

WEED RISK ASSESSMENTS OF THE EXOTIC SPECIES OF *PLECTRANTHUS* L'HÉR. (LAMIACEAE) IN SINGAPORE

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ABSTRACT. — *Plectranthus amboinicus* (Lour.) Spreng., *Plectranthus monostachyus* (P.Beauv.) B.J.Pollard, and *Plectranthus scutellarioides* (L.) R.Br. are exotic herbs in Singapore. A Weed Risk Assessment (WRA) was conducted for each species in order to assess its potential for invasiveness in Singapore. No spontaneous growth of *Plectranthus amboinicus* is known in Singapore as it rarely flowers in Southeast Asia, although it has a WRA score of 9, which indicates weediness, since scores above 6 indicate high risk. *Plectranthus monostachyus*, first recorded in 2009 and now naturalised in Singapore, received a high WRA score of 14 so should be considered as a locally high-risk weed and be removed, especially from the edges of the nature reserves. The WRA score of *Plectranthus scutellarioides* is 13, indicating that it also has a high risk of becoming an agricultural or environmental weed. Although spontaneous growth of *Plectranthus scutellarioides* is unknown in Singapore, its cultivation should be avoided to be cautious. This article is our second attempt at using the modified Australia Weed Risk Assessment system for assessing exotic plants in Singapore. We recommend its use for any new exotic species imports.

KEY WORDS. — Lamiaceae, *Plectranthus*, Weed Risk Assessment, new record, naturalised

INTRODUCTION

In the family Lamiaceae, *Plectranthus* L'Hér. is a large genus consisting of approximately 300 species (Potgieter, 2009). *Plectranthus* species are widely distributed in the tropical and warm regions of the Old World (Retief, 2000). The generic boundaries of *Plectranthus* are controversial, as Paton et al. (2004) showed that the current circumscription is paraphyletic and requires expansion. In the same year, Suddee et al. (2004) reviewed 14 species in continental Southeast Asia.

Based on Keng (1990), specimens at the Herbarium, Singapore Botanic Gardens (SING), and the Herbarium, Lee Kong Chian Natural History Museum, National University of Singapore (SINU), there are three *Plectranthus* species found here—*Plectranthus amboinicus* (Lour.) Spreng., *Plectranthus rotundifolius* (Poir.) Spreng., and *Plectranthus scutellarioides* (L.) R. Br. Boo et al. (2012) also recorded a cultivated variety (cultivar) derived from a hybrid—*Plectranthus* 'Mona Lavender' (see Harrower, 2003). *Plectranthus monostachyus* (P.Beauv.) B.J.Pollard was first recorded by Kwan Han Ong in Singapore on 25 Apr.2009 (<http://www.natureloveyou.sg/Plants-P.html>; <http://www.natureloveyou.sg/Plectranthus%20monostachyus/Main.html>).

In continental Southeast Asia, *Plectranthus* species are erect or ascending herbs (Suddee et al., 2004). The stem is often succulent and branched, and its cross section is quadrangular or round-quadrangular. The leaves are opposite and the leaf blades have serrate or crenate margins. The flower has a persistent, campanulate or tubular calyx and a long, curved or conspicuously sigmoid corolla that protrudes from the calyx tube. The corolla lip consists of a 4-lobed upper lip and a longer 1-lobed lower lip with a boat shape (Keng, 1978; Keng, 1990; Suddee et al., 2004). Potgieter (2009) showed that *Plectranthus* species with sigmoid corolla tubes in southern Africa are mainly bee-pollinated, with fly-pollination prevalent in some. The seeds are smooth or minutely tuberculate, producing mucilage when wet (Suddee et al., 2004). From our observations, *Plectranthus monostachyus* and *Plectranthus scutellarioides* have buoyant seeds that are sticky when wet, suggesting that they may be dispersed by water, animals, or both. As the seed of *Plectranthus amboinicus* has a similar morphology to that of *Plectranthus scutellarioides* (Suddee et al., 2004), we infer that this species may also possess a similar dispersal mode.

We have noted the presence of spontaneous and cultivated *Plectranthus* species in many parts of Singapore. Since *Plectranthus rotundifolius* and *Plectranthus* 'Mona Lavender' are not encountered frequently and no spontaneous

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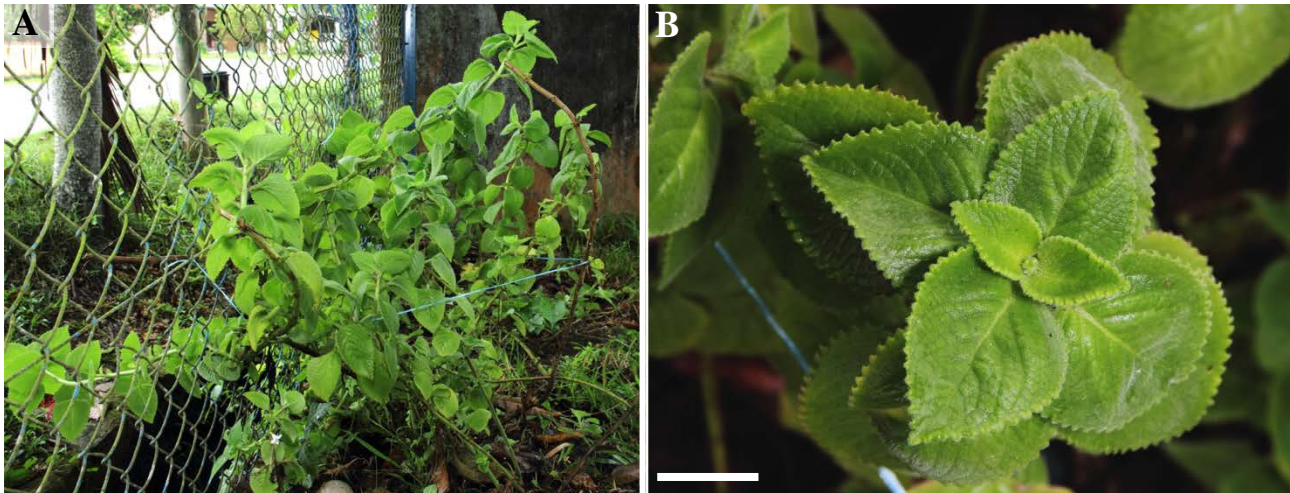


Fig. 1. *Plectranthus amboinicus*. A, Cultivated plant, about 1 m tall in a garden of a Singapore home; B, Decussate, hairy leaves. Scale bars = 2 cm. (Photographs by: Chung Yi Fei).

individuals have been observed, they are unlikely as yet to pose any significant ecological threat here. On the other hand, *Plectranthus monostachyus* was found to be spontaneous and very widespread around Singapore and the other two are frequently cultivated here. Hence, for this paper, we will only concentrate on *Plectranthus amboinicus*, *Plectranthus monostachyus*, and *Plectranthus scutellarioides*.

MATERIAL AND METHODS

Plectranthus amboinicus, *Plectranthus monostachyus*, and *Plectranthus scutellarioides* are briefly described based on the literature and our observations. A Weed Risk Assessment (WRA) was conducted for each species in order to assess its potential for invasiveness in Singapore (Tables 1–3, Supplementary Material). The WRA score-sheet was obtained from USFS-PIER (2008), which in turn was adapted from Pheloung et al. (1999). The questions were systematically answered and the scores computed. Species with a total score of less than 1 are of low risk; species with scores between 1–6 require further evaluation; species with scores greater than 6 have a high risk of becoming an invasive pest plant (Pheloung et al., 1999; Chong et al. 2011).

OBSERVATIONS, RESULTS AND DISCUSSION

Although *Plectranthus amboinicus*, *Plectranthus monostachyus* and *Plectranthus scutellarioides* are congeners and morphologically quite similar, *Plectranthus amboinicus* can be easily distinguished from the others by its aromatic and fleshy leaves (Keng, 1978). *Plectranthus monostachyus* and *Plectranthus scutellarioides* have similar morphology, except that the cymes of *Plectranthus scutellarioides* produce obvious lateral cincinni, whereas the cymes of *Plectranthus monostachyus* are more or less sessile and lack any obvious lateral cincinni (Figs. 2B, 3B).

***Plectranthus amboinicus* (Lour.) Spreng.** — This species is commonly known as Indian borage (Suddee et al., 2004). *Plectranthus amboinicus* is a perennial herb up to 1 m tall (Keng, 1978). The round-quadrangular stems (in cross section), are succulent, solid, and hairy when young, but hollow and hairy above and glabrescent below when older (Suddee et al., 2004). The decussate, stalked leaves are fleshy and have hairy, crenate-margined laminae. The inflorescences develop at the stem tips and bear flowers with purple corollas and occur in sessile cymes. The fruits are pale-roundish, flattened nutlets about 0.7 by 0.5 mm (Keng, 1978).

Owing to early introductions to many warmer parts of the world (even up to altitudes of 1,500 m [Suddee et al., 2004]), the native range for *Plectranthus amboinicus* is uncertain, but it is suspected to be of Indian or tropical African origin (Keng, 1978). It is widely cultivated for its aromatic leaves which are used in traditional medicine to cure urinary diseases, vaginal discharge, coughing in children, and pains near the stomach or heart (Keng, 1978; Likhoba et al., 2006). More information on its ethnobotanical uses is provided by Likhoba et al. (2006).

Plectranthus amboinicus is commonly cultivated in Singapore home gardens, as evident from our sighting this plant at many localities including along Bukit Batok West Ave 5, Lorong Semangka, Malta Crescent, Orange Grove Road, Senoko Drive, Siglap Hill, South Bouna Vista Road, Sungei Pang Sua Park Connector, and in the housing estates of

Queenstown, Punggol, and Sengkang. However, the only locally flowering individual we are aware of was recorded at the Oh Chin Huat Hydroponic Farm by Wilson Wong in 2009.

From our risk assessment form (Table 1, Supplementary Material), the WRA score for *Plectranthus amboinicus* is 9, indicating that there is a high risk of it becoming an agricultural or environmental weed. Also, *Plectranthus amboinicus* has been reported as being invasive in some Pacific Islands: Nuku Hiva Island, Savai'i Island, Solomon Islands, Tahiti Island, Taveuni Island, Tongatapu Island, Ua Pou Island, Vanua Levu Island, Viti Levu Island, and Yasawas Island as well as La Réunion Island in the Indian Ocean (USFS-PIER, 1999a).

No spontaneous growth of *Plectranthus amboinicus* is known in Singapore as it rarely flowers in Southeast Asia (Keng, 1978; Suddee, 2010). Hence, despite being widely cultivated here, *Plectranthus amboinicus* is not likely to be a threat to native-dominated, closed-canopy forests. However, in light of the high WRA score and records documenting the invasiveness of this plant, cultivation of *Plectranthus amboinicus* should be avoided along forest fringes or agricultural areas as it may escape from cultivation or even become naturalised in the event that local populations start flowering and fruiting.

***Plectranthus monostachyus* (P.Beauv.) B.J.Pollard.** — Synonyms of this species include *Solenostemon monostachyus* (P.Beauv.) Briq. and *Ocimum monostachyum* P.Beauv. (The Plant List, 2013). *Plectranthus monostachyus* is a short-lived perennial herb (Morton, 1963; Pollard & Paton, 2001; Lemmens, 2004). Its succulent stem is round-quadrangular in cross section and decumbent at the base or erect. The leaf blades, which are broadly ovate, have thin to coarsely crenate margins, a usually obtuse apex, and sharply cuneate base (Morton, 1963; our observations). The stems, the inflorescent axis, mature calyx and the veins on both sides of leaves are hairy. The inflorescences are terminal and the cymes do not produce obvious lateral cincinni (Morton, 1963). The corolla is pale violet with a whitish tube. The median teeth of the calyx are lanceolate, and have acute or acuminate tips.

The native range of *Plectranthus monostachyus* is tropical West Africa, ranging from Senegal to Chad, Central African Republic, Democratic Republic of Congo, and Angola (Morton, 1963; Lemmens, 2004). In Singapore, *Plectranthus monostachyus* has been cultivated in community gardens within the residential estate of Sengkang and home gardens along Compassvale Street. We also encountered spontaneous populations in many localities including: Bah Soon Pah Road nurseries, edges of and trails in the Bukit Timah Nature Reserve and adjacent nature parks, Cecil Street, Commonwealth West Avenue, Greenridge Crescent, Hillview Avenue, HortPark, along the former Keretapi Tanah Melayu (KTM) railway line, the National University of Singapore Kent Ridge Campus, Pulau Ubin, Singapore Botanic Gardens, and Teban Gardens Crescent.

Spontaneous plants grow in the ground as well as on zinc roofs, in the cracks of rough concrete surfaces as well as in the crotches of tree trunks and branches. The individuals were observed to have short life cycles with high fecundity. Some fruiting individuals were less than 25 cm tall in shady areas. Given the very high WRA score of 14 and locally spontaneous occurrence, *Plectranthus monostachyus* should be considered as a local high risk weed and should be removed, especially from the edges of the nature reserves.

Because of the numerous records of spontaneous populations, we recommended that it be considered a naturalised species in Singapore.

***Plectranthus scutellarioides* (L.) R.Br.** — This species is commonly known as coleus or painted nettle (Boo et al., 2012). Its synonyms include *Solenostemon scutellarioides* (L.) Codd, *Coleus scutellarioides* (L.) Benth., and *Ocimum scutellarioides* L. (Keng, 1978; USFS-PIER, 1999b; Chong et al., 2009). *Plectranthus scutellarioides* is a short-lived, perennial herb that can grow up to 1 m tall (Keng, 1978). Its succulent stem frequently branches and has a round-quadrangular cross section (Suddee et al., 2004). The sub-fleshy leaves have laminas with crenate to serrate margins that are extremely variable in size, shape, and colour, especially in the cultivated forms (Keng 1978; Boo et al., 2012). The stems, the inflorescence axis and both sides of the leaf blade are hairy and bear sessile glands (Suddee et al., 2004). The inflorescences are terminal and cymes produce obvious lateral cincinni (Suddee et al., 2004). The corolla is bluish purple with a whitish tube (Keng, 1978; Suddee et al., 2004). The median teeth of the calyx have acuminate tips (Suddee et al., 2004). Flowering and fruiting occurs all year round (Suddee et al., 2004). The nutlets are brown, broadly ovoid or orbicular, and about 1 mm long (Keng, 1978).

Although *Plectranthus scutellarioides* is native to East Asia and Malesia (Keng, 1978), this herb is now distributed pan-tropically through cultivation (USFS-PIER, 1999b). Possible reasons for its popularity in cultivation include its attractiveness as an ornamental plant (with highly variable leaf morphology and colours), and medicinal value in treating dyspepsia and ophthalmic ailments (Keng, 1978). According to records in SING, the first specimens of *Plectranthus scutellarioides* (SING bar code numbers 0011214 and 0011218) were collected in 1889 by H. N. Ridley in

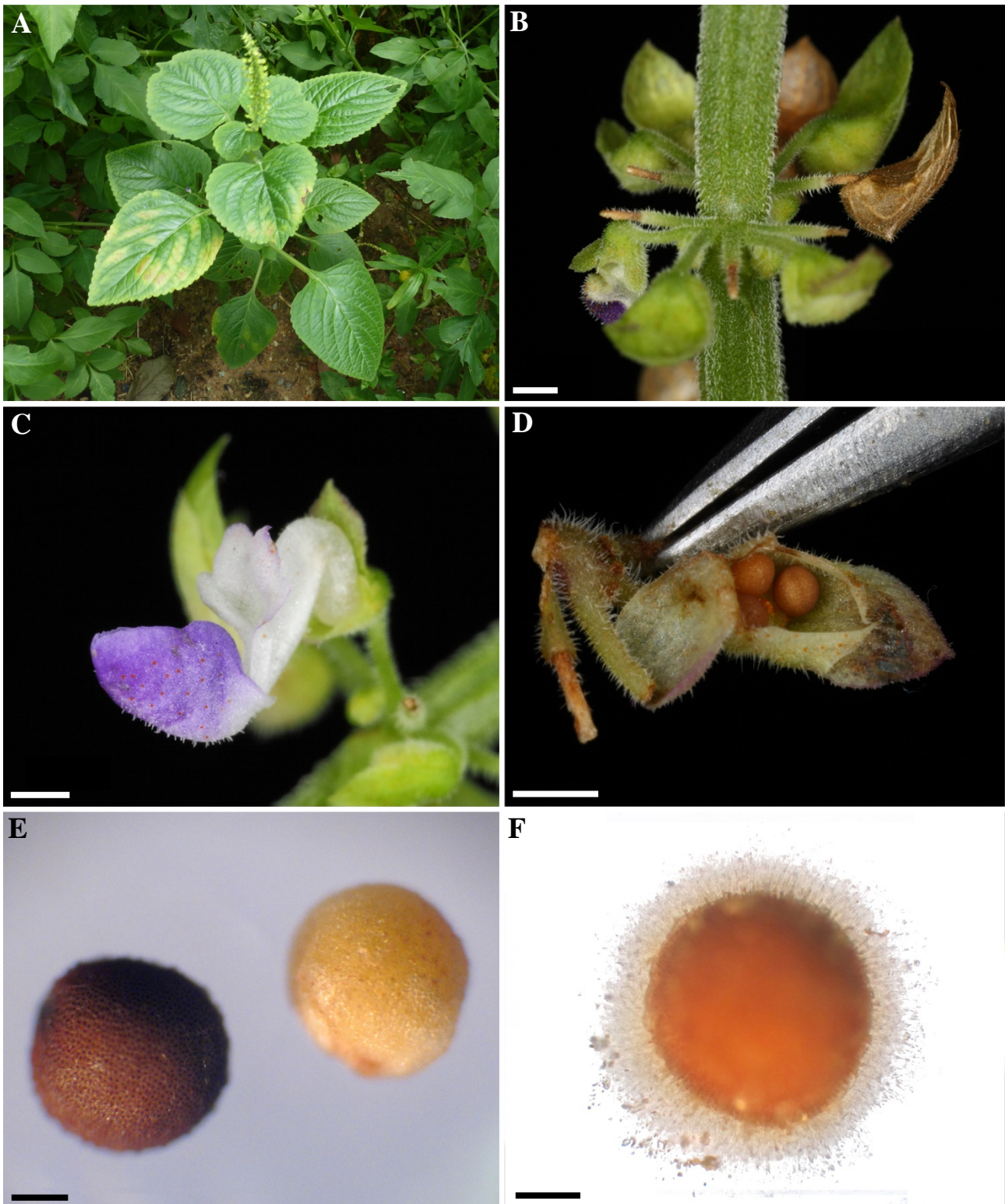


Fig. 2. *Plectranthus monostachyus*. A, Flowering, leafy shoot of a spontaneously growing individual about 0.5 m tall in a garden along Cecil Street; B, Flower bud and fruits in sessile cymes that lack obvious lateral cincinni; C, Flower with a boat-shaped anterior corolla-lip that is bright purple with minute orange spots; D, Each calyx contains four nutlets; E, Dark brown (mature) and light brown (immature) nutlets have shiny surfaces with very fine hairs; F, Mucilage surrounding a wet mature nutlet. Scale bars = A–C, 1 mm; E, F, 0.2 mm. (Photographs by: Chung Yi Fei [A–E] and Phạm Nguyệt Minh [F]).

Ang Mo Kio and Chan Chu Kang Forest Reserve. Based on our observations, it is available in most commercial nurseries and widely cultivated in home gardens.

The WRA score of *Plectranthus scutellarioides* is 13 (Table 3, Supplementary Material), indicating that it is of high risk of becoming an agricultural or environmental weed as is evident from it being invasive in 48 Pacific Islands (USFS-PIER, 1999b) and becoming naturalised in disturbed parts of mesic to wet forest (Wagner et al., 1999). However,



Fig. 3. *Plectranthus scutellarioides*. A, Flowering plants at the front of a terrace house near the Bukit Timah Nature Reserve; B, Cyme of flowers and fruits showing the obvious lateral cincinni; C, Inflorescences at the tips of leafy shoots; D, The mature calyces are less curved than those of *Plectranthus monostachyus* (Fig. 2B). E, Flower with a boat-shaped anterior corolla-lip that is bright purple with minute orange spots. F, Each mature fruiting calyx contains four nutlets. Scale bars = 1 mm (A–E), 0.2 mm (F). (Photographs by: Chung Yi Fei).

spontaneous growth of *Plectranthus scutellarioides* is so far unknown in Singapore, although flowering and fruiting have been regularly observed. Considering the extremely high WRA score and records of invasiveness of this species in the Pacific Islands, cultivation of *Plectranthus scutellarioides* in Singapore should be avoided.

CONCLUSIONS

This article is our second attempt to use the modified Australia WRA system for assessing the invasiveness of exotic plants in Singapore, the first being Teo et al. (2011). The assessments have been fairly adequate in predicting the current statuses of *Plectranthus amboinicus*, *Plectranthus monostachyus*, and *Plectranthus scutellarioides* based on previous floristic reviews and our observations in the field. *Plectranthus amboinicus* has a WRA score of 9, *Plectranthus monostachyus* a score of 14, and *Plectranthus scutellarioides* a score of 13, which indicate that all are considered plants with a high risk of becoming naturalised, which is a pre-requisite for becoming an invasive. Hence, we strongly recommend the use of the Australia WRA system for new exotic species imports. However, we also note that some level of prudence has to be exercised for sterile species or species that rarely or infrequently flower, as these might yield a false positive for the WRA assessment, as was the case for *Plectranthus amboinicus*.

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SUPPLEMENTARY MATERIAL

Table 1. Weed Risk Assessment (WRA) for *Plectranthus amboinicus* (Lour) Spreng in Singapore.

S/N.	Category	Question	Scoring System	Answer	Score	Reference
1.01	Domestication/ Cultivation	Is the species highly domesticated?	y=-3, n=0	y	-3	Keng (1978), Smith (1991), Suddee et al. (2004)
1.02		Has the species become naturalised where grown?	y=1, n=-1	y	1	Smith (1991), USFS-PIER (1999a)
1.03		Does the species have weedy races?	y=1, n=-1	no evidence	-	
2.01	Climate and distribution	Species suited to tropical or subtropical climate(s) (0-low; 1-intermediate; 2-high) – If island is primarily wet habitat, then substitute “wet tropical” for “tropical or subtropical”	refer to question (score used with 2.02 to answer 3.01–3.05)	high	-	Keng (1978), Smith (1991)
2.02		Quality of climate match data (0-low; 1-intermediate; 2-high) see appendix 2	refer to question (score used with 2.01 to answer 3.01–3.05)	intermediate	-	
2.03		Broad climate suitability (environmental versatility)	y=1, n=0	y	1	Keng (1978), Smith (1991)
2.04		Native or naturalised in regions with tropical or subtropical climates	y=1, n=0	y	1	Keng (1978), Smith (1991), Le et al. (2002), Suddee et al. (2004), Batianoff et al. (2009)
2.05		Does the species have a history of repeated introductions outside its natural range?	y=-2, No evidence=-1, n=0	y	-2	Keng (1978), Suddee et al. (2004)
3.01	Weed elsewhere	Naturalised beyond native range y = 1*multiplier; n= answer to question 2.05	refer to question	y	2	Smith (1991), USFS-PIER (1999a)
3.02		Garden/amenity/disturbance weed	y=1*multiplier, n=0	n	2	Smith (1991), USFS-PIER (1999a)
3.03		Agricultural/forestry/horticultural weed	y=2*multiplier, n=0	n	0	
3.04		Environmental weed	y=2*multiplier, n=0	y	4	USFS-PIER (1999a)
3.05		Congeneric weed	y=1*multiplier, n=0	y	2	USFS-PIER (2010)
4.01	Undesirable traits	Produces spines, thorns or burrs	y=1, n=0	n	0	
4.02		Allelopathic	y=1, n=0	no evidence	-	
4.03		Parasitic	y=1, n=0	n	0	
4.04		Unpalatable to grazing animals	y=1, n=-1	no evidence	-	
4.05		Toxic to animals	y=1, n=0	n	0	
4.06		Host for recognised pests and pathogens	y=1, n=0	no evidence	-	
4.07		Causes allergies or is otherwise toxic to humans	y=1, n=0	n	0	
4.08		Creates a fire hazard in natural ecosystems	y=1, n=0	n	0	
4.09		Is a shade tolerant plant at some stage of its life cycle	y=1, n=0	y	1	USFS-PIER (1999a)

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S/N.	Category	Question	Scoring System	Answer	Score	Reference
4.10		Tolerates a wide range of soil conditions (or limestone conditions if not a volcanic island)	y=1, n=0	y	1	USFS-PIER (1999a)
4.11		Climbing or smothering growth habit	y=1, n=0	n	0	
4.12		Forms dense thickets	y=1, n=0	n	0	
5.01	Plant type	Aquatic	y=5, n=0	n	0	
5.02		Grass	y=1, n=0	n	0	
5.03		Nitrogen fixing woody plant	y=1, n=0	n	0	
5.04		Geophyte (herbaceous with underground storage organs -- bulbs, corms, or tubers)	y=1, n=0	n	0	
6.01	Reproduction	Evidence of substantial reproductive failure in native habitat	y=1, n=0	n	0	
6.02		Produces viable seed.	y=1, n=-1	no evidence	0	
6.03		Hybridises naturally	y=1, n=-1	no evidence	-	
6.04		Self-compatible or apomictic	y=1, n=-1	no evidence	-	
6.05		Requires specialist pollinators	y=-1, n=0	no evidence	-	
6.06		Reproduction by vegetative fragmentation	y=1, n=-1	y	1	Keng (1978), Suddee et al. (2004)
6.07		Minimum generative time (years) 1 year = 1, 2 or 3 years = 0, 4+ years = -1	refer to question	< 1 year	1	Keng (1978), Suddee et al. (2004)
7.01	Dispersal mechanism	Propagules likely to be dispersed unintentionally (plants growing in heavily trafficked areas)	y=1, n=-1	y	1	Keng (1978), Suddee et al. (2004)
7.02		Propagules dispersed intentionally by people	y=1, n=-1	y	1	Keng (1978), Smith (1991)
7.03		Propagules likely to disperse as a produce contaminant	y=1, n=-1	n	-1	Keng (1978), Suddee et al. (2004)
7.04		Propagules adapted to wind dispersal	y=1, n=-1	n	-1	Keng (1978), Suddee et al. (2004)
7.05		Propagules water dispersed	y=1, n=-1	n	-1	Keng (1978), Suddee et al. (2004)
7.06		Propagules bird dispersed	y=1, n=-1	no evidence	-	
7.07		Propagules dispersed by other animals (externally)	y=1, n=-1	no evidence	-	
7.08		Propagules survive passage through the gut	y=1, n=-1	no evidence	-	
8.01	Persistence attributes	Prolific seed production (>1000 m ⁻²)	y=1, n=-1	n	-1	Keng (1978), Suddee et al. (2004)
8.02		Evidence that a persistent propagule bank is formed (>1 yr)	y=1, n=-1	n	-1	Keng (1978), Suddee et al. (2004)
8.03		Well controlled by herbicides	y=-1, n=1	no evidence	-	
8.04		Tolerates, or benefits from, mutilation, cultivation, or fire	y=1, n=-1	no evidence	-	
8.05		Effective natural enemies present locally (e.g. introduced biocontrol agents)	y=-1, n=1	no evidence	-	
Total Score					9	

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Table 2. Weed Risk Assessment (WRA) for *Plectranthus monostachyus* (P Beauv.) B. J. Pollard in Singapore.

S/N.	Category	Question	Scoring System	Answer	Score	Reference
1.01	Domestication/ Cultivation	Is the species highly domesticated?	y=-3, n=0	y	-3	Pers. obs.(CYF)
1.02		Has the species become naturalised where grown?	y=1, n=-1	y	1	Pers. obs.(CYF)
1.03		Does the species have weedy races?	y=1, n=-1	y	1	Wagner (1999)
2.01	Climate and distribution	Species suited to tropical or subtropical climate(s) (0-low; 1-intermediate; 2-high) – If island is primarily wet habitat, then substitute “wet tropical” for “tropical or subtropical”	refer to question (score used with 2.02 to answer 3.01–3.05)	high		
2.02		Quality of climate match data (0-low; 1-intermediate; 2-high) see appendix 2	refer to question (score used with 2.01 to answer 3.01–3.05)	high		
2.03		Broad climate suitability (environmental versatility)	y=1, n=0			
2.04		Native or naturalised in regions with tropical or subtropical climates	y=1, n=0	y	1	
2.05		Does the species have a history of repeated introductions outside its natural range?	y=-2, No evidence=-1, n=0	y	-2	Pers. obs.(CYF)
3.01	Weed elsewhere	Naturalised beyond native range y = 1*multiplier; n= answer to question 2.05	refer to question	y	2	Pers. obs.(CYF)
3.02		Garden/amenity/disturbance weed	y=1*multiplier, n=0	y	2	Multiple records in Singapore
3.03		Agricultural/forestry/horticultural weed	y=2*multiplier, n=0	y	4	Multiple records in Singapore
3.04		Environmental weed	y=2*multiplier, n=0	no evidence	0	
3.05		Congeneric weed	y=1*multiplier, n=0	y	2	<i>Plectranthus neochilus</i>
4.01	Undesirable traits	Produces spines, thorns or burrs	y=1, n=0	n	0	
4.02		Allelopathic	y=1, n=0	no evidence	-	
4.03		Parasitic	y=1, n=0	n	0	
4.04		Unpalatable to grazing animals	y=1, n=-1	no evidence	-	
4.05		Toxic to animals	y=1, n=0	n	0	
4.06		Host for recognised pests and pathogens	y=1, n=0	no evidence	-	
4.07		Causes allergies or is otherwise toxic to humans	y=1, n=0	n	0	
4.08		Creates a fire hazard in natural ecosystems	y=1, n=0	n	0	
4.09		Is a shade tolerant plant at some stage of its life cycle	y=1, n=0	y	1	Pers. obs.(CYF)
4.10		Tolerates a wide range of soil conditions (or limestone conditions if not a volcanic island)	y=1, n=0	y	1	Pers. obs.(CYF)
4.11		Climbing or smothering growth habit	y=1, n=0	n	0	
4.12		Forms dense thickets	y=1, n=0	y	1	Pers. obs.(CYF)

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S/N.	Category	Question	Scoring System	Answer	Score	Reference
5.01		Aquatic	y=5, n=0	no evidence	0	
5.02		Grass	y=1, n=0	n	0	
5.03	Plant type	Nitrogen fixing woody plant	y=1, n=0	n	0	
5.04		Geophyte (herbaceous with underground storage organs -- bulbs, corms, or tubers)	y=1, n=0	n	0	
6.01		Evidence of substantial reproductive failure in native habitat	y=1, n=0	n	0	
6.02		Produces viable seed.	y=1, n=-1	y	1	Pers. obs.(CYF); Fig. 2
6.03		Hybridises naturally	y=1, n=-1	no evidence	-	
6.04	Reproduction	Self-compatible or apomictic	y=1, n=-1	no evidence	-	
6.05		Requires specialist pollinators	y=-1, n=0	no evidence	-	
6.06		Reproduction by vegetative fragmentation	y=1, n=-1	y	1	Pers. obs.(CYF)
6.07		Minimum generative time (years) 1 year = 1, 2 or 3 years = 0, 4+ years = -1	refer to question	< 1 year	1	Pers. obs.(CYF)
7.01		Propagules likely to be dispersed unintentionally (plants growing in heavily trafficked areas)	y=1, n=-1	y	1	Pers. obs.(CYF); Fig. 2
7.02		Propagules dispersed intentionally by people	y=1, n=-1	n	-1	Pers. obs.(CYF)
7.03	Dispersal mechanism	Propagules likely to disperse as a produce contaminant	y=1, n=-1	n	-1	Pers. obs.(CYF)
7.04		Propagules adapted to wind dispersal	y=1, n=-1	no evidence	-	
7.05		Propagules water dispersed	y=1, n=-1	no evidence	-	
7.06		Propagules bird dispersed	y=1, n=-1	no evidence	-	
7.07		Propagules dispersed by other animals (externally)	y=1, n=-1	no evidence	-	
7.08		Propagules survive passage through the gut	y=1, n=-1	no evidence	-	
8.01		Prolific seed production (>1000 m ⁻²)	y=1, n=-1	y	-1	Estimate based on Fig. 2
8.02		Evidence that a persistent propagule bank is formed (>1 yr)	y=1, n=-1	no evidence	-	
8.03	Persistence attributes	Well controlled by herbicides	y=-1, n=1	no evidence	-	
8.04		Tolerates, or benefits from, mutilation, cultivation, or fire	y=1, n=-1	no evidence	-	
8.05		Effective natural enemies present locally (e.g. introduced biocontrol agents)	y=-1, n=1	no evidence	-	
Total Score					14	

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Table 3. Weed Risk Assessment for *Plectranthus scutellarioides* (L.) R.Br. in Singapore.

S/N.	Category	Question	Scoring System	Answer	Score	Reference
1.01		Is the species highly domesticated?	y=-3, n=0	y	-3	Keng (1978), USFS-PIER (1999b), Suddee et al. (2004)
1.02	Domestication/ Cultivation	Has the species become naturalised where grown?	y=1, n=-1	y	1	Keng (1978), USFS-PIER (1999b), Wagner (1999), Suddee et al. (2004)
1.03		Does the species have weedy races?	y=1, n=-1	y	1	Wagner (1999)
2.01		Species suited to tropical or subtropical climate(s) (0-low; 1-intermediate; 2-high) – If island is primarily wet habitat, then substitute “wet tropical” for “tropical or subtropical”	refer to question (score used with 2.02 to answer 3.01–3.05)	high	-	Keng (1978), Suddee et al. (2004), Foxcroft et al. (2008)
2.02		Quality of climate match data (0-low; 1-intermediate; 2-high) see appendix 2	refer to question (score used with 2.01 to answer 3.01–3.05)	high	-	
2.03	Climate and distribution	Broad climate suitability (environmental versatility)	y=1, n=0	y	1	Keng (1978), USFS-PIER (1999b), Suddee et al. (2004)
2.04		Native or naturalised in regions with tropical or subtropical climates	y=1, n=0	y	1	Space & Flynn (2001), Space & Flynn (2002)
2.05		Does the species have a history of repeated introductions outside its natural range?	y=-2, No evidence=-1, n=0	y	-2	Keng (1978), USFS-PIER (1999b), Suddee et al. (2004), Foxcroft et al. (2008)
3.01		Naturalised beyond native range y = 1*multiplier; n= answer to question 2.05	refer to question	y	2	USFS-PIER (1999b)HEAR, Wagner et al. (1999), Space & Flynn (2000), Space & Flynn (2001)
3.02	Weed elsewhere	Garden/amenity/disturbance weed	y = 1*multiplier, n=0	y	2	USFS-PIER (1999b)
3.03		Agricultural/forestry/horticultural weed	y = 2*multiplier, n=0	y	4	Wagner et al. (1999)
3.04		Environmental weed	y = 2*multiplier, n=0	y	4	Wagner et al. (1999)
3.05		Congeneric weed	y = 1*multiplier, n=0	y	2	USFS-PIER (2010)
4.01		Produces spines, thorns or burrs	y=1, n=0	n	0	
4.02		Allelopathic	y=1, n=0	no evidence	-	
4.03		Parasitic	y=1, n=0	n	0	
4.04		Unpalatable to grazing animals	y=1, n=-1	no evidence	-	
4.05	Undesirable traits	Toxic to animals	y=1, n=0	n	0	
4.06		Host for recognised pests and pathogens	y=1, n=0	no evidence	-	
4.07		Causes allergies or is otherwise toxic to humans	y=1, n=0	n	0	
4.08		Creates a fire hazard in natural ecosystems	y=1, n=0	n	0	
4.09		Is a shade tolerant plant at some stage of its life cycle	y=1, n=0	y	0	

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S/N.	Category	Question	Scoring System	Answer	Score	Reference
4.10		Tolerates a wide range of soil conditions (or limestone conditions if not a volcanic island)	y=1, n=0	y	1	USFS-PIER (1999b) Wagner et al. (1999), Space & Flynn (2000), Space & Flynn (2001)
4.11		Climbing or smothering growth habit	y=1, n=0	n	0	
4.12		Forms dense thickets	y=1, n=0	n	0	
5.01	Plant type	Aquatic	y=5, n=0	n	0	
5.02		Grass	y=1, n=0	n	0	
5.03		Nitrogen fixing woody plant	y=1, n=0	n	0	
5.04		Geophyte (herbaceous with underground storage organs -- bulbs, corms, or tubers)	y=1, n=0	n	0	
6.01	Reproduction	Evidence of substantial reproductive failure in native habitat	y=1, n=0	n	0	
6.02		Produces viable seed.	y=1, n=-1	no evidence	-	
6.03		Hybridises naturally	y=1, n=-1	no evidence	-	
6.04		Self-compatible or apomictic	y=1, n=-1	no evidence	-	
6.05		Requires specialist pollinators	y=-1, n=0	no evidence	-	
6.06		Reproduction by vegetative fragmentation	y=1, n=-1	no evidence	-1	
6.07		Minimum generative time (years) 1 year = 1, 2 or 3 years = 0, 4+ years = -1	refer to question	< 1 year	1	Keng (1978), Suddee et al. (2004)
7.01	Dispersal mechanism	Propagules likely to be dispersed unintentionally (plants growing in heavily trafficked areas)	y=1, n=-1	n	-1	Pers. obs.(CYF)
7.02		Propagules dispersed intentionally by people	y=1, n=-1	y	1	Keng (1978), Keng et al. (1990), Suddee et al. (2004)
7.03		Propagules likely to disperse as a produce contaminant	y=1, n=-1	n	-1	
7.04		Propagules adapted to wind dispersal	y=1, n=-1	no evidence	-	
7.05		Propagules water dispersed	y=1, n=-1	no evidence	-	
7.06		Propagules bird dispersed	y=1, n=-1	no evidence	-	
7.07		Propagules dispersed by other animals (externally)	y=1, n=-1	no evidence	-	
7.08		Propagules survive passage through the gut	y=1, n=-1	no evidence	-	
8.01	Persistence attributes	Prolific seed production (>1000 m ⁻²)	y=1, n=-1	y	1	Estimated based on Fig. 3
8.02		Evidence that a persistent propagule bank is formed (>1 yr)	y=1, n=-1	no evidence	-1	
8.03		Well controlled by herbicides	y=-1, n=1	no evidence	-	
8.04		Tolerates, or benefits from, mutilation, cultivation, or fire	y=1, n=-1	no evidence	-	
8.05		Effective natural enemies present locally (e.g. introduced biocontrol agents)	y=-1, n=1	no evidence	-	
Total Score					13	