PUNCTUREVINE
Tribulus terrestris L.

BIOLOGY AND MANAGEMENT IN THE PACIFIC NORTHWEST

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SYNONYMS
caltrop, goat head, tackweed

INTRODUCTION
Puncturevine, *Tribulus terrestris* (Zygophyllaceae), is an annual plant native to Africa, Asia, and the Mediterranean. It was accidentally introduced to North America by 1900 as a contaminant with livestock shipments (Winston et al. 2014). Now occurring throughout most of the United States, puncturevine is often found in dense mats in areas of frequent disturbance (**Fig. 1**), including roadways, crop margins, pastures, corrals, sidewalks, stackyards, and vacant lots. Although puncturevine can tolerate a wide range of conditions, it grows best in dry, sandy soils where there is little competition from other plants (DiTomaso et al. 2013).

Figure 1. Dense mat of puncturevine growing on disturbed soil (Jennifer Andreas, WSU Extension).

Puncturevine rapidly forms large mats that crowd out more desirable species. Plants produce numerous spiny burs that are injurious to livestock digestive tracts, hides, and feet. The burs puncture bicycle tires and footwear, proving a nuisance to recreationalists. Burs also contaminate wool, hay, food crops, and crop seed production. Puncturevine foliage is toxic to grazing animals, especially sheep, when consumed in large quantities (Parker and Boydston 2007).

IDENTIFICATION
Growth
Puncturevine is a prostrate annual weed spreading only by seed. Seeds germinate in spring and summer when there is sufficient soil moisture and warm temperatures (Donaldson and Rafferty 2003). The plant rapidly grows a deep taproot that enables it to tolerate dry soils after establishment. Flowering occurs as quickly as three weeks after germination and continues throughout summer. The spiny bur fruits readily puncture and adhere to tires, clothing, fur, and feet (**Fig. 2**), transporting seeds great distances. Seeds are typically dormant the first growing season and remain viable in the soil for up to five years (Parker and Boydston 2007). Plants die with the onset of winter.

Figure 2. Spiny puncturevine fruits readily adhere to tires, clothing, fur, and feet (Jennifer Andreas, WSU Extension).

Stems and Leaves
Stems radiate from a single point at the crown, creating a mat typically 2–7 ft (0.6–2.1 m) in diameter (**Fig. 3**; Porter 2016). While most stems are prostrate along the ground, plants may grow somewhat vertically under shaded conditions and when growing overtop other plants. Stems vary from green to reddish-brown and are somewhat hairy (**Fig. 4**). The leaves are opposite and compound, with three to seven pairs of elliptical leaflets (**Fig. 4**; DiTomaso et al. 2013). Leaflets are typically dark green, hairy along their margins and midveins, and ¼–½ in (6–12 mm) long (**Fig. 5**).

Figure 3. Puncturevine stems radiate from a central point at the crown (Howard F. Schwartz, Colorado State University, Bugwood.org, CC BY 3.0 US).

Figure 4. Puncturevine stems are green to reddish-brown and somewhat hairy (Travis McMahon, MIA Consulting).

Figure 5. Puncturevine leaves are opposite and compound, each with three to seven pairs of leaflets (Jennifer Andreas, WSU Extension).

Flowers

Flowers appear in leaf axils, where leaves attach to stems (**Fig. 6**). They have five lemon-yellow petals and are typically less than ½ in (12 mm) across (Porter 2016).

Fruits

The spiny fruits are ½ in (12 mm) across (**Fig. 7a**), becoming woody at maturity and breaking apart into five wedge-shaped burs. Each bur contains one to four seeds and is armed with two large spines, sometimes two additional smaller spines, and several short prickles (**Fig. 7b**; DiTomaso et al. 2013).

SIMILAR SPECIES

Several other species resemble puncturevine during one or more stages of their growth. These are differentiated from puncturevine in **Table 1**.

Figure 6. Puncturevine flowers appear in leaf axils and have five yellow petals (Jennifer Andreas, WSU Extension).

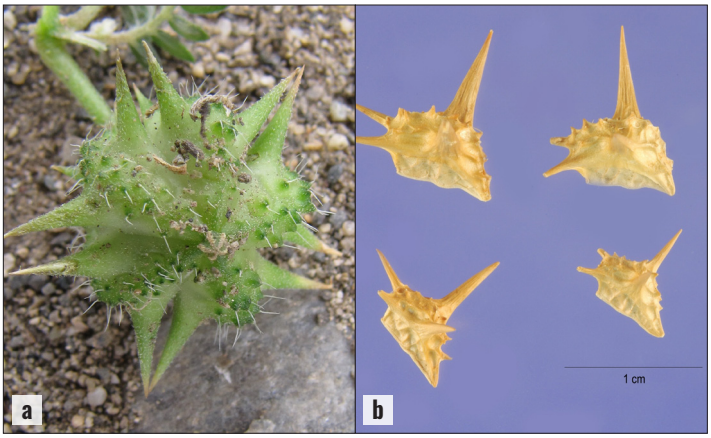

Figure 7. Puncturevine fruits (a) separate into five spiny, wedge-shaped burs at maturity (b) (a: Jennifer Andreas, WSU Extension; b: Steve Hurst, USDA NRCS PLANTS Database, Bugwood.org, CC BY 3.0 US).

Table 1. Key traits for differentiating puncturevine from similar species.

SPECIES	SIMILARITIES	DIFFERENCES	PLANT	LEAVES	FLOWER
Sandmat *Cardionema ramosissima*	Prostrate growth; taproot; opposite leaves; prickly leaves may resemble young spiny puncturevine fruit	Perennial; stems only up to 1 ft (30 cm) long; leaves needle-like, crowded; flowers tiny, greenish, and non-showy; fruit tiny, brown, not spiny			
Common purslane *Portulaca oleracea*	Annual; prostrate growth; taproot; stems may be reddish; some leaves opposite; leaves similar size, shape to puncturevine leaflets; flowers with five yellow petals	Stems typically only 1 ft (30 cm) long; leaves not compound; leaves succulent, not hairy; some leaves alternate; pod fruit, not spiny			
Storksbill, redstem filaree *Erodium cicutarium*	Annual; rosette leaves prostrate, arise from center point; taproot; stems may be reddish, hairy; leaves hairy, finely divided, resembling puncturevine compound leaves from distance	Flower stems may be erect; leaves up to 1 ft (30 cm) long with fern-like divisions; flowers pink to lavender; long, thin capsule fruits burst into spirals at maturity			
Prostrate knotweed *Polygonum aviculare*	Annual; prostrate growth; stems up to 5 ft (90 cm) long (typically shorter); leaves alternate; some leaves similar size, shape	Leaves not compound; some leaves more lance-shaped, longer (up to 1.2 in or 3 cm); papery sheath at leaf bases; flowers tiny, whitish or pink petals; fruit tiny, brown, not spiny			
California caltrop *Kallstroemia californica* *This species is native to the Southwestern USA. It is not present in the Pacific Northwest	Annual; prostrate growth; taproot; stems may be reddish, hairy; leaves opposite, compound; leaflets elliptical; flowers with five yellow petals	Stems only up to 2 ft (60 cm) long; leaflet pairs only up to six; flowers slightly smaller; fruits with beaked tip, break apart into 10 woody burs; burs not nearly as spiny			

Photos: sandmat plant (Tiyumq, iNaturalist.org, CC BY-NC 4.0), sandmat leaves and flower (Ken-ichi Ueda, iNaturalist.org, CC BY 4.0); common purslane plant (Forest & Kim Starr, Starr Environmental, CC BY 4.0), common purslane leaves (willko5, iNaturalist.org, CC BY-NC 4.0), common purslane flower (Randy A. Nonenmacher, iNaturalist.org, CC BY-SA 4.0); storksbill plant (liddlebobeep, iNaturalist.org, CC BY-NC 4.0), storksbill leaves and flower (Bonnie Minnion, BLM, Bugwood.org, CC BY 3.0 US); prostrate knotweed plant (Norma Malinowski, CC BY-NC 4.0), prostrate knotweed leaves (megachile, iNaturalist.org, CC BY-NC 4.0), prostrate knotweed flower (Andreas Rockstein, iNaturalist.org, CC BY-SA 4.0); California caltrop plant and leaves (Frankie Coburn, iNaturalist.org, CC BY-NC 4.0), California caltrop flower (Heriberto Avila G., iNaturalist.org, CC BY-NC 4.0).

MANAGEMENT

Prevention

Prevention is the most cost-effective solution for puncturevine management, followed by eradication of small populations. Because of its long-lived seeds, if puncturevine is not detected and removed early, intense and long-term control efforts will be unavoidable. In areas where puncturevine is not yet present, it is important to minimize soil disturbance and regularly monitor sites to confirm they remain uninfested. Puncturevine is spread by the movement of burs, which are usually transported by animals, people, and vehicles/equipment (Parker and Boydston 2007). Where grazing occurs, livestock should be kept off weed-infested land when puncturevine fruits mature and seeds are viable and easily spread. If it is not possible to avoid driving vehicles and machinery through puncturevine infestations, it is crucial that a thorough cleaning is conducted before equipment leaves the contaminated area.

Cultural Control

Revegetating disturbed sites with more desirable, fast-growing, competitive plants can be useful in limiting puncturevine spread. The best species will depend on land management goals and site conditions; contact your local county weed office, extension office, or conservation district for recommendations. Grazing is not an appropriate control method due to the toxicity of puncturevine foliage. In gardens, orchards, and vineyards, puncturevine can be controlled by applying mulches 4–6 in (10–15 cm) thick to screen out all light. Because puncturevine burs falling on organic mulch may release seeds, organic mulches must be monitored regularly for germinating seedlings, and synthetic mulches may prove more effective (Parker and Boydston 2007). In open areas with a large puncturevine seed bank and little to no other vegetation, burs can be removed by adhering carpet or other soft material to boards or large rollers, which can then be applied to or rolled over the soil. After several passes, most puncturevine burs can be removed from the soil surface of the infested area (DiTomaso et al. 2013). Burs must be properly disposed of to prevent their spread. Because the spiny burs often protect the seeds within, composting and burning are typically not suitable methods of disposal. All burs should be sealed within garbage bags and taken to a waste transfer station (Donaldson and Rafferty 2003).

Manual Control

Pulling can be an effective removal method on small infestations, as it removes the entire plant and eliminates any regrowth. If the soil is hard and compacted, shallow tilling, scraping, or hoeing/clipping just below the root crown are suitable alternatives (DiTomaso et al. 2013). Mowing is not an appropriate control method because of puncturevine's prostrate growth form. All manual control options should be applied prior to fruit formation. Because puncturevine seeds sprout throughout spring and summer, and plants can re-grow after being hoed or clipped, all sites must be visited and, when necessary, re-treated every two weeks during the growing season. Replant bare ground with appropriate, more desirable species.

Chemical Control

Several herbicides applied alone or in combination can be effective in controlling puncturevine infestations in a variety of habitats. When applied before seeds sprout, pre-emergent herbicides such as bromacil, chlorsulfuron, diuron, fomesafen, imazapyr, norflurazon, pendimethalin, and topramezone provide control of seedlings (DiTomaso et al. 2013, Peachey 2021). Select sites carefully, however, as many of these products will control all seedlings, including desirable species, and certain herbicides may persist for more than one year.

A variety of herbicides are also available for control of existing plants, including 2,4-D, aminocyclopyrachlor, bentazon, dicamba, fluroxypyr, glyphosate, imazamox, imazapic, MSMA, paraquat, and rimsulfuron (DiTomaso et al. 2013, Peachey 2021). Many post-emergent products are not specific to puncturevine so care should be taken to ensure only puncturevine foliage is treated with these herbicides. For best results, apply post-emergent products prior to fruit formation. Follow up by frequently checking the site for new plants or regrowth, and repeat treatments when necessary. Re-plant bare ground with appropriate, more desirable species.

Many of the products listed in this section are restricted use, meaning they are regulated by state departments of agriculture and are only available to licensed applicators. Unrestricted herbicides are more readily available to homeowners. Regardless of the product used, always read and follow label directions when using herbicides. Not all products are registered for use in all locations. Refer to the Pacific Northwest Weed Management Handbook (Peachey 2021) or contact your local county noxious weed progam or county extension educator for recommendations and information about the proper, safe, and legal use of herbicides in your area.

Biological Control

Two weevils have been introduced as biological control agents of puncturevine in the United States. Adults of the puncturevine stem miner, *Microlarinus lypriformis*, are mottled brown, typically 3/16 in (4–5 mm) long, and have short, broad snouts (Coombs et al. 2004; **Fig. 8a**). Adults feed on puncturevine stems and leaves, but their damage is only minor. It is the larval stage of this species that causes the most damage. Adults lay eggs in puncturevine stem bases and the root crown. Hatching larvae mine the stems (**Fig. 8b**), weakening the plant and often causing stem breakage. This, in turn, reduces the vigor and reproductive output of attacked plants.

Adults of the puncturevine seed weevil, *Microlarinus lareynii*, are very similar to *M. lypriformis* but are mottled gray-brown and are slightly larger (Coombs et al. 2004; **Fig. 9a**). Adults feed on the bottom of puncturevine stems throughout the growing season, leaving round scars (**Fig. 9b**); however, their feeding is typically insignificant and doesn't harm the plant. It is again the larval stage of this species that causes the most damage. Adults lay eggs inside young puncturevine fruits. Hatching larvae feed on seeds, producing holes in the fruits (**Fig. 9c**) and burs (**Fig. 9d**). Although larvae consume seeds,

Figure 8. Adult puncturevine stem weevils (a) lay eggs inside puncturevine stems and root crowns. Hatching larvae mine the stems (b), often causing stem breakage (a–b USDA ARS European Biological Control Laboratory, Bugwood.org, CC BY 3.0 US).

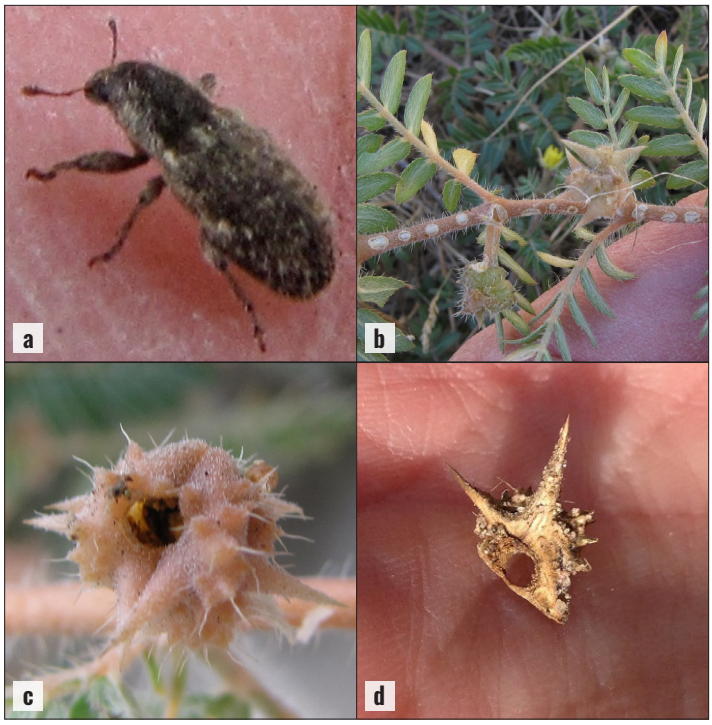

Figure 9. Adult puncturevine seed weevils (a) feed on the underside of puncturevine stems (b) causing only minor damage. Seed weevil larvae feed within developing fruits, leaving characteristic feeding holes in fruits (c) and burs (d) (a–d Jennifer Andreas, WSU Extension).

the damaging spines of fruits still develop. This weevil does not alleviate problems caused by the spiny fruits produced during the current and past growing seasons, but it does decrease the seed bank and can have an impact over time under ideal conditions.

Both species were introduced from Italy and released throughout the United States beginning in 1961 (Coombs et al. 2004). They have successfully established in several states; however both species are severely limited by cold winter temperatures. While these weevils have dramatically reduced puncturevine populations at some warm, low-elevation sites in southern California, Alabama, and Hawaii, winter temperatures in the Pacific Northwest are generally too cold to sustain weevil populations large enough to provide adequate control of puncturevine (Winston et al. 2022). Both weevils are present at low densities in Idaho, but only the seed weevil has survived in Washington and Oregon.

Recent efforts to redistribute cold-hardy weevils from Colorado to Oregon in the hopes of improving overwintering have thus far proven unsuccessful. In addition, seed weevils may be heavily parasitized by wasps which reduce their populations and, ultimately, their effectiveness. Consequently, biological control is not considered a viable management tool for puncturevine in the Pacific Northwest.

Both weevil species have been observed attacking caltrop (*Kallstroemia*) species native to the southern United States and should not be released at any sites where native caltrop species occur.

RESOURCES

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SUGGESTED CITATION

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