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Corrigenda

Chandler Gregory T, Westaway John O, Conn Barry J. (20 June 2014) Taxonomic uncertainty of *Stachytarpheta* (Verbenaceae) in the Asia-Pacific and implications for invasive weed recognition and management *Telopea* 16: 83–88. <http://dx.doi.org/10.7751/telopea20147536>

Page 84, **Discussion**, reference to Hammel and Grayum (2011) incorrectly cited in first sentence. First sentence should read:

Species of *Stachytarpheta* usually have four or five calyx lobes, but in *S. indica*, two of these lobes are extremely reduced so that the calyx appears to be 2-lobed (Hammel and Grayum 2011; Rajendran and Daniel 1992; Verdcourt 1992).

Page 86, **References**, change the final reference to read:

Hammel BE, Grayum MH (2011) Lectotypification and reinstatement of *Stachytarpheta friedrichsthalii* (Verbenaceae), with notes on the lectotypification of *S. indica*. *Novon* 21: 437–439. <http://dx.doi.org/10.3417/2011019>

Taxonomic uncertainty of *Stachytarpheta* (Verbenaceae) in the Asia-Pacific and implications for invasive weed recognition and management

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Abstract

Stachytarpheta indica has been regarded as an agricultural weed occurring throughout south-east Asia. In Australia, it is classified as an invasive weed by the Northern Australia Quarantine Strategy (NAQS) (Brown *et al.* 2008). After examining several papers from the 1990s, we conclude that there is no evidence to support *S. indica* being in this region and that the name has been historically misapplied to several other species of *Stachytarpheta*. We recommend its removal from the NAQS invasive weed target list. A table of morphological characters is provided for four species of *Stachytarpheta* showing major differences in several character and highlights the confusion still surrounding some of the species. *Stachytarpheta cayennensis* should be added to the flora of Christmas Island, whereas the taxonomic status of *S. urticifolia* needs to be examined in further detail.

Introduction

Stachytarpheta indica (L.) Vahl is on the appendix of the Northern Australia Quarantine Strategy (NAQS) invasive weed target list (Brown *et al.* 2008), which is used to focus NAQS weed surveillance efforts towards early detection of new incursions of potentially invasive plant species. This is based on the premise that early detection provides improved prospects of eradication or containment, reducing impacts on the agricultural sector of the Australian economy and on the environment. Early detection of invasive species requires a solid taxonomic foundation to make reliable and timely identifications. In cases where significant conflict exists in taxonomic treatments, long delays will occur, hampering biosecurity responses such as an eradication program. One of the problems faced by anyone working with invasive weeds is that revising their taxonomy is usually low on a taxonomist's agenda unless they are part of a group that is being actively researched. Furthermore, invasive species are often only problematic outside their natural distribution. The consequence of this is that those who are concerned about the distinctiveness and potential invasive risk of these taxa do not have an in-depth understanding of the group in their natural environment.

Although *S. indica* is restricted to tropical east Africa and tropical America (Rajendran and Daniel 1992; Verdcourt 1992), it has long been erroneously considered to occur throughout India and south eastern Asia (e.g. Backer and Bakhuizen van der Brink 1965; Brenan 1950; Clarke 1885; Danser 1929; Graham 1839; Hallier

1918). Rajendran and Daniel (1992) describe in detail the historical aspects of this misapplication of *S. indica*, from the incorrect citation of Ceylon as the type location by Linnaeus to the misapplication of species names in early taxonomic treatments, beginning with Persoon (1806). Rajendran and Daniel (1992) and Verdcourt (1992) concluded that the misapplication of the name *S. indica* has mostly referred to *S. jamaicensis* (L.) Vahl and less often to *S. urticifolia* Sims.¹ *Stachytarpheta jamaicensis* is another potentially invasive species that could be considered for the NAQS invasive weed target list as it is cited as occurring within the neighbouring region (e.g. Baker and Bakhuizen van der Brink 1965; Chen and Wu 2003; Moldenke and Moldenke 1983; Rajendran and Daniel 1992). There is significant confusion surrounding its taxonomic identity, with Munir (1992) regarding *S. urticifolia* as a synonym of *S. cayennensis* (Rich.) J.Vahl, a taxonomic decision supported by the Australian Plant Census (2014). However, this species is still recognized in some regional taxonomic treatments (for example, Chen and Wu 2003; Devi and Singh 2005; Rajendran and Daniel 1992). Since the type of *S. urticifolia* has not been located (Munir 1992) nor seen (Chen and Wu 2003), these two conflicting taxonomic decisions are based on the description and illustration of the protologue (Sims 1816). Munir (1992) concluded that the taxonomic concept of *S. urticifolia*, based on the protologue is conspecific with *S. cayennensis*, whilst Chen and Wu (2003) concluded that the description by Moldenke and Moldenke (1983) was sufficient to regard this species as distinct from *S. jamaicensis*. Unfortunately, these authors did not compare *S. urticifolia* with *S. cayennensis*.

A comparison of the diagnostic features of the four problematic species: *S. cayennensis*, *S. indica*, *S. jamaicensis* and *S. urticifolia*, as used in three important publications (Munir 1992; Rajendran and Daniel 1992; Verdcourt 1992), is provided here (Table 1). Minor differences in morphological terminology make it slightly difficult to identify the species concepts being used by these different authors. *Stachytarpheta indica* is regarded as having narrower leaves than the other three species. *Stachytarpheta cayennensis* has a crenate-serrate leaf margin, whereas the other species are variously coarsely serrate, although Rajendran and Daniel (1992) and Verdcourt (1992) both circumscribe *S. jamaicensis* as having crenate-serrate leaves. There is agreement about the number and shape of calyx lobes for *S. cayennensis* and *S. indica*, but no agreement for *S. jamaicensis* or *S. urticifolia*. Both *S. cayennensis* and *S. jamaicensis* are regarded as having a pale blue to white corolla, or at least with a white centre, and *S. urticifolia* as having corollas that are darker, purple-blue, mauve or royal blue with a pale or white throat. However, in *S. indica* the colour of the corolla is either more variable, from pale to dark, blue, mauve, or lavender, often with a white centre, or Rajendran and Daniel (1992) are applying a different species concept of *S. indica* from that of Verdcourt (1992). Such unsettled taxonomy could seriously impact surveillance efforts in terms of speed and efficiency, leading to misidentifications that could take years to uncover as well as playing havoc with the creation of meaningful invasive species target lists.

Discussion

Species of *Stachytarpheta* usually have four or five calyx lobes, but in *S. indica*, two of these lobes are extremely reduced so that the calyx appears to be 2-lobed (Hammel-Lierheimer and Grayum 2011; Rajendran and Daniel 1992; Verdcourt 1992). While vegetative characters, together with the width of the rachis can be used to distinguish introduced species of *Stachytarpheta* in Australia, *S. indica* can be distinguished from these by its seemingly bifid calyx and narrower, more lanceolate leaves. There are some anatomical differences that distinguish *S. indica* from *S. cayennensis*, including aborted guard cells in *S. indica* and contiguous stomata on the adaxial surface of the leaves of *S. cayennensis* (Adedeji 2012). Although these stomatal features are difficult to discern, they may be of interest in future phylogenetic studies of the genus. The number and arrangement of calyx teeth (lobes) appears to be an important taxonomic character, yet as can be seen in Table 1, as well as the characters used in Backer and Bakhuizen van der Brink (1965), there is little agreement among treatments around which taxon has a given arrangement, casting doubt over the robustness of these features.

According to Rajendran and Daniel (1992, p. 166), there are five species of *Stachytarpheta* present in India, but *S. indica* is not one of them, because "... there are no specimens in any Indian herbarium that can be identified with the type of *S. indica*." In their *Flora of Java* treatment, one of the characters used by Backer and Bakhuizen van der Brink (1965) to distinguish *S. indica* and *S. jamaicensis* from *S. cayennensis* (Rich.) Vahl is the presence of four teeth in the former two species as opposed to five teeth in the latter. If *S. indica* does indeed possess a clearly bifid calyx, then it seems likely that those authors have also misapplied the name, in this case to *S. jamaicensis*. According to Verdcourt (1992), *S. indica* is widespread in tropical Africa and tropical America, and is a weed in heavy, cultivated soils and rice fields. It also appears likely that Backer and Bakhuizen van der

¹The authority of *S. urticifolia* is sometimes incorrectly cited as '(Salisb.)Sims' rather than 'Sims' (refer Verdcourt 1992, p. 19). Note: *Cymburus urticifolius* Salisb. is illegitimate (ICN 2012: Art. 52.1, 52.2, also refer Ex. 2).

Brink (1965) are referring to *S. urticifolia* (5-lobed calyx, Verdcourt 1992) and not to *S. cayennensis* (4-lobed calyx, Munir 1992).

The presence of several hybrids (Danser 1929; Urban and Ekman 1929; Wagner et al. 1990) causes difficulties distinguishing the above four species. However, a comparison of the publications by Munir (1992), Rajendran and Daniel (1992) and Verdcourt (1992) suggest that there is some disagreement about the taxonomic concepts being applied. The reduction of *S. urticifolia* to the synonymy of *S. cayennensis* by Munir (1992), even though recognised as a distinct species by other authors, results in the application of a broad species concept that may not be useful for understanding the taxonomic variability or for recognising the potential invasiveness of the taxa included in the concept, leading to problems identifying effective control mechanisms. Broad species concepts are also being used to circumscribe *S. jamaicensis*, a morphologically variable taxon similar to *S. cayennensis* (*s. lat.*). There is clearly a need for a thorough taxonomic review of the genus.

The misapplication of scientific names impacts directly on biosecurity measures, from early detection to the creation of meaningful alien invasive species lists (McGeoch et al. 2012). *Stachytarpheta indica* was placed onto the NAQS weed target list appendix based on regional taxonomic treatments and advice from collaborators in nearby countries. *Stachytarpheta* species can be high impact weeds (Parsons and Cuthbertson 1992; Motooka et al. 1969; Simmonds 1934; Swarbrick 1989), therefore, it is prudent to be on the lookout for previously unrecorded species with potential to enter Australia. The most likely candidates for the historical misapplication for *S. indica*, i.e., *S. cayennensis* and *S. jamaicensis*, are already prevalent throughout northern Australia, whereas *S. urticifolia* (or, if not recognised as a distinct species, then the variant characterised by this taxon) is currently not known for Australia. We believe that a comprehensive taxonomic concept map needs to be created for these four species of *Stachytarpheta* that covers at least the floras and other major taxonomic treatments of the Asia-Pacific region so that a taxonomic consensus of these taxa is of obtained. This would maintain the utility of regional treatments as well as allowing the end user to correct taxonomic determinations.

Table 1. Major distinguishing characters used in the three most relevant taxonomic publications to distinguish between *Stachytarpheta cayennensis*, *S. indica*, *S. jamaicensis* and *S. urticifolia*. ¹Munir (1992); ²Rajendran and Daniel (1992); ³Verdcourt (1992).

Species	Leaf Shape	Leaf Margin	Calyx Lobes	Corolla Colour
<i>S. cayennensis</i>	<ul style="list-style-type: none"> •ovate to oblong elliptic¹ •ovate or elliptic³ 	<ul style="list-style-type: none"> •crenate-serrate¹ •closely serrate³ 	<ul style="list-style-type: none"> •4 equal teeth^{1,3} 	<ul style="list-style-type: none"> •(pale) blue, (pale) violet or lavender¹ •white to pale blue with a white centre³
<i>S. indica</i>	<ul style="list-style-type: none"> •lanceolate to oblong lanceolate² •narrowly oblong to oblanceolate³ 	<ul style="list-style-type: none"> •remotely coarsely serrate³ 	<ul style="list-style-type: none"> •appearing bifid with 2 prominent teeth plus 2 extremely reduced teeth ^{2,3} 	<ul style="list-style-type: none"> •pale blue without a white centre² •deep to light blue, mauve or lavender, often with a white centre³
<i>S. jamaicensis</i>	<ul style="list-style-type: none"> •elliptic-obovate or spatulate² •ovate, elliptic or oblong³ 	<ul style="list-style-type: none"> •coarsely serrate-dentate¹ •crenate-serrate with blunt serrations^{2,3} 	<ul style="list-style-type: none"> •4 equal teeth plus 1 minutely reduced¹ •4-fid² •4-fid, 2-long + 2-short³ 	<ul style="list-style-type: none"> •pale mauve-blue, violet, or purple¹ •pale to deep blue or purple³
<i>S. urticifolia</i>	<ul style="list-style-type: none"> •ovate to ovate-elliptic² •ovate, elliptic or oblong³ 	<ul style="list-style-type: none"> •dentate-serrate with very acute serrations^{2,3} 	<ul style="list-style-type: none"> •4-fid² •shortly 5-toothed³ 	<ul style="list-style-type: none"> •dark purple-blue, mauve or royal blue with a light or white throat³

Stachytarpheta cayennensis was inadvertently omitted from the Oceanic Islands volume of the 'Flora of Australia' treatment of the genus (Barker and Telford 1993). However, the first two collections listed below were cited by Munir (1992) as occurring on Christmas Island:

Cemetery Road, North East Point, *B.A. Mitchell* 35, 12 Jun 1984 (AD, CBG, K); Dales Track, *T. Stokes* 18, 14 Aug 1983 (CBG); adjacent to Kanakers quarters which is near the Pink House, *A.A. Mitchell* 6298, 2 Jun 2000 (AD, CANB, PERTH); [without specific locality] *R. Pal* 9, 3 Nov 1983 (CBG); Grants Well Track, 50 yards [45 m] from Grants Well, *P. van Tets* 3, 1 Jun 1965 (CBG)

Conclusions

There is no evidence of *S. indica* occurring outside of its tropical African-American range, and it appears to be of no immediate threat to northern Australia, so we recommend its removal from the NAQS invasive weed target list. *Stachytarpheta jamaicensis* is a potentially invasive species that could be investigated by NAQS. Recognising invasive species at an early stage gives the best chance for removal, but an inadequate understanding of the taxonomy of a group can severely reduce reaction times and the chances of successful eradication of invasive taxa. The taxonomic status of *S. urticifolia* and the circumscription of other species require further investigation. Since the genus is not being actively revised at the moment, it is unclear how long this will take. By disseminating taxonomic information concerning weedy members of *Stachytarpheta* and by drawing attention to a serious taxonomic problem, we hope that research into the systematics of this genus will be initiated. Further work may be needed to evaluate the risk that *Stachytarpheta* species pose to northern Australia. Despite several species already being present, this research would provide crucial information about the invasiveness and the impact that the genus could have in the future.

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