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

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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 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.

1. 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 and 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 and 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 and 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, 2014). 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

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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, 2010; 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 and Lamb, 2011). The orchid horticultural trade dates back over 2 000 years in China and Japan (Paek and 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 network 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 and 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 and Webb, 2015). Whilst trade in wild-collected plants at markets in tropical regions has been the focus of some research (e.g. Flores-Palacios and Valencia-Diaz, 2007; Phelps and 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., 2009), environmental planning (e.g. Hanley et al., 2003) and conservation (e.g. Verissimo 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. Methods

2.1. 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.

Using a combination of the significantly preferred attributes (see Table 1) from both pilot surveys, the main survey was designed using Ngene (version 1.0.1, ChoiceMetrics, Sydney, Australia), to produce a D-efficient Bayesian design (Jaeger and Rose, 2008). We chose this design type as it maximises statistical efficiency in estimating preference parameters by minimising D error over the prior distribution of the parameters while accounting for uncertainty (Jaeger and 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, one of which is shown in Fig. 1. The design was attribute balanced,

Table 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 colours 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.

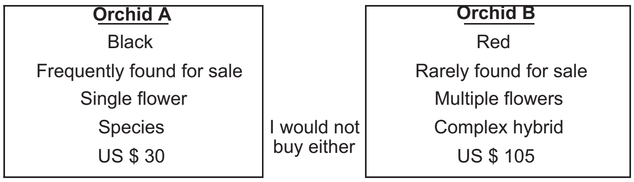

Fig. 1. Example choice set used in the study. Presented with the instruction: "Using only the description provided, and assuming that all other factors are identical (e.g. both plants are suitable to your growing conditions), please select which orchid you would buy in a real-life situation".

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 and 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. 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.

2.2. 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 and Webb, 2015).

2.3. 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 and Yabe, 2006; Birol et al., 2009; Verissimo 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.

3. 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 4). 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

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

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.
$^{**}p \leqslant 0.05$.
$^{***}p \leqslant 0.01$.

Table 3
Summary of measures of model fit for the Multinomial logit (MNL) and Latent Class Models (LCM), with minimised 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 + 3 K).

Table 4
Multinomial logit (MNL) and Latent Class Model (LCM) estimates of utility function for each attribute, with standard errors in parentheses (95% confidence intervals). Reference levels: 'Colour: black' and 'complex hybrid'.

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)

Shading denotes significant utility scores.
$^{*}p \leqslant 0.10$.
$^{**}p \leqslant 0.05$.
$^{***}p \leqslant 0.01$.

AIC and AIC3 continue to improve with small marginal improvements between four and five segments (Table 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 and 4). In addition, unlike AIC, BIC does not overfit so, as overfitting of models produces a greater parameter bias than underfitting (Andrews and 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). This group showed strong significant attribute preferences for white flowers, multiple flowers and a low price (Table 4). 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 \leqslant 0.05$). They would also pay $3.61 more for a plant with multiple flowers compared to a plant with single flowers ($p \leqslant 0.05$).

The smallest class in our sample was significantly more likely to include male hobbyists who buy their orchids online (Table 2). 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 4). People in this group would be willing to pay a premium of $8.01 for a species ($p \leqslant 0.05$) and $4.39 to buy an orchid rarely found in trade ($p \leqslant 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 \leqslant 0.01$) but would need a $2.52 discount before they would be willing to accept a yellow-flowered plant ($p \leqslant 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 × $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: $p = 0.651$).

4. 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.

4.1. 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 and Swanson, 2003; Verissimo 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 and Lyons, 2012) and the pet bird trade (Tella and 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 and St John, 2014). 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 and Brown, 2009), or the swearing of a 'solemn oath' to answer honestly (de-Magistris and 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.

4.2. 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 and 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 and 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 flower colour and multiple flowers combined with no preference for rarity matches demand trends for these markets (Paek and 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 and 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 (Hinsley and Roberts, 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 and 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 and 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.

4.3. 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 to reduce demand 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 and 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 and 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 Verissimo 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 *Paphiopedilum 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 (RBG Kew, 2014). 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 and Courchamp, 2009). This is likely to be especially true for 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 (Hinsley and Roberts, pers. obs.). 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.

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