Biol Invasions (2026) 28:125
https://doi.org/10.1007/s10530-026-03841-3

ORIGINAL PAPER

An invasive plant may overcome pollination specialisation with a versatile breeding system

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Received: 11 June 2025 / Accepted: 24 April 2026 / Published online: 10 May 2026

Abstract Plants with specialised pollination syndromes are less likely to become invasive compared to those with generalist syndromes, yet some highly invasive species have specialised syndromes. Few empirical studies have investigated the reproductive biology of invasive plants with specialised pollination syndromes, preventing a deep understanding of this apparent contradiction. *Senna* species (Fabaceae) exhibit the specialised buzz-pollination syndrome, and several *Senna* species are invasive globally. We assessed whether *Senna obtusifolia* could reproduce uniparentally via autonomous selfing, vector-mediated selfing, or without pollen (apomixis). We assessed whether it was pollen limited in either the studied native (Mexico) or invaded (Australia) regions. We experimentally manipulated pollinator access and pollen deposition in both regions and found that up to 40% of flowers set fruit from self-pollination and up to 24% of flowers set fruit in the absence of pollen. We found no evidence that *S. obtusifolia* was pollen limited in either region, suggesting that it has attracted suitable pollinators in both studied regions. Our findings suggest that *S. obtusifolia* has a mixed breeding system, combining selfing, apomixis, and outcrossing. This versatile breeding system may be key to its invasiveness, enabling uniparental reproduction during the early stage of colonization, while maintaining genetic diversity through outcrossing.

Keywords Apomixis · Plant-animal interaction · Specialised pollination syndrome · Mating system

Associate Editor - Margherita Gioria

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1007/s10530-026-03841-3.

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Introduction

A plethora of research attempts to identify shared traits to predict which species might become invasive (i.e., species that spread outside their native range and negatively affect native biodiversity (Larson 2011)). For example, plant species with generalist pollination syndromes are hypothesised to be more likely to become invasive, when compared to plants with specialist pollination syndromes (Baker 1974; Richardson et al. 2000; Rodger et al. 2010). This is because plants with specialist pollination syndromes are less likely to encounter and attract a specialised or efficient pollinator when introduced to a new region compared to generalists. Invasive species often have generalist floral traits, which allows them to use a wide range of pollinators (Parra-Tabla and Arceo-Gómez 2021), and examples within, including Bartomeus et al. 2008; Vilà et al. 2009; Larson et al. 2016]. Yet, few studies have directly assessed whether specialization poses a barrier to plant invasions, or what factors facilitate invasion success for those species that have overcome this theoretical specialization barrier (Rodger et al. 2010; Morgan et al. 2018; Lopresti et al. 2024).

One strategy to overcome the barrier of finding a pollinator when introduced to a new region may be to reproduce in the absence of pollinators (Traveset et al. 2020). Uniparental reproduction has been hypothesised to be a beneficial trait where pollinators or mates are scarce (Darwin 1876; Baker 1955). Flowering plants employ diverse reproductive strategies, commonly including cross-fertilisation (outcrossing), uniparental reproduction through self-pollen seed set (geitonogamy), self-pollen seed set in the absence of a pollen vector (autonomous selfing), or uniparental reproduction through seed set in the absence of pollen (apomixis) (definitions in (Harder and Barrett 2007)). While most flowering plants need a pollinator for both outcrossing and geitonogamy, autonomous selfing and apomixis allow for reproduction without one. Mixed breeding systems enable plants to reproduce from the same parent, which is beneficial under low population densities or pollinator absence, while also allowing for outcrossing, which is beneficial to promote genetic recombination and, in turn, enhance adaptability (reviewed in (Goodwillie et al. 2005)). Outcrossing, therefore, can be instrumental in enabling local adaptations that may be important for invasion success (Rodger et al. 2010). Most generalist invasive species display mixed breeding systems in either their introduced or native range (see reviews and meta-analyses Rambuda and Johnson 2004; van Kleunen et al. 2008; Korpelainen and Pietiläinen 2023)). Yet, few studies have compared the breeding system and pollen limitation in both the native and invaded regions for plants with a specialist pollination syndrome (but see: Petanidou et al. 2012; Vallejo-Marín et al. 2013; Zhang et al. 2017). Such a comparison would reveal whether reproduction in the absence of pollinators is a pre-existing trait that facilitates invasion success for alien species, or whether invasive plants benefit from having a plastic breeding system.

One specialist pollination syndrome is the buzz pollination syndrome. Globally, there are 94 invasive angiosperm species listed on the Centre for Agriculture and Bioscience International (CABI) Invasive Species Compendium (CABI 2025) that have poricidal anthers (reviewed in Lopresti et al. 2024). Yet, we are at the early stages of understanding what factors contribute to invasion success of species with the buzz pollination syndrome. Plants that exhibit the buzz pollination syndrome have specialist floral morphologies that restrict pollen access. Commonly, this is in the form of poricidal anther morphology, which has evolved in an estimated 6–10% of angiosperms (Buchmann et al. 1983; Russell et al. 2024). To efficiently extract pollen from poricidal anthers, an insect typically vibrates its thoracic muscles to produce an audible vibratory frequency (Cooley and Vallejo-Marín 2021). Although, non-buzzing insects can release pollen from some plants with poricidal anthers, such as by inserting their proboscis inside the anther pore, or biting the anthers (reviewed in Lopresti et al. 2024), and even wind has been shown to release pollen from some plants with poricidal anthers (Gaines-Day and Gratton 2015).

In this study, we assessed the breeding system and pollen limitation of an invasive alien plant with a specialist pollination syndrome. *Senna obtusifolia* (L.) H.S.Irwin & Barneby (Fabaceae) has poricidal anthers and exhibits the buzz pollination syndrome. The species is native to the tropical Americas and has been introduced to every other continent except Antarctica (CABI 2025). The reproductive biology of *S. obtusifolia* in either the native or invaded regions is largely unknown. We addressed the following specific questions: can *S. obtusifolia* reproduce uniparentally via (1) autonomous selfing, (2) apomixis, or (3) geitonogamy and (4) is *S. obtusifolia* pollen limited in either of its native or invaded regions? Given that *S. obtusifolia* is highly invasive in some introduced regions, we expected that it has a mixed breeding system and can reproduce both in the absence of pollinators (autonomous selfing and apomixis) and with self-pollen (geitonogamous), and that it may be pollen limited in the invaded region only.

Methods

Study sites

Senna obtusifolia is native to tropical America, and it has been introduced to six continents, becoming highly invasive in North and South America (beyond the tropics), Africa, and Australasia (CABI 2021). It was introduced to Australia in the 1940 s and declared invasive across tropical Australia by the 1960 s (Mackey et al. 1997). *Senna obtusifolia* has common traits of buzz-pollinated plants, including poricidal anthers and nectarless flowers (Fig. 1).

We conducted this study in an invaded region (Australia) and a native region (Mexico) during the respective *Senna obtusifolia* flowering seasons (Fig. 2; Supplementary File 1).

We undertook the experiment between April and August 2022 in the invaded region (Australia) at five sites: White Rock, Kamerunga, Trinity Beach, Lakeland, and the West Normanby River. Sites in the invaded region were dense monocultures of *S. obtusifolia* on disturbed riparian corridors or agricultural land. We created a path through each stand (approximately 25 m in length), and haphazardly selected plants along this path to include in the experiment.

We undertook the experiment between September and November 2023 in the native region at three sites in Yucatan, Mexico: Chochola, Tekik de Regil, and Xmatkuil. Sites in this region were in disturbed habitats dominated by herbaceous plants, predominantly *S. uniflora*. *S. obtusifolia* individuals were scattered throughout the sites.

Sites in both regions were located at least 6.5 km apart and separated by either suburbia, farmland, native vegetation communities, or a combination of the three. Each site contained at least 50 *S. obtusifolia* plants.

Breeding system

To determine the breeding system of *S. obtusifolia*, we experimentally manipulated pollinator access and pollen deposition. We haphazardly selected flower

Fig. 1 **A** *Senna obtusifolia* stand flowering and fruiting in Queensland, Australia and **B** flower morphology including poricidal anthers

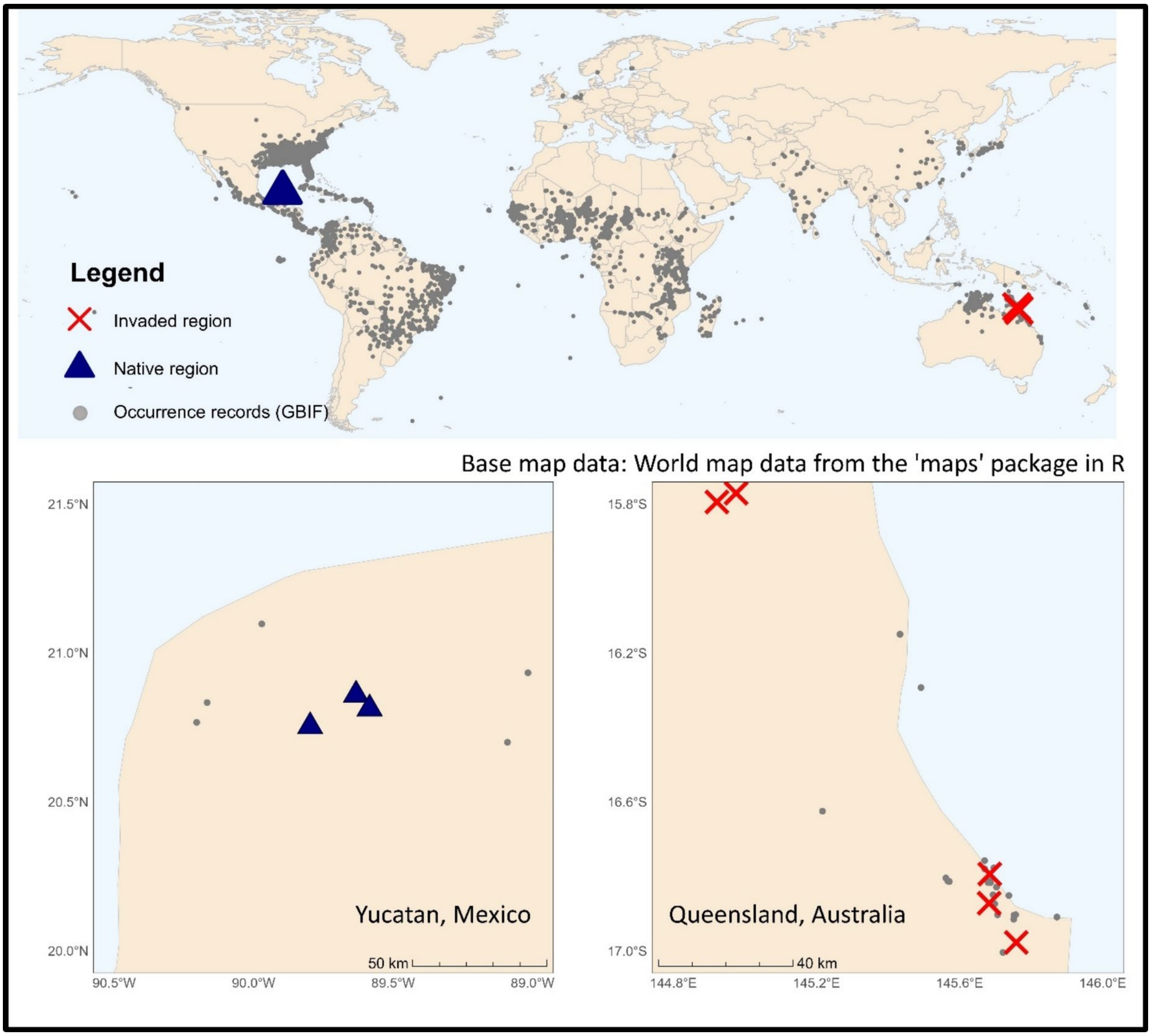

Fig. 2 The spatial distribution of *Senna obtusifolia* sites in both the native and invaded study regions. We provide the site coordinates in Supplementary File 1. Occurrence records sourced from Global Biodiversity Information Facility database (Global Biodiversity Information Facility 2025

buds near to opening and subjected them to one of six randomly assigned treatments, as follows.

To test for uniparental reproduction via autonomous selfing, we applied treatment (1) unpollinated – flowers were bagged to exclude floral visitors and left intact (no floral manipulation). To test for uniparental reproduction via apomixis, we applied treatment (2) unpollinated (emasculated) – flowers were bagged, and anthers were removed. To test for uniparental reproduction via geitonogamy, we applied treatment (3) selfed – flowers were bagged, emasculated, and hand-pollinated using pollen sourced from the same plant.

To assess pollen limitation, we applied three additional treatments: (4) natural pollination – no floral manipulation, (5) natural pollination (emasculated) – flowers were emasculated but left open to natural pollinators, and (6) outcrossed – flowers were bagged, emasculated, and hand-pollinated with pollen from a donor plant located at least 10 m away. At three sites in the invaded region, we applied all six treatments to each of 20 plants. At two of the sites in the invaded region (Lakeland and Normanby River) we applied only treatments (1) and (4) because other treatments needed daily access to manipulate the flowers and regular site access was not logistically possible. In the native region plants were smaller and did not produce sufficient flowers to receive all six treatments. Hence, we had to apply each treatment to a different individual plant. We maintained 20 full treatment-set replications per site, totalling 120 plants per site in the native region.

To ensure synchronicity of stigma receptivity within and among treatments, we selected flowers on a given plant on the same day at each site. White fine mesh bags (20 cm × 30 cm, or 16 cm × 23 cm; © Trestina, Australia) were used to bag buds and exclude floral visitors during the experiment. We emasculated each flower on the morning of floral anthesis by removing all anthers with forceps before the anthers were mature. Anther maturity was estimated based on the anther size and flaxen-yellow anther colour. Pollen was sourced on the day of hand pollination for the outcross and self treatments from flowers that had not been assigned a pollination treatment that were at least 10 m away in the same population, or the same plant, respectively. We extracted pollen from selected flowers onto a sterile slide with the help of an electric toothbrush (Tayal et al. 2020), transferred the pollen onto the receptive stigma of the tagged flower, and confirmed pollen deposition by visual inspection through a hand lens. Bags that were compromised during the experimental period, such as those where the branch broke, the bag tore, or there were signs of insect activity (such as frass), were excluded from the final analysis.

We monitored all flowers for reproductive success from the time of pollination to fruit maturation about two months later. To prevent seed predation, we retained the bags on the pod during their development, but we exchanged the smaller bags (16 cm × 23 cm) for larger bags (20 cm × 30 cm) when the pods outgrew the small bags. Fruit was classed as mature when the pod browned and was near to splitting. Mature pods and seeds from each site were collected and counted, and seeds were classed as aborted (where the seed looked malformed) or likely viable. We did a germination experiment to examine viability of seeds that we classed as likely viable in the invaded region. Most seeds (95%; 489/551) germinated and hereafter we refer to all likely viable seeds as viable. We measured reproductive success as the proportion of flowers that produced a fruit and the count of viable seeds per flower.

Statistical analysis

All data analyses were done in R 4.4.1 (R Core Team 2024; Lopresti et al. 2026a). As a result of the treatments being applied to the same plants in the invaded region and different plants in the native region, the data structures differed. Consequently, we analysed the data from each region separately and compared the results qualitatively. To examine whether fruit set varied among treatments in both the invaded and native regions, we analysed the data using generalised linear models with a binomial link function. In both regions, fruit set was the response variable and treatment were the predictor. In the invaded region model we nested plant in site and included this as a random effect; we also included an optimizer with a quadratic approximation to ensure model convergence using the *lme4* package (Bates et al. 2015). In the native region model we included site as a fixed factor as there were fewer than five locations (Gelman and Hill 2006). For both regions, we performed a Tukey HSD post hoc analysis using the *emmeans* package (Lenth et al. 2025) to determine which treatment pairs were significantly different.

To assess whether seed set significantly differed among treatments, for both regions we used generalised linear mixed models where seed count per flower was the response variable, and treatment was the fixed factor. In the invaded region, we used a Poisson error distribution and included plant nested in site as a random effect. We included treatment as a zero inflated factor because the data were over dispersed and zero inflated. In the native region, we used a negative binomial link function because the data were zero inflated and one site (Chochola) had a much higher rate of zeros compared to the others. Consequently, the model we present here included site as both a fixed factor and a zero inflated factor. For both regions, we undertook select pairwise comparisons to examine whether select treatments of interest were significantly different because Tukeys HSD post hoc analysis lost power when adjusting for the multiple comparisons, and the output was not logical. Supplementary Data 2 details the specific comparisons and the aim which each comparison addresses.

Results and discussion

Self-compatibility is generally considered to be a beneficial trait for invasive species because it ensures that plants can reproduce when populations are small, such as when colonising new regions (Baker 1955). However, self-compatible species may still require a pollen vector for pollination, particularly when there is spatial separation between the pollen and stigma (herkogamy), like with the poricidal anther structure of *Senna obtusifolia.* We found that *S. obtusifolia* reproduced via uniparental sexual reproduction (selfed) (generalised linear mixed model predictions: Figs. 3 and 4; based on the raw data Fig. S1 and S2. There was no difference in fruit set when we compared manual pollination crosses on flowers that received pollen from either another flower in the same plant (selfed) or another flower from a different

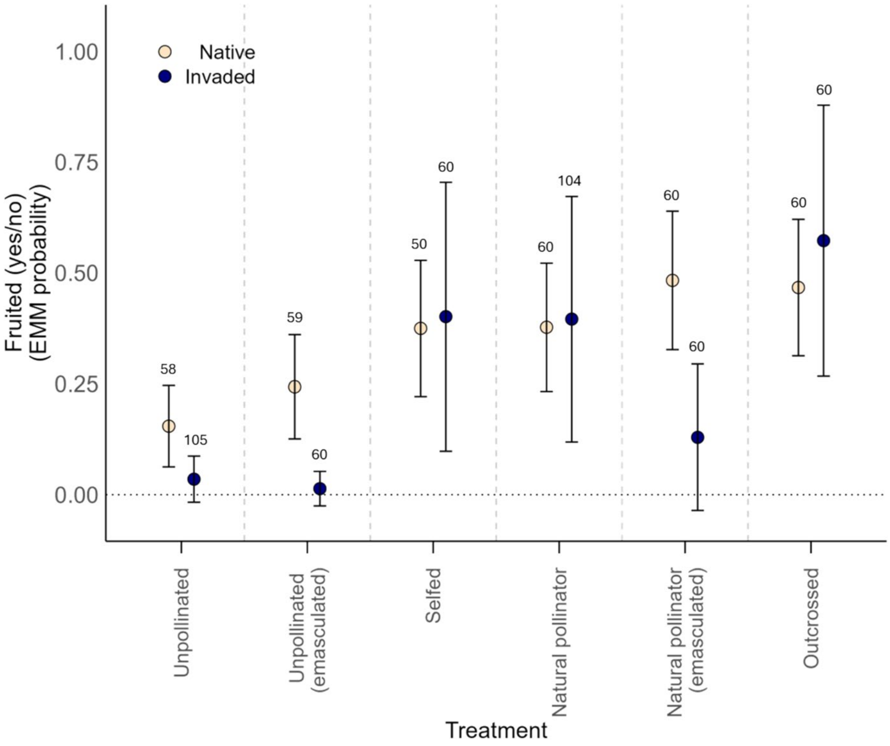

Fig. 3 The back-transformed Estimated Marginal Mean (EMM) ± the standard error of the proportion of flowers that set fruit after exposure to one of six pollination treatments. Invaded and native region data were analysed in independent models, and Table 1 details the generalised linear mixed model summaries presented here. Tukeys comparisons are provided in Supplementary Data 4. N values are presented above each mean

Table 1 Summary of results from the generalised linear mixed models for each response variable in each region

Response variable	Region	Effect or Intercept	Chisq or Estimate	DF or Z-value	Pr(> Chisq) or Pr(>|z|)
Proportion fruited	Invaded	Treatment	54.15	5	< 0.001
		Intercept	0.29	0.45	0.65
Proportion fruited	Native	Treatment	30.39	5	< 0.001
		Site	87.95	2	< 0.001
		Intercept	− 2.01	− 4.63	< 0.001
Seed count (per flower)	Invaded	Treatment	22.04	5	< 0.001
		Intercept	0.48	1.79	0.07
Seed count (per flower)	Native	Treatment	18.44	5	0.002
	Native	Site	1.76	2	0.415
		Intercept	2.67	0.21	< 0.001

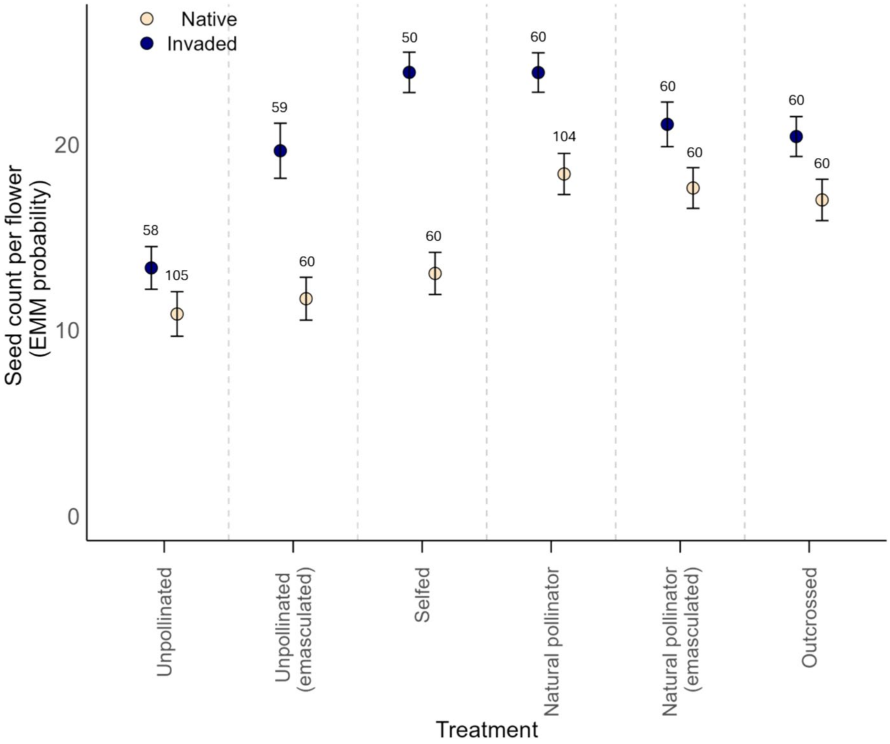

Fig. 4 The back-transformed Estimated Marginal Mean (EMM) ± the standard error from zero inflated generalised linear mixed models of seed count per flower after exposure to one of six pollination treatments. Invaded and native region data were analysed in independent models, and Table 1 details the model summary for the generalised linear mixed model summaries presented here. Post hoc pairwise comparisons are provided in Supplementary Data 4. N values are presented above each mean

plant (outcrossed) (invaded region: $Z=1.53$, $p=0.64$; native region: $Z=0.86$, $p=0.96$) demonstrating that *S. obtusifolia* is fully self-compatible in both the invaded and native study regions. Further, we found that *S. obtusifolia* could set some fruit and seed in the apomictic reproduction (unpollinated (emasculated) treatment) (Figs. 3, 4, S1 and S2). In the invaded region, 1% (±3.8) of flowers set fruit from the unpollinated (emasculated) treatment (Fig. 3), and the fruit contained 20 (±0.0) seeds (Supplementary Data 3). In the native region, 24% (±11.8) of flowers set fruit from the same treatment (unpollinated (emasculated); Fig. 3), and each fruit set 12 (±1.7) viable seeds (Supplementary Data 3). Therefore, *S. obtusifolia* is capable of uniparental reproduction and does not require a specialist pollinator, or even pollen, to produce some viable seed in either region.

Similarly, many other plants with specialised pollination systems can reproduce uniparentally. For example, numerous orchid (Krawczyk et al. 2016; Xiao et al. 2021), bird (Issaly et al. 2020), bat (Núñez-Hidalgo and Cascante-Marín 2024), and hawkmoth (Rodger et al. 2010, 2013) pollinated plants, are capable of autonomous selfing or apomixis. Uniparental reproduction may help to buffer population decline when specialist pollinators are absent or unreliable, including during colonisation of new regions (e.g., Rodger et al. 2013). A recent review also found that plants with generalist pollination syndromes are more successful colonisers of islands, although this pattern depends strongly on breeding system traits such as self-compatibility (Zell et al. 2025). These parallels suggest that the patterns observed in *S. obtusifolia* may reflect a broader trend in which reproductive-assurance mechanisms compensate for pollinator specificity in specialised systems. Assessments on the reproductive and pollination ecology of invasive plants with specialist pollination syndromes will clarify the extent to which uniparental reproduction contributes to invasion success for plants with specialist pollinators.

Apomictic reproduction may be an important form of reproductive assurance for species that would otherwise need to find suitable pollinators to reproduce when introduced to new regions (Baker 1955, 1967). Most invasive species display mixed breeding systems in their native or introduced ranges (Rambuda and Johnson 2004; Korpelainen and Pietiläinen 2023), and 97% of the 32 invasive buzz-pollinated plants for which we have data can reproduce uniparentally in either their native or introduced regions (Lopresti et al. 2024). However, less than half of the invasive buzz-pollinated species (43%; 10 of 23 species for which we have data) can set fruit in the absence of pollen (reviewed in (Lopresti et al. 2024)). Cytogenetic and molecular analyses have shown that some other *Senna* species can reproduce asexually (Randell 1970; Holman and Playford 2000; Resende et al. 2014; Delnevo et al. 2024). The presence of multiple chromosomes (haploidy) is correlated with having multiple embryos (Resende et al. 2014), and polyembryony suggests that some asexual reproduction (via apomixis) is involved (Xue et al. 2024). It is likely that *S. obtusifolia* can reproduce apomictically, because some populations are polyploids ((Li et al. 2016), but see (Dinh et al. 2024)), and our studied showed that some fruits and seeds were produced from the unpollinated (emasculated) treatment. Few fruits and seeds were set apomictically in the invaded region. The difference in apomictic reproduction between regions may be a result of genetic differences among populations or environmental conditions that influence the expression of apomixis (see Hörandl et al. 2025). *Senna obtusifolia* seeds are long-lasting (The State of Queensland, Department of Agriculture and Fisheries 2024) and have a high germination rate (Tungate et al. 2002). Apomictic reproduction may allow *S. obtusifolia* to reproduce immediately following introduction, potentially providing a temporal buffer if suitable pollinators are not immediately available. However, and given the low rate of apomixis, it is unlikely for the species to successfully spread in the long term in the absence of pollinators (Richardson et al. 2000).

We found no support for the expectation that *S. obtusifolia* shifted its breeding systems towards higher uniparental reproduction following introduction, which could facilitate plant invasions (Lopresti et al. 2024). Neither fruit set (Fig. 3) nor seed set (Fig. 4) significantly differed between the selfed and outcrossed treatments within either the native or invaded regions (Supplementary Data 4). Whilst our comparison between regions is limited to a qualitative assessment only, this result depicted that *S. obtusifolia* has not shifted breeding systems between the native and invaded studied regions (Ferrer et al. 2009). Yet, more seeds were set per flower when exposed to self-pollen (self treatment) in the invaded region compared to the native region (Fig. 4). Flowers also produced more seed uniparentally (unpollinated and unpollinated (emasculated) treatments) in the invaded region than in the native region (Fig. 4). Only four other studies have compared the breeding systems of invasive buzz-pollinated plants in both their native and introduced regions, and these studies found either a shift towards reduced autogamy or no change (Lopresti et al. 2026a; Petanidou et al. 2012; Vallejo-Marín et al. 2013; Zhang et al. 2017; Erfmeier and Bruelheide 2004; in Lopresti et al. 2024). One study which assessed the breeding system of an invasive plant adapted for bird pollination in its native and non-native regions found that *Nicotiana glauca* (Solanaceae) was self-compatible in all study regions (Issaly et al. 2020). The author's concluded that self-compatibility may be a conserved trait which could facilitate colonization of new habitats. Similarly, this logic may apply to our study and self-compatibility may be a conserved trait in *S. obtusifolia* which contributes to its invasion success as it introduced to new world regions. Unfortunately, too few studies have assessed the reproductive biology of buzz pollinated invasive plants to draw broad conclusions or generalisations about whether a shift to increased selfing or autogamy aids in the invasion success for buzz-pollinated plants.

Despite *S. obtusifolia* being capable of uniparental reproduction, fertility rates were very low in the absence of pollen transfer (Fig. 4). We found no immediate fitness reduction associated with selfing for *S. obtusifolia* in the either region, and seed set was comparable between the outcrossed and selfed treatments (invaded: $Z = -0.15$, $p = 0.06$; native: $Z = 0.26$, $p = 0.06$). This pattern may reflect polyploidy in the populations studied, similar to some other *S. obtusifolia* populations (Li et al. 2016). In polyploid species, the presence of multiple copies of each chromosome can mask deleterious alleles and, thereby, prevent inbreeding depression (Rosche et al. 2017). The short-term benefit of reproductive assurance through uniparental reproduction, along with the long-term drawback of inbreeding depression, has led to the notion that there is a fitness advantage to a mixed breeding system (Becerra and Lloyd 1992; Barrett and Harder 2017), although the adaptive significance of mixed breeding systems remains a topic of ongoing debate [see (Harder and Barrett 2007; Whitehead et al. 2018)]. Our findings suggest that *S. obtusifolia* can benefit from uniparental sexual reproduction when mates are scarce via selfing, however, abundant reproductive outputs can only be achieved by entomophilous pollen transfer.

We did not find any evidence that *S. obtusifolia* was pollen limited in either region. Fruit set did not significantly differ between the outcrossed and the unmanipulated treatments (invaded: $Z = 1.63$, $p = 0.80$; native: $Z = 0.85$, $p = 0.96$). Similarly, the number of viable seeds produced from each flower was not significantly greater in the outcrossed treatment compared to the natural pollination treatment (invaded: $Z = -1.12$, $p = 0.04$; native: $Z = 0.64$, $p = 0.52$). Our finding that *S. obtusifolia* is not pollen limited indicates that pollinators are attracted to and effectively pollinate *S. obtusifolia* in both the invaded and native study regions. Many Australian bees can buzz pollinate (62 species identified in (Vallejo-Marin et al. 2024), including species from tropical Australia that carried *Senna* pollen (Lopresti et al. 2026b). In turn, this may facilitate its reproduction and, hence, its invasion success. We observed many buzzing and non-buzzing floral visitors foraging on *S. obtusifolia* flowers in both the native (15 morphospecies) and introduced (19 morphospecies) regions of our study (Lopresti et al. 2026a; Supplementary Data 5). *S. obtusifolia* may not exclusively require specialist buzz-pollinators, if it can also benefit from other pollinator functional groups (e.g., non-buzzing pollinators that are capable of pollinating plants with the specialist buzz-pollination syndrome [reviewed in (Lopresti et al. 2024)]; Lopresti et al. 2026b). We are still in the early stages of understanding the importance of non-buzzing pollinator behaviours for fitness of plants with the buzz pollination syndrome. To our knowledge, no study has assessed whether a single or multiple pollinator species and functional group(s) are required for invasive buzz pollinated plants to succeed in their invaded regions. Yet, a broader pollinator community could make finding a pollinator match easier because the newly introduced plant is more likely to find a pollinator match upon introduction to a new region. In turn a broader pollinator community may facilitate species establishment when introduced into new regions.

Regional differences should be interpreted cautiously because the ecological and methodological contexts of our studied populations differed. In the native region, *S. obtusifolia* occurred as sparse, scattered individuals, whereas in the invaded range it formed dense monocultures. These conditions can alter pollinator attraction and mating opportunities in ways which are difficult to control for experimentally (Grindeland et al. 2005; Carvalheiro et al. 2025), and that can potentially influence the breeding system of the plant (Lyons and Mully 1992). Consequently, our sampling design had to be slightly adapted to each region: multiple treatments were applied to each individual plant in the invaded region, whereas treatments had to be applied to different nearby plants in the native region. These ecological and methodological asymmetries prevent direct quantitative comparisons, and our conclusions about differences between regions can only be interpreted qualitatively. Nonetheless, the differences stem from a standard ecological scenario: plants in the invaded region formed dense monocultures, whilst in the native region conspecifics are scattered throughout the environment (e.g., Jakobs et al. 2004; Gallé et al. 2023).

Conclusions

Our study was a rare comparison of the breeding system for an important tropical invasive plant. We found that *Senna obtusifolia* had a mixed breeding system, it was able to reproduce via autonomous selfing and apomixis, and it was also able to reproduce sexually from both outcross and self-pollen (geitonogamy). Autonomous selfing and apomixis can be critical in the absence of pollinators, such as in the early stages of colonization (Molnar and Gair 2015; Capel et al. 2017); self-compatibility is important during early establishment and spread, when mates are scarce (Razanajatovo et al. 2016); whereas high outcrossing is beneficial in the long-term because it can facilitate rapid evolution (reviewed in (Whitney and Gabler 2008)). A versatile breeding system is particularly important for species exhibiting specialised pollination syndromes because a newly introduced individual may not need to find a pollinator match to initially reproduce [(Rodger et al. 2010), and references therein]. Our study provides novel empirical evidence that suggests versatile breeding systems are important for colonization and invasion success, particularly when considering the role of specialist pollinator mutualisms.

Aknowledgements We thank Rosie Kinnaird, Ashleigh Harman, Mohit Deolankar, Christine Goosem, Vilda Wiklund, Brianna Bjordahl, Flor Elizabeth Herrera Perez, Juan Pablo Calderon Aguilar, Abiel Sansores, and Uhkin Mijangos for laboratory and field assistance; two anonymous reviewers for comments that improved the manuscript; the landowners for enabling us to use their properties; and the Traditional Owners of the lands on which we worked.

Author contributions L.C.L: funding acquisition, data collection, formal analysis, writing—original draft; L.L: conceptualization, funding acquisition, supervision, writing—review and editing; P.S.: supervision, writing—review and editing; V.P.-T.: supervision, writing—review and editing. D.M.: resources, funding acquisition, conceptualization, supervision, writing—review and editing. All authors gave final approval for publication and agreed to be held accountable for the work performed therein.

Funding Open Access funding enabled and organized by CAUL and its Member Institutions. This work was funded by the Australian Tropical Herbarium, the College of Science and Engineering, James Cook University, and the Association for Tropical Biology and Conservation Seed Research Grant. Laura C. Lopresti was supported by the Australian Government Research Training Program Scholarship.

Data availability This submission uses novel code, which has been provided as supplementary material. The data sets and code generated during this study are archived in the Research Data Australia repository and are publicly available from Lopresti et al. (2026a; https://doi.org/10.25903/5d3m-8898).

Declarations

Conflict of interest The authors have no relevant financial or non-financial interests to disclose.

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