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Prospects for biological control of weedy sesbanias (Fabaceae) in the southeastern United States of America

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Abstract. The cosmopolitan genus *Sesbania* Scopoli (Fabaceae) is represented in the United States of America by seven species, only two of which may be considered native. Five species are weeds of humid pastures, roadsides and cultivated crops throughout the southern USA. Interest in biological control of weedy sesbanias has increased in the USA during the last decade as chemical herbicide registrations have declined and public demand for pesticide-free agricultural commodities and improved environmental quality has risen. Although weeds of humid pastures and crops have often been viewed as difficult targets for biological control, the recent shift to sustainable agricultural practices (e.g. no till) increases the likelihood that weedy sesbanias can be effectively controlled biologically in those habitats traditionally thought of as too unstable to support biological control agents. Three species of *Sesbania* (*S. exaltata*, *S. drummondii*, and *S. punicea*) are good candidates for biological control in the USA because they cause sufficient economic damage to justify the cost of the research, are poisonous to livestock, have no critical beneficial values, and have natural enemies capable of providing excellent control. The costs for implementing a biological control programme in the USA can be further reduced via the 'short route', which would utilize existing technology that resulted in the successful biological control of *S. punicea* in South Africa.

Introduction

The genus *Sesbania* Scopoli (Fabaceae) encompasses approximately 50 species worldwide, and is represented in tropical and subtropical regions of all continents (Isely 1990). Seven species occur commonly in the southern United States of America (Table 1), including two species of uncertain origin, *Sesbania exaltata* (Rafinesque) Cory, and *S. drummondii* (Rydberg) Cory, and five naturalized ornamental introductions (*S. grandiflora* (L.) Persoon, *S. punicea* (Cavanilles) Bentham, *S. virgata* (Cavanilles) Persoon, *S. sericea* (Willdenow) Link, and *S. emerus* (Aublet) Urban).

Three of the aforementioned species are troublesome weeds in the southern USA and may be good candidates for biological control. Hemp sesbania, *S. exaltata*, is an annual species which invades disturbed, ruderal and agricultural sites. Its present distribution includes the Coastal Plain and Piedmont regions of the southeastern USA, extending northward to southern New York and Pennsylvania and westward to southern Illinois, Missouri and Texas (Godfrey and Wooten 1981). Regarding the origin of hemp sesbania, Isely (1990) states that this species may be nothing more than an annual northerly derivative of the adventive, perennial *S. emerus*. If this assertion can be substantiated, then the present status of hemp sesbania as a native weed species may have to be re-evaluated.

Drummond rattlebox, *S. drummondii*, is a perennial shrub which normally forms dense stands along roadsides and in unimproved pastures and natural areas of the southern coastal states, but recently has become a problem in cropland situations (Eastin 1984). Drummond rattlebox is presumably a native species that ranges from Vermont to Texas and south into Mexico (Correll and Johnston 1970; Holm *et al.* 1979; Godfrey 1988). However, Isely (1990) observed that drummond rattlebox is so closely related to the introduced *S. punicea* that hybridized populations

Table 1. *Sesbania* species inhabiting the southeastern United States of America (State names abbreviated).

Species	Origin	Growth Habit	USA distribution
S. grandiflora (L.) Persoon	Southeast Asia	Perennial shrub	Subtropical Fla
S. punicea (Cavanilles) Bentham	South America	Perennial shrub	Ala, Ark, Fla, Ga, La, Miss, NC SC, and Tex
S. drummondii (Rydberg) Cory	Southern USA and Mexico	Perennial shrub	Ala, Ark, Fla, La, Miss and Tex
S. virgata (Cavanilles) Persoon	South America	Perennial shrub	Fla and Miss
S. sericea (Willdenow) Link	Africa	Short-lived shrub	Fla, Key West Tortugas
S. exaltata (Rafiinesque) Cory	Southern USA and Mexico	Annual herb	Ala, Ark, Fla, Ga, La, Miss, NC, SC, Tenn, Tex, and Okla
S. emerus (Aublet) Urban	Antilles, Mexico, Central America	Short-lived shrub	subtropical Fla

occur naturally in southern Mississippi where the two species are sympatric. This being the case, the presumption that drummond rattlebox is a separate species distinct from *S. punicea* is questionable.

Coffeeweed, *S. punicea*, is a perennial shrub of South American origin that is also a weed of humid pastures and natural areas across the southern USA (USDA-ARS 1971; Isely 1990). This introduced species has become naturalized throughout the Coastal Plain region and extends northward to North Carolina and westward to east Texas (USDA-ARS 1971; Godfrey 1988).

The introduction of hemp sesbania and coffeeweed into other parts of the world has had important ecological consequences. For example, following its accidental introduction into Ecuador where native species of *Sesbania* and their natural enemies are absent, hemp sesbania became established in the Rio Guayas basin (Vogt and Cordo 1976). The weed was so aggressive that it displaced all the native vegetation of the region to the extent that a cottage industry which utilized a naturally-occurring spikerush as a stuffing material was threatened (Vogt and Cordo 1976). According to Hoffmann and Moran (1988, 1991a), coffeeweed was probably introduced into South Africa from South America early in this century where it was cultivated as a garden ornamental. By 1966, coffeeweed had begun to displace indigenous vegetation in disturbed areas and riparian habitats throughout the country (Harris and Hoffmann 1985). The explosive spread and spectacular increase of coffeeweed documented in South Africa during the 1980s was attributed to a lack of natural enemies that regulate the plant's population in South America (Graaff and van Staden 1984; Hoffmann and Moran 1988).

In this paper we attempt to determine the status of *Sesbania* spp. as weeds in the USA, survey the insects and diseases that are potential natural enemies of the plants, and briefly discuss the prospects for biological control of hemp sesbania, drummond rattlebox and coffeeweed in this country.

Undesirable aspects of *Sesbania* spp.

Competition by hemp sesbania for nutrients, water and light in agricultural production areas of the mid-south USA can significantly reduce crop yields, interfere with harvesting operations and lower the market value of the commodity. In Mississippi, hemp sesbania is considered one of the ten most costly weeds (Snipes and Jordan 1987). When left uncontrolled, hemp sesbania reduced soybean yields up to 80% and the presence of hemp sesbania seeds at harvest lowered soybean seed-quality ratings (Lunsford *et al.* 1976; McWhorter and Anderson 1979). A similar trend was observed in cotton producing areas of Mississippi. Bryson (1987) reported cotton yields were reduced by over 50% when hemp sesbania infestations attained a density of 10 plants/3.3 m^2, and that the trash from this

weed obstructed the mechanical picker and lowered cotton lint grades. In Arkansas, sunflower yields were reduced up to 35% when hemp sesbania was not controlled early in the season (Woon 1987). Arkansas rice producers also experienced significant economic losses (up to $5 million) as a result of price reductions caused by hemp sesbania seed in milled rice (Baldwin *et al.* 1977).

Herbicide applications are required to control hemp sesbania infestations in soybeans (Barrentine 1991), rice (Richard and Street 1984) and cotton (Snipes and Jordan 1987)). Although herbicides can provide excellent control and are relatively inexpensive, they can also lead to resistance problems (Gould 1991) and are a major contributor to groundwater pollution in sandy areas of the southeastern USA (Soper and King 1989).

The tendency for drummond rattlebox to become a problem in cropland situations was not apparent until recently. According to Eastin (1984), drummond rattlebox has begun to invade soybean fields in southeast Texas and now poses a serious threat to soybean production in this region. The seeds of drummond rattlebox which are approximately the same size as soybean seeds are not unlike hemp sesbania in that they are difficult to separate from harvested soybeans.

In the southeastern USA, the exotic coffeeweed is of some importance (Holm *et al.* 1979) but it is not as prominent a weed as it is in South Africa (Hoffmann and Moran 1988, 1991a). The aggressiveness of coffeeweed following its introduction in the USA may have been diminished by the activity of the root feeding weevil *Eudiagogus rosenschoeldi* Fahraeus. This 'new associate' on coffeeweed is the North American ecological homologue of *Eudiagogus episcopalis* Schoenherr, one of the principal natural enemies of coffeeweed in South America (Warner 1979; Harris and Hoffmann 1985; Hoffmann and Moran 1988). The impact of coffeeweed on native vegetation in this country is unknown. There is some concern, however, that coffeeweed is displacing indigenous flora in some habitats as it did in South Africa (Harris and Hoffmann 1985; Hoffmann and Moran 1991a).

In addition to their weedy tendencies, the aforementioned *Sesbania* spp. are poisonous when ingested (Kingsbury 1964; Terblanche *et al.* 1966). The principle toxins in *Sesbania* spp. are saponins (Duke 1977). These toxic glycosides are concentrated primarily in the seeds but distribution in other plant parts appears to be species dependent. Cattle often develop a craving for the seeds of hemp sesbania in late summer when they are moved to new pastures containing the plant. Symptoms of hemp sesbania poisoning in livestock appear approximately one day after ingestion of the seeds, and include hemorrhagic diarrhoea or constipation, arched back, shallow respiration, rapid and irregular pulse, coma and death. Although ground hemp sesbania seed in the diet of broiler chickens reduces food intake and growth (Flunker *et al.* 1990), no symptoms were produced when chicks ingested only the leaves in feeding trials (Perkins and Payne 1978).

Drummond rattlebox and coffeeweed have been shown to be even more poisonous than hemp sesbania. Only 28-56 gm (1-2 oz) of drummond rattlebox seeds can be fatal to livestock (Perkins and Payne 1978). More recently, Flory and Hebert (1984) reported that drummond rattlebox seed extracts administered daily to chickens at dosages equaling 1% of their body weight caused death within five days.

Shealy and Thomas (1928) demonstrated that a chicken would die if it ingested nine whole coffeeweed seeds. Sheep are particularly vulnerable to coffeeweed poisoning and can be killed after consuming as little as 50 gm/100 pounds of body weight (Miller *et al.* 1980). Terblanche *et al.* (1966) reported that all parts of coffeeweed are lethal to reptiles, birds and mammals.

Beneficial aspects of *Sesbania* spp.

Sesbania spp. in the USA probably have some ecological value because they are capable of fixing atmospheric nitrogen through the symbiotic relationship of *Rhizobium* sp. bacteria contained in root nodules (Barrentine 1991). With greater emphasis on sustainable agriculture, there may be renewed interest in utilizing *Sesbania* spp. as a green manure to substitute for inorganic fertilizer in some non-leguminous crops which, unlike soybeans, are incapable of fixing nitrogen. For example, hemp sesbania is planted on irrigated lands in the southwestern USA as a cover crop and is turned-under prior to planting winter vegetables (Magness *et al.* 1971). The introduced *S. grandiflora* apparently has highly specific rhizobial requirements (Turk and Keyser 1992). *Sesbania grandiflora* is a shrub or small tree native to southeast Asia where it is widely planted for reforestation, firewood, timber, shade, forage and

soil improvement (Isely 1990). The bark of *S. grandiflora* is also reported to have some medicinal value (Perkins and Payne 1978).

In south Florida, the exotic *S. grandiflora* is cultivated as an ornamental shade tree and has become naturalized there (Isely 1990). Drummond rattlebox and coffeeweed may also have limited value as ornamentals. Both species are cultivated as ornamental shrubs in some urban areas of the southeastern USA (Isely 1990).

At least one species of *Sesbania* has some value as food for wildlife. Landers and Mueller (1986) recommended planting a *Sesbania* spp. in poorly drained areas for managing bobwhite quail populations and the seeds of hemp sesbania are apparently a good food source for these birds (Flunker *et al.* 1990). These authors concluded that quail have a greater tolerance to the toxins contained in the seeds, compared to domesticated poultry.

Natural enemies of *Sesbania* spp.

In 1987, an anthracnose disease was discovered on seedlings of hemp sesbania in Mississippi and was later identified as *Colletotrichum truncatum* (Schwein.) Andrus and W. D. Moore, isolate CT 18434 (Boyette 1991). This fungal pathogen is highly virulent to hemp sesbania yet was found to be non-pathogenic to all non-target crop and plant species tested, including drummond rattlebox. Further studies are needed to test the susceptibility of coffeeweed to this pathogen. Research is currently underway to develop CT 18434 as a commercial bioherbicide for hemp sesbania control (Silman *et al.* 1991; Hardin 1995).

Following its accidental introduction into Santa Cruz, Bolivia, hemp sesbania was attacked by the South American sesbania weevils *E. episcopalis* and *Neodiplogrammus quadrivittatus* (Olivier) (Vogt and Cordo 1976). These 'new associates' suppressed hemp sesbania so effectively that the native flora in the region was not threatened, in contrast to what had occurred in Ecuador.

Successful biological control of coffeeweed in South Africa has been achieved following the introduction of three South American insects: the flower-bud weevil, *Trichapion lativentre* (Beguin-Billecocq), the stem-boring weevil, *N. quadrivittatus*, and the seed weevil, *Rhyssomatus marginatus* Fahraeus (Hoffmann and Moran 1988; 1991a, b; Hoffmann *et al.* 1990). The prospects for classical biological control of North American weedy sesbanias are excellent because no ecological homologues of these three weevil genera are known to occur in the southern USA (Vogt and Cordo 1976). Laboratory and field studies recently completed in Argentina (Logarzo and Casalinuovo 1996) showed that hemp sesbania and drummond rattlebox are suitable host plants for *N. quadrivittatus*. They also reported that *T. lativentre* is a promising biocontrol agent for drummond rattlebox, a close relative of its natural host coffeeweed. Further research is needed to determine the suitability of hemp sesbania and drummond rattlebox as host plants for *R. marginatus* and *E. episcopalis*.

Potential for biological control

Interest in biological control of weedy sesbanias has increased in the USA during the last decade as chemical herbicide registrations have declined and public demand for pesticide-free agricultural commodities and improved environmental quality has risen (Boyette 1991; Silman *et al.* 1991; Hardin 1995; DeLoach 1995). With the commercial development of the indigenous fungal pathogen *C. truncatum* as an economical bioherbicide (Silman *et al.* 1991; Hardin 1995), a non-chemical tool for controlling hemp sesbania will soon be available to farmers.

The rationale for introducing foreign natural enemies to control *Sesbania* spp. that have invaded pastures, crops and natural areas in the USA has been reviewed by DeLoach (1995), and should be given serious consideration. We believe hemp sesbania, drummond rattlebox, and coffeeweed are appropriate targets for classical biological control because they cause sufficient economic damage to justify the research costs. By specifically targeting the introduced coffeeweed, we can take advantage of the 'short route' in the context of Harley and Forno (1992), and at the same time alleviate some of the concerns that may be raised about the appropriateness of classical biological control introductions for suppressing weedy sesbanias. Finally, if the true origins of hemp sesbania and drummond rattlebox cannot be resolved, then any conflict that may arise over biological control of these target plants (Pemberton 1985; Turner 1985) may be deemed irrelevant.

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