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1 **Short Communication**

2

3 **Running Header:** The wild origin dilemma

4

5 **Title:** The wild origin dilemma

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8

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14

15

16 **Abstract**

17 The sustainable production of trade plants, animals and their products, including through
18 artificial propagation and captive breeding, is an important strategy to supply the global
19 wildlife market, particularly when the trade in wild specimens is restricted by CITES or other
20 wildlife trade legislation. However, these production methods can become a potential
21 mechanism for the laundering of material illegally collected from the wild, leading to recent
22 calls for the development of traceability methods to determine the origin of traded products.
23 Currently, identifying wild origin can be complex and may require expert knowledge and/or
24 resource intensive molecular techniques. Here we show, using CITES Appendix I slipper
25 orchids as a model system, that production times can be used as a threshold to identify plants
26 in trade that have a high likelihood of being of wild origin. We suggest that this framework
27 could be used by enforcement officers, online vendors, and others to flag material of potential
28 concern for orchids and other high value plants in trade. Specifically, this knowledge
29 combined with nomenclature and the CITES trade database could be used to construct a
30 species watch list and automate online search. The results suggest that had this been applied,
31 questions would have been raised regarding online sales of three recently described species.

32

33 **Keyword:** CITES, enforcement, horticulture, illegal wildlife trade, Orchidaceae, traceability

34

35 **Highlights**

- 36 • Laundering of wild origin material has resulted in calls for improve traceability
- 37 • Frequently used methods can be expensive and impractical for species-rich taxa
- 38 • Production times can provide thresholds to identify material of questionable origin

39

40

41 **1. Introduction**

42 Whilst artificial propagation and captive breeding may provide a sustainable source of
43 wildlife for trade, both plants and animals, it also provides an opportunity for laundering of
44 wild specimens into legal trade. Physical examination of specimens is often used to identify
45 wild-origin, using factors including the general size and condition of the individual, and
46 specific signs such as insect damage on the leaves and roots in plants, or damage such as
47 scars in animals. Due to the subjective nature of this approach, and the difficulty that non-
48 experts may face in making this judgement, there has been a move towards the use of
49 molecular techniques such as DNA fingerprinting (Dawnay et al., 2009) and isotope analysis
50 (Kelly et al., 2008) to determine wild-origin. Whilst these techniques have great utility, they
51 require time, funding and technical capacity that makes them difficult to apply universally
52 (Hinsley et al., 2016a).

53

54 The threat that laundering poses to legal, sustainable wildlife trade has led to an increased
55 awareness of the need for traceability within the Convention on the International Trade in
56 Endangered Species of Wild Fauna and Flora (CITES). Traceability was the focus of multiple
57 decisions at the 2016 CITES Conference of Parties (e.g. Decision 17.152) and there have
58 been several reports on traceability in major CITES species groups in recent years (e.g.
59 reptiles: UNCTAD, 2013; sharks: Mundy and Sant, 2015; ornamental plants: UNCTAD,
60 2016). One such report commissioned by the United Nations Conference on Trade and
61 Development's (UNCTAD) BioTrade Initiative in consultation with the CITES Secretariat
62 highlighted the need for improved traceability in ornamental plants, the product group
63 containing the largest number of species listed by the Convention (CITES, 2011). The high
64 number of ornamental plant species on CITES is mainly due the listing of all orchids, which
65 account for over 70% of all CITES taxa, with over 26,000 species known to science and a

66 further 5,000 likely awaiting discovery (Joppa et al., 2010). Currently several hundred new
67 orchid species names are published annually (e.g. 370 in 2013: Schuiteman, 2017) and the
68 family level listing means that these are automatically included on the CITES Appendices.
69 New species of certain genera are listed automatically on Appendix I, including the entire
70 Southeast Asian slipper orchid genus *Paphiopedilum*. This group is highly sought-after by the
71 trade, leading to extreme depletion and extinction of wild populations of newly described
72 species in some cases (e.g. *Paphiopedilum canhii*: Rankou and Averyanov, 2015). The
73 process of species discovery, description and entry into the trade can vary. Following
74 discovery, species can then be described relatively soon after, or in some cases they can
75 languish unnoticed in museum collections before description. However, some species enter
76 the trade under the name of an existing species, or as a trade name, only to be recognised as a
77 distinct species at a later date.

78
79 Here we describe a potential method to address the need for improved traceability to prevent
80 laundering of ornamental plants, using the trade in CITES Appendix I *Paphiopedilum* orchids
81 as a model system. Laundering to bypass CITES rules is known to occur in the orchid trade
82 (Hinsley et al., 2016b) and laundering via plant nurseries may give plants the appearance of
83 being artificially propagated, making the identification of wild plants using physical features
84 particularly difficult for a non-specialist. One strategy that may help address both points is to
85 identify those species that have the greatest likelihood of being of wild origin, to focus
86 attention and resources on the most ‘at risk’ species. Here we outline a method to do this,
87 using the minimum timings for key growth stages as a potential metric to identify those
88 species that are unlikely to have been artificially propagated. This method could equally be
89 applied to animals to determine whether, given their growth rates, they could have been
90 captive bred.

91

92 **2. Materials and Methods**

93 Our study was approved by the University of Kent, School of Anthropology and
94 Conservation's Research and Ethics Committee. We sent an online survey (hosted on
95 SurveyGizmo.com) to professional commercial and hobbyist growers, and botanical gardens
96 with *Paphiopedilum* collections (See Supplementary material A1 for survey). A call for
97 survey participants was also shared through the British Paphiopedilum Society newsletter.
98 Snowball sampling was also used to reach more experts; participants were asked to suggest
99 anybody they knew with experience growing Paphiopedilums from seed until all new
100 suggestions had already been contacted.

101

102 We asked participants to state the geographical location where they grew their orchids, and to
103 rate the extent of their growing experience at the genus level, and specifically in relation to
104 each subgenus and section of *Paphiopedilum*. For each section or subgenus where they had
105 the relevant experience, we asked for the shortest, longest and average time (in months) from
106 (a) seed to flowering and (b) pollination to seed. On the last page of the survey we provided
107 an open text box for feedback, including a request for any specific information not gathered
108 that may influence the timings from seed to flowering size.

109

110 We used the shortest and longest times reported by respondents to produce descriptive
111 statistics for all sections and subgenera, including mean, median, maximum and minimum
112 length of time from seed to flowering, and pollination to seed. We used these statistics to
113 produce box and whisker graphs to show the distribution of the times stated, and a summary
114 of estimated timings to produce key traded orchid products.

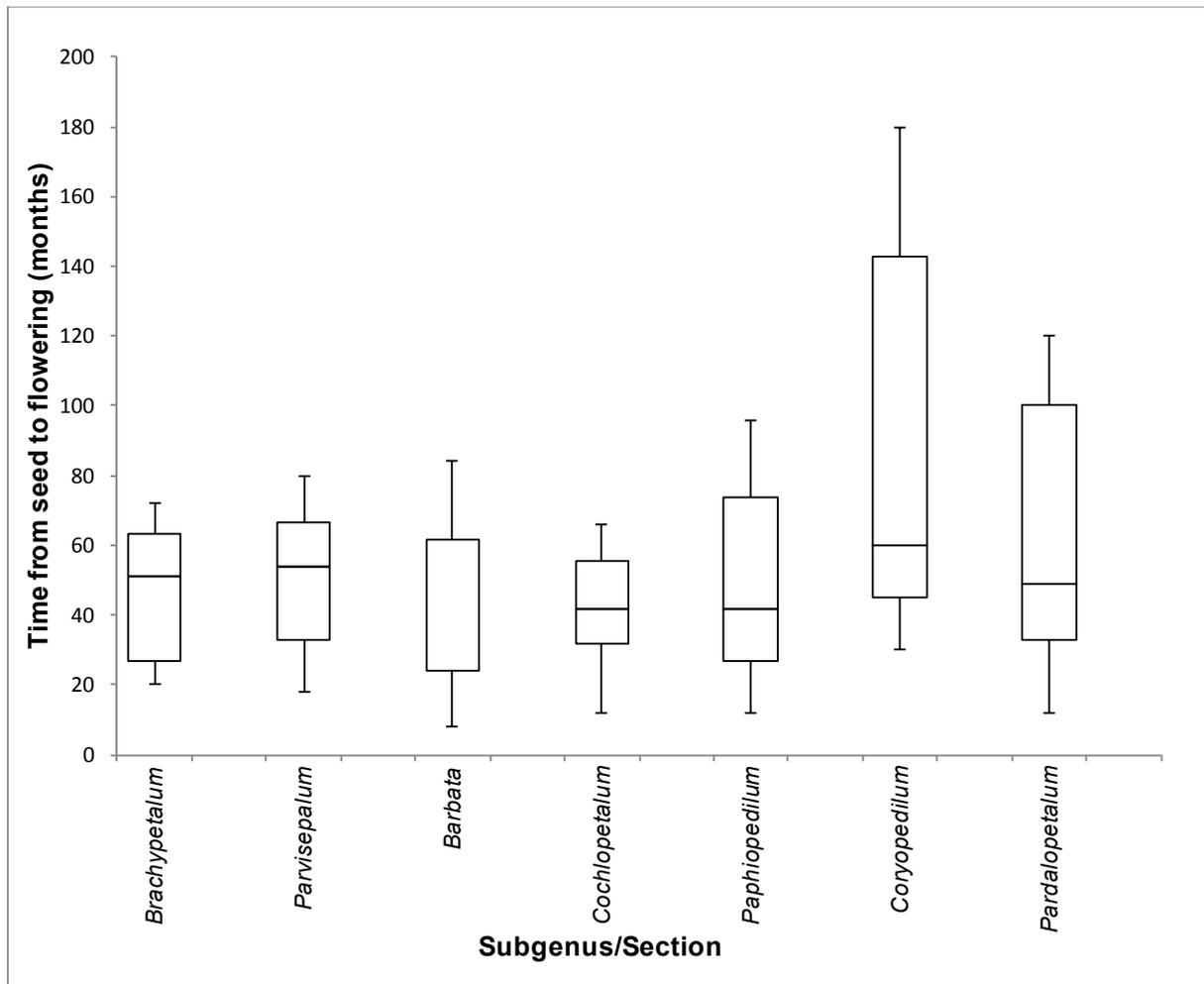
115

116 3. Results

117 We sent questions about seed to flowering, and pollination to seed timings for *Paphiopedilum*
118 orchids to international experts. A total of 37 people accessed the survey page, with 18
119 completing at least one of the questions about pollination to seed, or seed to flowering times.
120 The majority of people (n = 14) who abandoned the survey did so on the first question about
121 specific experience of growing different subgenera and sections. As not all growers have
122 expertise on all species, questions on timings from pollination to seed for specific subgenera
123 or sections received between five and eight responses, and for seed to flowering between four
124 and six. Some people responded by email to say that very few in the industry had specific
125 knowledge of the growing times requested. Respondents also noted that timings may be
126 affected by the growing conditions, including climatic conditions in different locations.

127

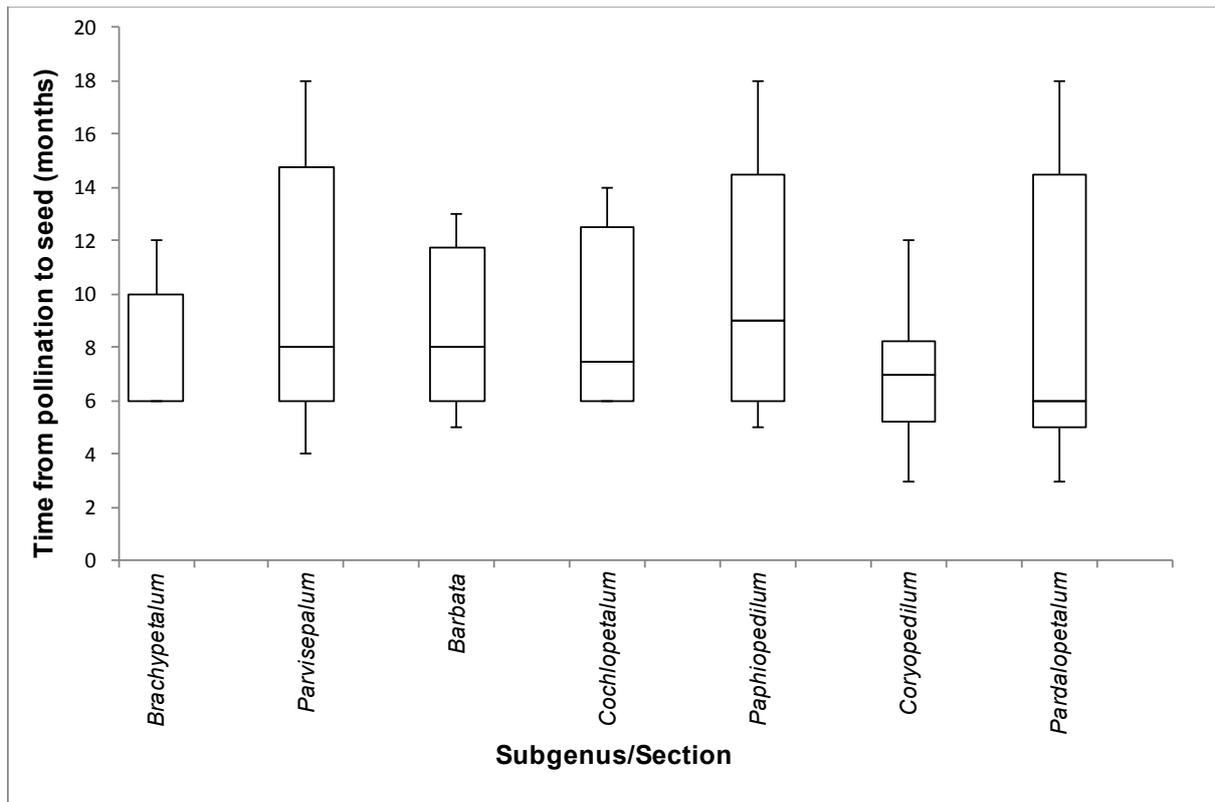
128 Respondents who gave their country of origin were from the United States (n = 9), United
129 Kingdom (n = 4), Malaysia, the Netherlands, Spain, Switzerland and Viet Nam (n = 1 each),
130 and were hobbyists specialising in *Paphiopedilums* (n = 7), professional growers (specialising
131 in *Paphiopedilum*: n = 5 or other genera: n = 3), and researchers (n = 4). The median timings
132 from pollination to seed ranged from 6 months (subgenus *Brachypetalum* and section
133 *Pardalopetalum*) to 9 months (section *Paphiopedilum*), and from seed to flowering from 24
134 months (section *Barbata*) to 60 months (section *Coryopedilum*). The minimum timings from
135 pollination to seed ranged from 3 months (sections *Pardalopetalum* and *Coryopedilum*) to 10
136 months (subgenus *Parvisepalum* and section *Coryopedilum*) and from seed to flowering from
137 8 months (section *Barbata*) to 96 months (section *Coryopedilum*). The distribution of timings
138 from seed to flowering are shown in Figure 1, and from pollination to seed in Figure 2 (See
139 Supplementary material A2 for all data).



140

141 **Figure 1:** Box and whisker plot showing distribution of responses for the shortest and longest

142 time from seed to flowering of different *Paphiopedilum* subgenera and sections



143

144 **Figure 2:** Box and whisker plot showing distribution of responses for the shortest and longest
 145 time from pollination to seed of different *Paphiopedilum* subgenera and sections

146

147 We can use the minimum timings to estimate the shortest amount of time needed to produce
 148 artificially propagated plants of a newly discovered species according to the following steps.
 149 While rumours may exist of new species, it is the point at which the species is described that
 150 it may become known within the wider community. Generally when orchids are collected
 151 from the wild for horticultural purposes it is as plants that can be flowering or non-flowering;
 152 it is unlikely to be as seeds. As a result for wild plants to flower it can take 0 (assuming it was
 153 collected in flower) to 1 year (assuming it flowers within the next season); although given the
 154 impact of collection it may take longer to recover and acclimatize. The plant is pollinated and
 155 seeds are produced, these are then sown and eventually, after a period of time, a flowering
 156 plant is produced. This would be the absolute minimum time required to produce artificially
 157 propagated plants. However, for international trade, the CITES definition of artificially

158 propagated states that the parent plant itself must be cultivated (except where the species is
 159 too long lived for this to be feasible) (CITES Res. Conf. 11.11 (Rev. CoP17)). This means
 160 that two generations are needed before a plant meets this definition of artificially propagated.
 161 Considering this requirement, plus the time that would be required to gain permission to
 162 collect material and commercialise the species, and obtain permits for export, as a precaution
 163 the time from pollination to flowering should be doubled to allow plants from artificially
 164 propagated parent stock to be potentially produced legally particularly in the case of an
 165 Appendix I species. This resulted in minimum timings of between approximately 2.0 to 6.5
 166 years, depending on the subgenus or section, (Table 1).

167

168 **Table 1:** Minimum number of months required following the description of a new
 169 *Paphiopedilum* species to produce artificially propagated material, assuming pollination on
 170 collection.

| Subgenus/ Section | Estimated minimum time to produce artificially propagated material (accumulated time) in months | | |
|-----------------------|---|--|------------------------------|
| | Pollination to first seed | Seed to flowering plant using micropropagation | Pollination to flowering x 2 |
| <i>Brachypetalum</i> | 6 | 20 (26) | 26 (52) |
| <i>Parvisepalum</i> | 4 | 18 (22) | 22 (44) |
| <i>Barbata</i> | 5 | 8 (13) | 13 (26) |
| <i>Cochlopetalum</i> | 6 | 12 (18) | 18 (36) |
| <i>Paphiopedilum</i> | 5 | 12 (17) | 17 (34) |
| <i>Coryopedilum</i> | 3 | 30 (33) | 33 (66) |
| <i>Pardalopetalum</i> | 3 | 12 (15) | 15 (30) |

171

172 4. Discussion

173 The global and diverse nature of the wildlife trade means that monitoring and controlling
 174 such trade requires a variety of approaches. As a result there are increasing moves towards

175 the use of ever more sophisticated techniques for providing traceability of wildlife, such as
176 molecular techniques and stable isotope analysis (Kelly et al., 2008; UNCTAD, 2013). Whilst
177 these methods have application in some cases, simple techniques are also needed to allow
178 effective trade regulation in cases where funding and capacity are limited. Here we
179 demonstrate a simple method for judging whether a traded plant is likely to be compliant with
180 CITES, using an example of an Appendix I orchid genus, *Paphiopedilum* (Southeast Asian
181 slipper orchids).

182

183 We estimated the time from pollination to seed and from seed to flowering of species from
184 the slipper orchid genus *Paphiopedilum*, a group that is in high demand within the
185 horticultural industry, and for which a number of species have been recently discovered (e.g.
186 *P. nataschae*: Braem, 2015). This knowledge can help focus attention on those species in
187 trade that are most likely to be of wild origin, as it is highly unlikely, if not impossible, for
188 plants to have been artificially propagated in less time. Further, CITES states that for a
189 species to be traded as artificially propagated the parent stock has to be legally acquired, or
190 the permit is invalidated (CITES Res. Conf. 11.11 (Rev. CoP17)). This includes material
191 traded *in vitro*, for which permits are usually not required (annotation #4: CITES, 2011).

192 Applying this to a real example, one of the most recently described *Paphiopedilum* species
193 was *P. nataschae*, a species in section *Barbata* that was described in May 2015 (Braem,
194 2015). Using our estimated timings, if plants were legally collected for propagation in the
195 month of description then seed from pollinated plants of *P. nataschae* would have been place
196 *in vitro* as early as October 2015, with flowering sized plants being available in June 2016.
197 Further, plants meeting the CITES definition of artificially propagated would be available in
198 July 2017, suggesting that any material offered for sale internationally until then should have
199 been questioned. It is interesting to note that a flowering size plant of this species was sold on

200 eBay from a non-range state in November 2016 (pers. obs.). A further example, again from
201 the section *Barbata*, is *P. canhii*, described in May 2010 (Averyanov et al., 2010), and
202 offered for sale on eBay from a non-range state in June 2011 (pers. obs.). The earliest we
203 estimate artificially propagated plants would have been produced is June 2011, assuming
204 legal collection of flowering material for the production of seed at the time of description. For
205 the production of *P. canhii* plants meeting the CITES definition of artificially propagated, the
206 earliest we estimate they would be available is July 2012 (using the 2 x from pollination to
207 flowering). It is important to note that in the case of orchids, they are, with a few exceptions,
208 grown for their flowers. It is the period, from discovery to the first legally artificially
209 propagated plants of flowering size, during which wild populations are particularly
210 vulnerable to over-exploitation as they are the only source of flowering plants for collectors
211 and those wishing to produce the first hybrids. In the case of *P. vietnamense* (section
212 *Parvisepalum*) it was described in 1999 new to science only to be declared extinct in the wild
213 in 2003 due to over-collection for the horticultural trade (Averyanov et al., 2003); ironically
214 this is approximately the precautionary threshold for legal production. In some cases, wild
215 plants are being collected before formal description, such as the species *P. lunatum* and *P.*
216 *bungebelangi* (section *Barbata*) described in March 2017 (Metusala, 2017). In these cases,
217 the threshold for legal plants would be May 2019, but *P. bungebelangi* was being traded on
218 Instagram under its new name in April 2017, only one month after its description (pers. obs.).
219 Although in cases such as these nursery-grown plants may enter trade earlier than described
220 here, the legality of plants produced from material collected before description would depend
221 on national legislation regulating collection of wild plants.

222

223 Newly described species from taxa that are sought after are at risk from over-exploitation
224 (Lindenmayer and Scheele, 2017). The framework described here could be applied beyond

225 orchids to other traded plant taxa that are species-rich, of horticultural value, and for which
226 new species are still being discovered. This includes aloes, euphorbias, carnivorous plants,
227 and cacti, with all newly discovered species of the latter reported to be under pressure from
228 illegal trade (Goettsch et al., 2015). Further, by the very fact that some species are only now
229 being discovered means they are likely restricted in range and therefore threatened (Joppa et
230 al., 2010; Roberts et al., 2016), including from over-exploitation. In some cases it is this
231 rarity that appeals to collectors (Courchamp et al., 2006; Hinsley et al., 2015). As a result
232 there have been calls for locality data to be withheld from descriptions from new species
233 (Lindenmayer and Scheele, 2017). The method could also be extended to species-rich animal
234 taxa that are collected for trade, and for which discoveries continue to be made, such as
235 poison arrow frogs and chameleons. The latter is an interesting case as until recently many
236 Malagasy chameleon species, particularly from the genera *Calumma* and *Furcifer*, were
237 largely unavailable in trade as they had a zero quota, in effect making them analogous to
238 newly discovered species.

239

240 Returning to plant related examples, this knowledge of production time could be used in
241 conjunction with the International Plant Names Index (www.ipni.org) or similar resources
242 (e.g. World Checklist of Selected Plant Families - <http://apps.kew.org/wcsp> or The Plant List
243 - www.theplantlist.org) that provide a continuously update list of species as they are
244 described, to construct a ‘Species To Watch’ list; a list of species that are unlikely to be
245 available for legal trade at the current time. Such a system could be automated and, with
246 moves towards electronic permitting (CITES, 2013), potentially linked into the CITES
247 permitting process, as well as online sites through which plants are be being sold. Certainly if
248 such a system had been in place, merely using the Latin name (most plants and animals in the
249 horticultural and the exotic pet trades are traded under their Latin name) of these newly

250 described slipper orchids, then their sale on eBay would undoubtedly have been identified
251 immediately by eBay and/or law enforcement.

252

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257

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