Prospects for the biological control of *Jatropha gossypiifolia*: *Stomphastis* sp. as a potential agent from South America

Dianne B.J. Taylor and Kunjithapatham Dhileepan
Biosecurity Queensland, Department of Agriculture and Fisheries, Ecosciences Precinct, GPO Box 267, Brisbane, Queensland 4001, Australia
(di.taylor@daf.qld.gov.au)

Summary *Jatropha gossypiifolia* L., commonly known as bellyache bush, is a serious weed of rangelands and riparian zones of northern Australia and has been identified as a Weed of National Significance. Bellyache bush has been a target of biological control in Australia since 1997, with one agent released to date. A renewed biological control effort, involving exploration in South America identified a number of potential biological control agents, the most promising of which, a small leaf-mining moth *Stomphastis* sp. (Lepidoptera: Gracillariidae), was imported from Peru into quarantine for further research in 2014. Newly emerged larvae mine directly into a leaf and remain there until pupation. Preliminary results suggest that *Stomphastis* sp. can complete development on bellyache bush and congener *J. curcas* L. (also a target for biological control) only. The leaf-miner has a short generation time and high fecundity, which bodes well for its future as a biological control agent

Keywords Bellyache bush, *Jatropha*, *Stomphastis*, leaf-miner, biological control.

INTRODUCTION

Jatropha gossypiifolia L. (Euphorbiaceae), commonly known as bellyache bush, is a serious weed of rangelands and riparian zones of northern Australia and has been identified as a Weed of National Significance (Australian Weeds Committee 2012, Bebawi *et al.* 2007). Well established infestations occur in the Burdekin, Fitzroy, Walsh, Palmer, Flinders and Gregory River catchments in Queensland, the Daly McArthur, Roper and Victoria river catchments in the Northern Territory, and the east Kimberley in Western Australia (Randall *et al*. 2009). Bellyache bush forms dense thickets, reducing the usefulness of land for pastoral and grazing purposes. All parts of the plants are toxic to stock. Dense infestations along the Burdekin River have reduced the carrying capacity to zero (Randall *et al.* 2009). Bellyache bush also reduces biodiversity, affects fire regimes and increases erosion along creek and river banks (Csurhes 1999, Bebawi *et al*. 2007). Based on morphological and phenological differences, a number of biotypes have been identified; Queensland Bronze, Queensland Green and Queensland Purple in Queensland, Darwin Purple and Katherine Green in the Northern Territory and Kununurra Green in Western Australia (Bebawi *et al*. 2007)

Biological control is an important component of the long-term management strategy for bellyache bush in Australia. Bellyache bush has been a target for biological control since 1997. Native range surveys in Mexico, northern South America, and the Caribbean resulted in the release of one agent, the seed feeding jewel bug *Agonosoma trilineatum* (F.) (Heteroptera: Scutelleridae), which failed to establish (Heard *et al.* 2012).

As part of a renewed biological control effort, recent exploration was undertaken in central South America, specifically Peru, Bolivia and Paraguay. Field surveys in 2012 and 2013 identified 11 insect species, one mite species and a leaf rust (Dhileepan *et al.* 2014). Of these species, a yet to be described leaf-mining moth *Stomphastis* sp. (Lepidoptera: Gracillariidae), was prioritised for further studies. In this paper we discuss current research on this potential biological control agent.

MATERIALS AND METHODS

Native range studies Widespread and severe leaf damage was observed by a leaf-mining microlepidopteran on *J. gossypiifolia* in the San Martin province in northern Peru and occasionally on *J. curcas* L. (Dhileepan *et al*. 2014). In the Manuel María Caballero province of central Bolivia the leaf miner was common on *J. gossypiifolia* and *J. excisa* Griseb., and uncommon on *J. curcas* and *J. clavuligera* Müll.Arg. Leaf-mining damage was not observed on *J. curcas* or castor oil (*Ricinus communis* L.) co-occurring with *J. gossypiifolia* (Dhileepan *et al*. 2014).

Similar to *S. thraustica* (Meyrick), a well-known pest of *J. gossypiifolia* and *J. curcas* in Asia and Africa, *Stomphastis* sp. is currently being described as a new species (Dhileepan *et al.* 2014). This is the first time a *Stomphastis* species has been recorded in South America.

Insect source In November 2014 more than 500 *Stomphastis* sp. larvae and pupae collected from

12 sites in Peru, were imported into our quarantine facility in Brisbane. As adults emerged from the imported leaf material they were collected and transferred to gauze covered cages (90 × 100 × 50 cm) containing potted *J. gossypiifolia* plants (mixture of biotypes). Female *Stomphastis* sp. readily oviposited on *J. gossypiifolia* plants under caged conditions and a colony was able to be quickly established in quarantine. The culture was established and maintained in a quarantine glasshouse kept at 27°C, 60% relative humidity and natural photoperiod. Once a colony had been established, lifecycle studies and host specificity testing were initiated. Newly emerged adults were used in all life cycle studies and host specificity tests.

Host specificity testing The host test list was compiled using the centrifugal phylogenetic method (Wapshere 1975), which proposes testing plants of increasingly distant relationship to the target until the host range is circumscribed, and is based on the host test list approved for *Agonosoma trilineatum* (Heard *et al.* 2009). The list contains 37 species from Euphorbiaceae and closely related families (Table 1). Since the testing of *A. trilineatum*, Euphorbiaceae has been split into four families (see Stevens 2001–). Phyllanthaceae Martynov contains most of the old Euphorbiaceae–Phyllanthoideae (with the exception of *Drypetes* and relatives, now part of Putranjivaceae Endlicher), while Picrodendraceae Small contains most of the taxa from Euphorbiaceae–Oldfieldioideae (Köhler & Webster). Species included in the test list approved for *Agonosoma trilineatum* but omitted from this proposed list were either difficult to source or were replaced by species deemed more suitable. Species from unrelated families were also removed. *Microstachys chamaelea* (L.) Hook.f., a recorded host of *S. thraustica*, was also added to the test list.

Host specificity testing is currently in progress. Initially, all test plants are being subjected to no-choice oviposition/larval development trials, with at least five replicates conducted for each species. Larval development trials using newly emerged larvae are not possible since the larvae enter the leaf directly from the egg. Thus larval development could only be monitored on plants on which eggs were laid. Twenty unsexed newly emerged adults are released into a gauze-covered cage (90 × 45 × 45 cm) containing a single test plant. For each round of testing, ten unsexed adults are released into a cage containing one *J. gossypiifolia* plant. Test plants and *J. gossypiifolia* plants are checked weekly for evidence of eggs and larval mines. Test plants are maintained until a new generation of adults is recovered from bellyache bush, at which time they are destroyed. Test species on which larvae develop will be subjected to further testing such as choice trials with bellyache bush.

RESULTS

Life cycle Adult *Stomphastis* sp. are small moths (less than 1 cm long) and live for an average of ten days under quarantine conditions. Females lay eggs singly on leaves; usually on the underside, near a leaf vein. One female moth can lay in excess of 100 eggs. Newly emerged larvae mine directly into the leaf and remain in the leaf as they develop. Larvae exit the leaf to pupate, which they do mainly on the leaf, though some pupate in other locations such as a branch crevice. A generation from adult to adult takes around 22 days under quarantine conditions, but has been completed in as little as 18 days.

Host specificity testing No-choice host specificity testing of *Stomphastis* sp. has been completed for 31 non-target species so far (Table 1) with another six or seven species remaining. Eggs have been laid on many of the non-target species (17), however larval development has only occurred on bellyache bush and its congener *J. curcas*. Damage to non-target species other than *J. curcas* has been limited to first instar mines.

DISCUSSION

The results from the host specificity testing of *Stomphastis* sp. conducted so far are extremely promising with the insect only completing development on bellyache bush and its congener *J. curcas*. It is likely that the oviposition that occurred on many of the non-target test species are false positive results prompted by the confined conditions under which the tests are necessarily conducted (Marohasy 1998, Heard 2000). The non-target species on which eggs were laid have been shown to be unsuitable hosts by the absence of any larval development (with the exception of *J. curcas*). The only damage recorded on non-target species other than *J. curcas* has been limited to first instar feeding.

Complete development of *Stomphastis* sp. on *J. curcas* is not unexpected and nor is it a hindrance to the moth being released for the biological control of bellyache bush. *Jatropha curcas* has invaded parts of northern Australia and is also an approved target for biological control. Eggs were laid, but no development occurred, on the congeners *J. podagrica* Hook. and *J. multifida* L., two species occasionally grown in Australia as ornamentals.

Stomphastis has completed development on all of the biotypes identified in Australia. Further work, comparing the suitability of the various biotypes, is in progress.

Table 1. Host specificity test list for *J. gossypiifolia* including status for no-choice oviposition and larval feeding and development trials with *Stomphastis* sp.

Test plant	Status[A]	Tested
Euphorbiaceae: Crotonoideae		
Jatropha gossypiifolia L.	Target	Y
Jatropha curcas L.	I	Y
Jatropha podagrica Hook.	O	Y
Jatropha multifida L.	O	Y
Aleurites moluccanus (L.) Willd	N	Y
Baloghia inophylla (G.Forst.) P.S.Green	N	Y
Beyeria lechenaultii (DC.) Baill.	N	Y
Beyeria viscose (Labill.) Miq.	N	Y
Codiaeum variegatum (L.) A.Juss.	E	Y
Croton acronychioides F.Muell.	N	Y
Croton insularis Baill.	N	Y
Croton verreauxii Baill.	N	Y
Dimorphocalyx australiensis C.T.White	N	N
Endospermum myrmecophilum L.S.Sm.	N	N
Manihot esculentum Crantz	C	Y
Manihot grahamii Hook.	I	Y
Euphorbiaceae: Acalyphoideae		
Acalypha eremorum Mull.Arg.	N	N
Alchornea ilicifolia (J.Sm.) Muell.Arg.	N	Y
Macaranga tanarius (L.) Müll.Arg.	N	Y
Mallotus philippensis (Lam.) Muell.Arg.	N	Y
Omphalea celata P.I.Forst.	N	N
Ricinus communis L.	I	Y
Euphorbiaceae: Euphorbioideae		
Euphorbia pulcherrima Willd. ex Klotzsch	O	Y
Homalanthus nutans (G.Forst.) Guill.	N	Y
Microstachys chamaelea (L.) Hook.f.	N	N
Phyllanthaceae		
Antidesma bunius (L.) Spreng.	N	Y
Actephila lindleyi (Steud.) Airy Shaw	N	Y
Breynia oblongifolia (Mull.Arg.) Mull.Arg	N	Y
Bridelia exaltata F.Muell.	N	Y
Cleistanthus hylandii Airy Shaw	N	Y
Flueggea virosa (Willd.) Voigt	N	Y
Glochidion ferdinandi (Muell.Arg.) F.M.Bailey	N	Y
Phyllanthus cuscutiflorus S.Moore	N	Y
Picrodendraceae		
Choriceras tricorne (Benth.) Airy Shaw	N	N
Dissiliaria baloghioides F.Muell. ex Baill.	N	Y
Petalostigma pubescens Domin	N	Y
Putranjivaceae		
Drypetes deplanchei (Brongn. & Gris) Merr.	N	Y

[A] N = native; O = ornamental; C = crop; I = invasive

Stomphastis sp. has a short generation time and high fecundity, which bodes well for its future as a biological control agent. We anticipate completing the host specificity testing by the end of 2016. If the insect is found to be host specific an application to release will be made.

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