Weeds of tropical Australia: how do they get here?

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Summary Early detection of new pests, diseases and weeds that might enter Australia through border pathways unique to northern Australia is a primary objective of the Northern Australia Quarantine Strategy (NAQS) plant health surveys. NAQS botanists have collected over 15 000 herbarium specimens some of which include the first Australian records for important weeds that are now targeted for eradication or containment. Our specimens have helped expand knowledge of weedy taxa shared by tropical Australia and Malesia. Incursion pathways specific to northern Australia are active for the arrival of new insect pests and pathogens but new weeds mostly arrive *via* conventional border pathways. Routine post-border weed surveillance focussed on common pathways would assist timely detection and response.

Keywords Biosecurity, NAQS, early detection, weed distribution, entry pathways.

INTRODUCTION

Northern Australia's close geographic proximity to New Guinea and the Indonesian archipelago, in combination with the annual northwest monsoon (wet season) and regular movement of traditional inhabitants between Papua New Guinea (PNG) and the Torres Strait Protected Zone predisposes the region to a unique set of biosecurity risks. The Northern Australia Quarantine Strategy (NAQS) was implemented in 1989 to help identify and mitigate biosecurity threats specific to northern Australia. Primary facets of the strategy include:

- employment of Indigenous Biosecurity Officers throughout the Torres Strait region and use of operational measures to reduce the likelihood of southwards spread of biosecurity risk items;
- employment of Community Liaison Officers at larger centres to facilitate engagement with stakeholders in remote communities;
- regular plant and animal health surveys throughout the region between Cairns and Broome.

Early detection and reporting of new pests, plant diseases and weeds is a primary goal of NAQS plant health surveys. We use target lists informed by knowledge of pests in neighbouring countries to help focus survey efforts (e.g. Brown *et al.* 2008), but at the same time look for and report anything new or unusual. Waterhouse (2003) discussed some of the important new weeds found or first reported in Australia by NAQS. These included *Chromolaena odorata* (L.) R.M. King & H. Rob., *Mikania micrantha* Kunth, *Cleome rutidosperma* DC., *Limnocharis flava* (L.) Buchenau, and *Clidemia hirta* (L.) D.Don). More recent detections have included *Croton hirtus* L'Her. and *Ruellia blechum* L. Some of these remain the focus of nationally funded eradication or containment campaigns.

MATERIALS AND METHODS

NAQS plant health surveys NAQS surveys primarily focus on the small communities dotted across coastal northern Australia. Survey frequency is determined by risk assessments that take into account proximity to neighbouring countries and associated people movements, abundance and diversity of agricultural and horticultural hosts and recent incursion history. Sites are visited annually (e.g. the Torres Strait Islands) to approximately once in 3 to 5 years.

Collection of vouchers NAQS botanists have a dual role in weed and host plant identification. During surveys we make notes on the common weed flora and host abundance, and collect herbarium specimens of anything new or that requires further identification. We also collect or report Weeds of National Significance (WoNS) and declared species as well as specimens of weeds or native taxa that are not well represented in herbaria. Vouchers are submitted to relevant state herbaria for verification and permanent storage, often with duplicate specimens for the Australian National Herbarium (CANB) and key regional herbaria. In Queensland (Qld) we actively participate in the 'Weed Spotter' network, receiving and identifying specimens submitted by members of the public and local council pest management staff. High quality specimens are forwarded to Queensland Herbarium (BRI).

Reporting detections NAQS has a protocol for reporting all new pest detections to state government stakeholders and the DAFF Office of the Chief Plant Protection Officer. WoNS and state declared weed detections are reported through relevant channels.

Table 1. Date of first naturalised record and probable entry pathways for some recent weeds of northern Australia (Queensland unless otherwise indicated).

Family/species	Date	Locality	Probable pathway	Comments
Acanthaceae				
Brillantaisia lamium	1996	El Arish	Botanic gardens & plant collectors	1966 record Brisbane Botanic Gardens
Ruellia blechum	2008A	Saibai Island	Directly from PNG	Now also recorded from Mer & Erub Islands
Asteraceae				
Chromolaena odorata	1994B	Tully region	Contaminant of pasture seed ex Brazil 1965-1972	Two sub-species. 1993 record submitted after 1994 report
C. squalida (DC.) R.M.King & H.Rob.	1998C	Tully region	As above	Not previously known outside native range
Praxelis clematidea R.M.King & H.Rob.	1993	Innisfail	As above	Not previously known outside native range
Mikania micrantha	1998C 2001C	Mission Beach Speewah	Botanic gardens & plant collectors	Possibly 2 separate introductions
Stevia ovata Willd.	2007	Ravenshoe area	Unknown	Well-established when found
Cleomaceae				
Cleome rutidosperma	2000A	Darwin Port (NT)	Possibly cargo contaminant	Containment suspended as already widespread
Cyperaceae				
Cyperus surinamensis Rottb.	2002A	Wyndham (WA)	Unknown	Found at two Wyndham Hotels near air conditioner outlets
Euphorbiaceae				
Croton hirtus	2004A	Scherger RAAF Base	Contaminant of military equipment	Likely late 1990s. Ongoing containment
Fabaceae				
Indigofera vohamerensis Baill.	2011	Shoalwater Bay	Contaminant of military equipment	Found during scheduled weed survey. A. Bean (pers. comm. 2011)
Hydrocharitaceae				
Limnobium laevigatum Humb. & Bonpl. ex Willd	2011	Redlands, Cairns	Via aquarium industry	Wild population at Redlands. In cultivation at Cairns
Limnocharitaceae				
Limnocharis flava	2001B	Cairns & Townsville	Botanic gardens & plant collectors	Probably introduced prior to listing as prohibited species
Malvaceae				
Sida ciliaris L.	2011	Shoalwater Bay	Contaminant of military equipment	Found during scheduled weed survey. A. Bean (pers. comm. 2011)
Melastomataceae				
Clidemia hirta	2001C	Julatten	Botanic gardens & plant collectors	Possible link to site of 2001 Mikania detection
Miconia calvescens DC.	1997	Oxley & Kuranda	Botanic gardens & plant collectors	Townsville Botanic Gardens c. 1963
Miconia racemosa (Aubl.) DC.	2002	Kuranda	Botanic gardens & plant collectors	Not previously known outside native range
Miconia nervosa (Sm.) Triana	2004	Whyanbeel	Botanic gardens & plant collectors	Not previously known outside native range
Miconia cionotricha L.Uribe	2010	Whyanbeel Mourilyan	Botanic gardens & plant collectors	Only two plants known. K. Erbacher (pers. comm. 2012)

Sources: Herbrecs (2011), Holtze (2012), Queensland Herbarium (2012).
A Detected on NAQS plant health survey. B Detected by NAQS but not associated with survey activities. C First specimen collected by NAQS after public or state/local government weed officer referral.

Where we suspect that our specimens represent new records for Australia or the region, we try to obtain further information that will help determine the origin and possible entry pathway.

RESULTS

NAQS botanical records Since plant surveys commenced in early 1990 NAQS botanists have collected over 15 000 specimens (native and introduced species) and have repeatedly visited sites from Cairns in the east to Broome in the west. This total includes around 3000 specimens collected overseas during surveys in Indonesia, Timor Leste, PNG, the Solomon Islands and Micronesia. The most comprehensive collections of NAQS specimens are held at BRI, the Northern Territory Herbarium (DNA) and CANB.

In addition to detection and notification of the serious weeds mentioned above, our specimens have provided new data on the distribution of WoNS (e.g. *Annona glabra* L.), National Environmental Alert List species (e.g. *Praxelis clematidea* R.M. King & H.Rob.), 'sleeper' weeds (e.g. *Brillantaisia lamium* (Nees) Benth.) and numerous declared species across northern Australia.

NAQS specimens have also contributed to a better understanding of the indigenous flora that tropical Australia shares with the broader Malesian region. Our records of *Ischaemum polystachyum* J. Presl. and *Leptochloa simoniana* N. Snow from the Torres Strait islands constitute the only Australian records of these taxa (Herbrecs 2011), which although considered native belong to weedy grass genera.

Some recent naturalisations In Table 1 we have listed the date of first collection and suggested possible entry pathways for selected weeds that have been recognised as naturalised in northern Australia since the early 1990s.

DISCUSSION

Northern Australian pathways Incursion pathways specific to Northern Australia are readily demonstrable for arthropod pests and plant pathogens. NAQS has extensive records of annual incursions by pest fruit fly species into the Torres Strait islands associated with the northwest monsoon and frequently record other new pests. A tropical cyclone is thought to have been responsible for the arrival of sugarcane smut, which was first recorded from the Ord River District, Western Australia (WA) in Australia in1998.

There is a lower incidence of new weeds arriving in northern Australia *via* these entry pathways. Aerial flotsam collected in a kytoon experiment on Saibai Island contained seeds of the grassy weed *Chloris inflata* Link but it was not possible to conclude whether these had originated from Saibai or the adjacent PNG coastline because the grass is widespread at both sites (Waterhouse pers. obs.1998). *Ruellia blechum* seems most likely to have arrived at Saibai, Mer and Erub islands from the adjoining Western Province of PNG where it is widely cultivated as an ornamental groundcover and has become invasive. As far as we are aware there are no records of this species in cultivation on the Australian mainland. Legislation to prevent the southwards movement of plants and other biosecurity risk material and inspection of incoming goods by DAFF Biosecurity staff has undoubtedly helped reduce the introduction of new weeds *via* a Torres Strait route. Conversely, in recent years there have been numerous additions to the Torres Strait weed flora that have originated from mainland Queensland. This is partly due to the lack of reciprocal safeguards to reduce the incidence of northwards movement of risk material.

In 2004 NAQS found a single plant of *Mimosa diplotricha* C.Wright adjacent to a track leading from the beach to the Willie Creek Detention Centre north of Broome (NAQS 2012). While long known from Queensland this species is not known to occur in the NT or WA. The site was formerly used to temporarily accommodate crews from apprehended foreign fishing vessels and an Indonesian origin appears most likely for this plant, which was subsequently destroyed.

In the Torres Strait region, weed incursion risk factors are changing over time. *Chromolaena odorata* was first confirmed from the Bensbach region in the south-west of PNG's Western Province in 2011, where locals reported it as a recent arrival (S. McKenna pers. comm. 2011). We expect that it has spread closer to the coastal (Treaty) villages immediately adjacent to Torres Strait since our last opportunity to survey those sites in 2001. If *C. odorata* establishes in the Treaty villages it is very likely to turn up in Torres Strait as a contaminant associated with people movements, and ongoing vigilance for it is essential.

Not quite Australian Northern Australia and New Guinea formed a contiguous landmass for much of the Pleistocene with the link being severed during sea level rise in the early Holocene (*c.* 9000–8000 BP). It is thus not surprising that some elements of the flora regarded as introduced weeds might actually be growing *in situ*. Alternatively, given the human proclivity to move plants from place to place it is likely that other species were early, pre-European introductions.

The leguminous vine *Pueraria montana* var. *lobata* (Willd.) Maesen & S.M.Almeida, is a declared species in Queensland and NSW although it is considered to be native in the NT (Holtze 2012). Its

native range includes New Guinea. In Torres Strait its language name and uses as a food are handed down as part of the oral tradition. It is also host to two fungal pathogens there, *Synchytrium minutum* (Pat.) Gäum and *Passalora puerariae* (D.E. Shaw & Deighton), which are apparently associated with *P. montana* throughout its native range. Using the schema proposed by Bean (2007), these additional data lend support to our hypothesis that this species may be indigenous or a long-established introduction. For this reason Torres Strait has been excluded from the Queensland declaration.

Origins of the dioecious cucurbit vine *Coccinia grandis* (L.) Voigt are also unclear. This species is considered native in the NT (Holtze 2012). Populations at some sites in Arnhem Land are not invasive although there are invasive and presumably introduced populations near Darwin and Nhulunbuy as well as in far north Queensland (Herbrecs 2011, Holtze 2012). We have postulated possible Macassan origins for the Arnhem Land populations of *C. grandis*. Future molecular studies of these species might help resolve questions of origin.

Post-border weed surveillance The invasive plants listed in Table 1 comprise a small subset of new naturalisations recorded in Australia over the last two decades. It is certain that there are others still to be found and more species will become invasive in the future. Time and experience have demonstrated that complete eradication is unlikely to be feasible for potentially devastating weeds like *C. odorata* which was already well-established when first reported in 1994. New weeds must be found sooner after their arrival and establishment for effective intervention.

It is not always possible to determine the source, entry pathway or time since arrival for each new naturalisation although for some species the pathway is obvious or can be suggested with a degree of reliability. Irrespective, the questions of 'where and how' should always be asked. In some cases, molecular studies may help to clarify the origin or relatedness of populations as well as identity.

Understanding the pathway and time since arrival will better inform decision making on the most appropriate response. Even with the limited data in Table 1 it is clear that certain modes of entry are repeatedly implicated for the establishment of new weeds. These include but are not restricted to the categories we have assigned as 'botanic gardens and plant collectors' and 'contaminant of military equipment'. Additional examples could have been presented to demonstrate that '*via* aquarium industry' is an important source of new aquatic weeds establishing in the wild.

It is our view that implementation of a national strategically focussed post-border weed surveillance program around these and other common entry pathways, would offer better prospects for timely detection of new weeds.

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