RISK ASSESSMENTS FOR EXOTIC REPTILES AND AMPHIBIANS INTRODUCED TO AUSTRALIA – Flowerpot Snake (*Ramphotyphlops braminus*) Daudin, 1803

Class - *Reptilia*, Order - Squamata, Family - Typhlopidae (Merrem, 1820), Genus - *Ramphotyphlops* (Fitzinger, 1843) (ITIS Integrated Taxonomic Information System 2007, Catalogue of Life 2008).

GOVERNMENT OF WESTERN AUSTRALIA

Department of Agriculture and Food

Score Sheet

SPECIES: Flowerpot Snake (*Ramphotyphlops braminus*) Other common names include: Brahminy Blind Snake **Synonyms:** *Argyrophis truncates* *Argyrophis bramicus* *Eryx braminus* *Glauconia braueri* *Onychocephalus capensis* *Ophthalmidium tenue* *Tortrix russelii* *Typhlina braminus* *Typhlopidae braminus* *Typhlops accedens* *Typhlops braminus* *Typhlops euproctus* *Typhlops fletcheri* *Typhlops inconspicuous* *Typhlops limbrickii* *Typhlops microcephalus* *Typhlops pseudosaurus* *Typhlops russeli* (McDiarmid et al 1999, The Reptile Database 2007a)	**SCORE**	**Species Description –** Small, burrowing snake, to 23 cm in length, but usually less than 15 cm. The body is slender and of uniform diameter throughout, charcoal grey or black in colour. The belly is greyish or brown. The scales are smooth and shiny, and are all of uniform size and shape (most other snakes have enlarged belly scales) . The tail is short and blunt, ending in a small spine at the tip (function of spine unknown, but may aid with burrowing). The eyes are highly reduced and concealed beneath the ocular scales. The jaw is small and mount is small and ventrally placed. Juveniles are 5-6 cm long, and resemble adults. Flowerpot snakes are frequently mistaken for earthworms (Whitaker 1978, Lim and Lim 1992, Cox et al 1998, Kley 2002, Casler et al 2004, Florida Museum of Natural History 2004, Greer 2006). **General Information –** The species is the only known parthenogenetic snake; all individuals are females and males are unknown. Females produce clutches of 1-8 eggs (average 3.7) without fertilisation. Clutch size is correlated with female length and mass. The eggs contain well developed embryos when laid, and all will be female (Greene 1997, Cox et al 1998, Kley 2002, Ernst and Ernst 2003, Casler et al 2004, Florida Museum of Natural History 2004, The Reptile Database 2007a). **Longevity** – No information found. **Status** – Is not listed on the IUCN Red List of Threatened Species (IUCN 2008) or the CITES Appendices (CITES 2007). This is probably due to the large global distribution of the species, abundance is assumed to exceed 100,000 individuals (NatureServe 2008).
DATE OF ASSESSMENT: 30/04/2008		**The Risk Assessment Model**

Bird and Mammal Model used: (Bomford 2008) using PC CLIMATE (Brown et al 2006, Bureau of Rural Sciences 2006)		Models for assessing the risk that exotic vertebrates could establish in Australia have been developed for mammals, birds (Bomford 2003, 2006, 2008), reptiles and amphibians (Bomford et al 2005, Bomford 2006, 2008). Developed by Dr Mary Bomford of the Bureau of Rural Sciences (BRS), the model uses criteria that have been demonstrated to have significant correlation between a risk factor and the establishment of populations of exotic species and the pest potential of those species that do establish. For example, a risk factor for establishment is similarity in climate (temperature and rainfall) within the species' distribution overseas and Australia. For pest potential, the species' overseas pest status is a risk factor. The model was originally published in 'Risk Assessment for the Import and Keeping of Exotic Vertebrates in Australia' (Bomford 2003) available online http://www.daff.gov.au/brs/land/feral-animals/management/risk . This model used the Apple Mac application CLIMATE (Pheloung 1996) for climate matching. The risk assessment model was revised and recalibrated 'Risk Assessment for the Establishment of Exotic Vertebrates in Australia: Recalibrated and Refinement of Models'(Bomford 2006) and the climate application changed to PC CLIMATE software (Bureau of Rural Sciences 2006), available online at http://affashop.gov.au/product.asp?prodid=13506. The most recent publication (Bomford 2008) includes updated instructions for using the exotic vertebrate risk assessment models and an additional model for freshwater fish. A bird and mammal model for New Zealand has also been included. **Which models are being used for the assessments:** Birds and mammals have been assessed using the Australian Bird and Mammal Model (Bomford 2008), pp 16-28, including both versions of stage B, models 1 (4 factors) and 2 (7 factors). All reptiles and amphibians were assessed using three models; the Australian Bird and Mammal Model (Bomford 2008), including Model A, using 3 factors from stage B (pp 54-55), and Model B, using 7 factors from stage B (pp 20), and the Australian Reptile and Amphibian Model (Bomford 2008), p 51-53. The rational for using additional models for reptiles and amphibians is to compare establishment risk ranks of the three models for a precautionary approach. If the models produce different outcomes for the establishment potential of any reptile or amphibian, the highest ranked outcome should be used (Bomford 2008). **Climate Matching Using PC CLIMATE** Sixteen climate parameters (variables) of temperature and rainfall are used to estimate the extent of similarity between data from meteorological stations located in the species' world distribution and in Australia. Worldwide, data (source; worlddata_all.txt CLIMATE database) from approximately 8000 locations are available for analysis. The number of locations used in an analysis will vary according to the size of the species' distribution. Data from approximately 762 Australian locations is used for analysis. To represent the climate match visually, the map of Australia has been divided into 2875 grid squares, each measured in 0.5 degrees in both longitude and latitude. CLIMATE calculates a match for each Australian grid by comparing it with all of the meteorological stations within the species' distribution (excluding any populations in Australia) and allocating a score ranging from ten for the highest level match to zero for the poorest match. These levels of climate match are used in the risk assessment for questions B1 (scores are summed to give a cumulative score), C6, and C8. For a grid square on the Australian map to score highly, it must match closely all 16 climatic variables of at least one meteorological station in the species' distribution for each level of climate match. [The score for each grid is based on the minimum Euclidian distance in the 16- dimensional variable space between it and all stations in the species' distribution. Each variable is normalized by dividing it by its worldwide standard deviation.]
LITERATURE SEARCH TYPE AND DATE: NCBI, CAB Direct, MEDLINE, Science Direct, Web of Knowledge (Zoological Records, Biological Abstracts), SCIRUS, SORA		

(Searchable ornithological research archive), Google Search and Google Scholar 22/10/2007		
FACTOR	**SCORE**	
PROBABILITY ESCAPED OR RELEASED INDIVIDUALS WILL ESTABLISH FREE-LIVING POPULATION		
Model A: Using the first three factors/questions from stage B of the Australian Bird and Mammal Model (Bomford 2008) pp 54-55)		
B1. Degree of climate match between species overseas range and Australia (1–6)	5	*Climate Match Score = 1757 Very high climate match with Australia* [See above information on climate matching.] Climate data from *1310* locations (see species worldwide distribution map) were used to calculate the CMS. Natural overseas distribution is southeast Asia, with introduced populations occurring worldwide (Lever 2006) (see B2 and B3 for details) (*Note: location data was unavailable for many of the smaller island locations where the species occurs.*)
B2. Exotic population established overseas (0–4)	4	*Exotic population established on island larger than 50 000 km^2 or anywhere on a continent* Many introductions outside the species natural range due to its ability to reproduce parthenogenetically, combined with its tendency to burrow among the roots of plants that has resulted in many accidental introduction via the horticultural trade. The history of many of these introductions has proved impossible to trace, but includes the following: ▪ **Asia:** – Introduced to Saudi Arabia and Iran (Lever 2006, The Reptile Database 2007a). – Japan – first discovered in the Bonin (Ogasawara) Islands in 1969, and has recently been discovered on Hachijojima in the Izu Islands, where it is now widespread and breeding (Lever 2006, The Reptile Database 2007a). – Philippines – the species is regarded as possibly introduced, or at least re-introduced by man (Ferner et al 2000, Lever 2006, The Reptile Database 2007a). ▪ **Africa:** – Introduced into southern Africa (date uncertain), and now isolated colonies at Cape Town and Durban, and Beira in Mozambique (Lever 2006, The Reptile Database 2007a). – Introduced populations in Benin, the Central African Republic, Nigeria, Senegal, and Togo (Chirio and Ineich 1997, Lever 2006, The Reptile Database 2007a). ▪ **North America:** – Mexico – it has been introduced into several localities in the states of Guerrero and Michoacan in central and southwestern Mexico, and more recently in Baja California del Sur and Sinaloa in north-western Mexico (Kley 2002, Lever 2006, The Reptile Database 2007a, NatureServe 2008). – Florida – established in southern Florida since at least 1979. It is found from the Florida Keys and southeastern peninsula north to Lake Okeechobee, and in isolated populations near Fort Myers and in Pinellas County and in Gainesville (Watkins-Colwell and Watkins-Colwell 1995, Owen et al 1998, Kley 2002, Ernst and Ernst 2003, Casler et al 2004, Lever 2006, The Reptile Database 2007a, NatureServe 2008). – Introduced to parts of south-eastern Louisiana, and now recorded from Boston, Massachusetts; possibly limited to inside buildings in Massachusetts because soil outside freezes during winter (Kley 2002, Ernst and Ernst 2003, Lever 2006, NatureServe 2008).

		▪ **South America:** – Introduced to Guatemala (Lever 2006). – West Indies – was first recorded in the West Indies on Anguilla in 1996 (*no CLIMATE data available*) (Lever 2006). ▪ **Oceania:** – Hawaii – first discovered in Hawaii in 1930, where it had been introduced in the soil surrounding the roots of palm trees and other exotic plants used for landscaping; now successfully colonised all the main Hawaiian Islands (Rillero 1998, Kley 2002, Lever 2006, The Reptile Database 2007a, NatureServe 2008). – Has been collected on the New Caledonia mainland of Grande Terre, established since at least 1974. The species has also been recorded on the Loyalty Islands north of New Caledonia (Lever 2006, The Reptile Database 2007a). – Mariana Islands – It is assumed that it was brought to the Marianas by prehistoric settlers, and may have arrived 1000 years ago with the Chamorros. it occurs on every well-studied island, including Guam, Rota, Tinian, Saipan, Alamagan, Anatahan, Sarigan, Pagan, and Agrihan, and it probably occurs on most of the others (Lever 2006). – Federal States of Micronesia – it is the only snake on the island of Pohnpei (Ponape) where it is known to have been introduced before 1936 (Lever 2006). – Vanuatu – it has been introduced and established on the island of Efate, likely to have been imported with agricultural or horticultural material (Lever 2006). ▪ **Indian Ocean:** – Seychelles – first recorded in the Seychelles in 1947 (Nussbaum 1980, Kley 2002, Lever 2006, The Reptile Database 2007a). – Madagascar – the occurs on mainland Madagascar, as well as the off-flying islands of Nose Be, Ambilobe, Betsako, Tamatave, and Ambatolampy, and in Foret de la Mandraka, Ambovombe (Kley 2002, Andreone et al 2003, Lever 2006, D'Cruze et al 2007, The Reptile Database 2007a). – Comoros Islands – occurs on the islands of Mayotte, Anjouan, and Moheli, and probably elsewhere (Lever 2006, The Reptile Database 2007a). – Mascarene Islands – recorded on Reunion Island, and also on Mauritius and Rodrigues (Lever 2006, The Reptile Database 2007a). – The species may have been transported by boats to many of the Andaman and Nicobar islands (Lever 2006, The Reptile Database 2007a). – Introduced to Cocos (Keeling) Islands, since at least 1909 (Gibson-Hill 1950, Lever 2006). – Introduced to Christmas Island (Gibson-Hill 1950, Lever 2006). ▪ **Australasia:** – Papua New Guinea – the species may have been introduced by the Japanese during World War II. The species is currently known from sea-level to 2600 m in East Sepik, Madang, Morobe, Oro Bay, Western Highlands, East New Britain, the Northern Solomon Islands, and Port Moresby (Lever 2006, The Reptile Database 2007a). – The species is known to occur in several localities across northern Australia, usually in areas of human habitation. It also occasionally appears in southern areas, such as Perth (Gaikhorst 2005) as cited in (Greer 2006). This

		distribution suggests the species was probably accidentally introduced, and has spread to other areas aided by humans. The species is easily transported, given its small size and that it occurs in soils that might be transported (e.g. ballast, potted plants. The species was first reported near Darwin in 1966, however it is not certain whether the species was introduced pre- or post-European arrival (Storr 1968, Cogger 2000, Greer 2006, Lever 2006, The Reptile Database 2007a); Storr (1968) suggested that there was little doubt that the species was a recent introduction to the city of Darwin.
B3. Overseas range size score (0–2) < 1 = 0; 1 – 70 = 1; >70 = 2	1	*Overseas range between 1-70 million km^2, estimated at 11.23 million km^2. Includes current and past 1000 years, natural and introduced range.* Natural distribution –occurs throughout much of south-east Asia from India and Sri Lanka eastward through Malaysia and Indonesia, north through southern China (including Hainan, Guangdong, Hong Kong and Taiwan, and presumably Yunnan, Guangxi, Guizhou, and Chongquing) to eastern Sichuan, and south to northern Australasia. This range includes Pakistan, Nepal, Bhutan, Bangladesh, Burma (Myanmar), Thailand, Laos, Vietnam, Cambodia, Singapore, Sumatra, Java, Borneo, Nias, the Riau Archipelago, Bangka, Bali, Madura, Flores, Lembata (Lomblen), Sumba, Timor, Sulawesi (Celebes), Saleyer, Buton (Butung), Seram, Ternate, Maluku Islands (including the Kei Islands), Aru Islands, Lombok, Sumbawa, Billiton, Saipan, Postitjon Island, Nila, Saparna, Buru, and Salajar (Ota et al 1991, Lim and Lim 1992, Florida Museum of Natural History 2004, Lever 2006, The Reptile Database 2007a, NatureServe 2008). The species occurs from sea-level to 2000 m elevation (Cox et al 1998, The Reptile Database 2007b). The Flowerpot Snake has been introduced to many localities outside of its natural range, including parts of America, Asia, Oceania, Australasia, as well as many islands (see B2 for details).
ESTABLISHMENT RISK SCORE **SUM OF SCORE A (B1) + SCORE B (B2) + SCORE C (B3) (1-12)**	**10**	
Model B: Using the seven factors/questions from stage B of the Australian Bird and Mammal Model (Bomford 2008) pp 20)		
B4. Taxonomic Class (0–1)	1	*Reptile* (ITIS Integrated Taxonomic Information System 2007, Catalogue of Life 2008).
B5. Diet score (0–1)	1	*Generalist with a broad diet of many food types* Because of its small mouth, the species is restricted to eating prey with narrow diameters. The diet mainly includes ants and termites including the eggs, larvae, pupae and sometimes adults. Other prey includes small beetles, soft-bodied larvae of other insects, and possibly small earthworms (Whitaker 1978, Lim and Lim 1992, Cox et al 1998, Ernst and Ernst 2003, Casler et al 2004, Florida Museum of Natural History 2004, Greer 2006).
B6. Habitat score - undisturbed or disturbed habitat (0–1)	1	*Can live in human-disturbed habitats* The Flowerpot Snake occurs in various terrestrial habitats, including forest, urban and agricultural areas. It is commonly found in garden beds and has been found in houses where it has emerged from cracks in the floor. The species prefers loose, often shady soil (humus, loam, and sand) and is commonly found in decaying logs and stumps, under rocks, moist leaves, or other plant debris on the ground. It requires a moderately moist habitat to balance water loss through skin transpiration. In Florida, the species is known to live under human refuse trash piles and dumps, and around plant nurseries (Ferner et al 2001, Ernst and Ernst 2003, Casler et al 2004, Florida Museum of Natural History 2004, D'Cruze et al 2007, NatureServe 2008).
B7. Non-migratory behaviour (0–1)	1	*Non-migratory or facultative migrant in its native range* Non-migratory species (NatureServe 2008). The species is almost entirely nocturnal, only occasionally coming to the soil surface at dusk or dawn. Presumably active all year in the tropics, but in more temperate areas it may be less active on

		the surface in the winter and hot, dry summers (Ernst and Ernst 2003)
ESTABLISHMENT RISK SCORE **SUM OF B1-7 (1–16)**	**14**	

Australian Reptile and Amphibian Model (Bomford 2008, pp 51-53)		
Score A. *Climate Match Risk Score Degree (Sum of species' 4 scores for Euclidian match classes 7 – 10)*	33	*CMRS = 100(931/2785)* Natural overseas distribution is southeast Asia, with introduced populations occurring worldwide (ITIS Integrated Taxonomic Information System 2007, Catalogue of Life 2008) (see B7 for details).
Score B. *Has the species established an exotic population in another country? (0–30)*	30	The species has established a breeding self-sustaining exotic population in another country (See B2 for more details) (Lever 2006).
Score C. *Taxonomic Family risk score (0–30)*	30	*Extreme risk family (Bomford 2006)* Family - Typhlopidae (Merrem, 1820), (ITIS Integrated Taxonomic Information System 2007, The Reptile Database 2007a, Catalogue of Life 2008).
ESTABLISHMENT RISK SCORE **SUM OF SCORE A + SCORE B + SCORE C (0 – ≥116)**	**93**	

SUMMARY OF RESULTS

ESTABLISHMENT RISK RANKS – RISK OF ESTABLISHING A WILD POPULATION

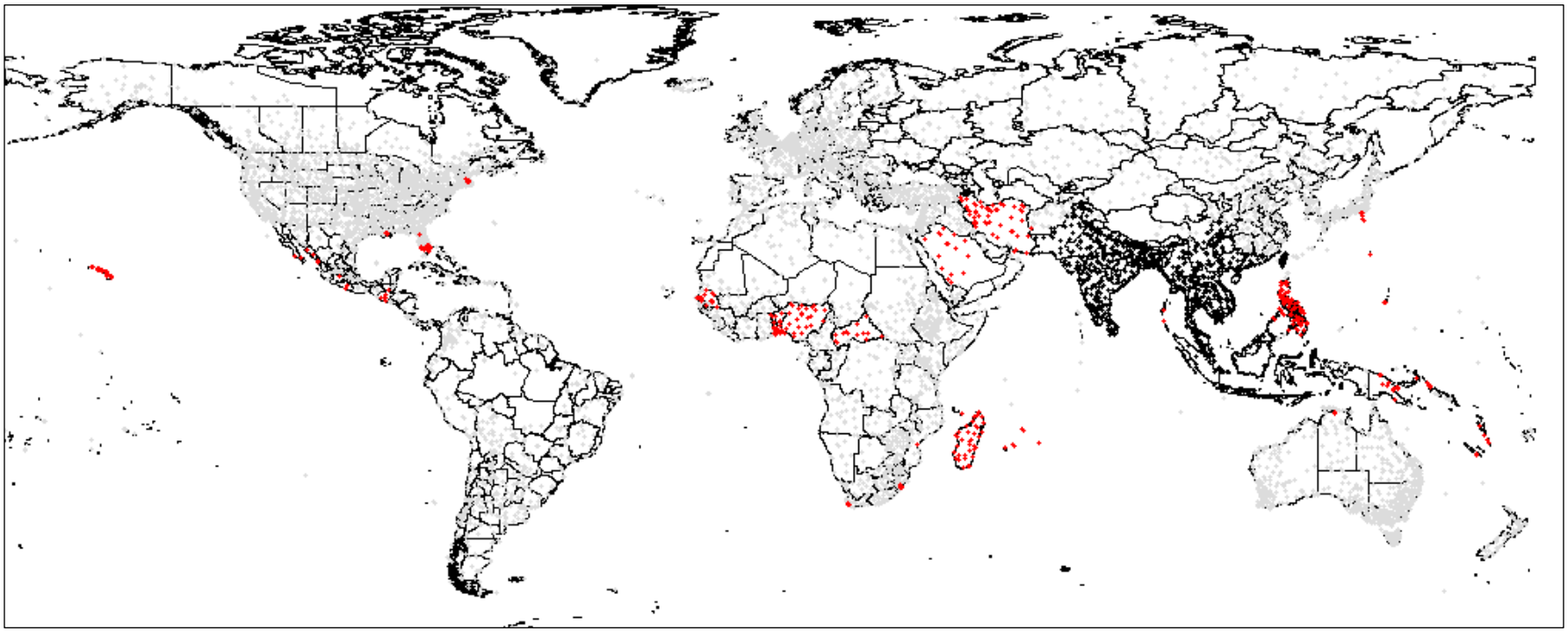
MODEL A: USING THE FIRST THREE FACTORS/QUESTIONS FROM STAGE B OF THE AUSTRALIAN BIRD AND MAMMAL MODEL (BOMFORD 2008) PP 54-55) ≤ 4 = LOW ESTABLISHMENT RISK; 5-7 = MODERATE ESTABLISHMENT RISK; 8-9 = SERIOUS ESTABLISHMENT RISK; 10-12 = EXTREME ESTABLISHMENT RISK	**10**	**EXTREME**
MODEL B: USING THE SEVEN FACTORS/QUESTIONS FROM STAGE B OF THE AUSTRALIAN BIRD AND MAMMAL MODEL (BOMFORD 2008) PP 20) ≤ 6 = LOW ESTABLISHMENT RISK; 7-11 = MODERATE ESTABLISHMENT RISK; 12-13 = SERIOUS ESTABLISHMENT RISK; ≥ 14 = EXTREME ESTABLISHMENT RISK	**14**	**EXTREME**

AUSTRALIAN REPTILE AND AMPHIBIAN MODEL (BOMFORD 2008, PP 51-53) ≤ 22 = LOW ESTABLISHMENT RISK; 23-60 = MODERATE ESTABLISHMENT RISK; 61-115 = SERIOUS ESTABLISHMENT RISK; ≥116 = EXTREME ESTABLISHMENT RISK	**93**	**SERIOUS**
HIGHEST ESTABLISHMENT RISK RANK (When establishment risk ranks differ between the models, the highest ranked outcome is used (Bomford 2008).		**EXTREME - ENDORSED BY VPC**
Median number of references for Establishment Risk for all reptiles assessed by (Massam et al 2010) (n=11) Total number of references for this species		15 22 – more than the median number of reptile references were used for this assessment, indicating a decreased level of uncertainty

World Distribution – Flowerpot Snake (*Ramphotyphlops braminus*) including natural populations (black) and introduced populations (red), includes current and past 1000 years

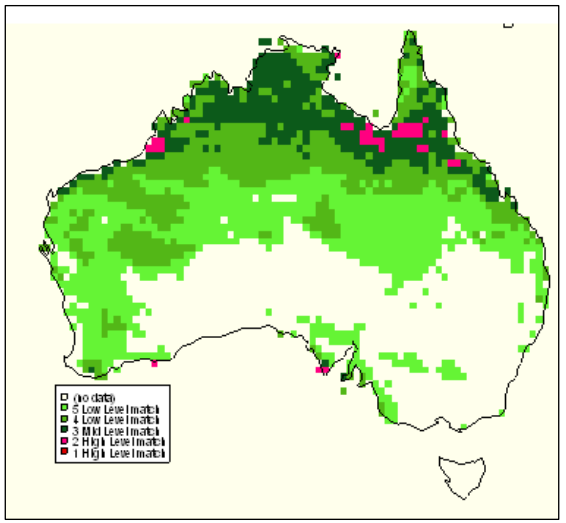
[Note: Australian distribution was not included in the climate analysis for this assessment. However, to assist predictions of further spread within Australia, an analysis that includes the Australian distribution has been included on page 10.]

Each red or black dot is a location where meteorological data was sourced for the climate analysis (see B1); faint grey dots are locations available for CLIMATE analysis but are not within the species distribution therefore not used.



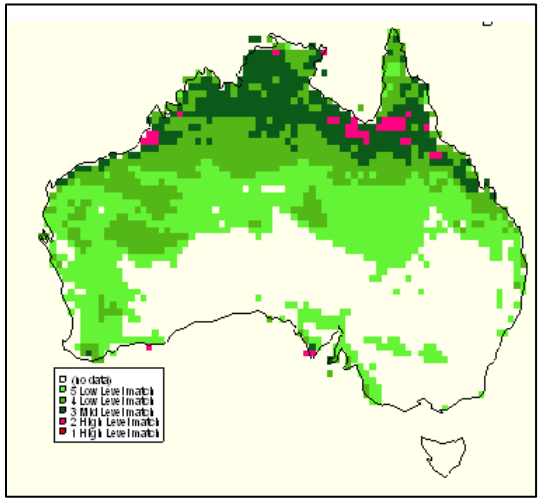
Map 1. Climate match between the world distribution of Flowerpot Snake (*Ramphotyphlops braminus*) and Australia for five match classes.

Colour on Map	Level of Match from Highest (10) to Lowest (6)	No. Grid Squares on Map
Red	10 HIGH MATCH	0
Pink	9 HIGH MATCH	35
Dark Green	8 MOD MATCH	326
Mid Green	7 MOD MATCH	570
Lime Green	6 LOW MATCH	826
		CMS = 1757



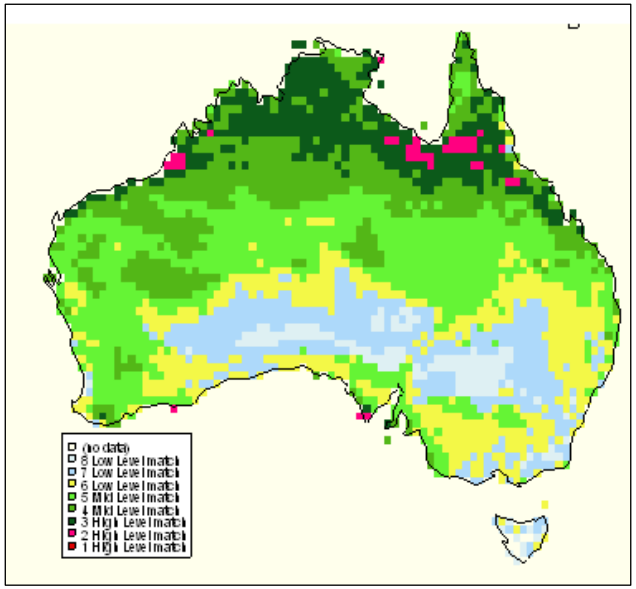
Map 2. Climate match between the world distribution (including Australian distribution) of Flowerpot Snake (*Ramphotyphlops braminus*) and Australia for five match classes.
[Only minor differences between the two analysis, as populations in Australia are restricted to a small area.]

Colour on Map	Level of Match from Highest (10) to Lowest (6)	No. Grid Squares on Map
Red	10 HIGH MATCH	0
Pink	9 HIGH MATCH	36
Dark Green	8 MOD MATCH	326
Mid Green	7 MOD MATCH	570
Lime Green	6 LOW MATCH	825
		CMS= 1757



Map 3. Climate match between the world distribution of Flowerpot Snake (Ramphotyphlops braminus) and Australia for eight match classes.

Colour on Map	Level of Match from Highest (10) to Lowest (3)	No. Grid Squares on Map
Red	10 HIGH MATCH	0
Pink	9 HIGH MATCH	35
Dark Green	8 HIGH MATCH	326
Mid Green	7 MOD MATCH	570
Lime Green	6 MOD MATCH	826
Yellow	5 MOD MATCH	481
Blue	4 LOW MATCH	412
Light blue	3 LOW MATCH	128



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