United States Department of Agriculture

Weed Risk Assessment for *Leptochilus pteropus* (Blume) Fraser-Jenk. (Polypodiaceae) – Java fern

United States Department of Agriculture

Animal and Plant Health Inspection Service

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Version 1

Left: *Leptochilus pteropus* in an aquarium (source: TROPICA, 2013). Right: The species in its native habitat in Malaysia (photographer: Naser, Anonymous, 2013).

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Introduction Plant Protection and Quarantine (PPQ) regulates noxious weeds under the authority of the Plant Protection Act (7 U.S.C. § 7701-7786, 2000) and the Federal Seed Act (7 U.S.C. § 1581-1610, 1939). A noxious weed is defined as "any plant or plant product that can directly or indirectly injure or cause damage to crops (including nursery stock or plant products), livestock, poultry, or other interests of agriculture, irrigation, navigation, the natural resources of the United States, the public health, or the environment" (7 U.S.C. § 7701-7786, 2000). We use weed risk assessment (WRA)—specifically, the PPQ WRA model (Koop et al., 2012)—to evaluate the risk potential of plants, including those newly detected in the United States, those proposed for import, and those emerging as weeds elsewhere in the world.

Because the PPQ WRA model is geographically and climatically neutral, it can be used to evaluate the baseline invasive/weed potential of any plant species for the entire United States or for any area within it. As part of this analysis, we use a stochastic simulation to evaluate how much the uncertainty associated with the analysis affects the model outcomes. We also use GIS overlays to evaluate those areas of the United States that may be suitable for the establishment of the plant. For more information on the PPQ WRA process, please refer to the document, *Background information on the PPQ Weed Risk Assessment*, which is available upon request.

***Leptochilus pteropus* (Blume) Fraser-Jenk. – Java fern**

Species Information

Family: Polypodiaceae

Synonyms: *Colysis pteropus* (Blume) Bosman; *Microsorum pteropus* (Blume) Copel; *Polypodium pteropus* Blume (NGRP, 2013). This species is primarily known as *Microsorum pteropus* in the trade and in the scientific literature.

Initiation: PPQ received a market access request for aquatic plants of *Leptochilus pteropus* for propagation from the Ministry of Food, Agriculture and Fisheries, the Danish Plant Directorate (MFAF, 2009). Because this species is not native to the United States (NGRP, 2013) and may pose a phytosanitary risk, the PERAL Weed Team initiated this assessment. The original request was for *Microsorum pteropus*, but this species has now been moved to the genus *Leptochilus* (NGRP, 2013).

Foreign distribution: This species is native to southeastern Asia: Bangladesh, China, India, Indonesia, Japan (Ryukyu Islands), Laos, Malaysia, Myanmar, Nepal, Papua New Guinea, the Philippines, Sri Lanka, Thailand, and Vietnam (NGRP, 2013; Tagawa and Iwatsuki, No Date).

U.S. distribution and status: This species has been in the United States since at least 1929 (Gordon and Gantz, 2011b) and is widely cultivated and available (APC, 2013; ExtraPlant, 2013; Maki and Galatowitsch, 2004;

Rixon et al., 2005). One study estimated that this species represented 8.2 percent of all aquatic plant sales in Montreal (Cohen et al., 2007), and it is likely equally popular in the United States. We found no evidence that *L. pteropus* has naturalized or escaped in the United States (NRCS, 2013).

WRA area[1]: Entire United States, including territories.

1. *Leptochilus pteropus* analysis

Establishment/Spread Potential We found no evidence that *L. pteropus* has escaped or established beyond its native range, in spite of being widely cultivated (APC, 2013; ExtraPlant, 2013; Maki and Galatowitsch, 2004; Rixon et al., 2005). It does possess, however, the following traits that may contribute to its establishment and spread potential: shade adapted, prolific reproduction, a short generation time, and dispersal by both air and water. This species is adapted to living on rocks in waterfalls and streams (Khwaiphan, 2005), and we suspect that has limited its ability to establish in other habitats. We had an average amount of uncertainty with this risk element.

Risk score = 1 Uncertainty index = 0.18

Impact Potential We found no evidence of impacts caused by this species. Because this species has been in cultivation for at least 70 years (Gordon and Gantz, 2011b) and is widely cultivated, our uncertainty was low for this risk element.

Risk score = 1.0 Uncertainty index = 0.02

Geographic Potential Based on three climatic variables, we estimate that about 6 percent of the United States is suitable for the establishment of *Leptochilus pteropus* (Fig. 1). This predicted distribution is based on the species' known distribution elsewhere in the world and includes point-referenced localities and areas of occurrence. The map for *L. pteropus* represents the joint distribution of Plant Hardiness Zones 9-13, areas with greater than 40 inches of annual precipitation, and the following Köppen-Geiger climate classes: tropical rainforest, tropical savanna, humid subtropical, and marine west coast. It was not clear whether *L. pteropus* occurs in steppe climates. This species is reported to be broadly distributed in southern India (Singh et al., 2012), which includes areas with steppe climate. Because *L. pteropus* is adapted to growing in aquatic and riparian habitats, it may not occur in that region of India. Here, we assumed with high uncertainty that it could not.

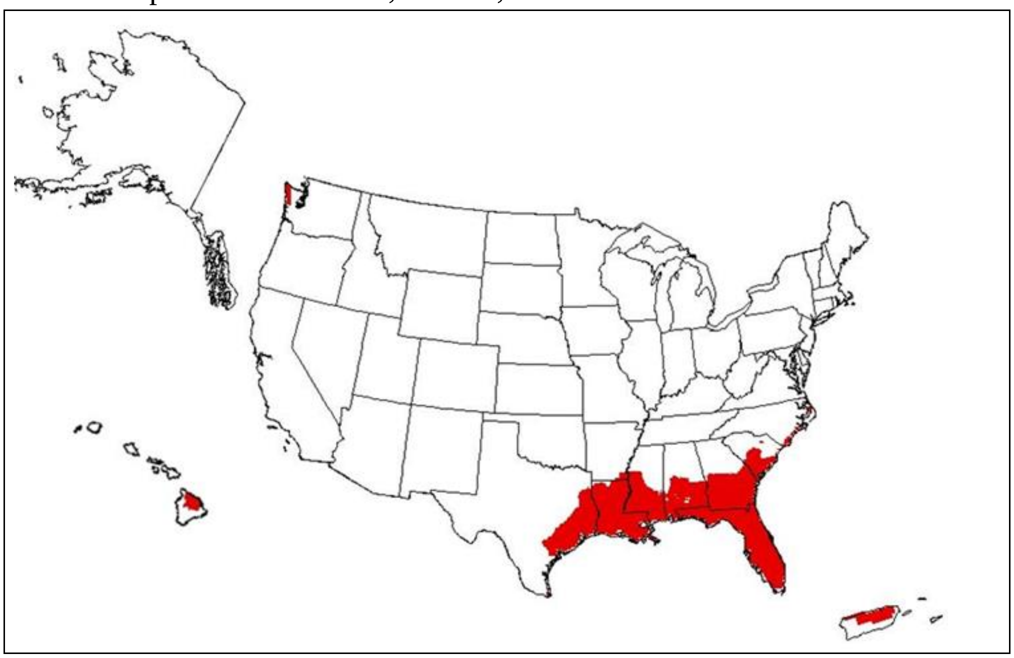
The area estimated likely represents a conservative estimate as it only uses three climatic variables. Other environmental variables, such as soil and habitat type, may further limit the areas in which this species is likely to establish. *Leptochilus pteropus* typically grows on muddy rocks near

[1] "WRA area" is the area in relation to which the weed risk assessment is conducted [definition modified from that for "PRA area" (IPPC, 2012).

waterfalls or in streamlets (Khwaiphan, 2005; Tagawa and Iwatsuki, No Date). This species can withstand flood conditions for considerable periods (Boonkerd and Pollawatn, 2006). One author argues it is more properly classified as a rheophyte, which is a plant species that is adapted to living in streambeds of swift-flowing streams and growing up to the flood level, but not beyond the reach of regular floods (Kato and Imaichi, 1992). Such species have morphological adaptations that differ from other aquatic species.

Entry Potential We did not assess *L. pteropus*' entry potential because it is already present in the United States (APC, 2013; ExtraPlant, 2013; Gordon and Gantz, 2011b; Maki and Galatowitsch, 2004; Rixon et al., 2005).

Figure 1. Predicted distribution of *Leptochilus pteropus* in the United States. Map insets for Alaska, Hawaii, and Puerto Rico are not to scale.



2. Results and Conclusion

Model Probabilities: P(Major Invader) = 3.6%
P(Minor Invader) = 51.4%
P(Non-Invader) = 45.0%

Risk Result = Low Risk

Secondary Screening = Not Applicable

Figure 2. *Leptochilus pteropus* risk score (black box) relative to the risk scores of species used to develop and validate the PPQ WRA model (other symbols). See Appendix A for the complete assessment.

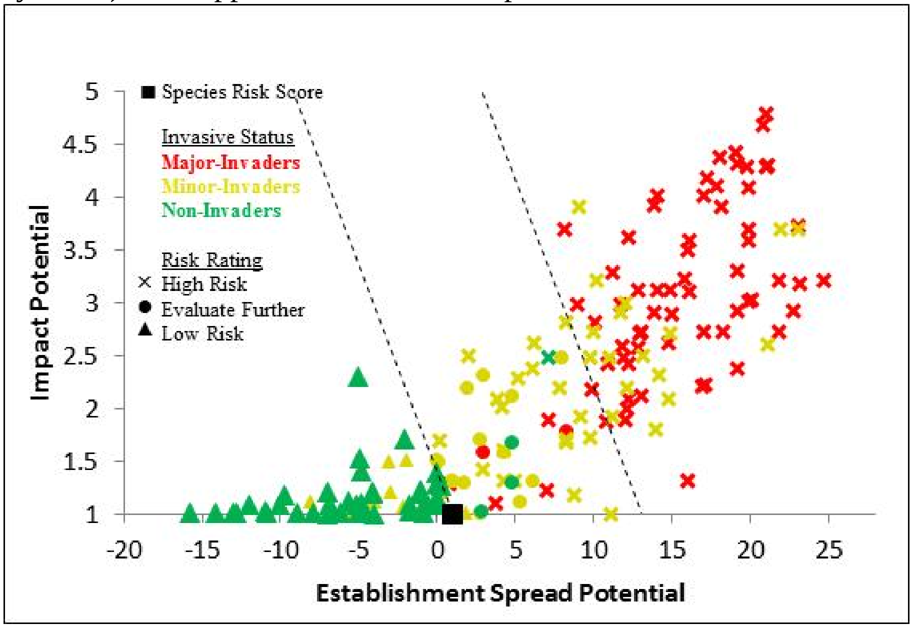
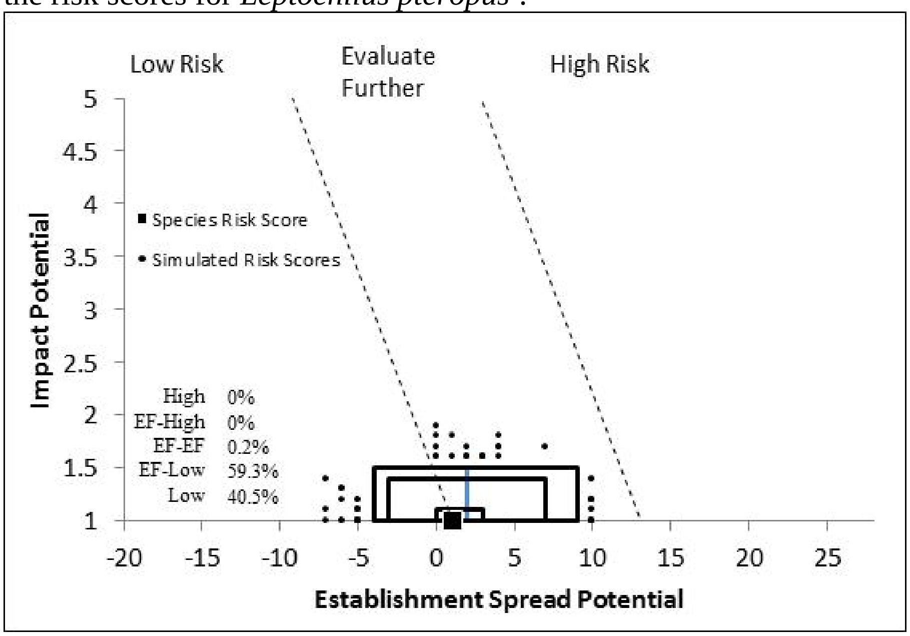


Figure 3. Monte Carlo simulation results (N=5,000) for uncertainty around the risk scores for *Leptochilus pteropus*[a].



[a] The blue "+" symbol represents the medians of the simulated outcomes. The smallest box contains 50 percent of the outcomes, the second 95 percent, and the largest 99 percent.

3. Discussion

The result of the weed risk assessment for *Leptochilus pteropus* is Low Risk (Fig. 2). One more point in either risk element would have placed this species in the Evaluate Further region of Fig. 2 but the final result would have still been Low Risk after secondary screening. Our uncertainty simulation supports that conclusion (Fig. 3). Despite limited biological information, our overall uncertainty level was low because *L. pteropus* has been cultivated for many years and has been in the United States since 1929 (Gordon and Gantz, 2011b). Assessment with the New Zealand aquatic weed risk assessment system, modified for the United States, also resulted in a conclusion of low risk (Gordon and Gantz, 2011a). *Leptochilus pteropus* grows slowly in aquaria (Anonymous, 2009) and may do so in the wild as well.

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Appendix A. Weed risk assessment for *Leptochilus pteropus* (Blume) Fraser-Jenk. (Polypodiaceae). The following information came from the original risk assessment, which is available upon request (full responses and all guidance). We modified the information to fit on the page.

Question ID	Answer - Uncertainty	Score	Notes (and references)
ESTABLISHMENT/SPREAD POTENTIAL			
ES-1 (Status/invasiveness outside its native range)	a - negl	-5	Introduced to and not known to have escaped in Australia (Randall, 2007), Canada (Cohen et al., 2007; Brouillet et al., 2013) [though that country is not climatically suitable], and Introduced to Germany (Billen and Strassen, 1995), and cultivated in Denmark (TROPICA, 2013). This species has been in the United States since at least 1929 (Gordon and Gantz, 2011b) and is widely cultivated (APC, 2013; ExtraPlant, 2013). We found no evidence that it has naturalized or escaped in the United States (NRCS, 2013). This species was classified as non-invasive in the United States in a weed risk assessment study (Gordon and Gantz, 2011b). Alternate answers for the Monte Carlo simulation were "b" and "d."
ES-2 (Is the species highly domesticated)	n - negl	0	Cultivated (Anonymous, 2009; NGRP, 2013). Popular aquarium plant that is widely cultivated and is suitable for beginners (Anonymous, 2009; APC, 2013). However, we found no evidence of breeding that has reduced its weed potential.
ES-3 (Weedy congeners)	n - mod	0	*Leptochilus* is a genus of about nine species (Mabberley, 2008). *Leptochilus* and *Microsorum* are closely related (Stuart, 2009), and *L. pteropus* is still primarily considered to be in *Microsorum*. *Microsorum* has about 100 species (Mabberley, 2008). *Microsorum scandens* is reported as a casual alien in Zimbabwe (Maroyi, 2012). *Microsorum scolopendrium* is listed as an invasive or potentially invasive cultivated plant in Hawaii (Staples et al., 2000). We found no evidence that any species in either of these two genera are significant weeds, however.
ES-4 (Shade tolerant at some stage of its life cycle)	y - low	1	Grows in light shade (Tagawa and Iwatsuki, No Date). In aquaria this species can grow in a wide range of lighting from bright light to marginal lighting (Randall, No Date). Based on pictures from its native range, this species appears to tolerate and grow in shade (Naser, 2011).
ES-5 (Climbing or smothering growth form)	n - negl	0	Species is not a vine; rather, it is a terrestrial, an aquatic, or grows on rocks in streams and waterfalls (Khwaiphan, 2005).
ES-6 (Forms dense thickets)	? - max	0	We found no evidence that this species forms dense thickets in nature. In aquaria, "Java fern will grow into a huge mass of plant upon plant if the aquarist does not occasionally groom it by removing the smaller plantlets" (Randall, No Date). Because this is not evidence of its behavior in natural conditions, we answered unknown.
ES-7 (Aquatic)	y - negl	1	Grows on rocks in streams and waterfalls, and tolerates being submerged (Boonkerd and Pollawatn, 2006; Khwaiphan, 2005). Herbaceous fern that can grow along streams (Tagawa and Iwatsuki, No Date) or under water (TROPICA, 2013). An aquatic plant (Oyedeji and Abowei, 2012).
ES-8 (Grass)	n - negl	0	The plant is not a grass; species is in the Polypodiaceae (NGRP, 2013).
ES-9 (Nitrogen-fixing woody plant)	n - negl	0	This is not a woody species (Khwaiphan, 2005). Furthermore, the Polypodiaceae (NGRP, 2013) is not one of the plant families

Question ID	**Answer - Uncertainty**	**Score**	**Notes (and references)**
			known to fix nitrogen (Martin and Dowd, 1990).
ES-10 (Does it produce viable seeds or spores)	y - low	1	Produces sporangia (TROPICA, 2013). Can be propagated via spores (Randall, No Date).
ES-11 (Self-compatible or apomictic)	? - max	0	Unknown.
ES-12 (Requires special pollinators)	n - negl	0	Ferns do not produce flowers and consequently do not depend on pollinators for sexual reproduction (Kaufman et al., 1989).
ES-13 (Minimum generation time)	b - high	1	*Leptochilus pteropus* is a perennial herb growing from thin rhizomes (Khwaiphan, 2005). We found no evidence of it being an annual. From spore to spore, we estimate it will take two or more years to complete a generation. However, because it produces plantlets at the end of fronds (Randall, No Date; TROPICA, 2013), it likely has a minimum generation time of one year through vegetative propagation. Alternate answers for the Monte Carlo simulation were "c" and "d."
ES-14 (Prolific reproduction)	y - negl	1	We found no evidence for this species but ferns can easily produce hundreds of thousands to millions of spores per square meter [see diagrams in Stuart, 2009) and description of the general biology of ferns in Kaufman et al. (1989)]. We answered yes based on the question-specific guidance.
ES-15 (Propagules likely to be dispersed unintentionally by people)	y - high	1	One pathway study estimated that about 247 plants per year of *L. pteropus* make it into the St. Lawrence Seaway due to "disposal" by hobbyists (Cohen et al., 2007); however, these numbers may not be reliable as they don't consider plant/propagule viability.
ES-16 (Propagules likely to disperse in trade as contaminants or hitchhikers)	n - mod	-1	We found no evidence. Plantlets or spores are highly unlikely to come in contact with or grow near most commodities.
ES-17 (Number of natural dispersal vectors)	2	0	Description for ES-17a through ES-17e: Ferns, including *L. pteropus*, produce spores in structures called sori (Kaufman et al., 1989; Khwaiphan, 2005)
ES-17a (Wind dispersal)	y - low		We found no direct evidence for this species but spores are commonly dispersed by wind. The congener *M. scolopendrium* is dispersed by wind (Staples et al., 2000).
ES-17b (Water dispersal)	y - negl		This species grows on rocks and on the ground adjacent to streams and in waterfalls (Khwaiphan, 2005), so it is highly likely to be dispersed by water.
ES-17c (Bird dispersal)	n - low		We found no evidence and not likely. Although some spores may get in bird feathers, that is unlikely to be an important dispersal vector.
ES-17d (Animal external dispersal)	n - low		We found no evidence and not likely. Although some spores may get in animal fur, that is unlikely to be an important dispersal vector.
ES-17e (Animal internal dispersal)	n - low		We found no evidence; spores seem unlikely to be attractive to animals.
ES-18 (Evidence that a persistent (>1yr) propagule bank (seed bank) is formed)	? - max	0	Unknown.
ES-19 (Tolerates/benefits from mutilation, cultivation or fire)	n - mod	-1	Although this species can be propagated from rhizome division and plantlets that grow from the end of fronds (Randall, No Date; TROPICA, 2013), we found no evidence that it is particularly tolerant of or responds well to mutilation.
ES-20 (Is resistant to some herbicides or has the potential	n - low	0	We found no evidence. Not listed by Heap (2013). As this species is not considered a weed, it is unlikely to have developed

Question ID	Answer - Uncertainty	Score	Notes (and references)
to become resistant)			herbicide resistance through selection.
ES-21 (Number of cold hardiness zones suitable for its survival)	5	0	
ES-22 (Number of climate types suitable for its survival)	4	2	
ES-23 (Number of precipitation bands suitable for its survival)	7	0	
IMPACT POTENTIAL			
General Impacts			
Imp-G1 (Allelopathic)	n - low	0	We found no evidence. Aquatic species seem unlikely to develop allelopathy.
Imp-G2 (Parasitic)	n - negl	0	The Polypodiaceae is not known to contain parasitic plants (Heide-Jorgensen, 2008; Nickrent, 2009).
Impacts to Natural Systems			
Imp-N1 (Change ecosystem processes and parameters that affect other species)	n - low	0	We found no evidence. Because this species has been in U.S. cultivation since at least 1929 (Gordon and Gantz, 2011b), is widely cultivated and available (APC, 2013; ExtraPlant, 2013; Maki and Galatowitsch, 2004; Rixon et al., 2005), and is not known to have escaped from cultivation, we answered most of the impact questions with low uncertainty.
Imp-N2 (Change community structure)	n - low	0	We found no evidence.
Imp-N3 (Change community composition)	n - low	0	We found no evidence.
Imp-N4 (Is it likely to affect federal Threatened and Endangered species)	n - low	0	We found no evidence.
Imp-N5 (Is it likely to affect any globally outstanding ecoregions)	n - low	0	We found no evidence.
Imp-N6 (Weed status in natural systems)	a - low	0	We found no evidence it is considered a weed. Alternate answers for the Monte Carlo simulation were both "b."
Impact to Anthropogenic Systems (cities, suburbs, roadways)			
Imp-A1 (Impacts human property, processes, civilization, or safety)	n - low	0	We found no evidence.
Imp-A2 (Changes or limits recreational use of an area)	n - low	0	We found no evidence.
Imp-A3 (Outcompetes, replaces, or otherwise affects desirable plants and vegetation)	n - low	0	We found no evidence.
Imp-A4 (Weed status in anthropogenic systems)	a - low	0	We found no evidence it is considered a weed. Alternate answers for the Monte Carlo simulation were both "b."
Impact to Production Systems (agriculture, nurseries, forest plantations, orchards, etc.)			
Imp-P1 (Reduces crop/product yield)	n - low	0	We found no evidence.
Imp-P2 (Lowers commodity value)	n - low	0	We found no evidence.

Question ID	Answer - Uncertainty	Score	Notes (and references)
Imp-P3 (Is it likely to impact trade)	n - negl	0	We found no evidence that this species is regulated by any country (APHIS, 2013).
Imp-P4 (Reduces the quality or availability of irrigation, or strongly competes with plants for water)	n - low	0	We found no evidence.
Imp-P5 (Toxic to animals, including livestock/range animals and poultry)	n - low	0	We found no evidence.
Imp-P6 (Weed status in production systems)	a - low	0	We found no evidence that it is considered a weed. Alternate answers for the Monte Carlo simulation were both "b."
GEOGRAPHIC POTENTIAL			Unless otherwise indicated, the following evidence represents geographically referenced, point references obtained from the Global Biodiversity Information Facility (GBIF, 2013).
Plant cold hardiness zones			
Geo-Z1 (Zone 1)	n - negl	N/A	We found no evidence.
Geo-Z2 (Zone 2)	n - negl	N/A	We found no evidence.
Geo-Z3 (Zone 3)	n - negl	N/A	We found no evidence.
Geo-Z4 (Zone 4)	n - negl	N/A	We found no evidence.
Geo-Z5 (Zone 5)	n - negl	N/A	We found no evidence.
Geo-Z6 (Zone 6)	n - negl	N/A	We found no evidence.
Geo-Z7 (Zone 7)	n - negl	N/A	We found no evidence.
Geo-Z8 (Zone 8)	n - mod	N/A	We found no evidence.
Geo-Z9 (Zone 9)	y - high	N/A	Occurrence: Yunnan and Guizhou, China (NGRP, 2013).
Geo-Z10 (Zone 10)	y - low	N/A	Vietnam (GBIF, 2013). Occurrence in Sikkim India (Kholia, No Date). Occurrence in Guangxi and Guangdong, China (NGRP, 2013).
Geo-Z11 (Zone 11)	y - negl	N/A	Occurrence: India, Thailand, Bangladesh (Khwaiphan, 2005; NGRP, 2013).
Geo-Z12 (Zone 12)	y - negl	N/A	Indonesia (GBIF, 2013). Occurs in numerous provinces (Khwaiphan, 2005).
Geo-Z13 (Zone 13)	y - negl	N/A	Malaysia and Indonesia.
Köppen-Geiger climate classes			
Geo-C1 (Tropical rainforest)	y - negl	N/A	Malaysia and Indonesia.
Geo-C2 (Tropical savanna)	y - negl	N/A	Broad occurrence in Thailand (Khwaiphan, 2005).
Geo-C3 (Steppe)	n - high	N/A	This species is broadly distributed in southern India (Singh et al., 2012), which includes steppe climates. However, it is unclear if it can occur in steppe climates as it is well adapted to wet habitats. We answered no with high uncertainty.
Geo-C4 (Desert)	n - low	N/A	We found no evidence.
Geo-C5 (Mediterranean)	n - mod	N/A	We found no evidence.
Geo-C6 (Humid subtropical)	y - negl	N/A	A few points in Vietnam (GBIF, 2013). Occurs in several southern China provinces (NGRP, 2013)
Geo-C7 (Marine west coast)	y - mod	N/A	Regional occurrences: Yunnan China (NGRP, 2013), Sikkim India (Kholia, No Date), and Tamil Nadu India (NGRP, 2013).
Geo-C8 (Humid cont. warm sum.)	n - low	N/A	We found no evidence.
Geo-C9 (Humid cont. cool sum.)	n - negl	N/A	We found no evidence.
Geo-C10 (Subarctic)	n - negl	N/A	We found no evidence.

Question ID	Answer - Uncertainty	Score	Notes (and references)
Geo-C11 (Tundra)	n - negl	N/A	We found no evidence.
Geo-C12 (Icecap)	n - negl	N/A	We found no evidence.
10-inch precipitation bands			
Geo-R1 (0-10 inches; 0-25 cm)	n - negl	N/A	We found no evidence.
Geo-R2 (10-20 inches; 25-51 cm)	n - negl	N/A	We found no evidence.
Geo-R3 (20-30 inches; 51-76 cm)	n - negl	N/A	We found no evidence.
Geo-R4 (30-40 inches; 76-102 cm)	n - high	N/A	We found no evidence.
Geo-R5 (40-50 inches; 102-127 cm)	y - mod	N/A	Geo-referenced points and regional occurrence in tropical southeast Asia (GBIF, 2013; Khwaiphan, 2005; NGRP, 2013; Singh et al., 2012).
Geo-R6 (50-60 inches; 127-152 cm)	y - negl	N/A	Geo-referenced points and regional occurrence in tropical southeast Asia (GBIF, 2013; Khwaiphan, 2005; NGRP, 2013; Singh et al., 2012).
Geo-R7 (60-70 inches; 152-178 cm)	y - negl	N/A	Geo-referenced points and regional occurrence in tropical southeast Asia (GBIF, 2013; Khwaiphan, 2005; NGRP, 2013; Singh et al., 2012).
Geo-R8 (70-80 inches; 178-203 cm)	y - negl	N/A	Geo-referenced points and regional occurrence in tropical southeast Asia (GBIF, 2013; Khwaiphan, 2005; NGRP, 2013; Singh et al., 2012).
Geo-R9 (80-90 inches; 203-229 cm)	y - negl	N/A	Geo-referenced points and regional occurrence in tropical southeast Asia (GBIF, 2013; Khwaiphan, 2005; NGRP, 2013; Singh et al., 2012).
Geo-R10 (90-100 inches; 229-254 cm)	y - negl	N/A	Geo-referenced points and regional occurrence in tropical southeast Asia (GBIF, 2013; Khwaiphan, 2005; NGRP, 2013; Singh et al., 2012).
Geo-R11 (100+ inches; 254+ cm))	y - negl	N/A	Indonesia and Malaysia.
ENTRY POTENTIAL			
Ent-1 (Plant already here)	y - negl	1	Widely cultivated in the United States (ExtraPlant, 2013) and in Canada (Cohen et al., 2007).
Ent-2 (Plant proposed for entry, or entry is imminent)	-	N/A	
Ent-3 (Human value & cultivation/trade status)	-	N/A	
Ent-4 (Entry as a contaminant)			
Ent-4a (Plant present in Canada, Mexico, Central America, the Caribbean or China)	-	N/A	
Ent-4b (Contaminant of plant propagative material (except seeds))	-	N/A	
Ent-4c (Contaminant of seeds for planting)	-	N/A	
Ent-4d (Contaminant of ballast water)	-	N/A	
Ent-4e (Contaminant of	-	N/A	

Question ID	**Answer - Uncertainty**	**Score**	**Notes (and references)**
aquarium plants or other aquarium products)			
Ent-4f (Contaminant of landscape products)	-	N/A	
Ent-4g (Contaminant of containers, packing materials, trade goods, equipment or conveyances)	-	N/A	
Ent-4h (Contaminants of fruit, vegetables, or other products for consumption or processing)	-	N/A	
Ent-4i (Contaminant of some other pathway)	-	N/A	
Ent-5 (Likely to enter through natural dispersal)	-	N/A	