereign right of a country to sustainably exploit its native wild species, and benefit when others use these resources is essential (CBD 1992). Ensuring the equitable sharing of benefits from the sustainable exploitation of genetic resources is one of the three core objectives of the Convention on Biological Diversity (CBD) (CBD 1992). Recently, specific guidance for the 193 Parties to the CBD on how to implement access and benefit sharing (ABS) was outlined in the 2010 Nagoya Protocol, which came into force in 2014 in line with the 16th Aichi Biodiversity Targets (Nagoya Protocol 2011). Methods of ABS include direct up-front or on-going resource access payments, royalties from sales, or capacity building for range states to develop their own products from the resource (Richerzhagen & Holm-Mueller 2005; Trommetter 2004; FAO 2009). Examples of ABS activities to date are diverse, ranging from Moroccan argan oil for the cosmetic industry (Lybbert et al. 2002) to pesticides derived from a tree in Costa Rica (Richerzhagen & Holm-Mueller 2005).

1.3 Illegal wildlife trade

Internationally, the legal trade is relatively easy to quantify and study. However, the characteristics of the illegal trade are difficult to determine due to its secretive nature (Roe et al. 2002; Broad et al. 2003). Estimates of the value of illegal wildlife trade range greatly, with a conservative estimate of between $7.8 and $10 billion often quoted, a higher estimated profit than the illegal small arms trade (Haken 2011). Whilst defining an exact figure is difficult, conservationists agree on its importance in terms of the threat to traded species and populations. Again, the number of species involved in trade is difficult to quantify. Of all species included on the IUCN Red List, 9,054 (25.5%) are listed as threatened by human collection (IUCN 2015b). Although this figure includes species collected for subsistence use as well as trade, it does not account for those that have not been assessed. Whilst 1,525 species of plant are listed as threatened by collection (IUCN 2015b), an estimated 96% of plant species are yet to be assessed, many of which are widely traded for timber, ornamental use and medicine (Mark et al. 2014). The focus of high-profile media and conservation attention tends to be on the charismatic megafauna affected by trade, predominantly elephants for their ivory and rhinos for their horn (e.g. United for Wildlife 2015). These high value products are the focus of trade by highly organised criminal networks, leading to the poaching of 25,000 elephants and 1,000 rhinos to supply the trade in 2013 (UNEP 2014b). Although less high-profile, trade in other taxa is also of conservation concern, including in amphibians, reptiles (Natusch & Lyons 2012), horticultural plants (Phelps & Webb 2015) insects and molluscs (Lipińska & Gołąb 2008). As is the case in the legal trade, the trade in flora has a value that is vastly greater than the trade in fauna, predominantly due to the illegal trade in timber (UNEP 2014a).

In addition to the direct conservation impacts of trade, the movement of animals and plants around the world can spread diseases that can infect wildlife, domestic animals, and humans (Gómez & Aguirre 2008; Smith et al. 2009; Rosen & Smith 2010). Trade also facilitates the spread of non-native species, such as highly invasive plants in Poland (Lenda et al. 2014) and New Zealand (Derraik & Phillips 2010). Whilst many recorded examples of these negative effects come from the legal trade, the unregulated and unmonitored movement of animals and plants in the illegal trade is likely to pose a similar or greater risk (Rosen & Smith 2010).

The diversion of resources and funds to the illicit trade can have significant economic impacts, which are often strongest in developing countries (OECD 2012). For these countries, the undermining of already delicate regulatory systems can also cause instability and encourage corruption (Haken 2011). Illegal traders can compete with and undercut legal operations, as they are not constrained by farming costs, applying for permits or abiding to quota systems (Gratwicke et al. 2008). The losses can be large; in 2001 alone, an estimated €60 million of legal caviar trade was lost by Caspian Sea range states due to illegal sturgeon fishing (Engler & Parry-Jones 2007). Whilst this may lead to a decline in national revenue from taxes (OECD 2012) it can also have an impact on the livelihoods of a diverse group of people working in the related industries it takes to support a legal trade operation (Jepson et al. 2011). Tackling illegal wildlife trade, whilst supporting the legal trade, therefore has the potential to bring benefits to both conservation and economic development, although the process of regulation is difficult.

1.4 Regulating wildlife trade

The complex and secretive nature of illegal wildlife trade networks makes tackling the threats they pose a serious challenge for conservation. The majority of wildlife trade takes place at a local and national level (OECD 2012), requiring the application of national legislation to ensure trade is sustainable, products are traceable and that illegal trade is controlled. However, due to international demand for high value products such as rhino horn, rare orchids and hardwood timber, many trade chains cross international borders to reach end consumers.

In 1975 in recognition of the international response that was needed to tackle the threat of trade, the Convention on the International Trade in Endangered Species (CITES) came into force (CITES 2015). By listing species of concern on one of its three Appendices, CITES monitors and restricts legal trade between countries to ensure that wild populations are not adversely affected. As of October 2013 there were 35,497 species, 71 subspecies and one variety listed by CITES; 30,000 of these taxa are plants (CITES 2013). Species at most risk from trade are listed in Appendix I, with commercial trade in wild individuals prohibited and any other trade allowed only in exceptional circumstances (CITES 2013). Currently, 978 taxa are listed on Appendix I, including extremely threatened species such as Brazilian rosewood *Dalbergia nigra* and all subspecies of tiger *Panthera tigris* (UNEP 2015; CITES 2013). Appendix II species are not necessarily threatened by trade but may become so, or are included as ‘lookalikes’ due to problems in distinguishing them from other listed species. This is where the majority of species are listed; there are currently 34,430 taxa, including over 1,000 cacti *Cactaceae* spp. and over 25,000 orchids *Orchidaceae* spp. Trade in Appendix II taxa is monitored and must be maintained at sustainable levels that are not detrimental to the species. Where trade volumes reach levels of concern the species may enter the Review of Significant Trade procedure, which aims to support range states to identify and tackle problems in the implementation of CITES (see CoP12 Resolution Conf. 12.8: CITES 2002). Appendix III species are given national protection by one or more Parties, and are listed so that other countries may assist in the control of trade. The 161 Appendix III taxa currently include the walrus, listed by Canada in 1975 (UNEP 2015). Species are listed on, moved between, and removed from Appendices following discussions at meetings of the Conference of Parties (CoP) or via the Secretariat between meetings (CITES 2015).

There are currently 181 CITES Parties, one of the largest memberships of any international conservation agreement (CITES 2015). However, in spite of this international commitment, transnational illegal trade still exists in many of those species listed by the convention, including those on Appendix I (Challender & MacMillan 2014). The reliability of CITES’ role in monitoring trade has also been questioned. Comparisons between CITES and Customs trade data has shown that it can differ by an order of magnitude (Blundell & Mascia 2005). CITES trade data are compiled from the national reports of Parties but these reports may not be submitted or may be incomplete or inaccurate (Roe et al. 2002; Blundell & Mascia 2005). Further concerns have been raised over the impact that CITES regulations can have on sustainable trade and livelihoods. Trade and ABS are closely linked but CITES currently maintains a neutral position on the subject (Roe et al 2002).

Due to the limitations of an enforcement approach, there has been growing interest in the use of market-based forces to alter trade chains in favour of conservation (Jepson & Ladle

2005; Jepson et al. 2011; Phelps et al. 2014; Challender et al. 2015). Supply side methods include providing a sustainable source of traded species by farming or artificially propagating, or flooding the market with stockpiles of seized products to reduce prices (Damania & Bulte 2007). Farming has been suggested for tigers in China, although this is a controversial approach that economic modelling suggests would only be successful in combination with improved enforcement (Abbott & van Kooten 2011). For plants, cultivated alternatives may not have an effect on trade in wild products (Phelps et al. 2014) or may even increase it (Williams et al. 2014). In addition to sustainably produced wildlife products, artificial substitutes may also replace the need for wildlife. For example, Viagra has been suggested to be a useful tool for reducing demand for aphrodisiacs derived from deer and seal parts (Von Hippel et al. 2006). Selling off of national ivory stockpiles from seizures or animals that have died of natural causes was once suggested as a potential solution to the trade (Kremer & Morcom 2000), this is controversial and may serve only to stimulate demand and increase poaching (Bennett 2015).

Many problems associated with supply side methods relate to unpredictability of the market and a lack of understanding of consumer demand patterns. For example, consumers of some products have been shown to continue to prefer wild products, even when sustainably produced alternatives are on offer (Dutton et al. 2011; Phelps et al. 2014). The reasons for this can be complex; legalising trade in products such as farmed tigers, whilst supported by traditional economic modelling, may increase consumer demand if the stigma associated with illegal products is removed (Fischer 2004). For these reasons, the importance of using a demand-led approach, in which educational or marketing campaigns are used to change consumer behaviour, has been suggested as an additional tool to tackle wildlife trade (Drury 2009; Challender et al. 2014). However, in the past these efforts have been unsuccessful, primarily due to a lack of understanding of demand complexities and how these are translated into consumer behaviour (Zain 2012). Recent high-profile behaviour change campaigns, including large-scale marketing to reduce ivory consumption in China (RapidAsia 2013) and rhino horn in Vietnam (Humane

Society International 2014) have been celebrated as successes by the organisations that carried them out. However, the evaluation of these schemes is often flawed, and the projects themselves lack rigorous empirical data on consumer demand and what drives it (Roberton 2014; Verissimo 2014). Poor understanding of consumer demand is likely to present a serious barrier to the use of both market-based and enforcement methods to tackle wildlife trade (Challender et al. 2015).

1.5 Online wildlife trade: a new challenge for conservation

Enforcement of wildlife trade regulations may not be effective due to the economic motivation for illegal traders to continue their businesses. Trade often shifts to a new route or method as soon as one is discovered and many traders have begun to use the internet due to the opportunity it presents to access consumers around the world whilst maintaining relative anonymity (Lavorgna 2014). At the 16th CoP in 2013, CITES recognised this threat with Decision 15.57, which urged Parties to assess the extent and trends in wildlife trade e-commerce (CITES 2010b). The first species to be included on CITES Appendix I due the threat from e-commerce was Kaiser's spotted newt *Neurergus kaiseri*, listed in 2010 following a rapid increase in online sales (CITES 2010a).

The first studies of online wildlife trade were carried out by animal welfare organisations (IFAW 2005; IFAW 2007; Kala & Kepel 2009; Ceballos 2010; Ceballos & Kepel 2010). These studies mainly looked at ivory, live birds and primates (IFAW 2007; Ceballos & Kepel 2010) although one study in Eastern Europe also recorded a large trade in invertebrates (Kala & Kepel 2009). Although legality is difficult to assess, two global studies estimated that 90% of listings for animal products were likely to be illegal (IFAW 2007; IFAW 2011). Studies focusing on the online plant trade have been relatively limited but those that have been conducted have found serious cause for concern (Sajeva et al. 2013; Shirey et al. 2013; Krigas et al. 2014).

Online, wildlife can be traded on a variety of different platforms, including auction websites such as eBay (IFAW 2007), forums and classified advertising websites (Kala & Kepel 2009), and more recently, social media (Yu & Jia 2015). Awareness of trade via traditional commerce websites has increased, leading to a blanket ban in 2007 by eBay on the sale of all ivory products. Although initially effective, large amounts of ivory products were still found for sale in 2009, and the ban's main effect appears to have been a rise in the use of slang terms for ivory (e.g. 'ox-bone') (IFAW 2011). Recently, illegal traders have begun to shift to platforms that offer more privacy, such as private message boards (IFAW 2011) and national social media websites (Yu & Jia 2015).

1.6 Case study: The international orchid horticultural trade

The trade in horticultural orchids is an ideal case study for exploring the complex issues relating to wildlife trade networks. Orchids have a global distribution and are one of the largest families of flowering plants, with 25,000 known species and 200-500 discovered each year (Royal Botanic Gardens Kew 2015). Orchids are traded widely as ornamental plants but are also collected for a diverse array of reasons, both for subsistence use and trade. One of the most well-known orchid products in trade is the seedpods of certain *Vanilla* species, a high-value flavouring that is now derived almost exclusively from artificially propagated plants (Cameron 2011). In several Eurasian countries the tubers of 30 terrestrial orchid species are collected and ground to make the hot drink salep and traditional ice cream (Ghorbani et al. 2014). Several species of orchid also form an important part of traditional medicine systems in countries such as Nepal (Pant & Raskoti 2013) and China, with wild collection of orchids in the latter of growing concern (Liu et al. 2014).

The greatest diversity of orchid species and hybrids in international trade are in the horticultural market. Orchids are consistently ranked amongst the top selling products in the global horticultural trade (FloraHolland 2013; FloraHolland 2014; USDA 2014; USDA 2015) but are also notorious for having an illegal market (Hansen 2000; Thomas

2006). The horticultural best sellers are predominantly mass-produced hybrid moth orchids *Phalaenopsis*, which were commercialised on a large scale following advances in horticultural technology in the 1980s (Griesbach 2002). While mass-produced hybrid orchids make up the largest proportion in terms of volume of trade, they are of little conservation concern compared to the smaller specialist market in orchid species. This market consists of hobbyists, whose demand for rarity (Hinsley et al. 2015) can lead some to buy illegally collected wild plants (Pittman 2012). Many of these hobbyists belong to an international network of orchid societies, such as the American Orchid Society, which in 2015 had over 16,000 members (AOS 2015). This means that, unlike buyers of entirely illegal wildlife products who may fear prosecution, many of the buyers in the international illegal orchid trade are relatively accessible to a researcher.

Orchids also present an interesting case for the study of legal trade and the efficacy of trade regulations, as all species have been listed by CITES since 1975. The majority of the family were originally listed in Appendix II, with species such as the Holy Ghost orchid *Peristeria elata* included on Appendix I (UNEP 2015). Later additions to Appendix I included *Dendrobium cruentum*, widely traded for Traditional Asian Medicine (TAM) and two genera of slipper orchids from Asia *Paphiopedilum* spp. and Latin America *Phragmipedium* spp. that are popular in horticultural trade (UNEP 2015). The Family listing is predominantly due to the problem non-experts face in discriminating between orchid species, especially when traded without flowers. Today 73% of species listed by CITES are orchids (Fig. 1.1).

In addition to the international regulation of trade by CITES, the ABS goals of the CBD have been emphasised for plants as part of the Global Strategy for Plant Conservation (CBD, 2002; CBD, 2012). For orchids and other horticultural plants ABS has particularly relevance as the market relies heavily on products derived from the wild species of different countries. In spite of this, there has been little awareness of the issues surrounding ABS within the horticultural industry to date (Ten Kate & Laird, 2000; Secretariat of the Convention on Biological Diversity, 2008).

Understanding the behaviour of the consumers of wildlife trade products is of increasing interest to conservation (Challender et al. 2014). Orchid growers and their hobby have a rich history, which provides an interesting context for understanding the structure and function of trade today. The first records of orchids being grown as horticultural plants are from 2,000 years ago in China (Hagsater et al. 1996) and Japanese samurai warriors in the 1600s (Reinikka 1995). In Europe orchids were relatively unknown until the 1800s when explorers and botanists began to send plants back from tropical areas. One story describes how a botanist named William Swainson used orchid plants as packing material for other more interesting botanical specimens collected near Rio de Janeiro in 1818 (Pittman 2012). When they arrived in London, the orchids, later named *Cattleya labiata*, produced such unusual flowers that it created an instant demand for orchids amongst horticulturalists (Reinikka 1995). This 'orchidelirium', likened to the mania for tulips in 17th century Holland, became so severe that it was referred to in almost medical terms. When the delirium spread to wealthy landowners in the 1830s, prices at auctions in London and Liverpool began to exceed £700 (£65,000 today) for a single plant and it became an extremely well paid, if dangerous, occupation to travel the world hunting orchids (Reinikka 1995). Without CITES or any other restrictions on the international movement of wild plants, the increase in consumer demand and potential profits from wild orchids led to large-scale over-collection. One collector in Colombia wrote in 1895 "*I shall despatch tomorrow 30 boxes…they are now extinguished in this spot and this will surely be the last season. I have now finished all along the Rio Dagua where there are no plants left*" (Reinikka 1995 p 29).

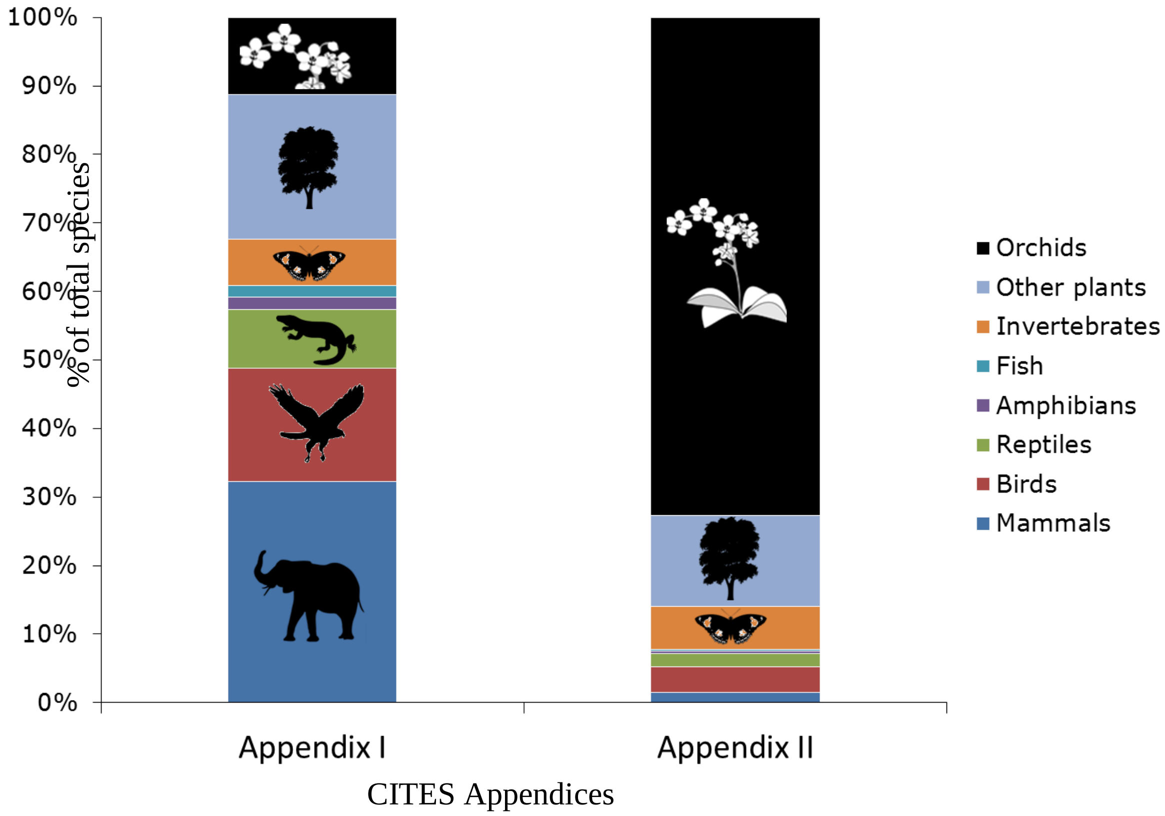

Figure 1.1. Breakdown of taxonomic groups listed on CITES Appendices I and II with a focus on the proportion of orchids. (data: CITES 2013)

Whilst 19th century orchidelirium may seem like an extreme example, orchids have remained at risk from over-exploitation for horticultural trade, even to the present day. The conservation status of many orchids is unknown but the Sampled Red List Index for Plants, an effort to assess a representative sample of all plants, concluded that one in five plant species were threatened (RBG Kew 2012). A recent project to Red List all tropical Asian slipper orchids (*Paphiopedilum* spp.) found that over 90% were threatened, many by trade (IUCN 2015a). Newly discovered orchid species are at particular risk of collection, especially if they have a novel form. In 2001 *Phragmipedium kovachii*, a slipper orchid with unusual large pink flowers unlike any other related species was discovered in Peru and quickly became the subject of great demand (Pittman 2012). This example raised questions relating to ABS and national sovereignty over natural resources when it was taken from Peru to the United States without the permission of the Peruvian authorities (Pittman 2012). Although wild collection for trade in this species was later restricted to licensed nurseries in Peru, other species have been collected to extinction before protection could be put in place. Following its discovery in 1999 the Vietnamese slipper orchid *Paphiopedilum vietnamense* was subject to such intense collection that it was extinct in the wild within five years (Averyanov et al. 2003). Similarly the discovery of *Paphiopedilum canhii* in Vietnam in 2010 was followed by a rapid escalation of prices and such an intense period of collection that 99.5% of the known population of wild plants were collected in six months (Averyanov et al. 2014). No CITES permits were ever issued for these plants but the majority are thought to have been sold to consumers in Taiwan and Europe (Averyanov et al. 2014). Increasingly, new orchid species are discovered in nurseries after they have already entered the trade (Vermeulen et al. 2014). One example, *Paphiopedilum rungsuryanum*, a Laotian species discovered in a nursery in Thailand in 2014, was found for sale on eBay within months of discovery (Hinsley pers. obs.). Similar examples of online trade have been documented (Vermeulen et al. 2014) but, even though hobbyists who buy orchids online prefer to purchase rare plants (Hinsley et al. 2015), there has been no published research into the role that the internet is playing in these trade networks.

1.7 Aims and objectives

This thesis aims to address some of the key issues currently faced by conservationists working on traded species, with a particular focus on the challenges created by the rise of online trade and communication.

Specific aims:

- To investigate the role of the internet in both the legal and illegal orchid trade

- To develop systematic techniques for the study of the structure and function of online trade networks, to provide evidence to allow effective conservation interventions
- To apply interdisciplinary methods to the study of the behaviour of traders and end consumers, to address the gaps in knowledge related to behaviour, demand and compliance
- To evaluate the success of current regulatory methods for the control of illegal trade and make recommendations for improving their effectiveness
- To understand the current barriers to the development of sustainable and legal trade

1.8 Thesis outline

This thesis has the following structure:

Chapter 2 applies a systematic method to the study of consumer preferences for physical attributes of orchids and the importance of rarity and price in buying decisions. The method is used to infer patterns of demand shown by different consumers, to identify specific groups that may be buying on the illegal market.

Chapter 3 tests the use of a specialised questioning technique to study illegal behaviour amongst a large international sample of orchid hobbyists. The study provides evidence of the extent to which the listing of all orchids on CITES has been successful in preventing illegal orchid trade in this group. The analysis also assesses the opinions of the orchid-growing community towards CITES and highlights how an understanding of the motivations for illegal behaviour has the potential to improve conservation.

Chapter 4 assesses the current status of online trade in orchids in Southeast Asia, one of the key regions for both orchid diversity and production for trade. The analysis identifies national-scale gaps in orchid trade and makes recommendations to meet the access and benefit sharing targets of the Convention on Biological Diversity.

Chapter 5 carries out a large-scale systematic survey of orchid trade occurring on a large international social media website. An analysis of the structure of the community using social network analysis is used to identify the major groups and their relationships. Further analysis of a sample of posts assesses the extent and nature of trade in wild plants, to provide evidence for the conservation community on the use of social media websites by wildlife traders.

Chapter 6 uses the findings of the previous chapters to draw conclusions and make recommendations for the application of these findings to conservation policy and practice. Finally, recommendations are outlined for potential areas of research that could build on these findings to provide evidence-based conservation solutions to the threat from trade.

Chapter 2.

Heterogeneity in consumer preferences for orchids in international trade and the potential for the use of market research methods to study demand for wildlife

2.1 Abstract

The demand for wildlife products drives an illegal trade estimated to be worth up to $10 billion per year, ranking it amongst the top transnational crimes in terms of value. Orchids are one of the best-selling plants in the legal horticultural trade but are also traded illegally and make up 70% of all species listed by the Convention on the International Trade in Endangered Species (CITES). To study consumer preferences for horticultural orchids we use choice experiments to survey 522 orchid buyers online and at large international orchid shows. Using latent class modelling we show that different groups of consumers in our sample have distinct preferences, and that these groups are based on gender, genera grown, online purchasing and type of grower. Over half of our sample, likely to be buyers of mass-produced orchids, prefer white, multi-flowered hybrid plants. Of greater conservation interest were a smaller group consisting of male hobbyist growers who buy their orchids online, and who were willing to pay significantly more for species that are rare in trade. This is the first in-depth study of consumer preferences in the international orchid trade and our findings confirm the importance of rarity as a driver of hobbyist trade. We show that market-research methods are a new tool for conservationists that could provide evidence for more effective conservation of species threatened by trade, especially via campaigns that focus on demand reduction or behaviour change.

2.2 Introduction

The illegal trade in wildlife is one of the highest value transnational organised crimes, with an estimated worth of $7 to $10 billion per year that makes it more lucrative than illicit diamond trafficking and the small arms trade (Haken 2011). Many wildlife products also have a legal trade, the total value of which is around $249 billion annually, which includes the $222 billion fish and timber trades (Engler & Parry-Jones 2007) and $27 billion of trade in species for other markets, including for medicine, food and pets (Broad et al 2003). Although smaller, the illegal trade is of significant conservation concern due to threats from over-harvesting and the wider implications of ‘by-catch’ of non-target species (Broad et al. 2003), the spread of diseases (Gómez & Aguirre 2008), as well as security concerns from the growth of organised crime syndicates (Haken 2011). For these reasons, efforts to tackle wildlife trade are a conservation priority and take many forms, a diversity of which is required to tackle an often secretive and evolving threat (Broad et al. 2003). International legislation to control wildlife trade takes the form of the 1975 Convention on the International Trade in Endangered Species (CITES). CITES aims to monitor and restrict trade in the 35,497 species and 71 subspecies of animals and plants that are listed on one of its three appendices (CITES 2013). In addition to legislation, ‘supply-side’ methods target producers by attempting to reduce market prices for illegal wildlife, for example by flooding the market with sustainable or farmed alternatives (Bulte & Damania 2005). At the opposite end of the trade chain, ‘demand side’ methods focus on reducing consumer demand, through targeted educational or high profile media or marketing campaigns (Broad et al. 2003; Williams et al. 2012; Coghlan 2014; United for Wildlife 2015). However, in spite of this recognised importance of demand there still exists a relatively poor understanding of factors that influence it, such as consumer preference for different products.

Here we present the first study aiming to address this shortfall in knowledge by testing a novel method for understanding the characteristics of wildlife products that are preferred by different groups of buyers. We use orchids as our case study as they are the largest taxonomic group listed by CITES. All 26,000 known species of orchid are listed by the convention, making up 9.8% of Appendix I, 73% of Appendix II and 70% of total CITES species (CITES 2013). Orchids are particularly susceptible to over-collection from trade due to naturally small populations and high sensitivity to other threats, such as habitat degradation (Koopowitz 2001). Large-scale over-harvesting of wild orchids has been recorded to supply the medicinal (e.g. Traditional Asian Medicine: Liu et al. 2014), edible (e.g. Salep in Iran: Ghorbani et al 2014) and horticultural (e.g. *Bulbophyllum* spp.: Vermeulen et al. 2014) trades. At greatest risk are those species listed on CITES Appendix I, including all Paphiopedilum and Phragmipedium species, part of the group known as slipper orchids that are extremely popular in horticultural trade. Over-collection of slipper orchid species has resulted in the decline of wild populations, species extinctions and, in the case of *Phragmipedium kovachii* smuggled to the US from Peru, even disputes between nations over sovereignty of natural resources (Averyanov et al. 2003; Averyanov et al. 2014; Pittman 2012). Although not all orchids are threatened by trade, the entire family was included on CITES due to the difficulty that non-experts face in discriminating between closely related species.

We focus on the orchid horticultural trade in particular as it is the most diverse market in terms of consumers and species sold and has both a well-developed legal trade and an illegal trade, which has been linked to the decline of orchids in the wild (Averyanov et al. 2003; Vermeulen & Lamb 2011). The orchid horticultural trade dates back over 2,000 years in China and Japan (Paek & Murthy 2002) and reached a peak in the nineteenth century when wealthy European collectors suffering from 'orchidelirium' imported large quantities of wild plants from around the world (Pittman 2012). Today orchids are no longer just for the rich, as improvements in horticultural technology have made mass-produced hybrids of a few genera one of the top selling pot plants in the world (FloraHolland 2013; USDA 2014). In addition, there still exists a smaller specialist market, where hobbyists in an international net- work of orchid societies grow a wider range of species and hybrids. Finally, growing domestic markets in Latin America, China and Southeast Asia may include hybrids and species sold to both specialist and non-specialist consumers (e.g. Phelps & Webb 2015). It is the latter two markets that have been linked to over-harvesting of wild plants for trade due to collection for sale at local markets or international orchid shows, orders from buyers for specific species, or from nursery owners hoping to incorporate desirable wild traits into new hybrids (Pittman 2012; Phelps & Webb 2015). Whilst trade in wild-collected plants at markets in tropical regions has been the focus of some research (e.g. Flores-Palacios & Valencia-Díaz 2007; Phelps & Webb 2015), little attention has been paid to the study of the conservation implications of the formal international orchid trade. Here we aim to address this shortfall in knowledge by focussing our study on important orchid buying countries including Japan and the UK.

To investigate preferences we use choice experiments, a stated preference method with its origins in economic consumer theory, which states that a preference is not for a product itself but for the characteristics that it possesses (Lancaster 1966). This theory, combined with random utility modelling (McFadden 1980), assumes that consumers will choose to buy the product with the characteristics that offer them the highest utility. Choice experiments also enable researchers to measure a respondent's Willingness to Accept (WTA) compensation or Willingness to Pay (WTP) a premium for different characteristics of a product. After extensive use in the marketing and transport sectors, choice experiments have been adopted in other fields, such as agriculture (e.g. Birol et al 2008), environmental planning (e.g. Hanley et al 2003) and conservation (e.g. Veríssimo et al. 2014). They have also been used to study consumer preferences for mass-market orchids in Hawaii, a major producer and consumer of pot-plant orchids (Palma et al. 2010). In this study we use choice experiments to assess consumers' preferences and WTP for horticultural orchids, with the dual aims of understanding which characteristics make certain species particularly 'tradable' in this market, and identifying consumer groups who may be most likely to buy wild-collected plants.

2.3 Methods

2.3.1. Choice experiment design and pilot study

We ran an online focus group of hobbyist growers to identify 10 attributes that were important to their buying decisions. These were used to create two experimental designs of 29 choice sets each, one focussing on physical characteristics of the flower (e.g. colour, shape) and the second on general plant characteristics (e.g. species or hybrid, rarity in trade) of orchid plants. We used an orthogonal design to ensure that there was statistically no correlation between attributes, and each experiment was split into three blocks (Hensher et al. 2005). We used these designs to survey 103 randomly selected visitors to the 2012 UK Peterborough International Orchid Show. Feedback on survey design, attributes and levels was gathered following each survey.

We used a combination of the significantly preferred attributes (see Table 2.1) from both pilot surveys, to design the main survey using Ngene (version 1.0.1, ChoiceMetrics, Sydney, Australia), to produce a D-efficient Bayesian design (Jaeger & Rose. 2008). To allow for uncertainty, we used 500 Halton draws from normal distributions for each parameter prior distribution. We then compared the mean Bayesian Dp error of over 50,000 Bayesian designs, selecting the one with the lowest error at 0.171. This design had 12 choice sets (see Fig. 2.1 for an example).

Orchid A		**Orchid B**
White Rarely found for sale Single flower Species US $ 105	I would not buy either	Black Frequently found for sale Multiple flowers Complex hybrid US $ 75
☐	☐	☐

Figure 2.1. Example choice set used in the study. Presented with the instruction: *Using only the description provided, and assuming that all other factors are identical (e.g. both plants are suitable to your growing conditions), please select which orchid you would buy in a real-life situation.*

Table 2.1 Attributes and attribute levels of orchids used in the final choice experiment

Attribute	Levels	Description
Flower colour	Red White Blue Yellow Green Black	Primary flower colour. Respondents were asked to ignore any possible secondary colour or patterns. Colours chosen to represent a range of orchid flower colours, based on complementary colour theory.
Frequency in trade	Rarely found for sale Frequently found for sale	References to wild plants were not included due to concerns of sensitivity following feedback during the pilot study, with 'rarity in trade' used to capture preferences for novelty whilst minimising social-desirability bias.
Number of flowers	Single flower Multiple flowers	The number of flowers present on the plant.
Species/ Hybrid	Species Hybrid Complex Hybrid	Whether the plant is a species, a hybrid or a complex hybrid (result of breeding hybrids together, or hybrids with species).
Price	$15 $30 $45 $75 $105 $150	Range based on upper and lower limits of orchid prices found on general sale online and at orchid shows. US$ used to provide continuity across different survey areas. Simple currency converter provided to each respondent.

The design was attribute balanced meaning each attribute level occurred equally often, which minimises the variance in parameter estimates (Mangham et al. 2009). Large numbers of choices can put high cognitive demand on respondents (Weller et al. 2014), so to avoid bias caused by fatigue, the 12 choice sets were split into two blocks of six, with each respondent completing one randomly assigned block. A 'neither' option was provided to reduce error resulting from forced choices, and the experiment was unlabelled to ensure that respondents based their choice decisions on the attributes provided rather than prior knowledge of the species named (Blamey et al 2000; Kontoleon & Yabe 2006). In addition to the choice sets, demographic questions about age, gender, nationality, and orchid growing and buying habits were asked of each respondent. Finally, every other respondent at one Japanese and one UK orchid show, along with a random selection of our online respondents (selected using survey software), answered one open-ended contingent valuation (CV) question. Selected respondents were asked to state their maximum WTP in their own currency for either CVa: their ‘perfect’ orchid (i.e. an orchid with a combination of all of their most preferred attributes) or CVb: three orchids taken directly from the choice sets (as in Fig. 2.1) with the price attribute removed. CVb aimed to test the assumption that any observed national WTP differences were due to differing preferences, rather than respondents discounting or misunderstanding the price attribute due to unfamiliarity with using US dollars. Both CVa and CVb aimed to test the accuracy of the range of price attribute levels for consumers in different countries.

2.3.2. Data collection

We administered the survey online (SurveyGizmo.com), at UK international orchid shows (Royal Horticultural Society London Orchid Show, April 2013; Malvern International Orchid Show, June 2013), and at Japanese International Orchid shows (Asia Pacific Orchid Congress, February 2013, Japanese Grand Prix Orchid Show, February 2014). Respondents were either self-selecting orchid society members contacted by email or randomly selected show visitors. Each respondent was randomly allocated to one of the two experimental blocks. The Japanese survey was professionally translated and checked by two Japanese speakers including one with experience in the orchid industry, after which minor changes were made. All face-to-face surveys were completed in the presence of a researcher who provided clarification and guidance. The online survey was self-completed but with extra clarification to match that given during face to face surveys, such as an example choice set and an in-depth description of each attribute. Data collection took place online and at international orchid shows due to the access both provide to a diversity of different nationalities and types of growers. This strategy, whilst clearly feasible for our aims, means that our sample does not represent all orchid consumers worldwide, or those without the resources and commitment to join orchid societies or attend large shows. As discussed, we acknowledge that there are a number of emerging orchid markets where buyers may be unlikely to be a member of a formal society, or where the majority of orchids are bought at local markets (Phelps & Webb 2015).

2.3.3 Analysis

We constructed both a multinomial logit model (MNL) and Latent Class Models (LCMs) using NLOGIT (version 5.0, Econometric Software, Inc., New York, USA). Rather than a conditional logit model that assumes the population will be homogeneous, an LCM approach was chosen to reflect the likely presence of heterogeneity amongst respondents' preferences (Birol et al. 2009). LCMs are a relatively recent development in the choice experiment literature but have been found to successfully identify preference heterogeneity (Kontoleon & Yabe 2006; Birol et al. 2009; Veríssimo et al. 2014). This was especially important in this study, due to the diversity of nationalities, ages and types of growers who visit large international orchid shows, and the range of orchids in trade. After fitting LCMs for all combinations of variables the final model is selected by extensive testing across all variables, considering criteria such as standard error, membership of different segments and utility score significance. This final model identifies the variables that best explain preferences but to identify the number of latent classes (e.g. different types of consumers) within these groups requires the use of tools for model selection. It is standard in the choice experiment literature to use a combination of model selection criteria (e.g. Birol et al. 2009), as each has its own strengths and weaknesses. Here we use Akaike's Information Criterion (AIC) and Bayesian Information Criterion (BIC) (e.g. Birol et al 2009) and a modified AIC with three as a penalty factor (AIC3), which was developed specifically to compare LCMs with different numbers of parameters (Bozdogan, 1993). Finally, a Wald's delta test was performed on the chosen model to estimate respondents' WTP as a price premium for desirable attributes or WTA as a discount for undesirable attributes. WTP answers to the open-ended CV questions were converted to US dollars (using exchange rates from the month of response from www.oanda.com) and grouped based on currency (USA, UK, EU, Japan, Canada and Australia). WTP answers were compared using a Kruskal–Wallis test.

2.4 Results

A total of 540 respondents took part, online (n = 143), at UK orchid shows (n = 145) and at Japanese orchid shows (n = 252), 18 were discarded as respondents did not complete the choice sets or gave invalid responses (e.g. selecting more than one choice option). This resulted in 3132 completed choice sets. The sample comprised 55% female, and the majority (60.9%) of respondents were born before 1959 (1950s: 21.5%; 1940s: 27.6%; 1930s: 11.8%). The most popular orchid genera grown were *Dendrobium* (55.7%), *Phalaenopsis* (50.5%) and *Paphiopedilum* (39.1%), and the majority of respondents described themselves as hobbyists (45.8%) or houseplant growers (23.8%). The sample was 50.7% Japanese, 28.8% British and the remaining 20.5% of respondents were from elsewhere in Asia and Europe, the USA, Canada and Australia. When respondents were treated as a homogenous group in the MNL, all attributes had a significant effect on choice, except for the flower colours green and yellow, and hybrid plants (Table 2.2).

The final selected LCM was constructed based on gender, whether the respondent was a hobbyist, whether they grew *Paphiopedilum* orchids and whether they had purchased plants online in the past year. Within this model, BIC is minimised at three segments and AIC and AIC3 continue to improve with small marginal improvements between four and five segments (Table 2.3). Despite these improvements, both the four and five-segments models included at least one segment with no significant membership or utility coefficients. All segments in the three-segment model selected by BIC had significant utility coefficients and both non-reference segments had significant membership coefficients (Tables 2.2 and 2.4).

Table 2.2 Multinomial logit (MNL) and Latent Class Model (LCM) estimates of utility function for each attribute, with standard errors in parentheses (95% confidence intervals).

Attribute levels	**MNL**	**LCM segment 1 (55.9%)**	**LCM segment 2 (19.9%)**	**LCM segment 3 (24.2%)**
Alternative Specific Constant	-0.545*** (0.13)	-1.028 (0.17)	-0.678 (0.52)	-0.368 (0.56)
Colour: Red	0.226* (0.12)	2.207 (0.51)	-0.080 (0.46)	-0.054 (0.46)
Colour: White	0.519*** (0.10)	4.614** (2.01)	-0.232 (0.33)	-0.089 (0.34)
Colour: Blue	0.281** (0.13)	-0.842 (0.81)	-0.217 (0.48)	-0.206 (0.46)
Colour: Green	0.092 (0.12)	-1.780 (0.15)	-0.165 (0.35)	-0.234 (0.28)
Colour: Yellow	0.132 (0.14)	4.148 (0.60)	-0.375 (0.52)	-1.462** (0.74)
Frequency in trade	-0.364*** (0.08)	1.602 (0.08)	-1.007*** (0.28)	-0.761*** (0.27)
Number of flowers	0.282*** (0.05)	1.650** (0.80)	0.244 (0.20)	-0.068 (0.22)
Species	0.272*** (0.09)	-0.234 (0.46)	1.840*** (0.36)	0.069 (0.43)
Primary hybrid	-0.097 (0.12)	5.676* (3.33)	0.260 (0.39)	-0.738 (0.53)
Price	-0.186*** (0.03)	-0.777** (0.34)	-0.230** (0.10)	-0.580*** (0.10)

Reference levels: ‘Colour: black’ and ‘complex hybrid’. Shading denotes significant utility scores (***: $p \leq 0.01$; **: $p \leq 0.05$; *: $p \leq 0.10$).

Table 2.3 Summary of measures of model fit for the Multinomial logit (MNL) and Latent Class Models (LCM), with minimized values shaded

Model	K[a]	LL[b]	AIC[c]	BIC[d]	AIC3[e]
MNL	11	-3329.927	6681.855	3364.323	6692.854
LCM2	27	-2988.701	6031.403	3097.369	6058.403
LCM3	43	-2916.754	5919.507	3089.816	5962.507
LCM4	59	-2872.452	5862.903	3109.910	5921.903
LCM5	75	-2840.997	5831.994	3142.851	5906.994

[a] Number of parameters; [b] Log Likelihood; [c] Akaike's information criterion (-2(LL-K)); [d] Bayesian information criterion (–LL+(K/2)*ln(N)); [e] Modified Akaike's information criterion using a penalty factor of 3 (-2LL+3K).

Table 2.4 Membership coefficients for the three segment Latent Class Model (LCM). Reference segment: Segment 3 (24.2% of the sample) 2

Demographic variable	LCM segment 1 (55.9%)	LCM segment 2 (19.9%)
Gender (male = 0, female = 1)	0.296	-2.157***
Hobbyist (no = 0, yes = 1)	-0.188	0.954**
Bought online in last 12 months (no = 0, yes = 1)	0.645	1.228**
Paphiopedilum grower (no = 0, yes = 1)	-0.699**	0.319

Shading denotes significant utility scores (***: p ≤ 0.01; **: p ≤ 0.05; *: p ≤ 0.10).

In addition, unlike AIC, BIC does not overfit so, as overfitting of models produces a greater parameter bias than underfitting (Andrews & Currim 2003), we identified the optimal number of segments for this model as three. The largest class in the selected model was significantly more likely to include respondents who did not grow any *Paphiopedilum* orchids (Table 2.4). This group showed strong significant attribute preferences for white flowers, multiple flowers and a low price (Table 2.2). WTP estimates show that compared to the reference level of black flowers, respondents in this group would pay a premium of \$10.91 for white flowers ($p \leq 0.05$). They would also pay \$3.61 more for a plant with multiple flowers compared to a plant with single flowers ($p \leq 0.05$).

The smallest class in our sample were significantly more likely to be male hobbyists who buy their orchids online (Table 2.4). Compared to the reference level of complex hybrids, this group showed a significant preference for species plants. They also preferred orchids that were rare in trade and that had a low price (Table 2.2). People in this group would be willing to pay a premium of \$8.01 for a species ($p \leq 0.05$) and \$4.39 to buy an orchid rarely found in trade ($p \leq 0.05$). The final class in a LCM is a reference class and so limited membership information is available, however the 24.2% respondents in this group may be more likely not to have bought orchids online in the past year. Rarity significantly affected preferences in this group and a significant negative coefficient for yellow flower colour suggests that yellow would be less preferred than the reference level of black. A low price was also significantly preferred, and the negative coefficient was larger than in both other groups. The respondents in this class would be willing to pay an extra \$1.31 for a rare versus a common plant ($p \leq 0.01$) but would need a \$2.52 discount before they would be willing to accept a yellow-flowered plant ($p \leq 0.05$).

A total of 204 open-ended CV answers were collected for either CVa ($n = 55$) or CVb (Block 1: $n = 70$; Block 2: $n = 79$). For the whole sample the mean WTP for CVa was \$67.20, the median \$48.00 and the range \$19.46 to \$1,452.36. Three extremely high CVa values were given by hobbyist growers of *Paphiopedilum* and *Phragmipedium* orchids from Japan (2 x $973) and Canada ($1,452.36). The median WTP did not differ significantly for any orchid in CVa (p = 0.480) or CVb (Orchid1: p = 0.974; Orchid2: p = 0.490; Orchid3: p = 0.585; Orchid4: p = 0.472; Orchid5: p = 0.786; Orchid6: p = 0.651).

2.5 Discussion

This study represents the first use of choice experiments to study consumer preferences for orchids in the international horticultural trade, and the first to use a full choice experiment to study preferences for attributes of a wildlife product. Our results demonstrate that market research methods have the potential to play an important role in the conservation of traded species by providing an understanding of the preferences that drive buying decisions. We found marked differences between different groups of consumers in the sampled orchid markets, with hobbyists who buy their plants online showing a preference for rare, species plants.

2.5.1 Potential for the application of choice experiments to study wildlife trade

In conservation, choice experiment and other stated preference methods have been widely accepted, with uses ranging from measuring public opinion on conservation policy (Hanley et al 2003), identifying suitable flagship species (Kontoleon & Swanson 2003; Veríssimo et al 2014) and assessing donor WTP for conservation projects (Morse-Jones et al 2012). However, prior to our study, their application to consumers of wildlife has been limited to assessing preferences for a single attribute (wild v. farmed bear bile: Dutton et al 2011), or identifying alternative livelihood strategies to reduce illegal hunting (Moro et al 2013). The results of this study suggest that choice experiments have the potential for wider application, as they reveal information about preferences that can be used as a proxy for understanding consumer demand and identifying the ‘tradability’ of different products in trade. The use of LCMs to analyse heterogeneous preferences, in particular has the potential for studying markets that are predominantly legal but that include small groups of consumers that prefer illegal or wild products. As well as orchids, this includes other horticultural plants such as cacti (Sajeva et al 2013), the reptile and amphibian trade (Natusch & Lyons 2012) and the pet bird trade (Tella & Hiraldo 2014).

For future application of these methods to the study of trade it is important to note potential problems that should be considered during the design phase. Methodological studies have found that providing too many attributes, alternatives, or choice sets to each respondent can increase the complexity of the choice task and cause some attributes to be ignored (Caussade et al 2005; Weller et al 2014). This ‘attribute non-attendance’ can produce inaccurate utility or WTP estimates, especially if price is one attribute that is not considered (Weller et al 2014). On a positive note, attribute non-attendance can be mitigated using an experimental design that reduces complexity (Weller et al 2014), and a pilot study to define subject-specific ranges for attribute levels. Specific considerations for the study of wildlife trade relate to the potential sensitivity of questions about illegal buying behaviour and preferences, which may, lead to non-response or social desirability biases. The use of indirect questioning techniques is growing in conservation, to preserve respondent anonymity and encourage more truthful reporting of illegal or sensitive behaviour (Nuno & St John 2015). A potential future direction for the use of choice experiments in conservation research could therefore make use of indirect questioning techniques to reduce bias in the study of preferences for illegal products. This could build on the techniques that have been developed to reduce bias in choice experiments that use hypothetical situations, which are prone to inflated WTP scores. These include asking respondents to evaluate their level of honesty after the experiment, or priming the respondent before they make their choices by using either ‘cheap talk’, in which the potential for bias and the importance of honesty is explained (Morrison & Brown 2009), or the swearing of a ‘solemn oath’ to answer honestly (de-Magistris & Pascucci 2014). These methods, if used correctly, can reduce bias in choices with hypothetical situations, and may have potential for the development of techniques to study socially undesirable preferences.

2.5.2 Difference between consumer groups

Our results show that there are distinct consumer groups within our sample of orchid buyers. Although our sample included orchid consumers from a diverse array of countries, the LCM did not find nationality to be a predicting covariate for preference heterogeneity. This was supported by the lack of significant differences between maximum WTP between different geographic groups answering the CV questions. As mean and median WTP for all groups was within the range of price attribute levels presented in our choice sets, we can conclude that prices were appropriate for respondents in the study. This reflects the international nature of the orchid trade and the shared preferences of hobbyist growers of similar genera, irrespective of nationality. The extreme WTP values given by two Japanese hobbyists are supported by trends in the orchid market: in the 1990s, buyers in Japan were willing to pay $3,333 for a highly sought after new *Paphiopedilum* species that would only reach $500 in the UK and US (Yokoi & Milliken, 1991).

The largest class of respondents in this study contained those who do not grow CITES Appendix I *Paphiopedilum* orchids (Southeast Asian slipper orchids). Although many species are relatively easy to grow compared to some other genera, Paphiopedilums are difficult to clone and therefore cannot be produced in as large a number as some other orchid genera (Chugh et al 2009). For this reason they tend to have higher prices and are seen as a more specialist plant (Yokoi & Milliken, 1991; Koopowitz 2001). They also have duller flower colours compared to other popular genera in trade (Koopowitz 2001). Respondents who do not grow Paphiopedilums are therefore likely to include growers of popular pot plant orchids, including *Cymbidium* in Japan and *Phalaenopsis* elsewhere. High standard errors for the significant coefficients in this class may be due to heterogeneity resulting from these different pot plant markets. Preferences for hybrids, flower colour and multiple flowers combined with no preference for rarity matches demand trends for these markets (Paek & Murthy 2002) and the only other study to date of orchid consumer preferences (Palma et al 2010). Preferences for white, multiple-flowered orchids in particular are supported by industry studies of demand for *Phalaenopsis* hybrids (Tang & Chen 2007).

The smallest group identified were male hobbyists who buy their orchids on the internet. Online orchid trade is increasing, with both legal nurseries and illegal traders using websites, online auction platforms and social media to sell their products (pers. obs.). Online trade allows specialist growers to find a wide range of species, buy from nurseries abroad and ensure a good deal. Our findings of smaller WTP values for the online buying class may be linked to this, as buying online cuts out middlemen and allows price comparison; in case studies of online animal trade, prices have been found to be lower than from other sources (Lavorgna 2014).

Although beneficial to buyers, online trade is difficult to police and there are large numbers of wild-collected plants, or those transported without the appropriate CITES paperwork for sale (Fleming 2013; Sajeva et al 2013; Shirey et al 2013). Our results show that online-buying hobbyists would be willing to pay significantly more for rarely traded species, although it should be noted that this combination of attributes may be confounding, as hybrid rarity is more difficult to assess than species rarity. The importance of rarity to this hobbyist group matches demand in other wildlife trades, particularly for luxury or specialist goods (Slone et al 1997; Hall et al 2008). In these trades, and in others where no substitute is available, consumers are predicted to be willing to pay higher prices for a rare product (Hall et al 2008). Here we do not suggest that all online buying hobbyists in this group have a preference for wild-collected plants, as the combination of rarity and species cannot be used as a perfect proxy for this. However, two of the primary reasons for rarity in trade are likely to be difficulty in cultivating a species quickly in large numbers (e.g. slow growing Paphiopedilums that cannot be tissue cultured) or recent discovery of the species or form in the wild. In both of these cases if WTP is high enough then traders may have an incentive to collect plants from the wild for sale. This corresponds to the theory of an ‘anthropogenic allee effect’, in which high prices act as compensation for the higher risks associated with finding and illegally transporting wild products, contributing to further decline of the species in the wild (Courchamp et al 2006). Although our choice experiment WTP scores were relatively small, our CV questions showed that some specialist orchid growers would pay high prices for a particularly desirable plant. This is supported by evidence of high prices being paid for new or rare orchid species (Yokoi & Milliken, 1991; Koopowitz 2001; Pittman 2012). As discussed, orchids may be sold in several other ways, including in large numbers via local markets (e.g. Phelps & Webb 2015). Further consumer research focussing on these markets would be beneficial to understand different patterns of preferences, especially to compare WTP and the importance of rarity to different groups.

2.5.3 Implications for conservation

Overall the implications of our results are twofold. Firstly, we demonstrate that consumer preference data gathered using choice experiments have the potential to be useful for understanding wildlife trade. Changing consumer behaviour for unsustainable or illegal wildlife products can only be successful if there is an understanding of the preferences that drive this behaviour. Without this, behaviour change campaigns risk being ineffective or, at worst, encouraging the behaviour that they seek to curb (Angulo & Courchamp 2009). To date, studies of consumer demand have primarily focussed on large-scale analysis of econometric data (Milner-Gulland, 1993), interviews with small numbers of buyers at street markets (Phelps et al 2014), or large social surveys of the general population to find out about past buying habits (Jepson & Ladle 2005). Recent high profile campaigns to reduce demand for rhino horn in Vietnam (Coghlan 2014) have been criticised for their lack of scientific rigour, both in design, analysis and evaluation (Roberton 2014; Verissimo 2014). Similarly, there is evidence that supply-side interventions are not always effective, and that demand for wild products still exists alongside sustainable alternatives (Phelps et al 2014; Williams et al 2014). One way to improve supply-side methods may therefore be to use choice experiments and other market research techniques to ensure that farmed or cultivated products have the right attributes to compete with wild-sourced alternatives. Other potential supply-side applications may include producing a 'tradability index' for species, based on consumer preferences and species attributes (using similar methods to Veríssimo et al 2014).

This may be especially useful for high-risk groups such as slipper orchids as, although our results highlighted rarity as key to hobbyist preferences, it is clear from real examples that all rare species are not equal. The high demand for and subsequent rapid over-collection to extinction of *Paphiopedilum vietnamense* (Averyanov et al 2003) was not suffered by *P. parnatanum*, a species also discovered in 1999 that remains the focus of little demand from the international market to this day. Although closely related and described at the same time, these species do differ in attributes such as flower shape, colour and size. This suggests that further research focussing only on slipper orchid buyers may reveal further preferences in additions to rarity, information that could be used to predict which newly discovered species will become most threatened by trade, allowing protection to be put in place before overharvesting begins. This could include increased protection of wild sites, collection of seed by registered nurseries to begin artificial propagation, or alerts and specific identification guidance for CITES enforcers checking exports of orchids from countries of origin. This is particularly useful for species rich groups such as orchids, in which an estimated 200-500 new species are described each year (Royal Botanic Gardens Kew 2015). In addition, an index could be used to track changes in consumer preferences, allowing adaptive management of trade policy such as CITES. We have shown that choice experiments are an effective method for measuring the preferences and willingness to pay of different groups of consumers for wildlife products.

Secondly, our results provide evidence of preferences of consumers in the orchid buying community that could be used in the conservation of traded species. As discussed, we acknowledge that rarely traded species are not a perfect proxy for wild plants (e.g. commonly traded plants may also be wild-collected: Phelps et al 2014)) but preferences for this combination of attributes both encompass groups at high risk from wild-collection and provide an economic incentive for their collection. With this in mind, the preferences our results reveal amongst online buyers support calls for increased monitoring of online trade in plants (Fleming 2013; Sajeva et al 2013). Our results may also be useful in the design of conservation campaigns that aim to change buying behaviour amongst online buyers. For example, conservation campaigns often highlight the rarity of a species in the wild but this approach may encourage demand for wild plants rather than reduce it (Angulo & Courchamp 2009). This is likely to be especially case with orchids, as new wild species are often subject to intense collecting pressure to supply the hobbyist market (Averyanov et al 2003; Pittman 2012). Indeed, rarity is often highlighted by traders on auction websites to sell their plants, including species that are rare in trade due to recent discovery and an absence of artificially propagated plants. In addition to strengthening orchid conservation, choice experiments have great potential to provide consumer preference data to underpin evidence-based interventions for the conservation of a wide range of traded wildlife.

2.6 Supplementary information

Full choice experiment survey. Block 1. (English version)

A An experiment to study consumer choices

Many thanks for taking the time to complete this survey, which aims to learn more consumer demand for orchids, especially what influence your decision to buy a particular plant The survey consists of multiple-choice questions and will take about 5 minutes of your time. All answers will be anonymous.

Section 1 The first six questions ask about you and your orchids

1. Which country do you live in? ☐ UK ☐ Other_______

2. What is your gender? ☐ Male ☐ Female

3. What is your year of birth? ___________________________

4. How would you describe your connection with orchids? (**Please tick all that apply)**
   ☐ Professional grower ☐ Show judge
   ☐ Hobbyist ☐ Researcher
   ☐ Casual grower ☐ A few windowsill orchids
   ☐ Other (Please state)_______________________________

5. Which orchids do you have in your collection? (**Please tick all that apply)**
   ☐ *Phalaenopsis* ☐ Hardy Orchids
   ☐ *Vanda* ☐ *Paphiopedilum*
   ☐ *Phragmipedium* ☐*Cattleya*

☐ Pleurothallids

☐ Not sure what type

☐ Other______________________

☐ *Dendrobium*

6. If you have bought or acquired orchids in the last 12 months, where have you done so? (**Please tick all that apply)**

☐ A nursery's paper catalogue

☐ A supermarket, garden centre or street market

☐ An online orchid forum

☐ A nursery's website

☐ Auction website (e.g. eBay)

☐ Received as a gift

☐ In person at a nursery

☐ At an orchid show

☐ At a society meeting

☐ On Facebook or Twitter

☐ Not acquired orchids in the last 12 months

☐ Other (Please state)

Section 2 The next six questions will ask you to chose between two orchids, using only the **main flower colour**, **rarity in trade, number of flowers**, **type**, and **price**.

Assuming that all other factors are identical (e.g. both plants are suitable to your growing conditions), please select which orchid you would buy. Prices are in **US Dollars** ($15 = £10, $30 = £20, $45 = £30, $75 = £50, $105 = £75, $150 = £100)

1	Orchid A		Orchid B
	White Rarely found for sale Single flower Species US $ 105	I would not buy either	Black Frequently found for sale Multiple flowers Complex hybrid US $ 75
	☐	☐	☐

2

Orchid A		Orchid B
Blue		Green
Frequently found for sale	I would not buy either	Rarely found for sale
Single flower		Single flower
Primary hybrid		Primary hybrid
US $ 150		US $ 15
☐	☐	☐

3

Orchid A		Orchid B
Black		Red
Frequently found for sale		Rarely found for sale
Single flower	I would not buy either	Multiple flowers
Species		Complex hybrid
US $ 30		US $ 105
☐	☐	☐

4

Orchid A		Orchid B
Yellow		Red
Rarely found for sale		Frequently found for sale
Multiple flowers	I would not buy either	Multiple flowers
Complex hybrid		Species
US $ 75		US $ 150
☐	☐	☐

Orchid A		Orchid B
Green		Blue
Rarely found for sale	I would not buy either	Frequently found for sale
Multiple flowers		Single flower
Primary hybrid		Species
US $ 75		US $ 105
☐	☐	☐

6

Orchid A		Orchid B
Red		Black
Frequently found for sale		Rarely found for sale
Multiple flowers	I would not buy either	Single flower
Complex hybrid		Primary hybrid
US $ 15		US $ 15
☐	☐	☐

Thank you for taking part in this research. For more information about this experiment, or my research in general please contact Amy on ah371@kent.ac.uk

Chapter 3.

Estimating the extent of CITES non-compliance amongst the global orchid growing community

3.1 Abstract

The Convention on the International Trade in Endangered Species (CITES) controls and monitors trade in 35,497 species, over 70% of which are orchids. To investigate rule-breaking behaviour amongst buyers in a specific international wildlife trading community, we used direct questions (DQs) and the Unmatched Count Technique (UCT) to survey orchid growers about CITES compliance and their knowledge and opinions of the rules. In DQ 9.9% had smuggled, 4.8% had laundered and 10.8% had been sent orchids from online purchases with no paperwork; UCT estimates did not differ significantly. Growers with greater knowledge of CITES rules were more likely to break them and this, coupled with widespread negative views of CITES in the orchid community, may suggest that rule breaking is used as a form of defiance. To improve compliance CITES should engage with and encourage the involvement of growers and traders in discussions on implementation of the rules.

3.2 Introduction

The illegal wildlife trade is a lucrative market that can threaten species and strengthen organised criminal networks (Haken, 2011, South & Wyatt, 2011). The Convention on the International Trade in Endangered Species (CITES) monitors and controls international trade of 35,497 species by listing them in one of three appendices (CITES, 2013). In some cases, enforcement of CITES and corresponding national legislation can be a deterrent (Doukakis et al., 2012), but the continued illicit trade in many listed species has called into question its effectiveness (Challender & MacMillan, 2014). Understanding the extent of, and motivations for, conservation rule-breaking is an important step towards encouraging compliance (Solomon et al., 2015). However, pressure to provide socially desirable answers and the threat of prosecution can make people unwilling to discuss their involvement.

We present the first study of CITES rule-breaking behaviour amongst buyers in a specific international wildlife trading community. We use a case study of orchids, all 26,000 species of which are CITES-listed, accounting for 73% of all listings and 9.8% of Appendix I (CITES, 2013). Any transnational trade of orchid species therefore requires CITES documentation (CITES, 2004). In addition, in several countries' national laws protect wild orchids from collection and export (e.g. Commonwealth of Australia 2015). Whilst orchid hybrids are top-sellers in the global horticultural trade (USDA, 2015), hobbyists prefer rare species (Hinsley et al., 2015) and there is evidence of wild-collection of orchids to supply this specialist international market (Thomas, 2006). Over-collection of orchids can lead to their decline and extinction in the wild (Averyanov et al., 2003), with certain groups in particularly high demand, such as the tropical Asian slipper orchids *Paphiopedilum* spp.; over 90% of which are threatened with extinction, many due to collection or trade (IUCN, 2015).

Here we use an online questionnaire to gather data on knowledge and opinions of CITES, and prevalence of CITES non-compliance amongst orchid growers. As this is illegal we use a specialised questioning method, the Unmatched Count Technique (UCT) to encourage truthful reporting (Nuno & St John, 2015). When applying UCT, respondents are presented with a list of statements and asked to report the total number that apply to them. This is either a control list of innocuous 'non-sensitive' statements (e.g. "I use fertiliser on my orchids") or a treatment list with the control items plus an additional 'sensitive' statement (e.g. "I have smuggled orchids"). In conservation, UCT has been used to study behaviours such as illegal hunting (Nuno et al., 2013) and unauthorized forest resource use (Harrison et al., 2015). However, in order to assess suitability of different techniques, a better understanding of the limitations of these methods in different conservation contexts is an essential but under-researched area (Nuno & St John, 2015). In our study, we employed both direct questions (DQs) and UCT to explore potential trade-offs between techniques, with a focus on statistical efficiency and comparison of study findings.

3.3 Methods

We designed pilot and final questionnaires using www.SurveyGizmo.com, which were translated into French, German, Indonesian, Japanese, Malaysian and Spanish and checked by native speakers with orchid expertise. Links to the final survey were emailed to all hobbyist societies listed in the American Orchid Society and British Orchid Grower's Association 2014 Directories, and to national or regional hobbyist organisations in Australia, Canada, Europe, Japan, Latin America, South Africa and Southeast Asia. The pilot survey was sent to a subset of societies.

3.3.1 Pilot study

UCT lists need to be carefully constructed as poorly designed control lists can cause bias (Glynn, 2013). A mixture of high and low prevalence statements reduces the likelihood of respondents agreeing with all or zero items, an outcome that removes the protection that UCT provides and decreases the likelihood of truthful answers by rule-breakers (Droitcour et al., 1991). Further, negatively associated statements reduce the variability of answers, increasing statistical efficiency (Glynn, 2013). We piloted 32 control statements to assess their prevalence (See supplementary information for pilot statements); all statements were related to orchid growing to ensure that the sensitive statement did not stand out (Glynn, 2013). We asked respondents to select all true statements and provide feedback. The order of statements was randomised for each respondent to avoid presentation order bias. We calculated the prevalence of each statement (% of respondents selecting it) and association between all pairs of statements, using chi-squared and odds ratio tests.

3.3.2 Main survey questions

Based on observations of the orchid community and consultation with the UK CITES Scientific Authority, we investigated four sensitive behaviours:

- Smuggling ("I have personally sent or carried an orchid across an international border without obtaining the required CITES paperwork");
- Laundering ("I have personally sent or carried an orchid across an international border using the wrong CITES paperwork for that plant [e.g. paperwork for a different species]").
- Buying online ("I have bought an orchid online that was sent to me without the correct or required CITES paperwork");
- Wild plants ("I have an orchid in my collection that I know or strongly suspect was wild-collected")

These behaviours range in sensitivity from active CITES rule-breaking ('smuggling' and 'laundering') to passive ('buying online') and finally socially undesirable but not necessarily illegal ('wild plants'). We included these statements in four UCT treatment lists instructing respondents to report how many statements applied to them. Respondents answered all four questions but were randomly assigned by SurveyGizmo to receive either the control or treatment list for each. Following the UCT, respondents were asked to answer each sensitive statement in a DQ.

Finally, we asked respondents to rate their knowledge of CITES rules for orchids on a five point Likert scale. An open text question for opinions on the efficacy of the CITES rules for orchid conservation was also asked (See supplementary information for full survey). All UCT questions required an answer before respondents could move to the next page. All other questions could be skipped but were not marked as optional.

3.3.3 Analysis

We analysed data using R version 3.2.1 (R Core Team, 2015) and, unless specified, the list package version 8.0 (Blair & Imai, 2010) designed specifically to analyse UCT.

UCT assumes that the presence of the sensitive item does not influence answers to the control items (no design effects) and that the treatment group is randomly assigned. It is also assumed that respondents do not lie or falsely confess to the sensitive question (Aronow et al., 2015). To investigate these assumptions, we used Blair & Imai's (2010) test for design effects, and Aronow et al.'s (2015) placebo tests for truthfulness, and for whether assignment to the treatment group influences the answer to the DQ.

For each behaviour we then calculated a prevalence estimate for DQ (proportion of people admitting to behaviour) and UCT (difference in mean between treatment and control groups). Finally, we used an estimate based on UCT that also incorporates extra information from DQ answers, to produce a combined estimate that has been demonstrated to be more efficient than the standard UCT difference in means (Aronow et al., 2015). Associations between answers to each pairwise combination of DQs were calculated using chi-squared and odds ratio tests.

To estimate the prevalence of sensitive behaviour as a function of respondent characteristics, we fitted logistic regression models to the DQ response and ordinary linear models to the UCT score. Demographic variables and self-assessed knowledge score were included as potential covariates, whilst interactions of the group variable with each potential covariate were also included for UCT models. We selected, ranked and averaged the most parsimonious models (with corrected Akaike's information criterion: AICc) using the MuMin package v.1.13.4 (Barton, 2015), considering only models with interactions for the UCT. Models with ΔAICc <4 were used for final model averaging (Burnham & Anderson, 2002).

The frequency of each self-knowledge level was calculated and opinion statements were manually categorised into 'positive', 'negative' and 'neutral'.

3.4 Results

3.4.1 Pilot study

We received 409 completed pilot surveys, mainly from hobbyists (86.6%) in the UK (31.1%), USA (22.1%) and Japan (18.6%). Statement prevalence ranged from 88.0% ("I use fertiliser on my orchids") to 1.2% ("I have been growing orchids for less than one year") and 102 statement pairs showed significant negative association (see supplementary information for pilot results). Four lists were constructed with means between 1.6 and 1.9 for use in the final experiment (Table 3.1).

Table 3.1 Pilot and final results for the control list of each of the four UCTs, showing list mean and proportion of respondents giving each answer (e.g. "4 statements apply to me").

	List mean	**% '0'**	**% '1'**	**% '2'**	**% '3'**	**% '4'**
Pilot						
Smuggling	1.6	4.9	42.7	36.8	14.5	0.7
Buying online	1.8	4.7	25.0	52.2	16.7	0.7
Owning wild plants	1.9	4.7	21.3	50.0	21.3	1.5
Laundering	1.9	3.9	22.6	54.7	17.1	0.0
Final						
Smuggling	2.2	1.3	22.2	38.6	28.1	9.8
Buying online	2.1	1.4	21.3	48.5	23.0	6.0
Owning wild plants	2.3	1.2	10.8	52.8	30.1	5.1
Laundering	2.3	0.5	9.1	49.6	38.3	2.5

The control statement list for the 'laundering' UCT demonstrates the combination of low and high prevalence, and negatively and positively associated statements (Table 3.2).

Table 3.2 Matrix of statement prevalence and association between different statements used to design the control list used in the 'Laundering' UCT.

Statements	**Prevalence**	**Odds ratios (>1 = +ve association; <1 = -ve association)**			
		I own at least one field guide to wild orchids	I have never been to an orchid show	The majority of my orchids are hybrids	I use fertiliser on my orchids
I own at least one field guide to wild orchids	60.5	NA	1.1	0.4	0.9
I have never been to an orchid show	3.4	1.1	NA	0.4	0.1
The majority of my orchids are hybrids	37.3	0.4	0.4	NA	2.0
I use fertiliser on my orchids	88.0	0.9	0.1	2.0	NA

3.4.2 Main study

A total of 1,354 people started the survey, with most survey abandons occurring at the first UCT (n = 144) or the page of DQ (n = 129). We used data from respondents who completed all UCT, DQ and main demographic questions (n = 814) for the multivariate analyses, of which 56.4% (n = 459) were male and the mean age was 60.4 (See supplementary information for full sample characteristics). No UCT showed design effects. The 'buying online' UCT had significantly more males assigned to the treatment group ($p < 0.01$). The assumption of no liars or monotonicity was false in two UCTSs (Table 3.3). There was a strong positive association between answers to all pairs of DQs ($p < 0.01$ for all combinations).

Table 3.3 Results of four tests of underlying assumptions of the UCT (Aronow et al 2015). Assumptions: no design effects (presence of sensitive statement does not influence answers to control items); random assignment to treatment group; placebo test 1 (there are no liars/monotonicity); placebo test 2 (assignment to treatment group does not influence answer to DQ)

UCT	**Design Effects***	**Random Assignment**	**Placebo test 1**		**Placebo test 2**	
			Est. (SE)	**p**	**Est. (SE)**	**p**
Smuggling	0.24	Yes	1.19 (0.16)	0.23	-0.001 (0.02)	0.98
Buying online	0.11	No (gender: $p < 0.01$)	0.66 (0.16)	0.04	0.01 (0.02)	0.51
Wild plants	1	Yes	0.80 (0.08)	0.01	0.02 (0.028)	0.48
Laundering	0.23	Yes	0.61 (0.21)	0.06	0.01 (0.013)	0.39

Shading denotes significance at $p \leq 0.05$. *Bonferroni corrected minimum p-value

The DQ results found that 9.9% of the sample had smuggled, 4.8% had laundered and 10.8% had been sent orchids from an online purchase without required paperwork. UCT and combined estimates did not differ significantly (Fig. 3.1).

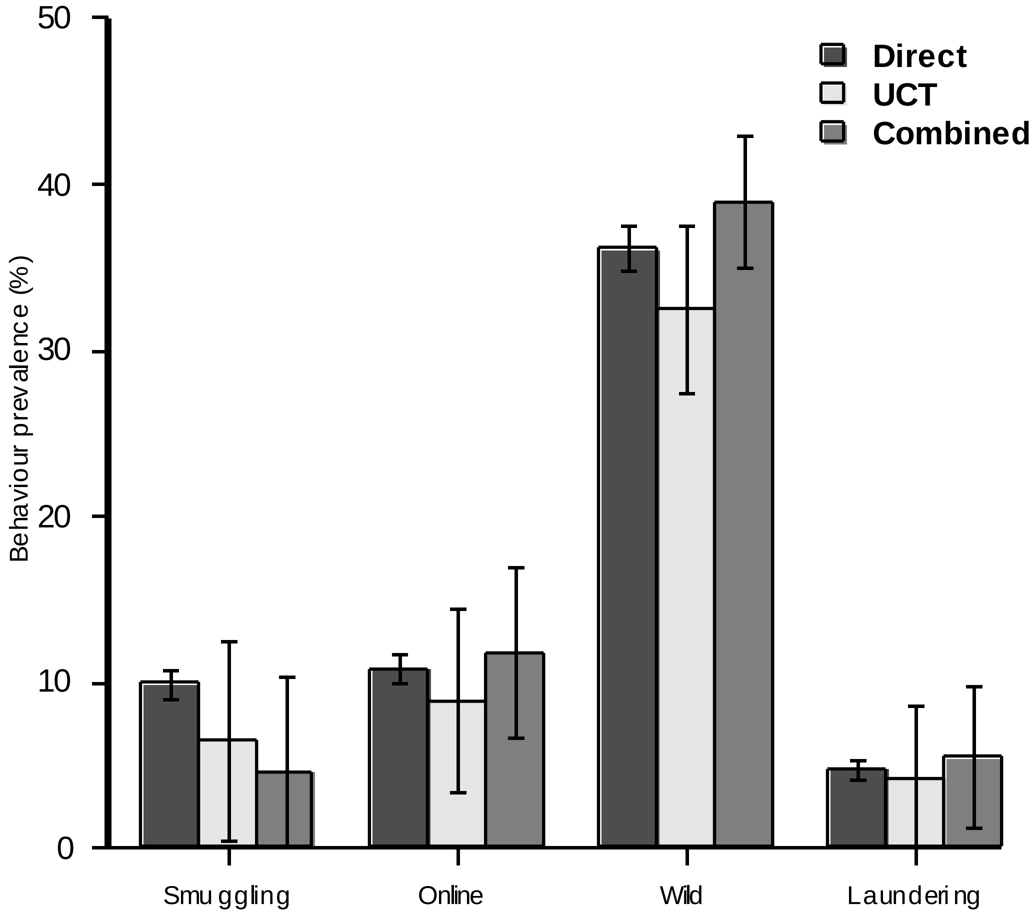

Figure 3.1 Direct Question, UCT and combined DQ-UCT prevalence estimates of all four behaviours: Smuggling plants, Receiving online purchases sent with no paperwork, owning wild collected plants and laundering orchids.

In the multivariate analysis with the exception of 'Latin America', '*Paphiopedilum'* and '*Phragmipedium'*, all covariates were found to be significant predictors of answers to at least one of the DQs (Table 3.4). The UCT produced fewer significant covariates for all behaviours than the DQ, even when confidence levels were broadened to include 90% confidence intervals (Table 3.4). Australasian respondents were more likely to admit to smuggling via DQ than the UCT.

Table 3.4 Summary effects of potential predictor variables on estimated prevalence of sensitive behaviour. Reference levels: U.S.; < median knowledge; no experience; male; < median genera; no *Phragmipedium*; non-professional; no *Paphiopedilum*; non-hobbyist; < median age (See supplementary information for relative variable importance and confidence intervals)

Covariate	Smuggling		Laundering		Buying online		Wild plants	
	DQ Est. (SE)	*UCT Est. (SE)*	*DQ Est. (SE)*	*UCT Est. (SE)*	*DQ Est. (SE)*	*UCT Est. (SE)*	*DQ Est. (SE)*	*UCT Est. (SE)*
(Intercept)	-4.13 (0.48)	2.2 (0.16)	-5.20 (0.74)	2.23 (0.08)	-4.91 (0.86)	1.73 (0.13)	-2.93 (0.52)	2.05 (0.19)
UK	0.35 (0.37)	0.15 (0.20)	0.16 (0.52)	-0.07 (0.16)	0.31 (0.39)	-0.16 (0.18)	-0.73 (0.28)	-0.37 (0.18)
EU	2.19 (0.40)	1.16 (0.30)	1.60 (0.51)	0.76 (0.23)	2.06 (0.41)	0.61 (0.27)	0.92 (0.34)	-0.47 (0.26)
Australasia	-0.46 (0.48)	0.41 (0.20)	0.55 (0.50)	0.21 (0.16)	-0.35 (0.43)	-0.13 (0.18)	0.90 (0.24)	0.54 (0.18)
L. America	-0.04 (0.60)	0.02 (0.3)	-0.39 (0.82)	0.11 (0.26)	0.02 (0.60)	-0.14 (0.30)	0.02 (0.39)	0.29 (0.30)
Other	1.54 (0.40)	0.84 (0.29)	0.88 (0.54)	0.09 (0.23)	0.88 (0.44)	0.05 (0.26)	2.24 (0.40)	-0.15 (0.25)
Knowledge	0.74 (0.28)	-0.17 (0.15)	1.12 (0.41)	-0.03 (0.11)	0.06 (0.27)	-0.16 (0.14)	0.42 (0.18)	0.20 (0.13)
Experience	1.79 (0.32)	0.18 (0.16)	1.86 (0.47)	0.01 (0.11)	1.98 (0.31)	0.13 (0.14)	0.91 (0.19)	-0.05 (0.14)
Gender	-0.42 (0.30)	0.01 (0.15)	-0.22 (0.41)	-0.07 (0.11)	-0.78 (0.31)	-0.03 (0.13)	-0.85 (0.19)	-0.04 (0.13)
No. genera	0.40 (0.31)	0.13 (0.15)	-0.35 (0.35)	-0.03 (0.11)	0.46 (0.32)	-0.09 (0.14)	0.61 (0.20)	0.25 (0.15)
Phrag*	0.28 (0.30)	NA	-0.11 (0.37)	-0.13 (0.11)	-0.13 (0.32)	-0.18 (0.15)	0.09 (0.21)	0.21 (0.14)
Professional	0.35 (0.41)	0.08 (0.25)	1.08 (0.47)	0.05 (0.18)	0.96 (0.46)	0.37 (0.23)	1.43 (0.43)	0.44 (0.22)
Paph†	0.15 (0.37)	0.03 (0.10)	-0.20 (0.40)	-0.12 (0.12)	0.52 (0.36)	-0.13 (0.15)	0.09 (0.25)	-0.06 (0.16)
Hobbyist	0.23 (0.51)	-0.00 (0.09)	0.64 (0.61)	-0.03 (0.23)	1.57 (0.68)	0.30 (0.26)	1.47 (0.47)	-0.10 (0.26)
Age	0.01 (0.27)	0.20 (0.14)	-0.07 (0.36)	-0.05 (0.11)	-0.62 (0.28)	-0.12 (0.12)	0.01 (0.18)	-0.13 (0.12)

Dark shading denotes significance at $p \leq 0.05$, lighter shading denotes significance at $0.05 \geq p \leq 0.1$. NA = not included in top models. *grow Phragmipediums or †Paphiopedilums

Self-rated knowledge scores are reported in Table 3.5. Opinions were provided by 65.0% of respondents (n = 649), of which 61.2% (n = 397) reported negative and 21.0% (n = 136) reported positive views. Of the positive statements, 14.0% (n = 19) expressed agreements with the aim of CITES but a negative view of its current application. Other positive opinions were generally short with little detail (e.g. "*Good*" or "*Adequate*") whilst negative statements were often more detailed, allowing them to be split into themes. The most common theme identified was that 'CITES hampered orchid conservation' (26.7% of negative statements) e.g. "*Orchids could be rescued when their habitat is cut down but CITES won't allow this*". Other popular themes were 'Too complicated' (21.4%), 'Too strict' (22.2%) and 'Not enforced uniformly' (18.9%). In addition, 9.3% (n = 37) of those expressing negative views alluded to the ease by which rules could be broken e.g. "*Stupid, counter-productive and generally ignored or got around".*

Table 3.5 Self-rated CITES knowledge scores reported using a Likert scale from 1: *"I have no understanding of CITES rules"* to 5: *"I have complete understanding of all CITES rules"* (n = 893).

Rating	**Frequency**	**% of total responses**
1. No understanding	165	18.5
2. Some understanding	199	22.3
3. Moderate understanding	183	20.5
4. Good understanding	244	27.3
5. Complete understanding	102	11.4

3.5 Discussion

This study represents the first in-depth investigation into CITES non-compliance amongst a specific international wildlife trading community. Understanding non-compliance with conservation rules is a priority (Solomon et al., 2015), providing information that can assist in encouraging compliance (St John et al., 2012). The degree of illegal trade in CITES-listed species has led to its efficacy being questioned (Challender & MacMillan, 2014). In addition, the illegal trade in horticultural plants is widespread but largely ignored

(Phelps & Webb, 2015). Our study was international in scope but respondents were self-selecting and many societies in Southeast Asia and Latin America did not have email lists for their members. Our sample is therefore likely to be biased towards countries with well-established networks, and growers with internet access. Whilst this bias is important to note, this sample may reflect a sector of the orchid trade that is of particular interest to conservation, as online buyers have a strong preference for rare plants (Hinsley et al., 2015).

3.5.1 Utility of the UCT method

The UCT has recently found increasing application in conservation (e.g. Nuno et al., 2013) and in face-to-face surveys has been shown to out-perform both DQs and other specialised methods such as the Randomised Response Technique (Glynn, 2013). In our comparison of DQ with UCT we found that the latter did not produce significantly higher estimates, even when confidence levels were broadened. In addition, combined estimates (Aronow et al., 2015), applied here for the first time in conservation, were slightly higher but not significantly different. Self-complete online surveys offer greater anonymity than face-to-face administration (Holbrook & Krosnick, 2010) thus possibly reducing the need for specialised questioning techniques. In our sample, widespread negative opinions of CITES may have reduced social desirability pressures to refrain from admitting to rule breaking. The ‘buying online’ and ‘wild plants’ UCTs failed assumption tests relating to honesty, suggesting respondents were not admitting to their rule-breaking or were claiming to break the rules when they had not. This further highlights the need to better understand and consider the limitations of specialised questioning techniques when designing surveys. We call for further research into how the use of these techniques can affect findings, what their limitations are, and to better define contexts in which they would be most appropriate.

3.5.2 Implications for conservation

National level compliance and cooperation with CITES have varied greatly, with several countries facing trade suspensions for enforcement failures (Reeve, 2006). This has included the EU, where enforcement is variable and trade from and via overseas territories and new member countries has been difficult to police (Reeve, 2006). Australasian respondents admitted via UCT to smuggling but not when asked directly. Whilst this may be a chance result it may also reflect Australian growers' reluctance to admit to CITES rule-breaking due to the strict enforcement of these rules for live plants in Australia (Commonwealth of Australia, 2015).

Respondents with better knowledge of CITES rules were more likely to have actively broken them, suggesting possible intent. Whilst greater knowledge of rules has been linked with higher compliance at a community level (Nkonya et al., 2008), other studies have found little effect on incidence of poaching (Kahler & Gore, 2012). Our findings may reflect the widespread negative view of CITES amongst the orchid community, who may be using rule breaking as defiance. Small-scale rule-breaking can be used as a form of protest by those who feel powerless to change laws they disagree with (Scott, 2008) and has been demonstrated in the case of wildlife poaching (Bell et al., 2007). Similarly, the respondents who expressed views that CITES is bad for conservation may be using 'neutralization', a process by which rule-breaking is justified, including by claiming that non-compliance is for the greater good (Sykes & Matza, 1957).

Professional growers are more likely than non-professionals to launder. Countries such as the UK charge for permits by genus (£74: UK Government, 2013) for plants, even orchids that have over 800 genera. This may be motivating professional growers, who are more likely to transport multiple genera, to launder plants to bypass these charges. As professionals were also more likely to own wild plants, this could represent illegal movement of wild orchids as artificially propagated plants but is also likely to include both wild and artificially propagated plants transported under the wrong names. This may be undermining the important role that CITES plays in monitoring which species are being traded and efforts should be made to review charges per genus to address this.

Finally, we found that male hobbyist growers, a group with known preferences for buying rare orchid species online (Hinsley et al., 2015), are more likely to receive plants bought online without CITES paperwork. Professional growers, who are likely to buy in higher volumes, were also more likely to have been sent a plant purchased online with no permits. Online wildlife trade is growing and hard to control (Lavorgna, 2014), and threatened wild plants can now be found for sale on a variety of online platforms (Shirey et al., 2013). Our findings highlight the potential for growers with a demand for rare species to bypass current rules, and reinforces calls for better monitoring of online plant trade (Sajeva et al., 2013).

We found positive associations between all DQ answers, suggesting that rule breaking was not widespread within the community but that the same people were more likely to break several rules. This supports previous findings of distinct subgroups within the orchid community who may be involved in the illegal trade (Hinsley et al., 2015).

Our results demonstrate that some orchid growers break CITES rules and do not see this non-compliance as sensitive or socially undesirable. Deliberate non-compliance and widespread negative views of CITES likely reflects disengagement and distrust, which the conservation community should take seriously. Many countries do not have the capacity to enforce wildlife trade legislation, and orchids are often a low priority, despite making up the majority of all CITES-listed species. The best chance of effectively controlling the trade may therefore be to engage with the orchid community to raise awareness of the need for trade rules. Whilst they may be initially unwilling, encouraging traders and growers to become involved as key stakeholders in discussions on how the rules could be improved may increase compliance and trust, and strengthen legal businesses.

3.6 Supplementary Information

3.6.1 Pilot survey (English version)

To design a new experiment I am trying to find out about people in the orchid community. Please read carefully and <u>tick all statements that apply to you</u>

- ☐ I have bought orchids on an online auction website (e.g. EBay)
- ☐ I am a member of a Facebook orchid group
- ☐ I have at least one *Phalaenopsis* in my collection
- ☐ I estimate that I currently have more than 50 orchid plants
- ☐ I specialise in growing fewer than 5 orchid genera
- ☐ I have a subscription to an orchid magazine or journal
- ☐ I have fewer than five species plants in my collection
- ☐ I have grown a *Paphiopedilum* from seed to flowering size
- ☐ I have fewer than five hybrid plants in my collection
- ☐ I am a member of an online orchid forum/message board
- ☐ I have been growing orchids for less than one year
- ☐ I own at least one field guide to wild orchids
- ☐ I have been a member of an orchid society for more than a year
- ☐ I have submitted a plant for judging at an orchid show
- ☐ I am, or am training to be, an orchid show judge
- ☐ The majority of my orchids are hybrids
- ☐ I raise my own orchids from seed
- ☐ I collect antiquarian orchid books
- ☐ I have won an award for one of my plants
- ☐ I grow other plants as well as orchids
- ☐ I have never bought orchids at an orchid show
- ☐ I have never bought orchids online
- ☐ I have seen orchids growing in the wild
- ☐ I produce my own hybrids
- ☐ I have a species collection
- ☐ I use fertiliser on my orchids
- ☐ I have never been to an orchid show
- ☐ I specialise in growing *Bulbophyllum*
- ☐ I have a generalist orchid collection

About you Country of residence_______________

- ☐ hobbyist
- ☐ professional grower
- ☐ one or two orchids as houseplants

3.6.2 Full survey

Page 1

Studying orchid growing around the world

Welcome to this survey

This experiment forms part of research at the University of Kent into the international orchid industry. We have designed this short set of questions to find out more about the orchid trade, particularly how orchid hobbyists interact with CITES.

All answers given will be anonymous and the final results will use a summary of all responses rather than individual answers. By continuing you are agreeing to take part in this study. The survey consists of only four main questions plus some follow-on questions to improve our understanding of the answers. We would be very grateful if you could answer all questions, which will take about 5-7 minutes. Questions marked with an asterisk (*) are required in order to move to the next page.

1) So that we can tailor the questions to suit you, please tell us which country (or territory) you live in. The survey is also available in several other languages, please click the bar marked 'Select Language' above to change the language.*

2) Please also select all categories that apply to you*

- [ ] Hobbyist
- [ ] Professional orchid grower
- [ ] Windowsill orchid grower/one or two orchids as houseplants
- [ ] I do not grow orchids, either professionally or as a hobby.

Page 2 Please read the following statements and tell us how many are true for you. You do not need to tell us which statements are true for you, just the total number.

Action: Percent Branch: 50% [50% of respondents see List 1, 50% see List 2]

List 1: Control

a) I have never bought orchids at an orchid show
b) I am a member of a Facebook orchid group
c) I have a species collection
d) I have been a member of an orchid society for more than a year

List 2: Treatment

a) I have never bought orchids at an orchid show
b) I am a member of a Facebook orchid group
c) I have personally sent or carried an orchid across an international border without obtaining the required CITES paperwork
d) I have a species collection
e) I have been a member of an orchid society for more than a year

4) How many of these statements are true for you?*

<drop – down menu of 0,1,2,3,4,5>

Page 3 Please read the following statements and tell us how many are true for you. You do not need to tell us which statements are true for you, just the total number.

Action: Percent Branch: 50% [50% of respondents see List 1, 50% see List 2]

List 1: Control

a) I specialise in growing Bulbophyllums
b) I have seen orchids growing in the wild
c) I raise my own orchids from seed
d) I grow other plants as well as orchids

List 2: Treatment

a) I specialise in growing Bulbophyllums
b) I have seen orchids growing in the wild
c) I have bought an orchid online that was sent to me without the correct or required CITES paperwork
d) I raise my own orchids from seed
e) I grow other plants as well as orchids

6) How many of these statements are true for you?*

<drop – down menu of 0,1,2,3,4,5>

Page 4: Please read the following statements and tell us how many are true for you. You do not need to tell us which statements are true for you, just the total number.

Action: Percent Branch: 50% [50% of respondents see List 1, 50% see List 2]

List 1: Control

a) I have at least one *Phalaenopsis* in my collection
b) I specialise in growing fewer than 5 orchid genera
c) I estimate that I currently have more than 50 orchid plants
d) I have never bought orchids online

List 2: Treatment

a) I have at least one *Phalaenopsis* in my collection
b) I have an orchid in my collection that I know or strongly suspect was wild-collected
c) I specialise in growing fewer than 5 orchid genera
d) I estimate that I currently have more than 50 orchid plants
e) I have never bought orchids online

8) How many of these statements are true for you?*

<drop – down menu of 0,1,2,3,4,5>

Page 5. Please read the following statements and tell us how many are true for you. You do not need to tell us which statements are true for you, just the total number.

Action: Percent Branch: 50% [50% of respondents see List 1, 50% see List 2]

List 1: Control

a) I own at least one field guide to wild orchids
b) The majority of my orchids are hybrids
c) I use fertiliser on my orchids
d) I have never been to an orchid show

List 2: Treatment

a) I own at least one field guide to wild orchids
b) I have personally carried or sent an orchid across an international border using the wrong CITES paperwork for that plant (e.g. paperwork for a different species)
c) The majority of my orchids are hybrids

d) I use fertiliser on my orchids e) I have never been to an orchid show

10) How many of these statements are true for you?*

[drop – down menu of 0,1,2,3,4,5]

Please answer 'true' or 'false' to the following statements. These answers will be anonymous, so please answer honestly.

11) I have an orchid in my collection that I know or strongly suspect was wild-collected.

○ True ○ False

12) I have personally carried or sent an orchid across an international border using the wrong CITES paperwork for that plant (e.g. paperwork for a different species)

○ True ○ False

13) I have personally carried or sent an orchid across an international border without obtaining CITES paperwork, even though it was required

○ True ○ False

14) I have bought an orchid online that was sent to me without the correct or required CITES paperwork

○ True ○ False

---

15) Please rate your current understanding of the CITES rules for orchids:

○ No understanding ◉ Some understanding ○ Moderate understanding ○ Good understanding ○ Complete understanding

16) To find out about your experiences with CITES, please tell us which of the following apply to you: *(EU growers please answer for export/import/re-export outside EU)

- [ ] I have imported orchids into my country (e.g. bought orchids online or in person from another country)
- [ ] I have exported orchids from my country
- [ ] I have re-exported orchids from my country
- [ ] All of the above
- [ ] None of the above

17) What is your opinion of the current CITES rules for orchids?

<open text box>

Final page: More about you and your orchids.

Finally, so that we learn more about how answers may differ between different groups within the orchid community, please answer the following questions, let us know if you have any comments or questions about this experiment, and then press submit.

18) Which orchids do you currently have? Please tick all that apply.

- [ ] Oncidium
- [ ] Paphiopedilum
- [ ] Vanda
- [ ] Dendrobium
- [ ] Phalaenopsis
- [ ] Hardy orchids
- [ ] Phragmipedium
- [ ] Pleurothallids (Masdevallia, Dracula etc.)

☐ Cattleya ☐ Bulbophyllum

☐ Cymbidium

☐ Other - please list any others: [ ]

19) Are you:

○ Male ○ Female

20) In what year were you born?

25) Do you have any comments or questions about this experiment?

<open text box>

26) If you would like to be sent a summary of results when they are analysed, please enter your email address here. Addresses will be kept in a separate database and will not be linked to survey answers.

Thank you for taking our survey. This research is being carried out at the University of Kent in the UK, please visit the University website for more information.

3.6.3 Pilot results

Table S3.1 All pilot survey prevalence results

Statement	Prevalence
I use fertiliser on my orchids	88.0
I have been a member of an orchid society for more than a year	81.6
I grow other plants as well as orchids	81.1
I have seen orchids growing in the wild	79.2
I have at least one *Phalaenopsis* in my collection	77.9
I estimate that I currently have more than 50 orchid plants	69.9
I own at least one field guide to wild orchids	60.5
I have a generalist orchid collection	53.4
I have submitted a plant for judging at an orchid show	53.4
I have a subscription to an orchid magazine or journal	51.5
I have won an award for one of my plants	45.3
I have a species collection	40.7
The majority of my orchids are hybrids	37.3
I have never bought orchids online	33.8
I am a member of an online orchid forum/message board	33.3
I am a member of a Facebook orchid group	32.8
I raise my own orchids from seed	18.9
I am, or am training to be, an orchid show judge	17.9
I produce my own hybrids	14.5
I have fewer than five species plants in my collection	13.7
I specialise in growing fewer than 5 orchid genera	12.0
I collect antiquarian orchid books	12.0
I have never bought orchids at an orchid show	8.3
I have fewer than five hybrid plants in my collection	8.1
I have grown a *Paphiopedilum* from seed to flowering size	7.4
I specialise in growing Bulbophyllums	4.7
I have never been to an orchid show	3.4
I have been growing orchids for less than one year	1.2

3.6.4 Descriptive summary of variables

Table S3.2 Descriptive summary tables.* question was required to move to the next page of the survey. All others could be skipped but were not marked as optional.

Continuous variables				
Variables	**Unit**	**Median**	**SD**	**Missing Data (%)**
Age	Years	63		18.2
Categorical variables				
Variables	**Level**	**Count**	**%**	**Missing Data (%)**
Gender	Male	550	47.6	16.5
	Female	415	35.9	
Type of grower*	Professional	132	11.4	0
	Hobbyist	1019	88.2	
	Casual Grower	105	9.1	
	Do not grow	8	0.7	
Country* (Existing list of all recognised countries provided with SurveyGizmo software. Only those with at least 1 respondent included here)	USA	534	46.2	0
	UK	201	17.4	
	Australia	151	13.1	
	EU (exc. UK)	70	6.1	
	Caribbean	39	3.4	
	South Africa	34	2.9	
	Canada	29	2.5	
	Japan	21	1.8	
	Colombia	19	1.6	

	Peru	14	1.2	
	Brazil	9	0.8	
	New Zealand	9	0.8	
	Argentina	3	0.3	
	Costa Rica	3	0.3	
	Ecuador	3	0.3	
	Switzerland	3	0.3	
	Indonesia	2	0.2	
	Malaysia	2	0.2	
	Venezuela	2	0.2	
	Brunei	1	0.1	
	Guatemala	1	0.1	
	Israel	1	0.1	
	Mexico	1	0.1	
	Taiwan	1	0.1	
	Ukraine	1	0.1	
	Vietnam	1	0.1	
Language*	German	11	1.0	0
	English	1019	88.2	
	Spanish	91	7.9	
	Japanese	20	1.7	
	Malay	0	0.0	
	Indonesian	1	0.1	
	French	11	1.0	
Which orchids do you grow?	Oncidium	724	62.7	16.2

	Vanda	584	50.6	
	Phalaenopsis	828	71.7	
	Phragmipedium	454	39.3	
	Paphiopedilum	672	58.2	
	Dendrobium	822	71.2	
	Hardy orchids	366	31.7	
	Pleurothallids	433	37.5	
	Cattleya	796	68.9	
	Cymbidium	621	53.8	
	Bulbophyllum	532	46.1	
	unsure	68	5.9	
	Other	376	32.6	
What experience do you have with CITES?	Import	332	28.7	21.6
	Export	70	6.1	
	Re-export	24	2.1	
	None	563	48.7	
How would you rate your knowledge of CITES?	None	164	14.2	23.3
	Some	196	17.0	
	Moderate	183	15.8	
	Good	244	21.1	
	Complete	100	8.7	
What are your opinions of the current CITES rules for orchids? (open text question manually categorised)	Positive	136	21.0	43.8
	Negative	397	61.2	
	Don't know/Neutral	116	17.9	

3.7.5 Summary effects tables for each sensitive statement, including confidence intervals. For all: Reference levels: U.S.; below median knowledge; no experience; male; below median genera; no Phragmipedium; non-professional; no Paphiopedilum; not a hobbyist; below median age

Table S3.3 Summary effects of potential predictor variables on estimated prevalence of smuggling (with confidence intervals).)

		Estimate	SE	Lower confidence interval (95%)	Upper confidence interval (95%)	Significance (*** =0; ** = 0.001; * = 0.01; . = 0.05)	Relative variable importance
DQ	(Intercept)	-4.13	0.48	-4.61	-3.65	***	
	UK	0.35	0.37	-0.02	0.72		1.00
	EU	2.19	0.40	1.80	2.59	***	1.00
	Australasia	-0.46	0.48	-0.94	0.02		1.00
	L. America	-0.04	0.60	-0.64	0.55		1.00
	Other	1.54	0.40	1.14	1.94	***	1.00
	Knowledge	0.74	0.28	0.46	1.02	**	1
	Experience	1.79	0.32	1.48	2.11	***	1
	Professional	0.35	0.41	-0.06	0.76		0
	Hobbyist	0.23	0.51	-0.28	0.74		0.21
	No. genera	0.40	0.31	0.09	0.71		0.44
	Gender	-0.42	0.30	-0.72	-0.12		0.49
	Paph	0.15	0.37	-0.21	0.52		0.21
	Phrag	0.28	0.30	-0.02	0.57		0.32
	Age	0.01	0.27	-0.26	0.29		0.16
UCT							
	(Intercept)	2.20	0.16	2.04	2.36	***	
	UK	0.15	0.20	-0.05	0.35		1.00
	EU	1.16	0.30	0.86	1.47	***	1.00
	Australasia	0.41	0.20	0.21	0.61	*	1.00
	L. America	0.02	0.33	-0.32	0.35		1.00
	Other	0.84	0.29	0.55	1.13	**	1.00
	Knowledge	-0.17	0.15	-0.33	-0.02		1.00
	Experience	0.18	0.16	0.03	0.34		0.94
	Professional	0.08	0.25	-0.17	0.32		0.64
	Hobbyist	-0.03	0.29	-0.32	0.26		0.11
	No. genera	0.13	0.15	-0.02	0.28		1.00
	Gender	0.01	0.15	-0.14	0.16		0.87
	Paph	0.20	0.18	0.03	0.38		0.14
	Phrag	NA	NA	NA	NA	NA	NA
	Age	0.20	0.14	0.06	0.33		1.00

Table S3.4 Summary effects of potential predictor variables on estimated prevalence of laundering (with confidence intervals).

		Estimate	SE	Lower confidence interval (95%)	Upper confidence interval (95%)	Significance (*** =0; ** = 0.001; * = 0.01; . = 0.05)	Relative variable importance
	(Intercept)	-5.20	0.74	-5.94	-4.46	***	
DQ	UK	0.16	0.52	-0.36	0.67		0.75
	EU	1.60	0.51	1.09	2.12	**	0.75
	Australasia	0.55	0.50	0.05	1.05		0.75
	L. America	-0.39	0.82	-1.21	0.43		0.75
	Other	0.88	0.54	0.34	1.41		0.75
	Knowledge	1.12	0.41	0.72	1.53	**	1.00
	Experience	1.86	0.47	1.38	2.33	***	1.00
	Professional	1.08	0.47	0.60	1.55	*	1.00
	Hobbyist	0.64	0.61	0.02	1.25		0.27
	No. genera	-0.35	0.35	-0.70	0.00		0.28
	Gender	-0.22	0.41	-0.63	0.19		0.19
	Paph	-0.20	0.40	-0.61	0.20		0.17
	Phrag	-0.11	0.37	-0.47	0.26		0.16
	Age	-0.07	0.36	-0.43	0.30		0.17
UCT							
	(Intercept)	2.23	0.08	2.14	2.31	***	
	UK	-0.07	0.16	-0.23	0.09		1.00
	EU	0.76	0.23	0.52	0.99	**	1.00
	Australasia	0.21	0.16	0.05	0.37		1.00
	L. America	0.11	0.26	-0.15	0.38		1.00
	Other	0.09	0.23	-0.15	0.32		1.00
	Knowledge	-0.03	0.11	-0.14	0.08		0.12
	Experience	0.01	0.11	-0.10	0.13		0.38
	Professional	0.05	0.18	-0.13	0.23		0.93
	Hobbyist	-0.03	0.23	-0.26	0.20		0.03
	No. genera	-0.03	0.11	-0.14	0.07		0.07
	Gender	-0.07	0.11	-0.18	0.04		0.09
	Paph	-0.12	0.12	-0.24	-0.01		0.26
	Phrag	-0.13	0.11	-0.24	-0.03		0.09
	Age	-0.05	0.11	-0.16	0.06		0.10

Table S3.5 Summary effects of potential predictor variables on estimated prevalence of buying online with no paperwork (with confidence intervals).

		Estimate	SE	Lower confidence interval (95%)	Upper confidence interval (95%)	Significance (*** =0; ** = 0.001; * = 0.01; . = 0.05)	Relative variable importance
DQ	(Intercept)	-4.91	0.86	-5.76	-4.05	***	
	UK	0.31	0.39	-0.08	0.70		1.00
	EU	2.06	0.41	1.65	2.47	***	0.78
	Australasia	-0.35	0.43	-0.78	0.08		1.00
	L. America	0.02	0.60	-0.58	0.63		0.78
	Other	0.88	0.44	0.44	1.32	*	0.78
	Knowledge	0.06	0.27	-0.21	0.33		0.21
	Experience	1.98	0.31	1.67	2.28	***	1.00
	Professional	0.96	0.46	0.50	1.42	*	0.78
	Hobbyist	1.57	0.68	0.89	2.26	*	0.78
	No. genera	0.46	0.32	0.14	0.79		0.50
	Gender	-0.78	0.31	-1.09	-0.47	*	0.78
	Paph	0.52	0.36	0.15	0.88		0.50
	Phrag	-0.13	0.32	-0.44	0.19		0.24
	Age	-0.65	0.28	-0.93	-0.37	*	0.95
UCT							
	(Intercept)	1.73	0.13	1.60	1.87	***	
	UK	-0.16	0.18	-0.34	0.02		1.00
	EU	0.61	0.27	0.34	0.88	*	1.00
	Australasia	-0.13	0.18	-0.31	0.05		1.00
	L. America	-0.14	0.30	-0.43	0.16		1.00
	Other	0.05	0.26	-0.21	0.30		1.00
	Knowledge	-0.16	0.14	-0.30	-0.02		1.00
	Experience	0.13	0.14	-0.01	0.27		1.00
	Professional	0.37	0.23	0.14	0.60		1.00
	Hobbyist	0.30	0.26	0.04	0.56		0.16
	No. genera	-0.09	0.14	-0.23	0.05		0.89
	Gender	-0.03	0.13	-0.17	0.10		1.00
	Paph	-0.13	0.15	-0.27	0.02		0.19
	Phrag	-0.18	0.15	-0.33	-0.03		0.20
	Age	-0.12	0.12	-0.24	0.01		0.13

Table S3.6 Summary effects of potential predictor variables on estimated prevalence of owning wild plants (with confidence intervals).

		Estimate	SE	Lower confidence interval (95%)	Upper confidence interval (95%)	Significance (*** =0; ** = 0.001; * = 0.01; . = 0.05)	Relative variable importance
DQ	(Intercept)	-2.93	0.52	-3.45	-2.41	***	
	UK	-0.73	0.28	-1.01	-0.45	**	0.78
	EU	0.92	0.34	0.57	1.26	**	0.78
	Australasia	0.90	0.24	0.66	1.14	***	0.78
	L. America	0.02	0.39	-0.37	0.41		0.78
	Other	2.24	0.40	1.85	2.64	***	0.78
	Knowledge	0.42	0.18	0.23	0.60	*	0.92
	Experience	0.91	0.19	0.72	1.10	***	0.78
	Professional	1.43	0.43	1.01	1.86	***	0.78
	Hobbyist	1.47	0.47	1.00	1.94	**	0.78
	No. genera	0.61	0.20	0.41	0.81	**	0.78
	Gender	-0.85	0.19	-1.04	-0.66	***	0.78
	Paph	0.09	0.25	-0.16	0.33		0.24
	Phrag	0.09	0.21	-0.12	0.29		0.24
	Age	0.01	0.18	-0.16	0.19		0.23
UCT							
	(Intercept)	2.05	0.19	1.86	2.25	***	
	UK	-0.37	0.18	-0.55	-0.19	*	1.00
	EU	-0.47	0.26	-0.72	-0.21	.	1.00
	Australasia	0.54	0.18	0.36	0.72	**	1.00
	L. America	0.29	0.30	-0.01	0.59		1.00
	Other	-0.15	0.25	-0.40	0.10		1.00
	Knowledge	0.20	0.13	0.07	0.32		0.66
	Experience	-0.05	0.14	-0.19	0.09		0.06
	Professional	0.44	0.22	0.22	0.67	*	1.00
	Hobbyist	-0.10	0.26	-0.36	0.15		0.27
	No. genera	0.25	0.15	0.10	0.40	.	0.30
	Gender	-0.04	0.13	-0.16	0.09		0.96
	Paph	-0.06	0.16	-0.22	0.09		0.96
	Phrag	0.21	0.14	0.07	0.35		0.16
	Age	-0.13	0.12	-0.25	-0.01	.	0.42

3.6.5 Full model importance results for all direct questions

Table S3.7 Full model importance results for the smuggling direct question df: degrees of freedom; LL: log likelihood; AICc: corrected AIC: DAICc: ΔAIC: AICw: AIC weight.

Model	df	LL	AICc	DAICc	AICw	Country	Knowledge	Exp	Pro	Hobbyist	Genera	Gender	Paph	Phrag	Age
1	10	-212.9	446.08	0	0.05	x	x	x			x	x			
2	9	-214	446.22	0.15	0.05	x	x	x			x				
3	8	-215.11	446.4	0.33	0.05	x	x	x							
4	9	-214.11	446.45	0.37	0.04	x	x	x				x			
5	9	-214.27	446.76	0.68	0.04	x	x	x						x	
6	10	-213.27	446.8	0.73	0.04	x	x	x				x		x	
7	10	-213.62	447.52	1.44	0.03	x	x	x	x		x				
8	11	-212.62	447.57	1.5	0.03	x	x	x	x		x	x			
9	9	-214.7	447.62	1.54	0.02	x	x	x					x		
10	10	-213.69	447.64	1.57	0.02	x	x	x				x	x		
11	9	-214.79	447.8	1.72	0.02	x	x	x	x						
12	11	-212.74	447.81	1.73	0.02	x	x	x			x	x		x	
13	10	-213.82	447.92	1.84	0.02	x	x	x			x			x	
14	10	-213.88	448.04	1.96	0.02	x	x	x	x			x			
15	11	-212.9	448.13	2.05	2.00E-02	x	x	x		x	x	x			
16	11	-212.9	448.13	2.05	0.02	x	x	x			x	x			x
17	11	-212.9	448.13	2.06	0.02	x	x	x			x	x	x		
18	10	-213.99	448.26	2.18	0.02	x	x	x	x					x	
19	10	-214	448.27	2.19	0.02	x	x	x			x				x
20	10	-214	448.27	2.19	0.02	x	x	x			x		x		

21	10	-214	448.27	2.19	0.02	x	x	x		x	x				
22	9	-215.11	448.44	2.36	0.02	x	x	x		x					
23	9	-215.11	448.45	2.37	0.02	x	x	x							x
24	10	-214.1	448.47	2.39	0.02	x	x	x		x		x			
25	11	-213.08	448.48	2.41	0.02	x	x	x	x			x		x	
26	10	-214.11	448.49	2.42	0.02	x	x	x				x			x
27	11	-213.13	448.6	2.52	0.02	x	x	x	x	x	x				
28	10	-214.24	448.75	2.67	0.01	x	x	x					x	x	
29	10	-214.25	448.77	2.7	0.01	x	x	x	x	x					
30	12	-212.19	448.77	2.7	0.01	x	x	x	x	x	x	x			
31	11	-213.23	448.79	2.71	0.01	x	x	x				x	x	x	
32	10	-214.26	448.8	2.72	0.01	x	x	x		x				x	
33	10	-214.27	448.81	2.73	0.01	x	x	x						x	
34	11	-213.25	448.84	2.76	0.01	x	x	x		x		x		x	
35	11	-213.26	448.86	2.78	0.01	x	x	x				x		x	x
36	10	-214.37	449.02	2.94	0.01	x	x	x	x				x		
37	11	-213.4	449.13	3.06	0.01	x	x	x	x	x		x			
38	11	-213.45	449.24	3.16	0.01	x	x	x	x			x	x		
39	11	-213.48	449.3	3.22	0.01	x	x	x	x		x			x	
40	12	-212.49	449.38	3.3	0.01	x	x	x	x		x	x		x	
41	11	-213.53	449.39	3.31	0.01	x	x	x	x	x				x	
42	11	-213.62	449.57	3.49	0.01	x			x		x				x
43	11	-213.62	449.57	3.5	0.01	x	x	x	x		x		x		
44	12	-212.62	449.63	3.55	0.01	x	x	x	x		x	x			x

45	12	-212.62	449.63	3.56	0.01	x	x	x	x		x	x	x		
46	10	-214.69	449.65	3.58	0.01	x	x	x		x			x		
47	10	-214.7	449.66	3.59	0.01	x	x	x					x		x
48	11	-213.67	449.67	3.59	0.01	x	x	x		x		x	x		
49	11	-213.69	449.7	3.62	0.01	x	x	x				x	x		x
50	12	-212.67	449.73	3.65	0.01	x	x	x	x	x		x		x	
51	12	-212.72	449.82	3.75	0.01	x	x	x			x	x	x	x	
52	10	-214.79	449.85	3.77	0.01	x	x	x	x						x
53	12	-212.74	449.86	3.79	0.01	x	x	x		x	x	x		x	
54	12	-212.74	449.87	3.79	0.01	x	x	x			x	x		x	x
55	11	-213.8	449.94	3.86	0.01	x	x	x	x	x			x		
56	11	-213.8	449.94	3.86	0.01	x	x	x			x		x	x	
57	11	-213.82	449.97	3.89	0.01	x	x	x		x	x			x	
58	11	-213.82	449.97	3.89	0.01	x	x	x			x			x	x

Table S3.8 Full model importance results for the laundering direct question df: degrees of freedom; LL: log likelihood; AICc: corrected AIC: DAICc: ΔAIC: AICw: AIC weight.

Model	df	LL	AICc	DAICc	AICw	Country	Knowledge	Experience	Professional	Hobbyist	Genera	Gender	Paph	Phrag	Age
1	9	-136.82	291.85	0	0.11	x	x	x	x						
2	10	-136.27	292.81	0.95	0.07	x	x	x	x	x					
3	10	-136.36	292.99	1.14	0.06	x	x	x	x		x				
4	4	-142.58	293.21	1.35	0.05		x	x	x						
5	10	-136.64	293.55	1.69	0.05	x	x	x	x			x			
6	10	-136.64	293.55	1.69	0.05	x	x	x	x				x		
7	10	-136.75	293.77	1.92	0.04	x	x	x	x					x	
8	11	-135.76	293.85	2	0.04	x	x	x	x	x	x				
9	10	-136.81	293.9	2.05	0.04	x	x	x	x						x
10	5	-141.93	293.94	2.08	0.04		x	x	x		x				
11	5	-142.18	294.44	2.58	0.03		x	x	x	x					
12	11	-136.1	294.54	2.68	0.03	x	x	x	x	x			x		
13	11	-136.11	294.55	2.70E+00	0.03	x	x	x	x	x		x			
14	11	-136.17	294.67	2.82	0.03	x	x	x	x	x				x	
15	5	-142.3	294.68	2.83	0.03		x	x	x						x
16	5	-142.34	294.75	2.9	0.02		x	x	x					x	
17	11	-136.22	294.78	2.92	0.02	x	x	x	x		x	x			
18	5	-142.36	294.79	2.93	0.02		x	x	x				x		
19	11	-136.27	294.86	3.01	0.02	x	x	x	x	x					x
20	6	-141.45	295.01	3.15	0.02		x	x	x	x	x				

21	**11**	**-136.34**	**295.01**	**3.16**	**0.02**	**x**	**x**	**x**	**x**		**x**			**x**	
22	**11**	**-136.36**	**295.05**	**3.19**	**0.02**	**x**	**x**	**x**	**x**		**x**				**x**
23	**11**	**-136.36**	**295.05**	**3.19**	**0.02**	**x**	**x**	**x**	**x**		**x**		**x**		
24	**5**	**-142.53**	**295.13**	**3.27**	**0.02**		**x**	**x**	**x**			**x**			
25	**11**	**-136.47**	**295.27**	**3.42**	**0.02**	**x**	**x**	**x**	**x**			**x**	**x**		
26	**6**	**-141.66**	**295.43**	**3.58**	**0.02**		**x**	**x**	**x**		**x**				**x**
27	**11**	**-136.58**	**295.49**	**3.64**	**0.02**	**x**	**x**	**x**	**x**			**x**		**x**	
28	**11**	**-136.64**	**295.6**	**3.75**	**0.02**	**x**	**x**	**x**	**x**			**x**			**x**
29	**11**	**-136.64**	**295.6**	**3.75**	**0.02**	**x**	**x**	**x**	**x**				**x**	**x**	
30	**11**	**-136.64**	**295.6**	**3.75**	**0.02**	**x**	**x**	**x**	**x**				**x**		**x**
31	**12**	**-135.65**	**295.69**	**3.83**	**0.02**	**x**	**x**	**x**	**x**	**x**	**x**	**x**			
32	**11**	**-136.75**	**295.83**	**3.97**	**0.01**	**x**	**x**	**x**	**x**					**x**	**x**

Table S3.9 Full model importance results for the 'buying online' direct question df: degrees of freedom; LL: log likelihood; AICc: corrected AIC: DAICc: ΔAIC: AICw: AIC weight.

Model	df	LL	AICc	DAICc	AICw	Country	Knowledge	Experience	Pro	Hobbyist	Genera	Gender	Paph	Phrag	Age
1	12	-213.92	452.24	0	0.13	x		x	x	x		x	x		x
2	12	-213.95	452.28	0.05	0.13	x		x	x	x	x	x			x
3	13	-213.53	453.52	1.28	0.07	x		x	x	x	x	x	x		x
4	11	-215.62	453.56	1.32	0.07	x		x	x	x		x			x
5	13	-213.78	454.02	1.78	0.05	x		x	x	x		x	x	x	x
6	11	-215.89	454.11	1.87	0.05	x		x		x	x	x			x
7	13	-213.83	454.11	1.87	0.05	x		x	x	x	x	x		x	x
8	11	-215.93	454.2	1.96	0.05	x		x		x		x	x		x
9	13	-213.9	454.26	2.02	0.05	x	x	x	x	x		x	x		x
10	13	-213.94	454.33	2.09	0.05	x	x	x	x	x	x	x			x
11	14	-213.19	454.9	2.66	0.03	x		x	x	x	x	x	x	x	x
12	12	-215.48	455.35	3.11	0.03	x		x	x	x				x	x
13	10	-217.54	455.35	3.11	0.03	x		x		x		x			x
14	12	-215.52	455.43	3.19	0.03	x		x		x	x	x	x		x
15	12	-215.57	455.52	3.28	0.02	x	x	x	x	x		x			x
16	11	-216.62	455.56	3.33	0.02	x		x	x	x	x	x			
17	14	-213.52	455.57	3.33	0.02	x	x	x	x	x	x	x	x		x
18	11	-216.75	455.84	3.6	0.02	x		x	x	x		x	x		
19	14	-213.75	456.02	3.79	0.02	x	x	x	x	x		x	x	x	x

20	**12**	**-215.84**	**456.06**	**3.83**	**0.02**	**x**		**x**		**x**	**x**	**x**		**x**	**x**
21	**12**	**-215.86**	**456.11**	**3.87**	**0.02**	**x**	**x**	**x**		**x**	**x**	**x**			**x**
22	**14**	**-213.81**	**456.14**	**3.91**	**0.02**	**x**	**x**	**x**	**x**	**x**	**x**	**x**		**x**	**x**
23	**12**	**-215.88**	**456.15**	**3.92**	**0.02**	**x**		**x**		**x**		**x**	**x**	**x**	**x**
24	**12**	**-215.89**	**456.17**	**3.93**	**0.02**	**x**	**x**	**x**		**x**		**x**	**x**		**x**

Table S3.10 Full model importance results for the 'owning wild plants' direct question df: degrees of freedom; LL: log likelihood; AICc: corrected AIC: DAICc: ΔAIC: AICw: AIC weight.

Model	df	LL	AICc	DAICc	AICw	Country	Knowledge	Exp	Pro	Hobbyist	Genera	Gender	Paph	Phrag	Age
1	12	-425.73	875.85	0	0.36	x	x	x	x	x	x	x			
2	13	-425.63	877.72	1.87	0.14	x	x	x	x	x	x	x		x	
3	13	-425.66	877.77	1.93	0.14	x	x	x	x	x	x	x	x		
4	13	-425.72	877.9	2.06	0.13	x	x	x	x	x	x	x			x
5	11	-428.26	878.86	3.01	0.08	x		x	x	x	x	x			
6	14	-425.6	879.72	3.88	0.05	x	x	x	x	x	x	x	x	x	
7	14	-425.63	879.78	3.94	0.05	x	x	x	x	x	x	x		x	x
8	14	-425.66	879.84	3.99	0.05	x	x	x	x	x	x	x	x		x

3.6.6 *Full model importance results for all UCT questions*

Table S3.11 Full model importance table for the smuggling UCT. Key: 1: age; 2: country; 3: knowledge; 4: experience; 5:gender; 6:genera; 7:hobbyist; 8:paph; 9:phrag; 10: pro; 11: sensitive; 12: age + sensitive; 13: country + sensitive; 14: knowledge + sensitive; 15: experience + sensitive; 16: gender + sensitive; 17: genera + sensitive; 18: hobbyist + sensitive; 19: paph + sensitive; 20: phrag + sensitive; 21: pro + sensitive.

Model	df	LL	AICc	DAICc	AICw	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
12	25	-1084.64	2220.92	0	0.31	x	x	x	x	x	x			x	x	x	x	x	x	x	x			x		
3	23	-1086.98	2221.36	0.44	0.25	x	x	x	x	x	x				x	x	x	x	x	x	x					
4	27	-1083.59	2223.1	2.18	0.11	x	x	x	x	x	x	x		x	x	x	x	x	x	x	x	x		x		
5	23	-1088.03	2223.45	2.53	0.09	x	x	x	x		x			x	x	x	x	x	x		x			x		
6	27	-1083.95	2223.82	2.9	0.07	x	x	x	x	x	x		x	x	x	x	x	x	x	x	x		x	x		
7	25	-1086.25	2224.15	3.23	0.06	x	x	x	x	x	x		x		x	x	x	x	x	x	x		x			
8	23	-1088.4	2224.21	3.29	0.06	x	x	x		x	x			x	x	x	x	x		x	x			x		
9	21	-1090.87	2224.92	4	0.04	x	x	x	x		x				x	x	x	x	x		x					

Table S3.12 Full model importance tables for the laundering UCT. Key: 1: age; 2: country; 3: knowledge; 4: experience; 5:gender; 6:genera; 7:hobbyist; 8:paph; 9:phrag; 10: pro; 11: sensitive; 12: age + sensitive; 13: country + sensitive; 14: knowledge + sensitive; 15: experience + sensitive; 16: gender + sensitive; 17: genera + sensitive; 18: hobbyist + sensitive; 19: paph + sensitive; 20: phrag + sensitive; 21: pro + sensitive.

Model	df	LL	AICc	DAICc	AICw	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1	15	-904.54	1839.68	0	0.15		x								x	x		x								x
2	17	-902.73	1840.24	0.56	0.12		x		x						x	x		x		x						x
3	17	-902.9	1840.56	0.89	0.1		x						x		x	x		x						x		x
4	17	-903.27	1841.3	1.63	0.07		x	x							x	x		x	x							x
5	17	-903.51	1841.79	2.12	0.05		x							x	x	x		x							x	x
6	19	-901.48	1841.92	2.24	0.05		x		x				x		x	x		x		x				x		x
7	15	-905.66	1841.92	2.25	0.05		x		x							x		x		x						
8	17	-903.69	1842.15	2.47	0.05	x	x								x	x	x	x								x
9	17	-903.69	1842.15	2.48	0.04		x			x					x	x		x			x					x
10	17	-903.72	1842.21	2.54	0.04		x								x	x		x				x				x
11	19	-901.89	1842.74	3.07	0.03	x	x		x						x	x	x	x		x						x
12	19	-901.92	1842.8	3.12	0.03		x	x					x		x	x		x	x					x		x
13	19	-901.94	1842.83	3.15	0.03		x		x					x	x	x		x		x					x	x
14	19	-902.12	1843.19	3.52	0.03		x			x			x		x	x		x			x			x		x
15	19	-902.13	1843.22	3.54	0.03	x	x						x		x	x	x	x						x		x
16	17	-904.23	1843.23	3.55	0.03		x					x			x	x		x					x			x
17	19	-902.19	1843.34	3.67	0.02		x		x		x				x	x		x		x		x				x
18	17	-904.31	1843.39	3.71	0.02		x		x				x			x		x		x				x		
19	19	-902.24	1843.45	3.77	0.02		x	x	x						x	x		x	x	x						x
20	19	-902.31	1843.58	3.91	0.02		x		x	x					x	x		x		x	x					x

Table S3.13 Full model importance tables for the buying online UCT. Key: 1: age; 2: country; 3: knowledge; 4: experience; 5:gender; 6:genera; 7:hobbyist; 8:paph; 9:phrag; 10: pro; 11: sensitive; 12: age + sensitive; 13: country + sensitive; 14: knowledge + sensitive; 15: experience + sensitive; 16: gender + sensitive; 17: genera + sensitive; 18: hobbyist + sensitive; 19: paph + sensitive; 20: phrag + sensitive; 21: pro + sensitive.

Model	df	LL	AICc	DAICc	AICw	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1	23	-997.65	2042.7	0	0.37		x	x	x	x	x				x	x		x	x	x	x	x				x
2	25	-996.44	2044.53	1.83	0.15		x	x	x	x	x			x	x	x		x	x	x	x	x			x	x
3	25	-996.56	2044.77	2.07	0.13	x	x	x	x	x	x				x	x	x	x	x	x	x	x				x
4	25	-996.71	2045.06	2.36	0.11		x	x	x	x	x	x			x	x		x	x	x	x	x	x			x
5	23	-998.89	2045.17	2.47	0.11		x	x	x	x			x		x	x		x	x	x	x			x		x
6	25	-997.05	2045.75	3.05	0.08		x	x	x	x	x		x		x	x		x	x	x	x	x		x		x
7	27	-995.38	2046.68	3.98	0.05		x	x	x	x	x	x		x	x	x		x	x	x	x	x	x		x	x

Table S3.14 Full model importance tables for the owning wild plants UCT. Key: 1: age; 2: country; 3: knowledge; 4: experience; 5:gender; 6:genera; 7:hobbyist; 8:paph; 9:phrag; 10: pro; 11: sensitive; 12: age + sensitive; 13: country + sensitive; 14: knowledge + sensitive; 15: experience + sensitive; 16: gender + sensitive; 17: genera + sensitive; 18: hobbyist + sensitive; 19: paph + sensitive; 20: phrag + sensitive; 21: pro + sensitive.

Model	df	LL	AICc	DAICc	AICw	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1	21	-981.1	2005.37	0	0.12		x	x		x			x		x	x		x	x		x			x		x
2	23	-979.3	2006	0.63	0.08	x	x	x		x			x		x	x	x	x	x		x			x		x
3	19	-983.93	2006.83	1.45	0.06		x			x			x		x	x		x			x			x		x
4	23	-979.8	2007	1.63	0.05		x	x		x	x		x		x	x		x	x		x	x		x		x
5	23	-979.85	2007.1	1.73	0.05		x	x		x		x	x		x	x		x	x		x		x	x		x
6	23	-979.9	2007.19	1.82	0.05		x	x		x			x	x	x	x		x	x		x			x	x	x
7	25	-977.79	2007.23	1.86	0.05	x	x	x		x	x		x		x	x	x	x	x		x	x		x		x
8	25	-977.86	2007.37	2	0.04	x	x	x		x		x	x		x	x	x	x	x		x		x	x		x
9	21	-982.14	2007.45	2.08	0.04		x			x	x		x		x	x		x			x	x		x		x
10	21	-982.16	2007.49	2.12	0.04	x	x			x			x		x	x	x	x			x			x		x
11	23	-980.16	2007.71	2.34	0.04	x	x			x	x		x			x	x	x			x	x		x		x
12	25	-978.08	2007.81	2.44	0.03	x	x	x		x			x	x	x	x	x	x	x		x			x	x	x
13	27	-976.23	2008.38	3	0.03	x	x	x		x	x	x	x		x	x	x	x	x		x	x	x	x		x
14	21	-982.63	2008.42	3.05	0.03		x			x			x	x	x	x		x			x			x	x	x
15	21	-982.64	2008.44	3.07	0.03		x			x		x	x		x	x		x			x		x	x		x
16	19	-984.81	2008.57	3.2	0.02		x	x					x		x	x		x	x					x		x
17	25	-978.48	2008.6	3.23	0.02		x	x		x	x	x	x		x	x		x	x		x	x	x	x		x
18	23	-980.61	2008.62	3.25	0.02		x	x	x	x			x		x	x		x	x	x	x			x		x
19	21	-982.79	2008.74	3.37	0.02		x	x		x	x				x	x		x	x		x	x				x
20	23	-980.68	2008.76	3.39	0.02	x	x			x		x	x		x	x	x	x			x		x	x		x
21	25	-978.57	2008.8	3.43	0.02		x	x		x		x	x	x	x	x		x	x		x		x	x	x	x
22	25	-978.58	2008.8	3.43	0.02	x	x			x	x	x	x		x	x	x	x			x	x	x	x		x

23	23	-980.8	2009	3.63	0.02		x			x	x	x	x		x	x		x			x	x	x	x		x
24	27	-976.55	2009.02	3.65	0.02	x	x	x		x		x	x	x	x	x	x	x	x		x		x	x	x	x
25	23	-980.84	2009.07	3.7	0.02	x	x			x			x	x	x	x	x	x			x			x	x	x
26	21	-982.98	2009.12	3.75	0.02	x	x	x					x		x	x	x	x	x					x		x
27	19	-985.13	2009.21	3.84	0.02		x			x	x				x	x		x			x	x				x
28	21	-983.03	2009.22	3.85	0.02		x		x	x			x		x	x		x		x	x			x		x
29	25	-978.82	2009.28	3.91	0.02	x	x	x	x	x			x		x	x	x	x	x	x	x			x		x

Chapter 4

Identifying the Gaps in Access and Benefit Sharing in the Southeast Asian Orchid Industry Using an Analysis of Online Trade.

4.1 Abstract

The equitable sharing of benefits from natural resources was emphasized in 1992 by the Convention on Biological Diversity and has relevance to the commercialization and trade of wildlife products. Horticulture is one industry that has always relied heavily on wild genetic resources for the development of new products but little attention has been paid to sharing the benefits of this trade with the range states of wild species. Within horticulture orchids are one of the most important pot plants in the world and increasing online sales mean that there is now potential even for small-scale traders to access the global market. Here we study access and benefit sharing using the case of Southeast Asia, a region with a rich diversity of native orchid species and several countries important in their trade. We surveyed all online orchid vendors in the region to determine which countries were not benefitting from international trade in their own native and endemic orchid flora. Our results show that online trade surveys can provide a good overall estimation of species sold, and countries participating in trade. Five countries were found to have very little or no trade in their own orchids, even though a market existed for these species. Further, some countries were growing endemics from other states for which no official trade permits seem to have ever been issued. Orchids are traded illegally in the region and although this can bring economic benefits to those who collect and trade them, the conservation implications can be serious. We suggest that addressing the gaps in access and benefit sharing would require efforts to build both the botanical and horticultural capacities of those countries currently benefitting least from their own species supported, and where possible, by a formal flow of revenue from trade back to the country of origin.

4.2 Introduction

Ensuring the equitable sharing of the benefits that arise from the sustainable use of genetic resources is one of the three core objectives of the Convention on Biological Diversity (CBD) (CBD, 1992). For the 193 parties to the convention the 2010 Nagoya protocol, which outlines how access and benefit sharing (ABS) should be best implemented, came in to force in later 2014, in line with the 16th Aichi Biodiversity Target (Nagoya Protocol, 2011). A focus on ABS attempts to address both conservation and development goals simultaneously by protecting the sovereign right of a country to sustainably exploit their native wild species, and benefit when these resources are used by others (CBD, 1992). To date traded products that have been the focus of ABS activities include those for the agricultural (e.g. Costa Rican nematicide: Richerzhagen & Holm-Mueller, 2005), cosmetic (e.g. Moroccan argan oil: Lybbert et al 2002) and horticultural markets (e.g. South African ornamental plants: Henne & Fakir, 1991). The use of natural resources in these ways may benefit a country via increased income in the form of taxes, greater in-country spending by businesses (e.g. on rent or materials), and creation of jobs in both the core and supporting industries (Jepson et al 2011). Compensation for the use of a country's resources by an external company may take the form of direct up-front or on-going resource access payments or royalties from sales (Richerzhagen & Holm-Mueller, 2005; Trommetter, 2004). They may also include the transfer of knowledge, goods or technology to build the capacity of lower income countries to produce, research and develop marketable products from their genetic resources (Trommetter, 2004; FAO, 2009). In addition to the tangible justifications of ABS, Schroeder (2007) argues that compensating a country for the use of its genetic resources is also an ethical issue.

For conservation, ABS may also contribute to protection for species and habitats, especially those species that are also traded illegally. For example, the growing international demand for butterflies has provided an incentive to protect traded species and their forest habitats, as well as funds to formally protect them once trade is profitable (Gordon & Ayiemba 2003). It may also be possible to use legal trade as a 'supply side' method to reduce the demand for unsustainably sourced or illegally traded wildlife products (Jepson & Ladle 2005), although studies on the horticultural trade suggest that this is not guaranteed (e.g. Phelps et al 2014; Williams et al 2014). Although ABS and trade are closely linked, the primary international agreement governing wildlife trade, the Convention on the International Trade in Endangered Species (CITES) maintains a neutral position on the subject (Roe et al 2002).

ABS is especially relevant to those markets that rely heavily on products derived from the wild species of several countries, a good example of which is the international horticultural industry. Although the majority of plants in trade are mass-produced hybrids, wild plants play an important role in the development of new products; a trend that is predicted to increase as breeding technology improves (Volk & Richards 2011). The trade is also extremely lucrative, with a global export value of at least US$21 billion in 2013, including $9.2 billion of cut flowers and $9.1 billion of live plants (ITC 2015). A model case for horticultural ABS was the 1999 agreement between the South African National Biodiversity Institute (SANBI) and the American horticultural company Ball, to jointly develop new products from South Africa's wild flora (Henne & Fakir, 1991). In spite of this high profile case, and the emphasis of ABS for plants by the Global Strategy for Plant Conservation (CBD 2002; CBD 2012), the horticultural industry has been cited as having a limited awareness of issues surrounding access and benefit sharing (Ten Kate & Laird 2000; Secretariat of the Convention on Biological Diversity 2008).

In this paper we explore the extent to which, over two decades since the CBD, the principles of ABS are reflected in real trade patterns. We have chosen to focus on the international trade in orchids, one of the most important plant families in international trade (Griesbach 2002) and one that is the subject of illegal trade (Brack 2002). Their popularity is thanks, in part, to their great diversity; an estimated 25,000 to 30,000 species (Joppa et al 2011) and over 150,000 artificial hybrids recorded to date (Shaw, RHS hybrid register, pers. comm.). Whilst their horticultural value is well established, with records of orchids being grown for over 2,000 years in China and Japan (Paek & Murthy 2002), their large-scale international trade began in the 1800s in response to demand from wealthy European collectors (Pittman 2012). These collectors, suffering from an intense obsession known as 'orchidelirium', sent professional orchid hunters around the world in search of new species to ship back to Europe (Reinikka, 1995). Today the orchid industry has grown into a high value international business, as biotechnological advances have allowed orchids to become a mass-market product, as well as one that is still popular amongst dedicated hobbyists (Griesbach 2002). For over a decade, orchids have been listed amongst the top ornamental plants in trade, both in terms of sale volume, net profits and consistency of prices over time (FloraHolland 2013; FloraHolland 2014; USDA 2014;

USDA 2015). Global data are not available for all orchid products but exports of cut orchid stems were worth over $228 million in 2013 (ITC 2015). The volume of sales for the hobbyist market is much lower, but well grown plants of certain species or award-winning hybrids can sell for extremely high prices (e.g. £9,000 for one plant, pers. obs.). High demand and high prices has resulted in some species being traded illegally, which can lead to the over-collection of wild plants (e.g. *Paphiopedilum canhii*: Averyanov et al 2014) or even extinction in the wild, such as the slipper orchid *P. vietnamense*, which was collected to extinction within five years of discovery in 1998 (Averyanov et al 2003). Threats from trade combined with the difficulty non-experts face when discriminating between different species and genera have led to all orchids being listed by CITES. This means that orchids make up 70% of the species listed by CITES, with all species in the Family listed on Appendix II and the five species and two genera most threatened by trade listed in Appendix I (CITES 2013).

Here we use Southeast Asia as a case study to determine the extent to which, over two decades since the CBD, countries are benefitting from the sustainable trade of their native orchid species. For the purposes of this study, Southeast Asia provides an interesting case study, as it is a centre of orchid diversity, especially of the tropical epiphytic species that are popular in trade, including two species and one genera listed in CITES Appendix I (CITES 2013). Countries in the region exported almost $92 million of cut orchid stems in 2013, over 40% of the global total (ITC 2015). The region is also a hub for the legal and illegal trade in wildlife (Nijman 2010) and the countries vary greatly in size, economic development and horticultural and technological capacity. In order to produce orchids sustainably for legal trade horticultural knowledge and access to propagation technology is essential. In this study we conduct a ‘gap analysis’ to identify those countries in Southeast Asia that may benefit most from capacity building for sustainable trade. The aims are: 1) to produce an overview of the online orchid industry in Southeast Asia, including species sold and the roles of different countries in the trade; 2) to identify which countries are selling their own species and which are not; 3) to use this information to make recommendations for conservation, in line with the CBD targets for access and benefit sharing.

4.3 Methods

We conducted a survey of online horticultural orchid trade from countries in Southeast Asia between April and June 2012. The countries included in the study were the ten members of the Association of Southeast Asian Nations (ASEAN): Brunei Darussalam (hereafter Brunei), Cambodia, Indonesia, Lao Peoples' Democratic Republic (hereafter Lao), Malaysia, Myanmar, the Philippines, Singapore, Thailand and Viet Nam (ASEAN 2013). In the study we use the term 'orchids' to refer only to species for the hobbyist market rather than mass propagated hybrids, for example of the moth orchid *Phalaenopsis*. The two markets are separate; mass-market orchids are generally complex hybrids sold in high-volumes for relatively low profits and the trade is dominated by countries with well-established, high-tech horticultural industries, such as the Netherlands and Taiwan (Griesbach 2002). The hobbyist market is smaller but includes a diverse array of species plants that generally fetch higher prices, are grown in smaller numbers and require smaller-scale investment to produce (Koopowitz 2001). This study focuses on the latter market as complex hybrids are far removed from wild species and the hobbyist market presents a greater opportunity for small-scale orchid producers.

Several studies of orchid trade via street markets have already taken place (e.g. Phelps et al 2014) but little attention has been paid to the study of internet trade, which is becoming increasingly important for horticultural plants (Fleming 2013; Sajeva et al 2013; Shirey et al 2013). As we aim to study ABS arising from the international legal trade we focused only on the sale of orchids via official nursery websites, although we acknowledge that this does not guarantee legality. Websites allow vendors to reach new customers all over the world and also act as an advertisement for the nursery and their products. Whilst orchids may also be sold to hobbyists at international orchid shows, informally via social media or online auction sites, and to a lesser extent by mail order, websites provide an accessible view of trade by established nurseries.

4.3.1 Website survey

We identified online orchid nursery websites using vendor directories (www.orchidmall.com and www.orchidwire.com) and Google searches of each country name plus "orchid nursery", "orchid for sale" and "orchid species" (after Shirey &

Lamberti 2011). We then consulted in-country orchid experts and hobbyists to check these preliminary lists for missed nurseries. Each website was visited and all orchid species for sale were recorded by hand or using a web scraper (www.datatoolbar.com). Primary or complex orchid hybrids for sale were not included in the analysis.

4.3.2 Determining distribution and taxonomic accuracy

We cross-referenced the final list of species names with the World Checklist of Selected Plant Families (Govaerts et al 2014) to identify synonyms, find the natural distribution of each traded species, and compile complete lists of native and endemic species for each country. The World Checklist of Selected Plant Families lists geographical information up to level 4 of the Taxonomic Databases for Plant Sciences system, which corresponds to botanical country (Govaerts et al 2014). This level of detail matched political boundaries for six countries in the study (Cambodia [CBD], Lao [LAO], Thailand [THA], Viet Nam [VIE], Myanmar [MYA], Philippines [PHI]), allowing all species from these countries to be found using the checklist. Indonesia spans five complete botanical countries (Java [JAW], Sulawesi [SUL], Sumatra [SUM], Maluku [MOL], Lesser Sunda Islands [LSI]) and part of two others (New Guinea [NWG] and Borneo [BOR]). The BOR code also included Brunei and Malaysian Borneo and, where available, additional information in each species listing was used to assign species as present or endemic to one of these countries. Species listed under the NWG code were omitted from the analysis due to the difficulty of distinguishing those found in Irian Jaya from those found in Papua New Guinea. East Timor was not included in the analysis and the seven species endemic to the country, included in the LSI code were removed from the Indonesian total (endemics identified using Silveira et al 2008). Singapore was listed under the MLY code so Singaporean species were identified using the Checklist of the Vascular Plants of Singapore (Chong et al 2009).

In order to look at variations in taxonomic accuracy and listing language in each country, we coded each listed name as (1) an accepted species name; (2) a recognized synonym; (3) an unknown name/trade name. Presence/absence and type of descriptors were also recorded, for examples whether the listing included a physical description (e.g. flower colour, size, shape), geographical information (country or region) or other information (such as ‘new species’).

4.3.3 Analysis

Descriptive statistics for regional and individual countries were produced and the percentage of taxonomically accurate listings (i.e. those that listed a recognized species name) for each country was determined. A Pearson’s Chi squared Goodness of Fit test was used to compare figures for each individual country to the regional figure for (a) proportion of total native species in trade; (b) proportion of total endemic species in trade; (c) proportion of own native and endemic species traded. As it was not possible to assign some species from Borneo to a specific geographical country, a sensitivity analysis was carried out to investigate the effect of this on the results. To determine the structure of trade we used simple weighted network analysis (as summarized by Opsahl et al 2010) to calculate for each individual country: a) the number of countries that sold its native and endemic species (out-degree); b) the number of countries it sold native and endemic species from (in-degree); c) the number of its native and endemic species sold by other countries (out-strength); and d) the number of native and endemic species from other countries that it sold (in-strength).

4.3.4 Export of endemic species

For each of the traded endemic species on our list we calculated the time from date of description (Govaerts et al 2014) to the first commercial export from the country of origin (UNEP WCMC 2014). New species resulting from the renaming of existing species were not included. As the reliability of CITES reporting improved after 1996 (UNEP WCMC 2013), a separate analysis of all species described since 1996 was also carried out. Lao only became a party to CITES in 2004 but non-parties must have equivalent documents for the export of listed species, so imports from Lao should still have been reported before this time (McGough, pers. comm.).

4.4 Results

4.4.1 Summary of trade

We found 87 websites advertising orchids, 43 (49%) of which were not included in the final analysis as: they only sold hybrid plants or cut flowers (n = 24), the website was for a micropropagation or other business, rather than a nursery (n = 7), the website was not working for the whole study period (n = 6) or there were no products listed for sale online (n = 6). A summary of results can be found in Table 4.1.

Table 4.1: Summary of the online orchid trade in Southeast Asia

Country	**No. nurseries included in study (total found)**	**No. listings (individual products)**	**No. unique taxa for sale**	**No. true species for sale (% taxonomic accuracy)**
Indonesia	5 (7)	279	210	184 (87.6)
Malaysia	5 (10)	749	681	591 (86.8)
Viet Nam	1 (4)	35	35	31 (88.6)
Cambodia	0 (0)	0	0	n/a
Lao	0 (1)	0	0	n/a
Philippines	4 (7)	268	265	213 (79.5)
Thailand	22 (45)	1,229	581	521 (89.7)
Brunei	0 (0)	0	0	n/a
Singapore	6 (11)	953	708	615 (86.7)
Myanmar	1 (2)	2	2	2 (100)
Region	44 (87)	4,496	1,859	1,520 (81.8)

4.4.2 Species in trade

In total 20.8% of all orchid species found in Southeast Asia were being sold. When Borneo was included in Indonesia (i.e. BOR = IND), 9.9% of species endemic to at least one country in the region were in trade; when Borneo was included in Malaysia (i.e. BOR = MLY) this figure was 9.6%. The observed proportions of native species sold by country of origin differed significantly from the expected value (BOR = IND: χ^2 = 979.0, 6 d.f., P<0.001; BOR = MLY: χ^2 = 868.1, 6 d.f., P<0.001). Similarly, sales by each country of their own endemic species differed significantly from the expected, both when the figure used was 9.9% (BOR = IND: χ^2 = 274.5, 6 d.f., P<0.001; BOR = MLY: χ^2 = 275.8, 6 d.f., P<0.001) and 9.6% (BOR = IND: χ^2 = 195.0, 6 d.f., P<0.001; BOR = MLY: χ^2 = 195.9, 6 d.f., P<0.001).

Native species from Cambodia, Lao, Myanmar, Indonesia (including Borneo), the Philippines and Malaysia were on sale in every country where trade was occurring (n = 6). Endemic species from Indonesia, Malaysia and the Philippines were on sale in the most countries (5 out of the 6 trading countries). Nurseries in Singapore and Malaysia were selling native species from every country in the region, whilst Thailand and Singapore were selling endemic species from the most other countries (6 out of 9). Further results of the network analysis can be found in Table 4.2.

4.4.3 CITES exports of endemic species

Of the 331 endemic species found in trade, 169 (48.6%) had no CITES record of export from their country of origin Of the 64 species described between 1996 and 2012, there were no recorded exports of 55 (85.9%) from the country of origin, including 4 out of 6 CITES Appendix I *Paphiopedilum* species (Figure 4.1). Of these 55, two species (*Bulbophyllum coweniorum* and *Holcoglossum calcicola*) were from Lao, which has no international orchid industry.

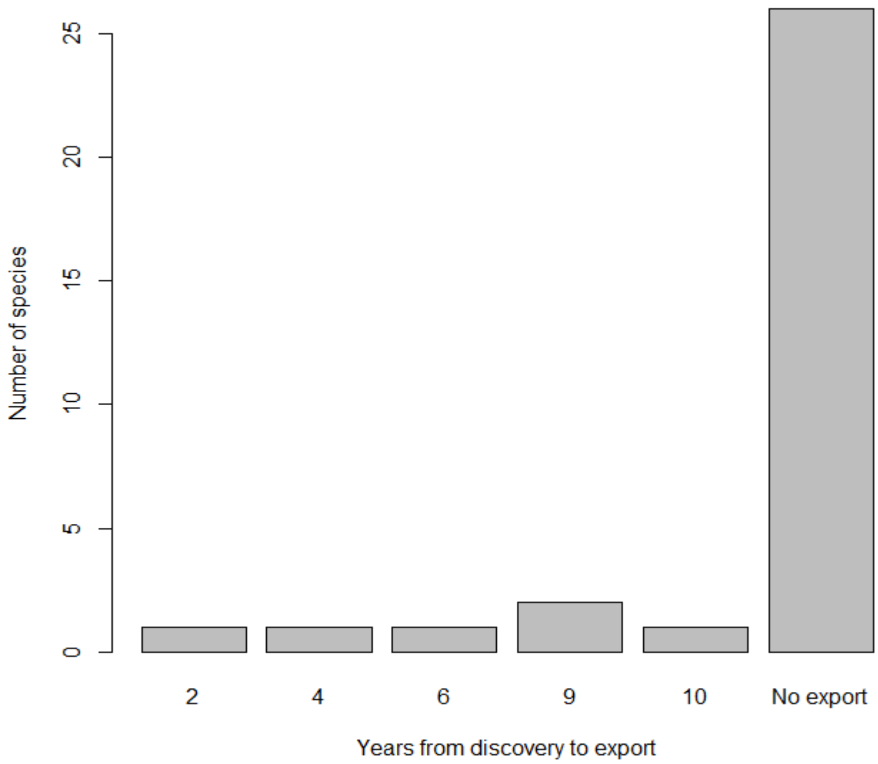

Figure 4.1: Number of years from discovery to first commercial export recorded in CITES database from country of origin for traded endemic orchid species in Southeast Asia (for species described between 1996 and 2012)

Table 4.2: Summary of directed network analysis of Southeast Asian online orchid trade

Country	No. other countries selling native species[1] (no. species in trade[2])	No. other countries selling endemic species[1] (no. endemic species in trade[2])	No. other countries' native species sold[3]	No. other countries' endemic species sold[3]	% native species in trade (% sold by country)	% endemic species in trade (% sold by country)
Cambodia	6 (150)	0 (0)	0	0	43.5 (0)	0 (0)
Lao	6 (225)	3 (3)	0	0	52.1 (0)	21.4 (0)
Myanmar	6 (326)	1 (2)	2	0	37.7 (0)	2.4 (0)
Thailand	5 (529)	3 (22)	8	6	41.0 (25.2)	15.0 (14.3)
Indonesia +BOR[4]	5 (495) 6 (565)	5 (84) 5 (125)	8 8	4 4	20.7 (4.8) 18.4 (3.8)	20.7 (3.1) 18. 4 (2.6)
Malaysia +BOR	6 (468) 6 (541)	5 (44) 5 (81)	9 9	5 5	26.2 (21.2) 20.7 (16.3)	26.2 (21.2) 20.7 (16.3)
Brunei	2 (4)	0 (0)	0	0	17.4 (0)	0 (0)
Philippines	6 (364)	5 (153)	8	2	33.5 (22.3)	20.4 (19.4)
Singapore	4 (34)	0 (0)	9	6	72.3 (25.5)	0 (0)
Viet Nam	5 (390)	4 (18)	7	3	34.0 (1.1)	8.0 (0.4)

[1] out-degree; [2] out-strength; [3] in-strength; [4] Borneo. The BOR botanical country code includes Malaysian and Indonesian Borneo, and Brunei. Extra rows for Malaysia and Indonesia show the effect of incorporating BOR species with no further location information in the analysis for this country. This was not done for Brunei due to its small size.

4.5 Discussion

Our results suggest that, two decades on from the 'birth' of the CBD, the countries of Southeast Asia are not benefitting equally from the formal horticultural trade of their orchid species. This is the first study of its kind of the species orchid trade and provides further evidence to support concerns of the limited awareness of ABS in the horticultural industry (Ten Kate & Laird 2000; Secretariat of the Convention on Biological Diversity 2008). We also show that a survey of online sales can provide a useful and accessible summary of trade.

4.5.1 Structure of the orchid trade in Southeast Asia

Our findings show large differences in the overall amounts of online orchid trade by countries in Southeast Asia. We acknowledge that our survey of formal online trade does not capture all sales, as plants are often sold offline for the domestic market (e.g. Phelps et al 2014) and informally, especially for the illegal market, via social media or auction websites (Shirey & Lamberti 2011; Shirey et al 2013). However, online sales are playing an increasingly prominent part in horticultural trade and surveying them provides an easily accessible method for studying the provenance and species of plants in trade (Sajeva et al 2013; Shirey et al 2013). Our results are particularly interesting in comparison to recent studies of trade via street markets; for example Phelps & Webb (2015) found 13% of Thailand's flora for sale in large flower markets in the region, compared to our finding that 41% of the country's species were in trade, with 25.2% sold from Thailand itself. Further, the trends revealed in our survey closely match those of the wider horticultural trade; Thailand, Singapore and Malaysia, our top trading countries had the highest value exports of both general horticultural products and cut orchid flowers in 2012 (ITC 2015). Similarly, the four countries with the least trade in our study: Myanmar, Cambodia, Lao and Brunei, also had the lowest value horticultural and cut orchid exports in the region (ITC 2015). An anomaly is Viet Nam, which ranked fourth in the region for horticultural exports and cut orchid flowers with large increases in recent years, which suggests that capacity is developing but that this is yet to transfer to the species orchid trade (ITC 2015). These overall similarities suggest that our results of online orchid sales are a good proxy for overall horticultural trade capacity, and may even give a better estimate of species in trade than traditional market surveys. Capacity is likely to be related to economic development and two of the countries with the least trade, Cambodia and Lao, are listed as Low or Lower-middle income by the World Bank, with the lowest Gross National Income (GNI) per capita in the region (no data available for Myanmar) (World Bank 2015). The exception is Brunei, rated as High Income (World Bank 2015), which is likely to have no trade due to a lack of economic need, although an orchid trade is being developed in order to diversify its economy (The Brunei Times 2012).

4.5.2 Countries are not benefitting equally from their own species

Building on these broad trade patterns, our results also reveal the identity and origin of the 1,520 species being traded. Using this information we found that countries with the greatest trade capacity in our study were also the ones trading the most in both their own species and those of other countries. Those countries selling few or none of their own species contributed large numbers of species to the trade: over half of Lao's native species and three of its 12 endemic species were being traded by other countries. Species of these countries present a great opportunity for trade, due to both the importance of novelty in specialist markets (Courchamp et al 2006; Hall et al 2008), and the saturation of the market for commonly traded horticultural species, which has increased the importance of the development of new products from wild species or varieties (Heywood 2003; Volk & Richards 2011). Our results highlight that the potential for trade that these species represent is not currently being realized by range countries and that benefits from trade are unlikely to remain or flow back to these countries. We acknowledge that this view does not recognize the benefits that may be transferred from local or illegal trade (e.g. Phelps & Webb 2015), which may be essential supplementary income for some households (Hinsley 2010). We argue that the potential benefits from formal trade are greater, due to increased income in the form of taxes, greater in-country spending by businesses (e.g. on rent or materials), and creation of jobs in both the core and supporting industries (Jepson et al 2011). In addition, the collection of wildlife for trade can be a significant conservation issue (Broad et al 2003), and several orchid species have declined or become extinct due to collection (Averyanov et al 2003; Averyanov et al 2014). Finally, Haken (2011) argues that the economic benefits received by the harvesters in wildlife and other illicit trades is offset by the negative effects these trades can have on the stability of a developing economy.

4.5.3 Recently discovered endemic species have not been exported with CITES permits

Since 1996, the majority of newly discovered endemic orchid species in trade have not been officially exported from their range countries according to the CITES database. All international movement of orchids must be accompanied by CITES paperwork, unless transported as cut flowers, seed, seedlings in sterile flasks or cultivated hybrids of certain genera (CITES 2004). Transporting orchids as seed is infrequent in the orchid trade (pers. obs.) but may be one explanation for our findings. Similarly, whilst transporting species in flask may account for some of this trade, this is less likely to be the case for a country such as Lao, which only began propagating orchids in 2006 (Lamxay 2009) and which still has limited capacity to produce orchids legally (Vernon, pers. comm.). For example, one of the Laotian endemic species with no CITES exports, *Bulbophyllum coweniorum*, has been popular in trade since at least 2007 (Cockel 2013) but was not one of the species propagated in Lao at this time (Lamxay 2009). New orchid species are often discovered after they have entered trade (Vermeulen et al 2014), including endemic species discovered outside the country of origin, such as *P. rungsuriyanum* from Lao, discovered in a nursery in Thailand (Gruß et al 2014). This is not surprising: Southeast Asia is a hub of illegal wildlife trade (Sodhi et al 2004) and the wild-collection of orchids for trade is widespread (Lamxay 2009; Phelps & Webb 2015), especially of newly discovered species (Averyanov et al 2003; Averyanov et al 2014). It is clear that, in its current form, CITES is not acting as a deterrent to the illegal trade of orchid species, a finding supported by other recent studies in the region (Phelps & Webb 2015). Even where plants are legally grown, CITES permits add an extra cost to each export and require documentation and inspections that may be difficult and expensive to arrange for a small business. For the international trade, hobbyists in the UK are often discouraged from buying online from businesses outside of the European Union due to the high cost associated with CITES documentation (pers. obs.).

4.5.4 Addressing inequities in access and benefit sharing

Our results identified Lao, Cambodia and Myanmar as being most in need of action to address ABS inequities. The Nagoya protocol recommends that equitable sharing of benefits should be achieved by "*appropriate transfer of relevant technologies … and by appropriate funding*" (Nagoya Protocol 2011 p4). Based on existing examples from other

ABS cases, addressing inequity in the Southeast Asia orchid trade could take two forms: direct payments for the bioprospecting of new products (Richerzhagen & Holm-Mueller 2005; Trommetter 2004), and capacity building to allow countries to develop their own trade (FAO 2009).

Direct payments for initial access to, or on-going use of, a country's genetic resources is an approach taken in the pharmaceutical industry (Artuso 2002; Trommetter 2004) but has had limited application in the wildlife or horticultural trade to date. The landmark agreement between Ball and SANBI in South Africa eventually resulted in benefits from trade being shared with SANBI but demonstrated that careful management was essential for success (Secretariat of the Convention on Biological Diversity 2008). The company in this case was large and had the resources to make a long-term commitment to fund SANBI. Whilst this may be a useful model for the mass-market horticultural industry, it is unlikely to work for the species orchid market, which is supplied by small businesses selling a large range of species in small numbers (pers. obs.). Additionally, direct payments would only be successful for newly commercialized species, as sharing the benefits of a highly demanded species is particularly difficult if captive breeding or propagation has been taking place for some time in different countries (Roe et al 2002; Richerzhagen & Holm-Mueller 2005). Finally, we found that almost 80% of Southeast Asian orchids are not currently being traded and, although some will be unsuitable for trade, this does provide a large number of potential products for the market.

Considering the limitations of direct access payments, capacity building to allow countries such as Lao, Myanmar and Cambodia to develop their own orchid industries may be a more effective way of ensuring ABS. The most effective conservation capacity building projects are based on local interests and need (Smith et al 2009) and several countries in the region have an interest in developing orchid trade for the purposes of economic development and diversification, or conservation of illegally traded species (Viet Nam News 2010; Hajramurni 2011; The Brunei Times 2012; Malanes 2014; Phyu 2014). Producing plants for trade requires laboratories and sterile equipment for propagation from seed and tissue culture, a well-developed infrastructure for transporting goods, and the expertise in breeding, growing and marketing plants for export. This capacity is well developed in those countries with existing horticultural industries (ITC 2015) but very limited in those such as Lao, where the majority of plants in trade are wild-sourced (Vernon, pers. comm) and only one company in the early stages of producing orchids legally for trade in 2009 (Lamxay 2009). Similarly, there are very few nurseries growing orchids in Cambodia (pers. obs.) and only one that is well established, growing hybrids to supply the local cut-flower market (Jancloes, pers. comm). In addition, botanical capacity and knowledge of native species in Cambodia, Lao and Myanmar are among the lowest in the region (Seidenfaden, 1993; Schuiteman & de Vogel 2000). Building the botanical capacity of these countries would be an important step towards establishing sustainable trade, and may allow species to be discovered before they are threatened by collection (Vermeulen & Lamb 2011).

Finally, it must be acknowledged that addressing ABS inequities is not necessarily a development and conservation panacea. The CBD recognizes access and benefit sharing rights at a state level, giving no guarantee that any payments or capacity building efforts would reach the places where it could have conservation and development benefits (Richerzhagen 2011). People in rural communities may rely on the income from wild-collecting animals or plants for trade (Broad et al 2003; UNEP 2014), including orchids (Hinsley 2010). If efforts are not made to involve these people in ABS activities, profits may shift away from the original beneficiaries of trade to a few wealthy business owners (Lybbert et al 2002; UNEP 2014) or large institutions (Secretariat of the Convention on Biological Diversity 2008). Where a community approach is taken, as was the case of the appetite suppressant *Hoodia*, it is essential that participants in capacity building projects are not given unrealistic expectations that trade will be an easy, risk-free source of income (Vermeylen 2007). For conservation, whilst there are examples of legal trade successfully reducing wild-collection (Entwistle et al 2002) there are many others showing that demand for wild-sourced products remains stable (Drury 2009; Dutton et al 2011), including for the Southeast Asian orchid *Rhynchostylis gigantea* (Phelps et al 2014). Further to this, legitimizing trade in a species may allow laundering of wild products (Wyatt 2009; Natusch & Lyons 2012), a problem already occurring in the orchid trade, as mature wild plants are transported as cultivated (McGough et al 2006) or CITES exempt seedlings in flask are produced from illegally collected wild parent stock. For mature plants, physical characteristics such as broken roots, microflora on the leaves or insect damage may allow laundered plants to be identified as wild (McGough et al 2006) but further work is needed to develop methods to identify the origin of plant material (wild vs. cultivated) more easily and reliably, thus allowing increased traceability within the industry.

4.5.5 Recommendations

Southeast Asia is a hotspot for orchid diversity and trade but the lowest income countries are not benefitting from the commercialization of their species, losing out to countries with better-developed industries. In order to address these inequities, efforts to build the botanical, horticultural and trade capacity of the lowest income countries should be a priority. In line with the Nagoya protocol’s recommendations, this should be done by transfer of resources, funding and expertise from those countries currently benefitting most from trade. Whilst we acknowledge that developing trade in a species is not guaranteed to prevent wild-collection (e.g. Phelps et al 2014) our results demonstrate that trade is already occurring in many of these species, and that CITES is not currently regulating it effectively. Therefore, with careful management to mitigate some of the potential negative effects that trade can have (e.g. Williams et al 2014), developing horticultural trade in those countries that are species-rich and capacity-poor may be an important step towards addressing ABS inequities.

Chapter 5.

Estimating the extent and structure of trade in horticultural orchids via social media

5.1 Abstract

The wildlife trade is a lucrative industry involving thousands of animal and plant species. The increasing use of the internet for both legal and illegal wildlife trade is well documented but there is evidence that trade may be emerging on new online technologies such as social media. We carry out the first systematic survey of trade on an international social-media website, using the orchid trade as a case study. We analyzed an online community consisting of 150 orchid focused groups on a large social media website, using social network analysis. Closely linked communities were found reflecting language groups, with most trade occurring in a community of English-speaking and Southeast Asian groups. In addition we randomly sampled 30 groups to assess the prevalence of trade in cultivated and wild plants. We found that 8.9% of posts contained trade, 22-46% of which was in wild-collected orchids. Although total numbers of trade posts are relatively small, the high proportion of wild plants for sale supports calls for better monitoring of social media for trade in wild-collected plants.

5.2 Introduction

The wildlife trade is a lucrative industry involving the sale of thousands of species for purposes ranging from plant derivatives for medicinal use to live animals for the pet trade (Broad et al. 2003). Although an important source of income for many people, the overexploitation of wildlife for trade can be a serious threat if collection is not sustainable. To ensure sustainability requires monitoring of trade, as well as the status of wild populations. This may take place within a framework of both national legislation that prohibits or set quotas for the wild-collection of certain species (e.g. Republic of Indonesia 1999), and internationally in the form of the Convention on the International Trade in Endangered Species (CITES).

The value of certain wildlife products can motivate traders to bypass the rules and sell illegally. The threat of prosecution may drive illegal traders to rapidly adopt new methods to evade detection (Broad et al. 2003) leading to constantly evolving trade routes, networks and methods (Bennett 2011). Little is known about the scale or value of the illegal wildlife trade but estimates have put its worth at approximately $10 billion each year (Haken 2011). Due to this secrecy, the volume of traded species, and the interactions between the legal and illegal trade, controlling wildlife trade is a complex undertaking. It requires law-enforcers and conservationists to discover, monitor and respond to new developments quickly.

The increasing use of the internet by wildlife traders, especially those involved in illegal trade, is a significant challenge to conservation of traded species (Bennett 2011) especially those in niche markets (Lavorgna 2014). Both legal and illegal traders use the internet in similar ways: to facilitate and enhance communication with suppliers and customers (Grabosky 2013). This allows illegal wildlife traders to procure animals and plants more efficiently and expand their networks and consumer base (Lavorgna 2014). E-commerce allows new traders and small businesses to establish themselves on the global market at relatively little cost (Brenner 2002) with the added benefit of increased anonymity for illegal traders (Grabosky 2013). There is evidence of the online trade in a wide range of wildlife products, including plants (Sajeva et al. 2013; Shirey et al. 2013; Krigas et al. 2014), reptiles and amphibians (De Magalhães & São-Pedro 2012) and ivory (IFAW

2005, 2007). To date, studies of the online wildlife trade have mainly focused on auction websites, resulting in eBay banning the ivory sales in 2009 (Coghlan 2008). However, recent evidence from China suggests that increased regulation of e-commerce websites may be driving wildlife traders to sell via social media (Yu & Jia 2015).

The benefits of social media for businesses are numerous. Social-media sites have grown and proliferated rapidly since the launch of MySpace in 2003 and the expansion of Facebook in 2005 (boyd & Ellison 2007). In mid-2015 social-media websites were the second (Facebook), third (YouTube), eighth (QQ) and ninth (Twitter) most-visited global websites (Alexa 2015). Users are numerous and diverse: in March 2015 Twitter had 302 million monthly users tweeting in 33 languages (Twitter 2015), whilst Facebook reported 1.44 billion, 83% of which were outside North America (Facebook 2015). Their size and reach means that the potential of 'social commerce' is being increasingly recognized, and networks are facilitating this trend by introducing easier ways to advertise and take payments (Chaumond 2010). This has been especially important for small businesses (Lee et al. 2008); in April 2015 there were over 40 million small businesses operating on Facebook alone (Facebook for Business 2015). Monitoring illegal businesses through social media is more challenging, so has received less attention. Yet monitoring of social-media wildlife trade has been highlighted as a conservation research priority (Yu & Jia 2015). Moreover, the anonymity available online may mean that illegal businesses are growing at an even faster rate than legal businesses.

Here, we build on previous work to uncover trade via local and national social-media networks (De Magalhães & São-Pedro 2012; Yu & Jia 2015) to carry out the first large-scale survey of wildlife trade on an international social-media site. We focus on orchids, a group that makes up over 70% of all CITES species (CITES 2013). Orchid hybrids are amongst the most high-value horticultural plants in mass-market trade (USDA 2015), with a separate hobbyist trade focused on species (Hinsley et al. 2015). Whilst much of it is based on nursery-grown stock, this hobbyist trade has been linked to over-collection of wild plants (Vermeulen et al. 2014) due, in part, to demand for rare species (Hinsley et al. 2015). This has led to several new species being described from plants already in the trade (Vermeulen et al. 2014). Trade in orchids via eBay (Vermeulen et al. 2014) and nursery websites (Krigas et al. 2014) has been recorded but no studies of their sale on social media has been carried out. Here we ask: 1) Is trade occurring in the orchid community on this website?; 2) What proportion of trade is in wild-collected plants?; and 3) Can analysis of the network within which trade is occurring reveal information useful for conservation?

5.3 Methods

5.3.1 Background and ethics

Due to the global nature of the orchid trade we focussed on a large international social-media website. The conditions of our ethical approval mean that the site used has not been named here, as is standard practice for studies of this type. We chose to focus on specialist forums within the website that allow members with shared interests to communicate and connect. These groups may be accessible to anybody with a website membership or visible by invitation only. According to the website terms and conditions, we did not visit personal pages, did not use automated web scrapers, collected only anonymised member names, and did not collect any other personal information about members. The research account displayed a prominent statement that research on social-media orchid trade was being conducted, and we did not interact with individual members, attempt to buy plants or post to any groups. Where group or member names were collected, these were immediately anonymised and stored on an encrypted USB drive. We carried out all work with approval of the University of Kent, School of Anthropology and Conservation's Research and Ethics Committee.

5.3.2 Sampling

We searched for the word 'orchid' in English, French, Spanish, Portuguese, German, Japanese, Indonesian, Malay, Chinese (traditional), Thai and Vietnamese. We did not include simplified Chinese, as most international social-media websites are restricted in Mainland China, and Chinese language social-media sites (e.g. QQ, Weibo) are much more widely used in the country (Alexa, 2015). Each group page provides an automatically generated list of groups with related content and we used this to perform a form of snowball sampling, a method in which new individuals are added to the sample after being referred by previous respondents (Biernacki & Waldorf 1981). We added all relevant suggested groups to our sample until no new groups were found, even after the page was refreshed twice. This resulted in 156 groups, of which six were removed due to being duplicates, or unrelated to orchids. We manually categorised groups into five sets based on themes using the title, description or content of the group. These were: taxonomic groups (focussed around one particular genus of orchid); geographic groups (specifically for orchid growers from a particular town, region or country); general hobbyist groups (with no specialisation other than orchids); natural history groups (focussed on discussion or photography of in-situ wild orchids); and trade groups (for the sole purpose of selling or exchanging plants). Some groups had a combined geographic and taxonomic focus. The language of each group was recorded along with the presence of trade, defined as either an explicit statement that trade was permitted, or visible presence of trade in the last 50 posts on the day of sampling.

5.3.3 Network analysis

We represented our data as an undirected, weighted network and conducted network analysis using the methodology described by Opsahl et al. (2010) and R version 3.1.2 (R Core Team, 2014) with package 'tnet' v.3.0.11 (Opsahl, 2012). Anonymised member lists were obtained manually for each group and an adjacency matrix constructed, showing shared members between all pairs of groups. We represent the network as an undirected, weighted graph, where each 'node' represents one group. When two groups share at least one member, they are connected by an 'edge' and the 'weight' of this edge is defined by the number of shared members. This network has 150 nodes, connected by 7,801 edges, with a total weight of 312,323. The simplest network measure is the degree (number of edges from a single node) and the node with the highest degree can be considered the most central. The sum of the weights of all edges from a node gives the node 'strength'. In some situations, one may consider the node with the highest strength, not degree, the most central. Opsahl et al. (2010) combine these two measures to give the centrality measure

$$C_D^{w\alpha}(i) = k_i \times \left(\frac{s_i}{k_i}\right)^{\alpha} = k_i^{(1-\alpha)} \times s_i^{\alpha} \qquad (1)$$

where k_i is the degree of node *i*, s_i is the strength of node *i* and $\alpha >= 0$. For a central node, $C_D^{w\alpha}$ is large. When $\alpha >= 1$, equation (1) gives the node degree, and when $\alpha = 1$, it gives the node strength. When α < 1, nodes with higher degree are considered more central. When α > 1, nodes with a larger mean weight are considered more central. For example, a node with an edge with weight 1 and an edge with weight 7 would have a mean weight of 4, which would have a higher C_D^{wa} than a node with three edges, each with weight 1. However, for α < 1, the latter node with more, but weaker connections, would be prioritised. Opsahl et al. (2010) were motivated by social networks, where the transfer and sharing of knowledge requires strong ties (Hansen 1999), which can be calculated from equation (1) with α >1.

The centrality measure (1) does not reveal anything about network structure as it does not consider the paths that pass through a particular node. For example, nodes A and B in Fig. 1 have the same degree, but B is the preferred node to transmit information since more paths pass through it.

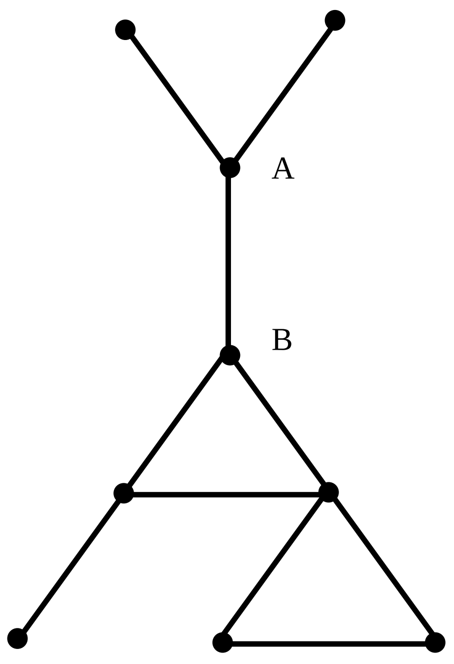

Figure 5.1. Diagram illustrating betweenness. Node B has greater betweenness (paths passing through it) than A, even though they have the same degree (number of edges connecting to other nodes).

Formally we use ‘betweenness’ to relay this information, which assesses the total amount of flow a node carries, when a unit of flow between each pair of nodes is divided up evenly over shortest paths (Easley & Kleinberg 2010). Nodes of high betweenness are critical to the network structure. Lastly, ‘closeness’ finds the smallest number of connections taken to reach all nodes in the network. We found consistently small closeness scores for all nodes, so do not discuss this further (See Supporting Information). Betweenness is defined as

$$C_B(i) = \frac{g_{jk}(i)}{g_{jk}} \tag{2}$$

where g_{jk} is the number of binary shortest paths between two nodes, $g_{jk}(i)$ is the number of these paths that pass through node i, and j = 1, 2...150. For example, in Figure 1 C_B (A) = 13, and C_B (B) = 19, quantifying what we can see - that node B is more critical to the network structure.

The maximum modularity, $0 \leq Q \leq 1$, of a network describes the best partition of a network into its communities, with large Q values representing distinct communities. There are a number of methods to produce the optimum partition, and thus the modularity (e.g. Fortunato 2010; Newman 2010). We use a standard method that successively identifies a bisection of subsets within the present partition that produces the maximal increase to the overall modularity. It halts when no further bisections of any subset improves the modularity. This method is implemented in Mathematica FindGraphCommunities, with the option Method -> Modularity (Wolfram Research 2014).

5.3.4 Trade survey and Kappa analysis

A sample of 20% (n= 30) of groups was chosen by randomly selecting unique members and sampling all groups they belonged to until 30 were reached. Email alerts of all posts to these groups were received for 12 weeks between November 2014 and January 2015. All sampled groups (26 open groups, 4 closed) accepted our requests to join. Due to the large number of alerts received (n = 55,805), a random sample of ~1% (n = 560) were selected for the final survey. We assessed sampled posts using a two-person Kappa analysis, which involves two independent raters with relevant expertise assigning each post to discrete categories (Cohen 1960). Two analyses were carried out for presence of trade and presence of wild-collected plants, with categories of 'yes', 'no' and 'maybe' for each. Both raters have extensive experience studying orchid trade, with different specific skills in taxonomy, knowledge of online trade, and relevant languages. We used the R ‘irr’ package v.0.84 (Gamer et al. 2012) to calculate percentage agreement, Cohen's weighted Kappa coefficient (Cohen 1968), Stuart-Maxwell test for marginal homogeneity (Stuart 1955; Maxwell 1970), and rater bias. All posts not agreed upon in the first analysis were reanalysed by both raters with discussion until an agreement was reached.

5.4 Results

5.4.1 Summary group statistics

A total of 150 groups containing 43,509 unique members were found, with a range of group types, sizes and language (Table 1). We found that 17.3% (*n* = 26) of groups prohibited trade and 28.6% (*n* = 43) explicitly permitted trade, or allowed it to occur. The presence of trade could not be ascertained in the remaining 54% (*n* = 81) of groups. Over 25% (n=11) of groups with visible trade operated in Indonesian, with trade occurring in 50% of all Indonesian groups sampled. Other notable languages of groups with trade included English, Portuguese, Vietnamese and Malay (each: 11.6% of total trade, *n* = 5). The majority of Portuguese and Spanish groups appeared to be predominantly made up of members in Latin America rather than Europe, and 10 out of 14 Chinese groups stated that they were based in Taiwan or Hong Kong. English speaking groups appeared to be predominantly composed of members from the United Kingdom, United States and Australia, although membership of many was international.

Table 5.1. Summary statistics of all groups found in the study, showing the number, size, language and trade prevalence in groups of different types.

Group type	No. groups	Members per group (mean)	Members per group (median)	No. languages	No. with visible trade[1]
Natural History	6	385.2	457.0	5	2
Geographic	28	636.5	269.5	8	7
Hobbyist	80	891.6	636.5	16	17
Taxonomic	16	851.7	707.0	8	5
Taxonomic + Geographic	5	535.8	231.0	3	1
Trade	15	601.5	736.0	8	15
All groups	150	778.6	360.5	17	47

[1] defined as either an explicit statement that trade was permitted, or visible presence of trade in the last 50 posts on the day of sampling.

5.4.2 Network analysis

The centrality results found that, generally, groups share members with many others, making the network highly connected. Our centrality scores ranged from 0 to 246,011, with a mean of 35,167. One group with a joint focus of orchids and bonsai was completely isolated from the network, with a score of 0 for all measures, suggesting that orchids were not the focus of this group. Betweenness ranged from 0 to 3897, with a mean of 204, implying that there are few heavily weighted paths.

The centrality results revealed three groups that are key to the network, with the both highest centrality (equation 1) and betweenness (equation 2) scores. All had centrality measures of over 235,617 (~200,000 above the mean) and betweenness of over 3,500. Two of these groups were English with visible trade (one taxonomic, one geographic) and one was an English/Spanish (English was the main language) hobbyist group with no trade. The network modularity was 0.0139 meaning many edges connect the communities that exist within the network. Nonetheless, we can identify five communities (Fig. 2).

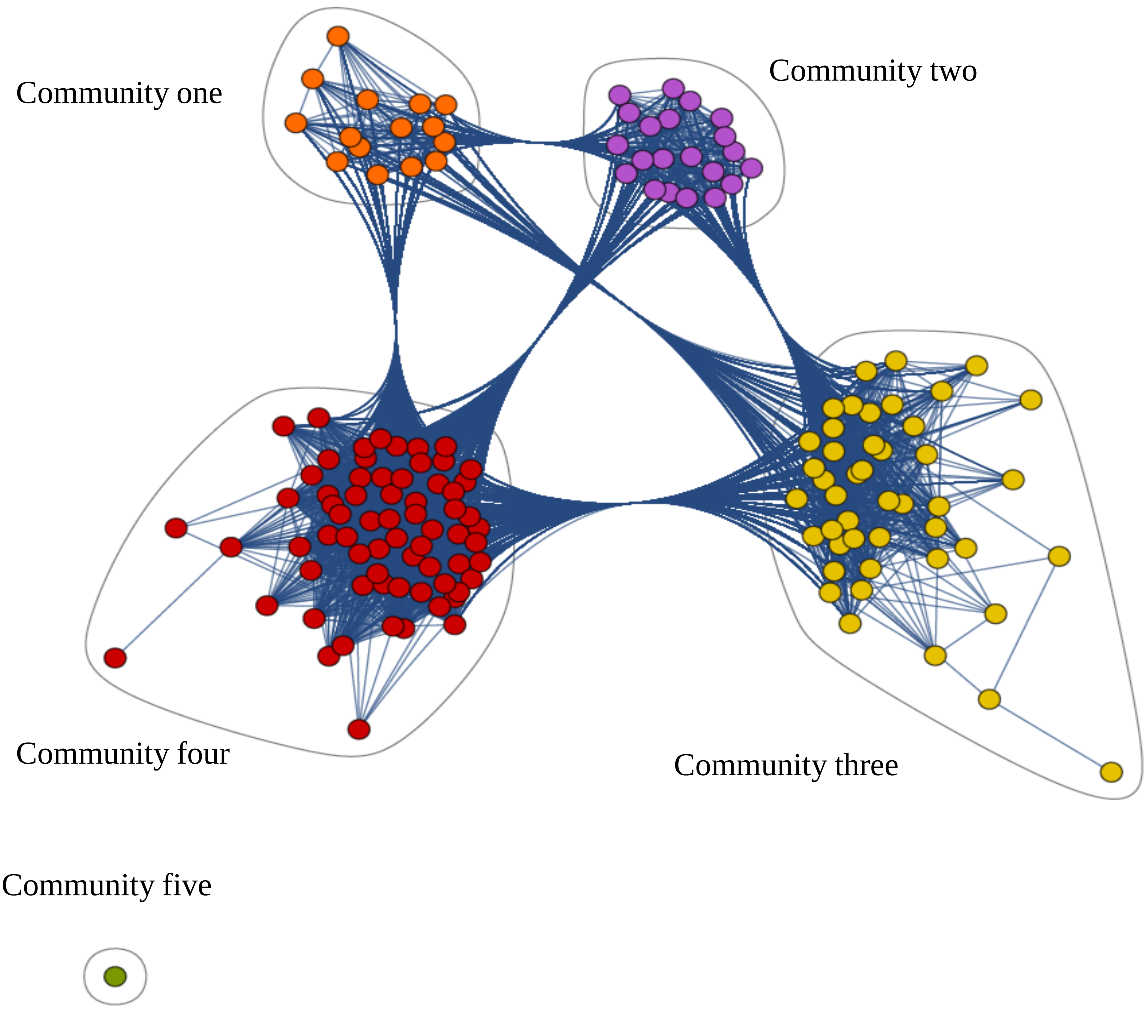

Figure 5.2 Cluster diagram showing the connections between the five communities in the network based on shared membership.

Community five represents the single isolated group and the remaining four communities were based on language groups, and showed distinct characteristics (Table 2). Community one had the most members and contained the three key groups. However, the centrality scores in this community varied greatly, with a median of 13,156 and a minimum of 1. In contrast, Community three had consistently high centrality scores, with a median of 104,346 and a minimum of 9805 (See Supporting Information). Whilst the centrality scores for Community two and four were relatively low, Community two had some betweenness scores that were almost as high as the top scoring groups in the network (Table 2).

Table 5.2. Characteristics of the four main communities within the network, including mean centrality and betweenness scores. The mean centrality and betweenness for the network overall is 35,167 and 204 respectively.

Community	No. groups	Mean group size (Median)	Type (% of community) H = Hobbyist; G = Geographic; Ta = Taxonomic; Tr = Trade; NH = Natural History	Languages (% of community)	Mean centrality (Max)	Mean between-ness (Max)
1	68	2928.5 (1048)	H (35.9); G (28.1); Ta (17.2); Tr (15.6); NH (3.1)	English (41.2); Indonesian (32.8); Malay (8.8); Thai (7.4); Chinese (4.4); French (2.9); Portuguese, German (1.5 each)	42623.8 (246011.2)	279.4 (3896.8)
2	45	282.7 (169)	H (75.6); G (11.1); NH (8.9); Ta (2.2); Tr (2.2)	German (33.3); Italian (24.4); French (17.8); Turkish (8.9); Indonesian (4.4); Greek, Danish, Filipino, Finnish, Norwegian (2.2 each)	3758.7 (48035.3)	188.6 (3261.0)
3	21	1535.0 (1264)	H (71.4); Tr (14.3); Ta (9.5); G (4.8)	Portuguese (76.2); Spanish (23.8)	92272.2 (155174.5)	86.4 (1100.0)
4	15	1459.2 (696)	H (53.8); G (30.8); Ta (7.7); Tr (7.7)	Chinese (66.7); Vietnamese (33.3)	17983.2 (59918.9)	87.7 (579.0)

5.4.3 Trade survey and Kappa results

One sampled group was deleted by its owner shortly after data-collection began, leaving 29 sampled groups. Over the study period there were 55,805 posts from 12,089 unique members, with groups having between 0 and 14,923 posts. The Kappa analyses found high levels of agreement but different uses of categories, with rater one more likely to use the 'wild' category (Table 3). Both the Kappa and sensitivity analyses found no significant differences in results if all 'maybes' were counted as 'yes' for either trade or wild analyses. A difference in use of ‘wild’ between raters was due to rater two's taxonomic skills (e. g.

identifying artificial hybrids that could not be wild) and rater one's language skills (e. g. familiarity with different phrases used to describe wild-collected plants in Indonesian and Malay).

Table 5.3. Two-rater Kappa analysis of presence of trade and wild plants in sampled posts, showing % agreement between the raters, the results of the Stuart Maxwell test of marginal homogeneity, the results of the Cohen's Kappa test for significant agreement between raters, and a measure of whether either rater showed bias towards a certain category. The Cohen's Kappa is unweighted as the categories (Yes, No, Maybe) were not ordinal.

	Agreement (%)	Stuart-Maxwell		Cohen's Kappa (unweighted)		Rater Bias	
		Chi sq.	*p*	Kappa	*p*	Chi sq.	*p*
Trade	93.6	0.6	0.8	0.6	<0.001	0.4	0.5
Wild	86.3	60.4	<0.001	0.3	<0.001	32.9	<0.001

After reanalysis 8.9% (*n* = 50) of posts were identified as likely trade (yes = 46; maybe = 4) and 7.0% (*n* = 39) as likely to contain wild plants (yes = 39; maybe = 13). Some wild plants were not for sale; with these removed, 4.1% (*n* = 23) of posts definitely (yes = 11) or possibly (maybe = 12) contained wild plant trade. Accounting for uncertainty, between 22% (*n* = 11) and 46% (*n* = 23) of trade posts in our sample contained wild-collected plants, although it is important to acknowledge that our sample was small. Unfortunately it is not possible to extrapolate this to the volume of plants being traded as, although one plant was often pictured, these may have been an advert for available stock. For example, one picture showing a few plants of a *Dendrobium* sp. was accompanied by pricing for up to 50kg (See Supporting Information).

Identification of wild-collected species for sale was not always possible but included *Bulbophyllum macrochilum*, *Coelogyne pandurata*, *Dendrobium amabile*, *Dendrobium* *findlayanum*, *Paphiopedilum kolopakingii*, *Paraphalaenopsis serpentilingua*, and unidentified species of *Dendrobium*, *Coelogyne*, *Flickingeria* and *Paphiopedilum* (See Supporting information). In addition, trade in horticultural plants such as *Hoya* spp. (wax flowers) and *Nepenthes* spp. (pitcher plants) was observed within study groups. No animal trade was found but several non-orchid 'suggested groups' visited during the sampling phase openly advertised a wide range of reptiles, mammals and birds for sale. This included live hornbills, leopard cats, macaques, lorises and turtles, with both captive and wild specimens advertised in the same groups (See Supporting Information).

5.5 Discussion

This study represents the first survey of wildlife trade via a global social-media site and the first systematic analysis of networks containing trade in wild-collected species on social media. Our network analysis results demonstrate that trade in orchids is likely occurring within each of the four main sub-communities within the orchid community on this website. Finally, although based on a small sample of posts, we found that 22% of posts with trade in our sample contained plants that are likely to have been wild-collected.

5.5.1 Implications for orchid conservation

We show that, in addition to real-world markets (Flores-Palacios & Valencia-Díaz 2007; Phelps et al. 2014) and traditional websites (Krigas et al. 2014; Vermeulen et al. 2014; Hinsley et al. 2015), wild orchids are also being traded openly via social media. Trade can pose a serious threat to groups such as this and is the number one threat to cacti, the largest plant group to be assessed for the IUCN Red List (Goettsch et al. 2015). Although relatively few orchids have been assessed, those that have show similar trends: 84% of tropical Asian slipper orchids *Paphiopedilum* spp. are threatened with extinction, with trade one of the primary threats (IUCN 2015).

In general, orchids are naturally vulnerable to over-collection due to their sensitivity to other threats and small population sizes (Koopowitz 2001) and it is likely that some of the trade in this study may be the result of collection that could be of conservation concern. One species identified, *P. kolopakingii*, was assessed by the IUCN as Critically Endangered (Rankou, 2015) and at least two others *C. pandurata* and *P. serpentilingua* are listed as protected in the country from which they were being sold. As orchid hobbyists who buy on the internet have a preference for rare species (Hinsley et al. 2015), the sale of wild orchids on social media, if left unchecked, is likely to contribute to pressure on vulnerable wild populations. However, relatively little attention is paid to the 'invisible' trade in horticultural plants (Phelps & Webb 2015) and, although all orchids are CITES-listed, and many are protected from collection under national legislation protected orchids are still collected for trade, and action is needed to address this.

Our results demonstrate where this action could be best targeted to monitor and address social media trade. The largest community in our study comprised all English speaking groups, some European groups, and the majority of those from Indonesia, Malaysia and Thailand, major centres of orchid diversity and export (Thomas 2006; WCSP 2015). The relatively strong ties between these groups matches the known trade connections between Southeast Asia and the important orchid-importing areas of the US, EU and Australia, and it is possible that these connections on social media may facilitate trade between individuals in these areas. Some groups in this community had the strongest connections to the rest of the network and scored highly for betweenness, suggesting that they are key to the network as a whole. This, along with the fact that this community had the most trade focused groups, suggests that social-media communities in these countries may be a priority for monitoring trade. In particular, a quarter of trade groups were based in Indonesia, a country with over 2,000 orchid species and a well-documented role in the legal and illegal wildlife trade (Lee et al. 2005), including online (Nijman et al. 2012). In Indonesia 28 orchid species are legally protected from collection for trade (Republic of Indonesia 1999) but wild plants of at least protected species, *C. pandurata* and *P. serpentilingua*, were found for sale from Indonesian vendors in our study.

Other communities in the network also contained trade, particularly a highly connected community of Latin American groups. There is evidence of wild orchid trade in the region (Flores-Palacios & Valencia-Díaz 2007) and these results suggest that this may also be occurring on social media. Finally, a community of groups from Vietnam, Taiwan and Hong Kong suggests a second community in Asia with little interaction with the first. Vietnam has been an important centre of discovery for new *Paphiopedilum* species that have become over collected for trade, including *P. vietnamense* in 1999 and *P. canhii* in 2010 (Averyanov et al. 2014). Reports suggest that one of the first destinations for trade in both species was Taiwan (Averyanov et al. 2014). Similarly, Hong Kong is a recognized trade hub for Southeast Asian wildlife (Lau 2014). Although originally omitted from our sample, no groups from Mainland China were found during snowball sampling, even though wildlife trade has been recorded on social media in the country (Yu & Jia 2015). This may be due to restrictions on international social media in the country but it is important to acknowledge this omission in a global study such as ours, as Mainland China is the biggest consumer of wildlife in Asia (Grieser-Johns & Thomson, 2005).

The largest community contained two of the most connected groups in our network, both of which had visible trade. Offline networks of plant enthusiasts focus on key individuals who disseminate important information and knowledge (Morris, 2010). Assuming that social-media members follow this pattern and share interesting information from key groups with their contacts, targeting one of these highly-connected groups with well-designed conservation marketing messages about over-collection of orchids for trade would be the most efficient way to spread messages through the network. Whilst we acknowledge that the field of conservation marketing is currently very new, there are rigorous studies from the field of health showing that social marketing can change behaviour if carefully designed (e.g. Stead et al. 2007). However, it is important to note that any conservation intervention in these groups may lead to greater secrecy by illegal traders, which may hamper monitoring efforts. In addition, education about the rules regulating trade may not be effective for all orchid growers as a subset of traders and buyers dismiss these rules and distrust conservationists (pers. obs). However, an understanding of how and why people break the rules is key to designing effective interventions, and the study of the networks and behaviour of illegal traders in an open forum such as social media is a good opportunity to do this.

5.5.2 Identifying the structure of online trade networks

The conservation community needs to strengthen its current approach to tackling wildlife trade (Toledo et al. 2012; Challender & MacMillan 2014) and apply more quantitative analytical methods to the study of the structure and function of trade networks (Schneider

2008). Network analysis has been used to identify major players in the international trade in tigers, ivory and rhino horn (Patel et al. 2015) and our results add further support to the use of this method for the study of wildlife trade. Our application of network analysis has demonstrated a clear need for further work to understand online wildlife trade networks, particularly on social media. The growth of social commerce is beneficial to small businesses (Chaumond 2010) but the potential for illicit trade is great. Large international social-media websites have been reported to host trade in illegal guns (Frier 2014) and drugs (Babb 2014) but scientific research into trade via these networks is scarce and limited to studies of counterfeit drugs (e. g. Mackey & Liang 2013). For wildlife, systematic research has been restricted to studies of national networks (De Magalhães & São-Pedro 2012; Yu & Jia 2015), although emerging trades on global networks have been noted (e.g. Instagram: Hernandez-Castro & Roberts 2015). Our findings demonstrate that these trades exist, take place in structured networks, and are relatively easy to observe. Although focused on orchids our study found links to groups trading in other wild-collected taxa; further analysis should focus on links between different trades to identify key groups or people in these extended networks.

In addition to research, our findings highlight the potential benefit that monitoring these websites could have for law-enforcement and conservation. Previous monitoring of online trade (IFAW 2007) resulted in eBay banning the sale of ivory products (Coghlan 2008). Even if this ban hass not been completely successful (Fleming 2013), it demonstrates that monitoring can provide information to underpin action. In addition to bans, this information could be used to provide intelligence to law-enforcement agencies on the key people involved in trade, or to conservationists and policy makers on the species being traded that may need further protection. Currently, large-scale monitoring by law-enforcement agencies would be difficult to achieve, primarily due to limitations of time to dedicate to this work, and problems that non-experts face in the identification of the species and origin of products for sale. One solution to this could be the development of automated tools to detect potentially illegal trade on different platforms. Currently, work is on-going to develop such tools to detect illegal online trade via auction websites (Hernandez-Castro & Roberts 2015). Whilst structured commerce websites facilitate this kind of detection, social-media websites with free-form text present more of a challenge.

However, developing similar tools in collaboration with social media companies may overcome these problems and improve our understanding of the nature and extent of the trade, and inform efforts to tackle it.

Supporting Information

Equation (S1): Closeness

Another common measure of network structure is closeness. This is the inverse sum of the shortest distances to all other nodes from a focal node - essentially the smallest number of connections taken to reach all nodes in the network. For our network closeness is very small in all cases, meaning that from each node, the path to cover all other nodes is very long. Opsahl et al. (2010) have generalized closeness for a weighted network, such as ours, which is defined as:

$$C_C(i) = \left[\sum_{j=1}^{N} \frac{1}{d(i,j)}\right]^{-1} \qquad \text{(S1)}$$

where d(i,j) is the shortest distance between nodes i and j, and j = 1, 2...150.

Table S5.1 Summary network analysis measures for the whole network and each of the four main communities.

	Mean	Median	Minimum	Maximum
Degree				
Whole network	104	119	0	139
Community 1	109.8	125	1	139
Community 2	87.3	101	1	134
Community 3	125.6	129	106	136
Community 4	105	116	31	130
Strength				
Whole network	4164.3	2163	0	20338
Community 1	4917.1	2809	1	20338
Community 2	849.7	280	1	6762
Community 3	9944.3	11370	2124	14740
Community 4	2881	2112	45	7737
Centrality				
Whole network	35166.8	9554	0	246011
Community 1	42623.8	13156	1	246011
Community 2	3758.7	439	1	48035
Community 3	92272.2	104346	9508	155175
Community 4	17983	9012	54	59919
Betweenness				
Whole network	204.1	0	0	3897
Community 1	279.4	0	0	3897
Community 2	188.6	0	0	3261
Community 3	86.4	0	0	1100
Community 4	88	1	0	579
Closeness				
Whole network	0.00138	0.00159	0.00006	0.00174
Community 1	0.00150	0.00164	0.00010	0.00174
Community 2	0.00103	0.00115	0.00006	0.00171
Community 3	0.00170	0.00172	0.00141	0.00174
Community 4	0.00130	0.00154	0.00006	0.00174

Table S5.2. All orchid taxa found for sale during each post identified as containing trade in the Kappa analysis

Trade	Wild	Species	Country of sale	Price	Additional details
Maybe	Yes	Possibly *Coelogyne* sp. and *Dendrobium* sp.	Indonesia		
Maybe	Yes	*Coelogyne pandurata*	Indonesia		Appeared to be trade but no text to confirm this.
Maybe	Yes	*Paphiopedilum* sp.	Vietnam		Plants clearly wild collected and picture taken in a nursery setting, but unsure whether post itself is selling.
Maybe	Yes	Unknown	Taiwan		
Yes	Maybe	*Phragmipedium sp.*	Brazil	90 reals	
Yes	Maybe	*Bulbophyllum affine*	Brazil	$39	
Yes	Maybe	Unknown	Vietnam		
Yes	Maybe	*Dendrobium kingianum variegata*	Indonesia		
Yes	Maybe	*Prosthechea cochleata*	Argentina	$270	
Yes	Maybe	*Paphiopedilum Leeanum*, *Epidendrum*	Brazil		Some in picture cultivated but one or two plants potentially wild collected. Advertised as for sale or for

Trade	Wild	Species	Country of sale	Price	Additional details
		Ibaguense, *Dendrobium hybrid*, *Bulbophyllum odoratissimum*, *Bulbophyllum Ambrosia*, *Dendrobium kingianum*			trade for other plants.
Yes	Maybe	*Cattleya* sp.	Vietnam		
Yes	Maybe	*Paraphalaenopsis serpentilingua*	Indonesia	150rb	Several plants in picture. No information on origin in this post (However, further posts observed from this seller confirmed wild-origin of these plants)
Yes	No	Unknown	Brazil		
Yes	No	*Cymbidium* sp.	Taiwan		
Yes	No	*Dendrobium* sp.	Vietnam		
Yes	No	Unknown	Unknown		
Yes	No	Unknown	Unknown		No information about
Yes	No	*C. amethystoglossa* x	Brazil	12 reals	

Trade	Wild	Species	Country of sale	Price	Additional details
		brassavola			
Yes	No	*Miltonia spectalis* var . *Moreliana*	Brazil		
Yes	No	*Dendrobium* hybrid	Indonesia	35rb, min order 10 pot	Advert for nursery stock rather than individual plants
Yes	No	*Cattleya* hybrid	Malaysia		
Yes	No	Several hybrids	Brazil		Advert for nursery stock rather than individual plants
Yes	No	*Dendrobium* hybrid x 6	Indonesia	20rb, min order 5 pot	Advert for nursery stock rather than individual plants
Yes	No	Unknown	Malaysia		
Yes	No	*Dendrobium bracteosum*	Indonesia		
Yes	No	*Brassolaeliocattleya* hybrids	Brazil	45 reals each or 3 for 110 reals	
Yes	No	*Dendrobium linawianum*	Taiwan		Advert for nursery stock rather than individual plants
Yes	No	*Coelogyne* sp.	Vietnam	120 thousand dong	

Trade	Wild	Species	Country of sale	Price	Additional details
Yes	No	*C. Amethystoglossa coerulia*	Brazil	40 reals	
Yes	No	*Dendrobium aggregatum*	Brazil	exchange	
Yes	No	*Dendrobium* hybrids	Indonesia	20rb seedling 50rb plant	Advert for nursery stock rather than individual plants
Yes	No	*Cymbidium madidum alba, Cymbidium canaliculatum x 3*	Australia	Expensive	
Yes	No	Unknown	Indonesia		
Yes	No	*Laelia anceps*	Taiwan		
Yes	No	*Dendrobium* hybrids	Indonesia		
Yes	No	*Dendrobium* sp.	Australia		5 plants
Yes	No	*Dendrobium/Phalaenopsis*	Brazil	$10	
Yes	No	*Epigeneium cacuminis*	Vietnam		
Yes	Yes	Unknown	Malaysia		

Trade	Wild	Species	Country of sale	Price	Additional details
Yes	Yes	*Bulbophyllum macrochilum*	Indonesia		
Yes	Yes	*Dendrobium* sp.	Vietnam	45 thousand dong per kg for 10kg, 35 thousand dong per kg for 50kg	
Yes	Yes	*Dendrobium amabile*	Vietnam		Several plants
Yes	Yes	*Dendrobium* sp.	Vietnam	160 thousand dong	
Yes	Yes	*Dendrobium amabile*	Vietnam	110 thousand dong per kg	
Yes	Yes	Possibly Aeridinae spp.	Vietnam		One plant in picture but several newly wild-collected *Paphiopedilum* plants in the background of picture
Yes	Yes	*Coelogyne* sp.	Vietnam		
Yes	Yes	*Flickingeria sp.*, *Dendrobium* sp., (plus one other with No ID)	Vietnam	80k	Several plants
Yes	Yes	*Paphiopedilum kolopakingii*	Indonesia	Wholesale	At least 10 plants

Table S5.3. All non-orchid taxa found opportunistically in orchid groups (flora) and non-orchid groups (fauna) during the course of the study.

Wild collected	Taxa (species if known)	Country sold from	Additional details
Yes	Pitcher plants *Nepenthes* spp.	Indonesia; Malaysia	Several large plants for sale in different posts, photographed both during collection in the forest and in nurseries.
No	*Hoya* spp.	Unsure	Cultivated plants
Yes	Asiatic soft-shelled turtle *Amyda cartilaginea*	Indonesia	At least two very large individuals. Identified by Peter Paul van Dijk, IUCN Turtle Specialist Group. This species is not captive bred due to its size but some collection is permitted (P.P. van Dijk, pers. comm.)
Yes	Snakes: Including: Reticulated python *Python reticulatus*	Indonesia	Wild collection stated in advert. One post identifying the species but several other python species found for sale in other posts with no ID.
Maybe	Macaques *Macaca* sp.	Indonesia	Several very young animals sold in different posts. Origin not advertised.
Yes	Slow loris *Nycticebus* sp.	Indonesia	One young wild individual. Only post in whole survey in which seller is hiding their identity in picture.
Maybe	Sugargliders *Petaurus breviceps*	Indonesia	Several listings. Some state captive breeding, others state wild.
Yes/No	Common palm civet *Paradoxurus hermaphroditus*	Indonesia	Several. Some adverts state that the animal is captive bred, some wild. 200,000 - 375,000 rupiah each.

Wild collected	Taxa (species if known)	Country sold from	Additional details
Maybe	Mouse deer *Tragulus* sp.	Indonesia	Several animals in one cage sold in one posts.
Maybe	Asian short clawed otter *Amblonyx cinerea*	Indonesia	Several animals of mixed ages sold in many posts. Origin not stated for any.
Yes	Leopard cats *Prionailurus bengalensis*	Indonesia	At least 3 posts. Advertised as 'blacan' or 'kucing hutan'. 300,000 rupiah each. Wild origin stated in one case.
Maybe	Lizards. Inc. Monitor lizards *Varanus* sp.	Indonesia	Several posts advertising lizards of various sizes. No origin stated.
Maybe	Owls. Including Barn owl *Tyto alba*	Indonesia x 4	A large number of posts o
Maybe	Crested serpent eagle *Spilornis cheela*	Indonesia	Identified by Simon Mitchell (bird expert, DICE, University of Kent)
Maybe	Spotted kestrel *Falco moluccensis*	Indonesia	Identified by Simon Mitchell (bird expert, DICE, University of Kent)
Yes	Wreathed hornbill *Rhyticeros undulatus*	Indonesia	550,000 rupiah. One very young individual for sale. Wild origin advertised.
Yes	Wrinkled hornbill *Aceros corrugatus*	Indonesia	Identified by Simon Mitchell (bird expert, DICE, University of Kent). Wild origin advertised.
Maybe	Songbirds	Indonesia	Large number of posts and species

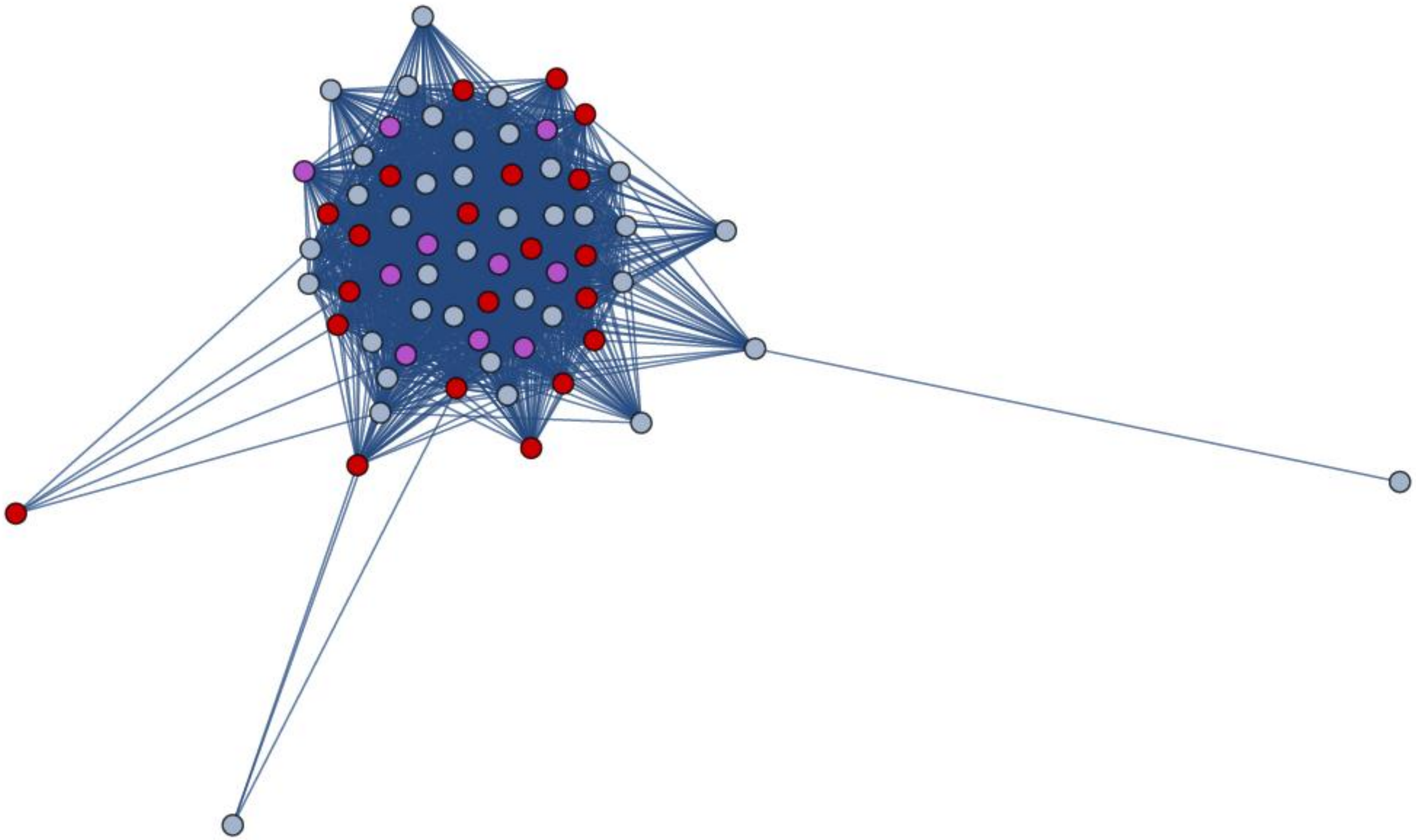

Figure S5.1. Diagram showing the presence/absence of visible trade in nodes within Community 1.

Key: Red: trade; purple: no trade. Grey nodes are groups in which it was not possible to observe visible trade, or where the presence of trade was unsure.

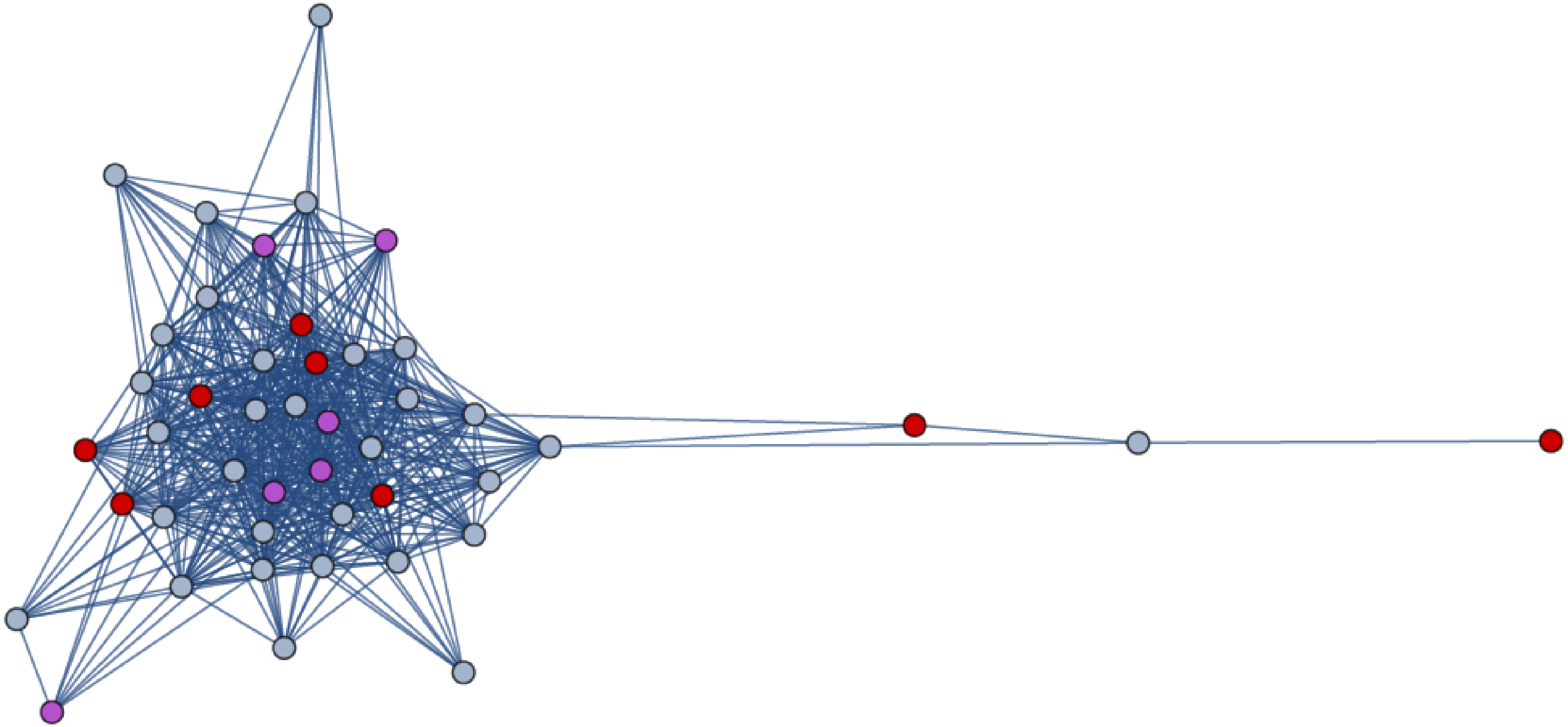

Figure S5.2. Diagram showing the presence/absence of visible trade in nodes within Community 2.

Key: Red: trade; purple: no trade. Grey nodes are groups in which it was not possible to observe visible trade, or where the presence of trade was unsure.

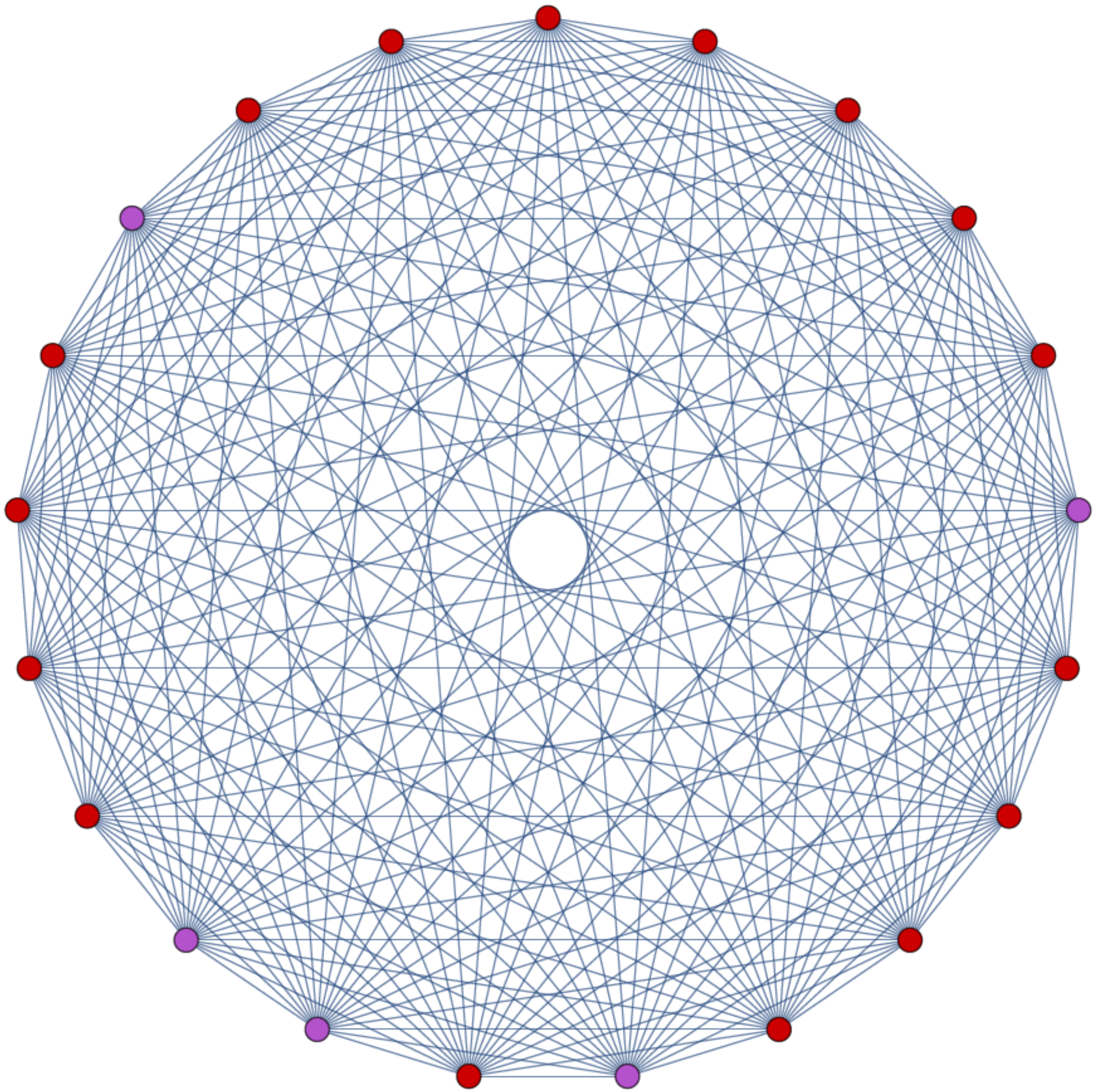

Figure S5.3. Diagram showing the presence/absence of visible trade in nodes within Community 3.

Key: Red: trade; purple: no trade. Grey nodes are groups in which it was not possible to observe visible trade, or where the presence of trade was unsure.

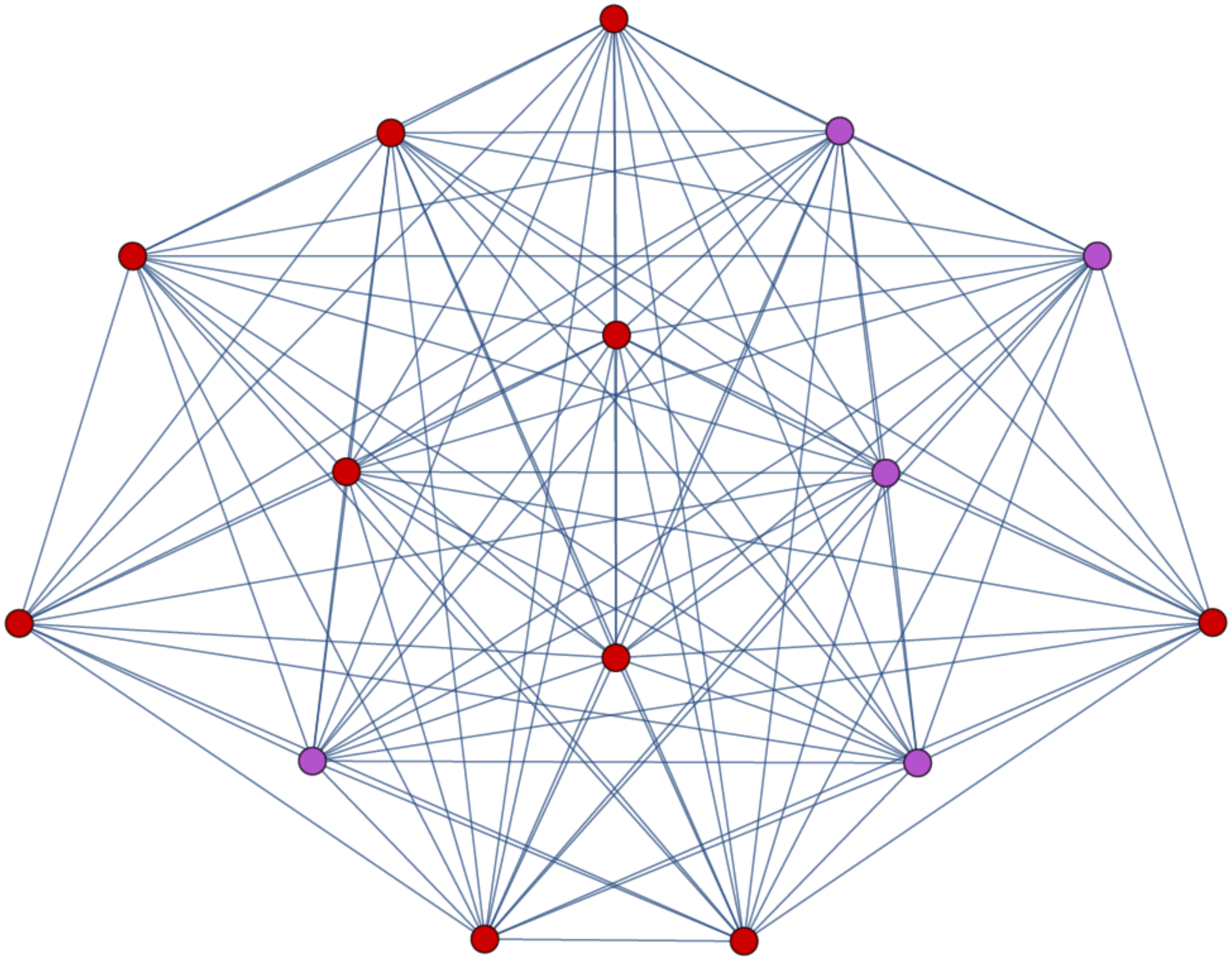

Figure S5.4. Diagram showing the presence/absence of visible trade in nodes within Community 4.

Key: Red: trade; purple: no trade. Grey nodes are groups in which it was not possible to observe visible trade, or where the presence of trade was unsure.

Chapter 6. General Discussion

6.1 Contributions to knowledge and recommendations for conservation policy and practice

This thesis aimed to further our understanding of the legal and illegal trade in wildlife, particularly the specific conservation challenges and opportunities arising from the development of new online communication methods. A case study of orchids allowed the specific investigation of an extensive specialist trade network spanning both legal and illegal markets. Interdisciplinary methods were used to address gaps in the our knowledge relating to consumer behaviour and compliance with the Convention on the International Trade in Endangered Species (CITES), the use of social media for trade and some of the barriers to the development of legal trade.

6.1.1 Evidence for taking plant trade more seriously

The estimated value of the legal ornamental plant trade is larger than the trade in all non-fisheries animal trades combined (Engler & Parry-Jones 2007). In addition, there are recent examples of plants collected to extinction in the wild for the illegal international trade (Averyanov et al. 2014). In spite of this, the majority of the attention from the international NGO community is focussed on the trade in a few charismatic species of animals. Whilst trade is a threat to these animals and conservation effort is needed, unsustainable trade in plants is going unmonitored and unchecked with little attention or resources directed to it (e.g. in Southeast Asia: Phelps & Webb 2015). Chapters 3 and 5 demonstrate that this is also the case for the international trade, with wild plants being sold openly online. In addition, the current blanket CITES listing of orchids is not acting as a serious deterrent to illegal traders (Chapter 3) but may in fact be hampering legal trade and the development of access and benefit sharing (Chapter 4).

6.1.2 Understanding behaviour to improve wildlife trade regulation

There is growing awareness of the need for a diverse strategy to tackle illegal wildlife trade, combining the use of market-based methods and enforcement (Challender et al. 2015). Conservation organisations are increasingly directing resources to behaviour change campaigns (e.g. Humane Society International 2014) but there has been little empirical work thus far to truly understand the nature and drivers of the behaviour to be changed (Verissimo 2014). Market-based methods focussing on the supply or demand side of trade often make assumptions about consumer behaviour but Chapters 2 and 3 demonstrate that these assumptions may be flawed. In particular, many behaviour change campaigns aim to educate or raise awareness about the rarity of a species, or the illegality of consuming it. Chapter 3 challenges the assumption that greater knowledge or awareness automatically promotes positive conservation behaviour. Similarly, Chapter 2 provides further evidence for the harm that advertising rarity can do, and the importance of understanding the underlying reasons for consumer preferences before trying to address them. Future campaigns should be designed carefully to assess the specific drivers influencing consumer behaviour, and to identify sub-groups of consumers that may respond to different messages. Social media, as well as providing a platform for illegal trade, also presents an opportunity to access communities of those with specialist interests. If consumers are active on social media this presents an excellent opportunity by which to disseminate carefully designed campaign messages, using methods similar to those outlined in Chapter 5.

6.1.3 The opportunities and challenges that online trade has for conservation

E-commerce can allow small businesses to advertise their products to international consumers quickly and at relatively low cost but does require capacity in certain skills to achieve this. These include skills in designing and operating e-commerce websites but also in navigating international trade laws, such as CITES and phytosanitary requirements. Developments in social media have provided a free platform for commerce that can be especially beneficial to small businesses selling to specialist consumers (Lee et al. 2008), such as the orchid hobbyist market. However, it is difficult to discover and monitor online wildlife trade networks, especially as traders are quick to adapt their businesses to new technologies such as social media (e.g. in China: Yu & Jia 2015). This thesis adds to the existing literature on internet wildlife trade by exploring the behaviour of consumers buying online (Chapter 2 and 3) and extending the study of social media trade to an international network (Chapter 5). In addition, Chapter 4 demonstrates that the use of the internet to sell orchids is widespread and that a lack of capacity for online trade, coupled with a lack of horticultural and botanical capacity, may be hampering access to international markets. However, Chapters 2, 3 and 5 show the potential pitfalls of encouraging online trade to international consumers, and highlight the importance of careful management and monitoring to ensure trade is sustainable. In particular, Chapter 5 provides the first systematic study of a specialist trade network operating on an international social media website.

A benefit of the current lack of policing of the online trade is that illegal traders are operating relatively openly, providing the opportunity for important intelligence about the structure of trade networks to be gathered. Recognition of the need for CITES Parties to monitor online trade in wildlife is a positive step (CITES 2010) but many may lack the capacity to do so effectively. All chapters in this thesis show that online trading communities are likely to be diverse and multi-national, which will require a coordinated international approach to monitor the trade, and identify and locate those trading illegally.

6.1.4 Supporting legal trade and controlling illegal trade

The legal wildlife trade can bring benefits to the livelihoods of many people but is difficult to manage to ensure the equitable sharing of these benefits, which is a key goal for conservation (CBD 1992). In addition, legal wildlife trade may help tackle the illegal trade but this relationship is complex and cannot be assumed (Phelps et al. 2014).

Chapter 4 highlights that the benefits of orchid trade in Southeast Asia are centred in more developed countries and are not flowing back to lower income range-states. These countries possess several species that are not currently traded and, as demonstrated by Chapter 2, novelty is an important attribute for online consumers, especially hobbyists buying online. Therefore, with horticultural and e-commerce capacity building, the diverse native orchids of these countries could provide a good basis for the development of small businesses in the international market. As highlighted in Chapter 3, this process would have to be carefully managed to prevent online trade being used to bypass CITES rules.

Illegal orchid trade is widespread in Southeast Asia in offline markets (Phelps & Webb 2015) and Chapter 5 demonstrates that this trade is also occurring via social media in the region, particularly in Indonesia and Vietnam. In addition, on a global scale CITES may not be acting as a deterrent to illegal international trade for many hobbyists and traders. A lack of capacity for enforcement coupled with widespread distrust and dislike of CITES is likely contributing to this. Whilst this a challenge to conservation it is also likely to be a barrier to legal businesses, as traders willing to break the rules will be at an advantage. One approach to this is improving traceability, the process of tracking a product throughout a trade chain from source to end consumer. The importance of traceability for products such as timber (CITES 2013a) and reptile skins (CITES 2013b) was recognised at the 16th CITES CoP in Bangkok. Whilst this is an important step forward, these recommendations focus on processed products rather than living, reproductive specimens such as orchids, which are not a finite resource. Although efforts should be made to develop specific methods for orchid traceability there should be a focus on developing an international standard for tracing orchids and other wildlife products, due to the global nature of the trade. If traceability information could be linked directly to export and import permits it would also serve to strengthen the monitoring role of CITES, and reduce the likelihood of laundering.

6.2 Limitations and recommendations for future research

6.2.1 The role of online networks in the wider trade

Gathering data on the structure and function of online trade networks is an important step that should form the basis of further monitoring. However, samples will be biased towards those consumer and trading countries with widespread internet access and may not be indicative of the wider wildlife trade. Parallels can be drawn, for example the countries with the least online trade in orchids identified in Chapter 4 match closely the official export data for ornamental plants (ITC 2015). Chapter 5 demonstrated that the social media orchid trade has close links to trade groups selling other wildlife and further application of social media surveys would be useful to investigate the crossover between different trades. Future research should focus on placing online trade in the wider context of wildlife trade by extending the network analysis methods outlined in this thesis to include offline interactions, where this is possible.

To better understand the extent of online trade networks and their linkages with offline trade it is essential that robust and adaptable methods for monitoring online trade are developed. Conservationists have long recognised the importance of using social science methods (Mascia et al. 2003) and our understanding of what makes multidisciplinary conservation work is improving (Pooley et al. 2014). Chapters 2, 3, 4 and 5 demonstrate that methods from different disciplines can reveal important information about the structure and function of trade networks, especially those that operate online. Online trading communities provide an opportunity to engage consumers and traders from around the world in research and study their networks. However, developing methods to study the trade on one social media website will only have limited value if traders change their practices in response, as they did when attention was paid to traditional e-commerce websites (Yu & Jia 2015). A process of 'horizon scanning' (Sutherland & Woodroof 2009) to identify emerging online platforms that may begin to host trade would greatly benefit efforts to monitor it. This should begin with research into the extent and nature of trade via social media websites, such as Facebook, Twitter, Instagram and Weibo, to identify the characteristics of platforms used for trade. Part of this should be the development of automated tools for the rapid detection of wildlife trade online and the adaptation of these for use on social media (Hernandez-Castro & Roberts 2015). Finally, this monitoring should be extended to the offline trade through research to develop new and robust traceability methods for products such as orchids in international trade.

6.2.2 Widening the study of consumer behaviour

The results presented here suggest that people who illegally buy or sell wildlife carry out this trade openly, or will admit to their involvement honestly. Due to the reasons discussed in Chapter 3 relating to defiance of CITES, the orchid trade is likely to be an unusual case and widening the application of these methods to other trades may face problems. Due to the great benefits that understanding consumer behaviour may have, efforts should be made to tailor these studies to the consumers in question. For completely illegal trade networks, or where social desirability may cause significant bias, carrying out surveys online may provide anonymity and the application of specialised questioning techniques should be explored further.

6.2.3 Translating research into practice

Recommendations for improving conservation practice are only useful if they are feasible in the real world and reach the people who can implement them. Adapting recommendations to local contexts is particularly important, for example, whilst potential gaps in access and benefit sharing may be identified online, it is difficult to ascertain the exact reason for these gaps. In Chapter 4, a lack of horticultural and botanical capacity and limited access to e-commerce platforms were suggested but working with stakeholders to identify the exact needs in each country would be required before any intervention could be effective.

In addition, methods used in this thesis have the potential for application to the study of different traded species and the evidence-based planning of conservation action. However, these methods require careful design, and the expertise and software to analyse them effectively. For conservation NGOs who may be restricted by time, resources and the need to justify all budget lines to donors, the use of systematic methods in project planning may be a luxury. Further, several findings presented here require action in developing countries, where there is a significant gap between conservation research and the application of its findings (Gossa et al. 2015). Collaboration between academics and practitioners would be one way to overcome these limitations, including efforts to encourage funders to recognise the importance of supporting the collection of this data for the success of projects. In addition, further research to refine and simplify methods may be beneficial, as would ensuring that all results of relevant studies are made open-access.

References

Abbott, B. & van Kooten, G.C., (2011). Can domestication of wildlife lead to conservation? The economics of tiger farming in China. *Ecological Economics*, 70 (4), 721–728.

Alexa, (2015). Alexa Top 500 Global Sites. Available at: http://www.alexa.com/topsites [Accessed July 23, 2015].

Andrews, R.L. & Currim, I.S., (2003). A Comparison of Segment Retention Criteria for Finite Mixture Logit Models. *Journal of Marketing Research*, 40 (2), 235–243.

Angulo, E. & Courchamp, F., (2009). Rare species are valued big time. *PloS One*, 4 (4), p.e5215.

AOS, (2015). About the American Orchid Society. *The American Orchid Society*. Available at: http://www.aos.org/Default.aspx?id=24 [Accessed September 18, 2015].

Aronow, P.M., Coppock, A. & Crawford, F.W., (2015). Combining List Experiment and Direct Question Estimates of Sensitive Behavior Prevalence. *Journal of Survey Statistics and Methodology*, 3 (1), 43–66.

Artuso, A., (2002). Bioprospecting, Benefit Sharing, and Biotechnological Capacity Building. *World Development*, 30 (8), 1355–1368.

ASEAN, (2013). The Association of Southeast Asian Nations. Available at: http://www.asean.org/asean/asean-member-states [Accessed April 1, 2012].

Averyanov, L. V. Cribb, P., Phan, K. L., Nguyen, T.H. (2003). *Slipper Orchids of Vietnam.*, Royal Botanic Gardens, Kew, Richmond, UK.

Averyanov, L. V., The, P. V., Phan K. L., Nguyen, H., Canh, C. X., Nguyen, T. V., Nguyen, H. Q., (2014). Field survey of Paphiopedilum canhii: from discovery to extinction. *Report to The Rufford Foundation*. Available at: http://www.rufford.org/files/www.slipperorchid.org__0.pdf [Accessed May 5, 2015].

Babb, F., (2014). Instagram has a drug problem. *Venturebeat*. Available at: http://venturebeat.com/2014/09/19/instagram-has-a-drug-problem/ [Accessed August 12, 2015].

Barton, K., (2015). R Package: MuMIn: Multi-Model Inference. v. 1.15.1.

Bell, S., Hampshire, K. & Topalidou, S., (2007). The political culture of poaching: a case study from northern Greece. *Biodiversity and Conservation*, 16 (2), 399–418.

Bennett, E.L., (2011). Another inconvenient truth: the failure of enforcement systems to save charismatic species. *Oryx*, 45 (04), 476–479

Bennett, E.L., (2015). Legal ivory trade in a corrupt world and its impact on African elephant populations. *Conservation Biology*, 29 (1), 54–60.

Biernacki, P. & Waldorf, D., (1981). Snowball Sampling: Problems and Techniques of Chain Referral Sampling. *Sociological Methods Research,* 10 (2), 141–163.

Birol, E., Villalba, E.R. & Smale, M., (2009). Farmer preferences for milpa diversity and genetically modified maize in Mexico: a latent class approach. *Environment and Development Economics*, 14 (4), 521–540.

Blair, G. & Imai, K., (2010). R Package: Statistical Methods for the Item Count Technique and List Experiment. v. 8.0.

Blamey, R.K., Bennett, J.W., Louviere, J.J., Morrison, M.D., Rolfe, J. (2000). A test of policy labels in environmental choice modelling studies. *Ecological Economics*, 32 (2), 269–286.

Blundell, A.G. & Mascia, M.B., (2005). Discrepancies in reported levels of international wildlife trade. *Conservation Biology*, 19 (6), 2020–2025.

boyd, danah m. & Ellison, N.B., (2007). Social Network Sites: Definition, History, and Scholarship. *Journal of Computer-Mediated Communication*, 13 (1), 210–230.

Bozdogan, H., (1993). *Choosing the Number of Component Clusters in the Mixture-Model using A New Informational Complexity Criterion of the Inverse-Fisher Information Matrix,* Springer, Berlin Heidelberg.

Brack, D., (2002). Combatting international environmental crime. *Global Environmental Change,* 12 (2), 143–147.

Brenner, S.W., (2002). Organized Cybercrime? How Cyberspace May Affect the Structure of Criminal Relationships. *North Carolina Journal of Law and Technology*, 4 (1).

Broad, S., Mulliken, T. & Roe, D., (2003). The nature and extent of legal and illegal trade in wildlife. p. 210 In S. Oldfield, ed. *The trade in wildlife: regulation for conservation*. Routledge, London.

Bulte, E.H. & Damania, R., (2005). An Economic Assessment of Wildlife Farming and Conservation. *Conservation Biology*, 19 (4), 1222–1233.

Burnham, K. & Anderson, D., (2002). *Model selection and multimodel inference: a practical information-theoretic approach*, Springer-Verlag, New York.

Cameron, K., (2011). *Vanilla Orchids: Natural History and Cultivation*, Timber Press Portland, Oregon, US

Caussade, S., Ortúzar, J. D., Rizzi, L. I., Hensher, D. A., (2005). Assessing the influence of design dimensions on stated choice experiment estimates. Transportation Research Part B: Methodological, 39 (7), 621–640.

CBD, (1992). Convention on Biological Diversity. Adopted 5 June 1992, Rio de Janeiro, Brazil. Available at: http://www.cbd.int/convention/text/ [Accessed November 1, 2013].

CBD, (2002). Decision VI/9, Global Strategy for Plant Conservation, 2002–2010. Available at: http://www.cbd.int/decision/cop/?id=7183 [Accessed June 15, 2015].

CBD, (2012). Decision X/17, Global Strategy for Plant Conservation, 2011–2020. Available at: http://www.cbd.int/gspc/strategy.shtml [Accessed June 15, 2015].

Ceballos, E. & Kepel, A., (2010). Internet trade of CITES species of animals in Ecuador. Available at: http://www.catcahelpanimals.org/docs/ecuadorreport2009.pdf [Accessed September 10, 2015].

Ceballos, E., (2010). Internet trade of elephant ivory in Latin America. Available at: http://www.catcahelpanimals.org/docs/ivoryreport2010.pdf [Accessed September 10, 2015].

Challender, D.W.S. & MacMillan, D.C., (2014). Poaching is more than an Enforcement Problem. *Conservation Letters*, 7 (5), 484–494.

Challender, D.W.S. Wu, S. B., Nijman, V., MacMillan, D. C., (2014). Changing behavior to tackle the wildlife trade. *Frontiers in Ecology and the Environment*, 12 (4), p.203.

Challender, D.W.S., Harrop, S.R. & MacMillan, D.C., (2015). Understanding markets to conserve trade-threatened species in CITES. *Biological Conservation*, 187, 249–259.

Chaumond, J., (2010). *Social commerce (French Edition)*, Digital Mammouth.

Chong, K.Y., Tan, H.T.W. & Corlett, R.T., (2009). *A Checklist of the Total Vascular Plant Flora of Singapore. Native, Naturalised and Cultivated Species*, Raffles Museum of Biodiversity Research, National University of Singapore, Singapore.

Chugh, S., Guha, S. & Rao, I.U., (2009). Micropropagation of orchids: A review on the potential of different explants. *Scientia Horticulturae*, 122 (4), 507–520.

CITES, (2002). Resolution Conf. 12.8 (Rev. CoP13): Review of Significant Trade in specimens of Appendix-II species. Twelfth meeting of the Conference of the Parties Santiago (Chile) 3-15 November 2002. Revised at the Thirteenth meeting of the Conference of the Parties. Bangkok (Thailand) 02-14 October 2004. Available at: https://www.cites.org/eng/res/12/12-08R13.php [Accessed September 22, 2015].

CITES, (2004). Orchid hybrids exempted from CITES. , 1–10. Available at: http://www.cites.org/common/cop/13/E13-P41Annex.pdf [Accessed May 18, 2015].

CITES, (2010a). CoP15 Prop. 14 . Consideration of Proposals for Amendment of Appendices I and II. *Fifteenth meeting of the Conference of the Parties Doha (Qatar), 13-25 March 2010.* Available at: https://www.cites.org/sites/default/files/eng/cop/15/prop/E-15-Prop-14.pdf [Accessed September 22, 2015].

CITES, (2010b). Decision 15.57 & 16.62: E-commerce of specimens of CITES-listed species. *Fifteenth meeting of the Conference of the Parties Doha (Qatar), 13-25 March 2010.* Available at: https://www.cites.org/eng/dec/valid16/208 [Accessed September 22, 2015].

CITES, (2013a). The CITES species. Available at: https://www.cites.org/eng/disc/species.php [Accessed July 22, 2015].

CITES, (2013b). Decision 16.58. Physical inspection of timber shipments. *Sixteenth meeting of the Conference of the Parties. Bangkok, Thailand. 03-14 March 2013*. Available at: https://cites.org/eng/dec/valid16/16_58.php [Accessed September 24, 2015].

CITES, (2013c). Decisions 16.102 to 16.108 Snake trade and conservation management (Serpentes spp.). *Sixteenth meeting of the Conference of the Parties. Bangkok, Thailand. 03-14 March 2013*. Available at: https://cites.org/eng/taxonomy/term/222 [Accessed September 24, 2015].

CITES, (2015). What is CITES? Available at: https://www.cites.org/eng/disc/what.php [Accessed September 15, 2015].

Coghlan, A., (2008). eBay ivory ban is good news for elephants. *New Scientist*. Available at: https://www.newscientist.com/article/dn15007-ebay-ivory-ban-is-good-news-for-elephants/ [Accessed July 22, 2015].

Coghlan, A., (2014). Campaign blunts Vietnamese demand for rhino horn. *New Scientist*. Available at: https://www.newscientist.com/article/dn26415-campaign-blunts-vietnamese-demand-for-rhino-horn/ [Accessed September 23, 2015].

Cohen, J., (1960). A Coefficient of Agreement for Nominal Scales. *Educational and Psychological Measurement*, 20 (1), 37–46.

Cohen, J., (1968). Weighted Kappa: nominal scale agreement with provision for scaled disagreement or partial credit. *Psychological Bulletin*, 70 (4), 213–220.

Commonwealth of Australia, (2015). How the Convention on International Trade in Endangered Species of Wild Fauna and Flora works - Wildlife trade and conservation in Australia. Australian Government. Department of Environment. Available at: http://www.environment.gov.au/biodiversity/wildlife-trade/cites/how-cites-works [Accessed September 12, 2015].

Courchamp, F., Angulo, E., Rivalan, P., Hall, R.J., Signoret, L., Bull, L. and Meinard, Y., (2006). Rarity value and species extinction: the anthropogenic Allee effect. *PLoS Biology*, 4 (12), p.e415.

Damania, R. & Bulte, E.H., (2007). The economics of wildlife farming and endangered species conservation. *Ecological Economics*, 62 (3-4), 461–472.

De Magalhães, A.L.B. & São-Pedro, V.A., (2012). Illegal trade on non-native amphibians and reptiles in southeast Brazil: The status of e-commerce. *Phyllomedusa*, 11 (2), 155–160.

de-Magistris, T. & Pascucci, S., (2014). The effect of the solemn oath script in hypothetical choice experiment survey: A pilot study. *Economics Letters,* 123 (2), 252–255.

Derraik, J.G.B. & Phillips, S., (2010). Online trade poses a threat to biosecurity in New Zealand. *Biological Invasions*, 12 (6), 1477–1480.

Doukakis, P., Pikitch, E. K., Rothschild, A., DeSalle, R., Amato, G., & Kolokotronis, S. O., (2012). Testing the effectiveness of an international conservation agreement: marketplace forensics and CITES caviar trade regulation. *PloS One*, 7 (7), p.e40907.

Droitcour, J., Caspar, R. A., Hubbard, M. L., Parsley, T. L., Visscher, W., & Ezzati, T. M., (1991). The Item Count Technique as a Method of Indirect Questioning: A Review of Its Development and a Case Study Application. In P. P. Biemer et al eds. *Measurement Errors in Surveys. Wiley Series in Probability and Statistics.* John Wiley & Sons, Hoboken, NJ, USA.

Drury, R., (2009). Reducing urban demand for wild animals in Vietnam: examining the potential of wildlife farming as a conservation tool. *Conservation Letters*, 2 (6), 263–270.

Dutton, A.J., Hepburn, C. & Macdonald, D.W., (2011). A stated preference investigation into the Chinese demand for farmed vs. Wild bear bile. *PloS One*, 6 (7). e21243.

Easley, D. & Kleinberg, J., (2010). *Networks, Crowds, and Markets: Reasoning About a Highly Connected World*, Cambridge University Press, Cambridge.

Engler, M. & Parry-Jones, R., (2007). *Opportunity or threat? The role of the European Union in global wildlife trade*, TRAFFIC Europe. Brussels, Belgium.

Entwistle, A., Atay, S., Byfield, A., & Oldfield, S., (2002). Alternatives for the bulb trade from Turkey: a case study of indigenous bulb propagation. Oryx, 36 (4), 333–341.

Facebook for Business, (2015). More Support For Small Businesses: Educational Events and Live Chat. Available at: https://www.facebook.com/business/news/small-business-support [Accessed July 23, 2015].

Facebook, (2015). Company Info | Facebook Newsroom. Available at: http://newsroom.fb.com/company-info/ [Accessed July 23, 2015].

FAO, (2009). International Treaty on Plant Genetic Resources for Food and Agriculture of the Food and Agricultural Organization. Available at: ftp://ftp.fao.org/docrep/fao/011/i0510e/i0510e.pdf [Accessed May 1, 2014].

Fischer, C., (2004). The complex interactions of markets for endangered species products. Journal of Environmental Economics and Management, 48 (2), 926–953.

Fleming, N., (2013). The online hunt for illegal wildlife traders. *New Scientist*, 218 (2914), 31. Available at: http://www.sciencedirect.com/science/article/pii/S0262407913610556 [Accessed July 24, 2015].

FloraHolland, (2013). Facts & Figures. FloraHolland Facts and Figures, 2013. Available at: https://www.floraholland.com/en/about-floraholland/who-we-are-what-we-do/facts-and-figures/ [Accessed March 1, 2015].

FloraHolland, (2014). Facts & Figures. *FloraHolland Facts and Figures 2014*. Available at: http://www.r-e-a.net/resources/facts-and-figures [Accessed September 16, 2015].

Flores-Palacios, A. & Valencia-Díaz, S., (2007). Local illegal trade reveals unknown diversity and involves a high species richness of wild vascular epiphytes. Biological Conservation, 136 (3), 372–387.

Fortunato, S., (2010). Community detection in graphs. Physics Reports, 486 (3-5), 75–174.

Frier, S., (2014). Facebook Cracking Down on Illegal Gun Sales Planned on Site - Bloomberg Business. *Bloomberg*. Available at: http://www.bloomberg.com/news/articles/2014-03-05/facebook-cracking-down-on-illegal-gun-sales-planned-through-site [Accessed September 8, 2015].

Gamer, M., Lemon, J., Fellows, I., Singh, P., (2012). R Package: Various Coefficients of Interrater Reliability and Agreement. v 0.84. Available at: http://cran.r-project.org/package=irr.

Ghorbani, A., Gravendeel, B., Naghibi, F. and de Boer, H., (2014). Wild orchid tuber collection in Iran: a wake-up call for conservation. Biodiversity and conservation, 23(11), 2749-2760.

Glynn, A.N., (2013). What Can We Learn with Statistical Truth Serum? Design and Analysis of the List Experiment. Public Opinion Quarterly, 77 (S1), 159–172.

Goettsch, B., Hilton-Taylor, C., Cruz-Piñón, G., Duffy, J.P., Frances, A., Hernández, H.M., Inger, R., Pollock, C., Schipper, J., Superina, M. and Taylor, N.P., (2015). High proportion of cactus species threatened with extinction. Nature Plants, 1, p.15142.

Gómez, A. & Aguirre, A.A., (2008). Infectious diseases and the illegal wildlife trade. Annals of the New York Academy of Sciences, 1149 (1), 16–9.

Gordon, I. & Ayiemba, W., (2003). Harnessing Butterfly Biodiversity for Improving Livelihoods and Forest Conservation: The Kipepeo Project. The Journal of Environment & Development, 12 (1), 82–98.

Gossa, C., Fisher, M. & Milner-Gulland, E.J., (2015). The research–implementation gap: how practitioners and researchers from developing countries perceive the role of peer-reviewed literature in conservation science. Oryx, 49 (1), 80–87.

Govaerts, R. et al (2014). World Checklist of Orchidaceae. *World Checklist of Orchidaceae. Facilitated by the Royal Botanic Gardens, Kew*. Available at: http://apps.kew.org/wcsp/ [Accessed December 1, 2014].

Grabosky, P., (2013). Organised Crime and the Internet. The RUSI Journal, 158 (5), 18–25.

Gratwicke, B., Bennett, E., Broad, S., Christie, S., Dutton, A., Gabriel, G., Kirkpatrick, C. and Nowell, K., (2008). The world can't have wild tigers and eat them, too. *Conservation Biology*, 22 (1), 222-223.

Griesbach, R., (2002). Development of Phalaenopsis orchids for the mass-market. In J. Janick & A. Whipkey, eds. Trends in New Crops and Uses. Alexandria, VA: ASHS Press, 458–465.

Grieser-Johns, A. and Thomson, J., (2005). Going, going, gone: The illegal trade in wildlife in East and Southeast Asia. World Bank, Washington, DC.

Gruß, O. Rungruang, N., Chaisuriyakul, Y., and Dionisio, I., (2014). A new and very distinct species of the genus Paphiopedilum from north-Laos is described as Paphiopedilum rungsuriyanum. OrchideenJournal, 2, 1–11.

Hajramurni, A., (2011). Indonesia encouraged to grow orchids. *The Jakarta Post 25th October 2011*. Available at: http://www.thejakartapost.com/news/2011/10/25/indonesia-encouraged-grow-orchids.html [Accessed May 1, 2014].

Haken, J., (2011). Transnational Crime In The Developing World, Global Financial Integrity, Washington D.C.

Hall, R.J., Milner-Gulland, E.J. & Courchamp, F., (2008). Endangering the endangered: The effects of perceived rarity on species exploitation. *Conservation Letters*, 1 (2), 75–81.

Hanley, N., MacMillan, D., Patterson, I. and Wright, R.E., (2003). Economics and the design of nature conservation policy: a case study of wild goose conservation in Scotland using choice experiments. *Animal conservation*, 6 (02), 123-129.

Hansen, E., (2000). *Orchid Fever: A Horticultural Tale of Love, Lust, and Lunacy* 2nd ed., Methuen Publishing Ltd. London, UK.

Hansen, M.T., (1999). The search-transfer problem: The role of weak ties in sharing knowledge across organization subunits. Administrative Science Quarterly, 44(1), 82–111.

Harrison, M., Baker, J., Twinamatsiko, M. and Milner-Gulland, E.J., (2015). Profiling unauthorized natural resource users for better targeting of conservation interventions. Conservation Biology, 29 (6), 1636-1646.

Henne, G. & Fakir, S., (1991). NBI-Ball Agreement: A new phase in bioprospecting? *Biotechnology and Development Monitor*, 39, 18–21.

Hensher, D.A., Rose, J.M. & Greene, Wi.H., (2005). *Applied Choice Analysis: A Primer*, Cambridge, UK: Cambridge University Press.

Hernandez-Castro, J. & Roberts, D.L., (2015). Automatic detection of potentially illegal online sales of elephant ivory via data mining. *PeerJ Computer Science*, 1, p.e10.

Heywood, V.H., (2003). Conservation and sustainable use of wild species as sources of new ornamentals. *International Symposium on Sustainable Use of Plant Biodiversity to Promote New Opportunities for Horticultural Production Development*, 598, 43–53.

Hinsley, A., (2010). Notes on the trade of orchids in the Cardamom Mountains, Pursat and Koh Kong Provinces. *Cambodian Journal of Natural History*, 1, 11–13.

Hinsley, A., Verissimo, D. & Roberts, D.L., (2015). Heterogeneity in consumer preferences for orchids in international trade and the potential for the use of market research methods to study demand for wildlife. *Biological Conservation*, 190, 80–85.

Holbrook, A.L. & Krosnick, J.A., (2010). Social desirability bias in voter turnout reports: Tests using the item count technique. *Public Opinion Quarterly*, 74(1), 37–67.

Humane Society International, (2014). Demand for Rhino Horns in Viet Nam Decreases as a Result of Humane Society International and Viet Nam CITES Management Authority Partnership Campaign, Poll Says. Human Society International. Available at www.hsi.org/assets/pdfs/vietnam-rhino-horn-campaign-poll-results.pdf [Accessed July 21, 2015]

IFAW, (2007). Bidding for Extinction. International Fund for Animal Welfare. London. Available at: http://www.ifaw.org/sites/default/files/Report 2007 Bidding for Extinction.pdf [Accessed July 21, 2015].

IFAW, (2011). Killing with Keystrokes 2.0. International Fund for Animal Welfare. London. Available at: http://www.ifaw.org/sites/default/files/FINAL Killing with Keystrokes 2.0 report 2011.pdf [Accessed July 21, 2015].

ITC, (2015). Trade Map. *International Trade Centre*. Available at: www.intracen.org/marketanalysis [Accessed January 15, 2015].

IUCN, (2015a). IUCN - Conservation successes overshadowed by more species declines – IUCN Red List update. Available at: http://www.iucn.org/?21561/Conservation-successes-overshadowed-by-more-species-declines--IUCN-Red-List-update [Accessed July 24, 2015].

IUCN, (2015b). The IUCN Red List of Threatened Species. Version 2015-3. Available at: http://www.iucnredlist.org/search [Accessed September 17, 2015].

Jaeger, S.R. & Rose, J.M., (2008). Stated choice experimentation, contextual influences and food choice: A case study. *Food Quality and Preference,* 19 (6), 539–564.

Jepson, P. & Ladle, R.J., (2005). Bird-keeping in Indonesia: conservation impacts and the potential for substitution-based conservation responses. *Oryx*, 39 (04), 442.

Jepson, P., Ladle, R.J. & Sujatnika, (2011). Assessing market-based conservation governance approaches: a socio-economic profile of Indonesian markets for wild birds. *Oryx*, 45 (04), 482–491.

Joppa, L.N., Roberts, D.L., Myers, N. and Pimm, S.L., (2011). Biodiversity hotspots house most undiscovered plant species. *Proceedings of the National Academy of Sciences*, 108 (32), 13171-13176.

Kahler, J.S. & Gore, M.L., (2012). Beyond the cooking pot and pocket book: Factors influencing noncompliance with wildlife poaching rules. *International Journal of Comparative and Applied Criminal Justice*, 36 (2), 103–120.

Kala, B. & Kepel, A., (2009). e-CEETES: Central and Eastern European e-trade in endangered species. Available at: http://www.ceeweb.org/wp-content/uploads/2011/12/e-CEETES.pdf [Accessed September 10, 2015].

Kontoleon, A. & Swanson, T., (2003). The Willingness to Pay for Property Rights for the Giant Panda: Can a Charismatic Species Be an Instrument for Nature Conservation? *Land Economics*, 79 (4), 483.

Kontoleon, A. & Yabe, M., (2006). Market Segmentation Analysis of Preferences for GM Derived Animal Foods in the UK. *Journal of Agricultural & Food Industrial Organization*, 4 (1).

Koopowitz, H., (2001). *Orchids and Their Conservation*, Timber Press.Portland, Oregon, US

Kremer, M. & Morcom, C., (2000). Elephants. *American Economic Review*, 90 (1), 212–234.

Krigas, N., Menteli, V. & Vokou, D., (2014). The Electronic Trade in Greek Endemic Plants: Biodiversity, Commercial and Legal Aspects. *Economic Botany*, 68 (1), 85–95.

Lajiun, J., (2015). Illegal wildlife trade via social media. *The Borneo Post*. Available at: http://www.theborneopost.com/2015/08/04/illegal-wildlife-trade-via-social-media/ [Accessed September 8, 2015].

Lamxay, V., (2009). Case study on orchid exports from Lao PDR: recommendations for using the Convention on International Trade in Endangered Species of Wild Fauna and Flora to increase sustainable orchid trade., IUCN, Gland Switzerland and Cambridge, UK.

Lancaster, K.J., (1966). A New Approach to Consumer Theory. *Journal of Political Economy*, 74 (2), 132–157.

Lau, W., (2014). *Taking from the Wild: Moving Towards Sustainability in Hong Kong's Wildlife Trade*, Civic Exchange, Hong Kong.

Lavorgna, A., (2014). Wildlife trafficking in the Internet age. *Crime Science*, 3 (1), 5–17.

Lee, R.J., Gorog, A.J., Dwiyahreni, A., Siwu, S., Riley, J., Alexander, H., Paoli, G.D. and Ramono, W., (2005). Wildlife trade and implications for law enforcement in Indonesia: a case study from North Sulawesi. *Biological Conservation,* 123 (4), 477-488.

Lee, S.-H., DeWester, D. & Park, S.R., (2008). Web 2.0 and opportunities for small businesses. *Service Business*, 2 (4), 335–345.

Lenda, M., Skórka, P., Knops, J.M., Moroń, D., Sutherland, W.J., Kuszewska, K. and Woyciechowski, M., (2014). Effect of the internet commerce on dispersal modes of invasive alien species. *PloS One*, 9 (6), p.e99786.

Lipińska, A.M. & Gołąb, M.J., (2008). Internet trade in Polish endangered species of butterflies, beetles and molluscs. *Nature Conservation*, 65, 79–87.

Liu, H., Luo, Y.B., Heinen, J., Bhat, M. and Liu, Z.J., (2014). Eat your orchid and have it too: a potentially new conservation formula for Chinese epiphytic medicinal orchids. *Biodiversity and Conservation*, 23 (5), 1215-1228.

Lybbert, T.J., Barrett, C.B. & Narjisse, H., (2002). Market-based conservation and local benefits: the case of argan oil in Morocco. *Ecological Economics*, 41 (1), 125–144.

Mackey, T.K. & Liang, B.A., (2013). Global reach of direct-to-consumer advertising using social media for illicit online drug sales. *Journal of medical Internet research*, 15 (5), p.e105.

Malanes, M., (2014). Orchid collecting grows into big business. *Inquirer North Luzon. 28th May 2014.* Available at: http://newsinfo.inquirer.net/606069/orchid-collecting-grows-into-big-busines [Accessed May 1, 2014].

Mangham, L.J., Hanson, K. & McPake, B., (2009). How to do (or not to do) ... Designing a discrete choice experiment for application in a low-income country. *Health policy and planning*, 24 (2), 151–8.

Mark, J., Newton, A.C., Oldfield, S. and Rivers, M., (2014). *The International Timber Trade: A Working List of Commercial Timber Tree Species*. Botanic Gardens Conservation International, Richmond, UK.

Mascia, M.B., Brosius, J.P., Dobson, T.A., Forbes, B.C., Horowitz, L., McKean, M.A. and Turner, N.J., (2003). Conservation and the social sciences. *Conservation Biology,* 17 (3), 649-650.

Maxwell, A.E., (1970). Comparing the Classification of Subjects by Two Independent Judges. *The British Journal of Psychiatry*, 116 (535), 651–655.

McFadden, D., (1980). Econometric Models for Probabilistic Choice Among Products. *The Journal of Business. Part 2: Interfaces Between Marketing and Economics*, 53 (3), S13–S29.

McGough, H.N., Roberts, D.L., Brodie, C. and Kowalczyk, J., 2006. *CITES and Slipper Orchids*. Kew Publishing, Kew, Richmond, UK.

Milner-Gulland, E.J. & Leader-Williams, N., (1992). Illegal exploitation of wildlife. In T. M. Swanson, ed. *Economics for the Wilds: Wildlife, Wildlands, Diversity and Development*. Earthscan, 195–213.

Milner-Gulland, E.J., (1993). An econometric analysis of consumer demand for ivory and rhino horn. *Environmental & Resource Economics*, 3 (1), 73–95.

Moro, M., Fischer, A., Czajkowski, M., Brennan, D., Lowassa, A., Naiman, L.C. and Hanley, N., (2013). An investigation using the choice experiment method into options for reducing illegal bushmeat hunting in western Serengeti. *Conservation Letters*, 6 (1), 37-45.

Morris, D. (2010). *The role of native plant and seed collectors and growers in protecting floral diversity* (PhD Dissertation). University of Waterloo, Waterloo, Ontario, Canada.

Morrison, M. & Brown, T.C., (2009). Testing the Effectiveness of Certainty Scales, Cheap Talk, and Dissonance-Minimization in Reducing Hypothetical Bias in Contingent Valuation Studies. *Environmental and Resource Economic*s, 44 (3), 307–326.

Morse-Jones, S., Bateman, I.J., Kontoleon, A., Ferrini, S., Burgess, N.D. and Turner, R.K., (2012). Stated preferences for tropical wildlife conservation amongst distant beneficiaries: charisma, endemism, scope and substitution effects. *Ecological Economics*, 78, 9-18.

Nagoya Protocol, (2011). The Nagoya Protocol on Access to Genetic Resources and the Fair and Equitable Sharing of Benefits Arising from their Utilization (ABS) to the Convention on Biological Diversity. Adopted 29 October 2010 in Nagoya, Japan. Available from. *The Secretariat of the Convention on Biological Diversity*. Available at: http://www.cbd.int/abs/doc/protocol/nagoya-protocol-en.pdf [Accessed May 1, 2014].

Natusch, D.J.D. & Lyons, J. a., (2012). Exploited for pets: the harvest and trade of amphibians and reptiles from Indonesian New Guinea. Biodiversity and Conservation, 21 (11), 2899–2911.

Nelson, V., Tallontire, A. & Collinson, C., (2002). Assessing the benefits of ethical trade schemes for forest dependent people: comparative experience from Peru and Ecuador. *International Forestry Review*, 4 (2), 99–109.

Newman, M., (2010). *Networks: An Introduction*, Oxford University Press, Oxford.

Nijman, V., (2010). An overview of international wildlife trade from Southeast Asia. *Biodiversity and Conservation*, 19 (4), 1101–1114.

Nijman, V., Todd, M. & Shepherd, C., (2012). Wildlife trade as an impediment to conservation as exemplified by the trade in reptiles in Southeast Asia. In D. Gower, ed. *Biotic Evolution and Environmental Change in Southeast Asia*. Cambridge, UK: Cambridge University Press, 475.

Nkonya, E., Pender, J. & Kato, E., (2008). Who knows, who cares? The determinants of enactment, awareness, and compliance with community Natural Resource Management regulations in Uganda. *Environment and Development Economics*, 13 (1), 79–101.

Novacek, M.J. & Cleland, E.E., (2001). The current biodiversity extinction event: scenarios for mitigation and recovery. *Proceedings of the National Academy of Sciences of the United States of America*, 98 (10), 5466–70.

Nuno, A. & St John, F.A.V., (2015). How to ask sensitive questions in conservation: A review of specialized questioning techniques. *Biological Conservation*, 189, 5–15.

Nuno, A.N.A., Bunnefeld, N., Naiman, L.C. and Milner-Gulland, E.J., (2013). A novel approach to assessing the prevalence and drivers of illegal bushmeat hunting in the Serengeti. *Conservation Biology*, 27 (6), 1355-1365.

OECD. (2012), *Illegal Trade in Environmentally Sensitive Goods*, OECD Trade Policy Studies, OECD Publishing, Paris.
DOI: http://dx.doi.org/10.1787/9789264174238-en

Onnela, J.P., Fenn, D.J., Reid, S., Porter, M.A., Mucha, P.J., Fricker, M.D. and Jones, N.S., (2012). Taxonomies of networks from community structure. *Physical Review E*, 86 (3), p.036104.

Opsahl, T., (2012). tnet: Software for Analysis of Weighted, Two-Mode, and Longitudinal Networks. R package version 3.0.11

Opsahl, T., Agneessens, F. & Skvoretz, J., (2010). Node centrality in weighted networks: Generalizing degree and shortest paths. *Social Networks*, 32 (3), 245–251.

Paek, K.-Y. & Murthy, H., (2002). Temperate Oriental Cymbidium Species. In T. Kull & J. Arditti, eds. *Orchid Biology VIII: Reviews and Perspectives*. Springer Science+Business Media, Dordrecht, Netherlands.

Palma, M. A., Chen, Y. J., Hall, C., Bessler, D., & Leatham, D. (2010). Consumer preferences for potted orchids in the Hawaiian market. *HortTechnology*, 20 (1), 239-244.

Pant, B. & Raskoti, B.B., (2013). *Medicinal Orchids of Nepal* 1st ed., Himalayan Map House Soft cover, Vedams eBooks.

Patel, N. G., Rorres, C., Joly, D. O., Brownstein, J. S., Boston, R., Levy, M. Z., & Smith, G. (2015). Quantitative methods of identifying the key nodes in the illegal wildlife trade network. *Proceedings of the National Academy of Sciences,* 112 (26), 7948-7953.

Phelps, J. & Webb, E.L., (2015). "' Invisible '" wildlife trades : Southeast Asia' s undocumented illegal trade in wild ornamental plants. *Biological Conservation*, 186, 296–305.

Phelps, J., Carrasco, L.R. & Webb, E.L., (2014). A framework for assessing supply-side wildlife conservation. *Conservation Biology*, 28 (1), 244–257.

Phelps, J., Webb, E. L., Bickford, D., Nijman, V., & Sodhi, N. S. (2010). Boosting cites. *Science*, 330 (6012), 1752-1753.
Phyu, A.S., (2014). Orchid smuggling putting rare species at risk, warn experts. *Myanmar Times. 10th March 2014*. Available at: http://www.mmtimes.com/index.php/national-news/9796-orchid-smuggling-putting-rare-species-at-risk-warn-experts.htm [Accessed May 1, 2014].
Pittman, C., (2012). *The Scent of Scandal: Greed, Betrayal and the World's Most Beautiful Orchid*, University Press of Florida, Gainseville, USA.

Pooley, S.P., Mendelsohn, J.A. & Milner-Gulland, E.J., 2014. Hunting down the chimera of multiple disciplinarity in conservation science. *Conservation Biology,* 28 (1), 22–32.

Pridgeon, A (1996). *Orchids: Status Survey and Conservation Action Plan*, Eds. Hagsater, E. and Dumont, V. IUCN Gland, Switzerland and Cambridge, UK.

RapidAsia, (2013). Impact Evaluation on Ivory Trade in China IFAW PSA: "Mom, I have teeth". Available at: http://www.ifaw.org/united-states/resource-centre/impact-evaluation-ivory-trade-china [Accessed December 2, 2014].

RBG Kew, (2012). Plants under pressure – a global assessment. IUCN Sampled Red List Index for Plants. Available at: http://www.kew.org/sites/default/files/kppcont_027709.pdf [Accessed September 22, 2015].

Reeve, R., (2006). Wildlife trade, sanctions and compliance: Lessons from the CITES regime. *International Affairs,* 82 (5), 881–897.

Reinikka, M.A., (1995). *A History of the Orchid*, Timber Press. Portland, Oregon, US

Republic of Indonesia, (1999). *Jenis-jenis tumbuhan dan satwa yang dilindungi. Lampiran peraturan pemerintah Republik Indonesia - Nomor 7 Tahun 1999,* Indonesia, Indonesia.

Richerzhagen, C. & Holm-Mueller, K., (2005). The effectiveness of access and benefit sharing in Costa Rica: implications for national and international regimes. *Ecological Economics,* 53 (4), 445–460.

Richerzhagen, C., (2011). Effective governance of access and benefit-sharing under the Convention on Biological Diversity. *Biodiversity and Conservation,* 20 (10), 2243–2261.

Roberton, S.I., (2014). Has Demand for Rhino Horn Truly Dropped in Vietnam? | National Geographic (blogs). *National Geographic*. Available at: http://voices.nationalgeographic.com/2014/11/03/has-demand-for-rhino-horn-truly-dropped-in-vietnam/ [Accessed September 18, 2015].

Roberts, D.L. & St John, F.A. V, (2014). Estimating the prevalence of researcher misconduct: a study of UK academics within biological sciences. *PeerJ,* 2, p.e562.

Roe, D., Mulliken, T., Milledge, S., Mremi, J., Mosha, S., & Grieg-Gran, M. (2002). *Making a killing or making a living. Wildlife trade, trade controls and rural livelihoods*. IIED, London and TRAFFIC, Cambridge, UK.

Rosen, G.E. & Smith, K.F., (2010). Summarizing the evidence on the international trade in illegal wildlife. *EcoHealth*, 7 (1), 24–32.

Royal Botanic Gardens Kew, (2015). Monocots III: Orchids. Available at: http://www.kew.org/science-conservation/research-data/science-directory/teams/monocots-iii-orchids [Accessed September 18, 2015].

Sajeva, M., Augugliaro, C., Smith, M. J., & Oddo, E. (2013). Regulating internet trade in CITES species. *Conservation Biology*, 27 (2), 429-430.

Schneider, J.L., (2008). Reducing the Illicit Trade in Endangered Wildlife: The Market Reduction Approach. *Journal of Contemporary Criminal Justice*, 24 (3), 274–295.

Schroeder, D., (2007). Benefit sharing: it's time for a definition. *Journal of medical ethics*, 33 (4), 205–9.

Schuiteman, A. & de Vogel, E., (2000). *Orchid genera of Thailand, Laos, Cambodia, and Vietnam*, Nationaal Herbarium Nederland, Leiden, The Netherlands.

Scott, J.C., (2008). *Weapons of the Weak: Everyday Forms of Peasant Resistance*, Yale University Press, New Haven, USA

Secretariat of the Convention on Biological Diversity, (2008). *Access and Benefit-Sharing in Practice: Trends in Partnerships Across Sectors.* Technical Series No. 38., Montreal.

Seidenfaden, G., (1993). The Orchids of Indochina. *Nordic Journal of Botany*, 13 (2), 226–226.

Shirey, P. D., Kunycky, B. N., Chaloner, D. T., Brueseke, M. A., & Lamberti, G. A. (2013). Commercial trade of federally listed threatened and endangered plants in the United States. *Conservation Letters*, 6 (5), 300–316.

Shirey, P.D. & Lamberti, G.A., (2011). Regulate trade in rare plants. *Nature*, 469 (7331), 465–7.

Slone, T.H., Orsak, L.J. & Malver, O., (1997). A comparison of price, rarity and cost of butterfly specimens: Implications for the insect trade and for habitat conservation. *Ecological Economics*, 21(1), 77–85.

Smith, K. F., Behrens, M., Schloegel, L. M., Marano, N., Burgiel, S., & Daszak, P. (2009). Reducing the risks of the wildlife trade. *Science*, 324(5927), 594–595.

Smith, R. J., Veríssimo, D., Leader-Williams, N., Cowling, R. M., & Knight, A. T. (2009). Let the locals lead. *Nature*, 462 (7271), 280-281.

Sodhi, N. S., Koh, L. P., Brook, B. W., & Ng, P. K. (2004). Southeast Asian biodiversity: an impending disaster. *Trends in Ecology & Evolution*, 19 (12), 654-660.

Solomon, J.N., Gavin, M.C. & Gore, M.L., (2015). Detecting and understanding non-compliance with conservation rules. *Biological Conservation*, 189, 1–4.

South, N. & Wyatt, T., (2011). Comparing Illicit Trades in Wildlife and Drugs: An Exploratory Study. *Deviant Behavior*, 32 (6), 538–561.

St John, F. A., Keane, A. M., Edwards-Jones, G., Jones, L., Yarnell, R. W., & Jones, J. P. (2011). Identifying indicators of illegal behaviour: carnivore killing in human-managed landscapes. *Proceedings of the Royal Society of London B: Biological Sciences*, rspb20111228.

Stead, M., Gordon, R., Angus, K. and McDermott, L., (2007). A systematic review of social marketing effectiveness. *Health Education*, 107:126-191.

Stuart, A., (1955). A Test for Homogeneity of the Marginal Distributions in a Two-Way Classification on JSTOR. Biometrika, 42 (3-4), 412–416.

Sulistyo, B. P., Boos, R., Cootes, J.E., and Gravendeel, B., (2015). *Dendrochilum hampelii* (Coelogyninae, Epidendroideae, Orchidaceae) traded as 'Big Pink'is a new species, not a hybrid: evidence from nrITS, matK and ycf1 sequence data. *PhytoKeys* 56: 83.

Sutherland, W.J. & Woodroof, H.J., (2009). The need for environmental horizon scanning. *Trends in Ecology & Evolution,* 24 (10), 523–7.

Sykes, G.M. & Matza, D., (1957). Techniques of neutralization: A theory of delinquency. *American Sociological Review*, 22, 664–670.

Tang, C.Y. & Chen, W.H., (2007). Breeding and development of new varieties in *Phalaenopsis*. In W. H. Chen & H. H. Chen, eds. *Orchid Biotechnology*. World Scientific, Singapore. 1–22.

Tella, J.L. & Hiraldo, F., (2014). Illegal and legal parrot trade shows a long-term, cross-cultural preference for the most attractive species increasing their risk of extinction. *PloS One*, 9 (9), p.e107546.

Ten Kate, K. & Laird, S.A., (2000). Biodiversity and Business: Coming to Terms with the "Grand Bargain." *International Affairs,* 76 (2), 241–264.

The Brunei Times, (2012). Pioneering orchid business blooms. *The Brunei Times. 21st December 2012*. Available at: http://www.bt.com.bn/2012/12/21/pioneering-orchid-business-blooms [Accessed May 1, 2014].

Thomas, A.S., Gavin, M.C. & Milfont, T.L., (2015). Estimating non-compliance among recreational fishers: Insights into factors affecting the usefulness of the randomized response and item count techniques. *Biological Conservation*, 189, 24–32.

Thomas, B., (2006). Slippers, thieves and smugglers - dealing with the illegal international trade on orchids. *Environmental Law Review,* 8, 85–92.

Toledo, L.F., Asmüssen, M. V & Rodríguez, J.P., (2012). Crime: track illegal trade in wildlife. *Nature*, 483 (7387), 36.

Trommetter, M., (2004). Biodiversity and international stakes : a question of access. *Working Papers*, 53 (4), 573–583.

Tsuchiya, T., Hirai, Y. & Ono, S., (2007). A Study of the Properties of the Item Count Technique. *Public Opinion Quarterly*, 71 (2), 253–272.

Twitter, (2015). Twitter Usage/Company Facts. Available at: https://about.twitter.com/company [Accessed July 23, 2015].

UK Government, (2013). Fees for CITES Applications for Plants. Animal Health and Veterinary Laboratories Agency, (June), 1–5. Available at: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/355265/cites-ag-ct-02.pdf [Accessed September 17, 2015].

UNEP WCMC, (2013). A guide to using the CITES trade database. Version 8. Available at: http://trade.cites.org/cites_trade_guidelines/en-CITES_Trade_Database_Guide.pdf [Accessed May 1, 2014].

UNEP WCMC, (2014). CITES trade statistics derived from the CITES Trade Database. *CITES Trade Database*. Available at: http://trade.cites.org [Accessed May 1, 2014].

UNEP, (2014a). Illegal Trade in Wildlife: The Environmental, Social and Economic Consequences for Sustainable Development., United Nations Environment Assembly of the United Nations Environment Programme First session. Nairobi, 23–27 June 2014. pp.1–9. Available at: http://www.grida.no/crime/news.aspx?id=6041 [Accessed September 18, 2015].

UNEP, (2014b). UNEP Year Book 2014 emerging issues update Illegal Trade in Wildlife, 25–29. Available at: http://www.unep.org/yearbook/2014/PDF/chapt4.pdf [Accessed September 19, 2015].

UNEP, (2015). Species+. *The Species+ Website. Compiled by UNEP-WCMC, Cambridge, UK.* Available at: http://www.speciesplus.net/species [Accessed September 18, 2015].

United for Wildlife, (2015). Home | United For Wildlife. Available at: http://www.unitedforwildlife.org/#!/home [Accessed September 17, 2015].

USDA, (2014). *Floriculture Crops 2013 Summary*, United States Department of Agriculture, National Agricultural Statistics Service, Washington DC, USA

USDA, (2015). *Floriculture Crops 2014 Summary*, United States Department of Agriculture, National Agricultural Statistics Service, Washington DC, USA.

Veríssimo, D., (2014). To reduce rhino poaching, take demand for horns seriously. *The Conversation*. Available at: https://theconversation.com/to-reduce-rhino-poaching-take-demand-for-horns-seriously-34265 [Accessed September 18, 2015].

Veríssimo, D., Pongiluppi, T., Santos, M. C. M., Develey, P. F., Fraser, I., Smith, R. J., & Macmilan, D. C., (2014). Using a systematic approach to select flagship species for bird conservation. *Conservation Biology*, 28 (1), 269–77.

Vermeulen, J. J., Phelps, J., & Thavipoke, P. (2014). Notes on Bulbophyllum (Dendrobiinae; Epidendroideae; Orchidaceae): two new species and the dilemmas of species discovery via illegal trade. *Phytotaxa*, 184 (1), 12-22.

Vermeulen, J.J. & Lamb, A., (2011). Endangered even before formally described: Bulbophyllum kubahense n.sp., a beautiful and assumedly narrowly endemic orchid from Borneo. *Plant Systematics and Evolution*, 292 (1-2), 51–53.

Vermeylen, S., (2007). Contextualizing "Fair" and "Equitable": The San's Reflections on the Hoodia Benefit-Sharing Agreement. *Local Environment*, 12 (4), 423–436.

Viet Nam News, (2010). Biotechnology needed for orchid industry'. *Viet Nam News. 2nd October 2010*. Available at: http://vietnamnews.vn/agriculture/204286/biotechnology-needed-for-orchid-industry-.html. [Accessed May 1, 2014].

Volk, G.M. & Richards, C.M., (2011). Horticultural Value of Wild Genetic Resources--Introduction to the Workshop. *HortScience,* 46 (11), 1436–1437.

Von Hippel, W., Von Hippel, F. A., Chan, N., & Cheng, C. (2005). Exploring the use of Viagra in place of animal and plant potency products in traditional Chinese medicine. *Environmental Conservation,* 32 (3), 235-238.

WCSP, (2015). World Checklist of Selected Plant Families. *Facilitated by the Royal Botanic Gardens, Kew*. Available at: http://apps.kew.org/wcsp/.

Weller, P., Oehlmann, M., Mariel, P., & Meyerhoff, J. (2014). Stated and inferred attribute non-attendance in a design of designs approach. *Journal of Choice Modelling*, 11, 43–56.

Williams, S. J., Jones, J. P. G., Annewandter, R., & Gibbons, J. M., (2014). Cultivation can increase harvesting pressure on overexploited plant populations. *Ecological Applications*, 24 (8), 2050–2062.

Williams, S. J., Jones, J. P., Clubbe, C., & Gibbons, J. M., (2012). Training programmes can change behaviour and encourage the cultivation of over-harvested plant species. *PloS One*, 7(3), p.e33012.

Wolfram Research, (2014). *Mathematica v. 10.0*, Champaign, IL: Wolfram Research.

World Bank, (2015). World Development indicators: 2012 GNI per capita, Atlas method (current US$). Available at: http://data.worldbank.org/indicator/NY.GNP.PCAP.CD [Accessed September 21, 2015].

Wyatt, T., (2009). Exploring the organization of Russia Far East's illegal wildlife trade: two case studies of the illegal fur and illegal falcon trades. *Global Crime*. 10 (1-2), 144-154.

Yokoi, K. & Milliken, T., (1991). Trade in wild-collected slipper orchids in Japan. *TRAFFIC Bulletin*, 12 (1-2), 12–16.

Yu, X. & Jia, W., (2015). *Moving targets: Tracking online sales of illegal wildlife products in China*, TRAFFIC Briefing, February 2015. TRAFFIC, Cambridge, UK.

Zain, S., (2012). *Behaviour Change We Can Believe In: Towards A Global Demand Reduction Strategy for Tigers*, TRAFFIC, Cambridge, UK.

Zigerell, L. J., (2011). You Wouldn't Like Me When I'm Angry: List Experiment Misreporting. *Social Science Quarterly*, 92 (2), 552–562.