

New upland sites for *Trifolium stoloniferum* (Fabaceae) in Missouri, with comments on the identification of sterile material

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ABSTRACT. — Previous Missouri records of *Trifolium stoloniferum* have been from disturbed areas with riparian influences. We report three new sites for *T. stoloniferum* from disturbed wooded uplands in Montgomery County. Techniques for distinguishing sterile material of *T. stoloniferum* from *T. repens* are presented. The discovery of *T. stoloniferum* on upland woodlands in Missouri provides increased opportunities to find additional sites of running buffalo clover in the state in similar habitats.

The status and history of *Trifolium stoloniferum* (running buffalo clover) (RBC) in Missouri were recently review by McKenzie and Newbold (2015). Based on May 2017 monitoring at extant sites in Missouri (Newbold, McKenzie, Schuette, pers. obs.), there were five documented records for this species: two at Cuivre River State Park in Lincoln County, two on private property in Callaway County, and one at Graham Cave State Park in Montgomery County. Most sites within riparian corridors were significantly impacted by floods that occurred throughout the state in late April and early May 2017. The Crow's Fork Creek site on private property in Callaway County was significantly damaged by deposition of silt and sand (Figure 1). The number of flowering stems decreased from 118 rooted crowns and 141 flowering heads in 2016 (Chris Newbold, unpubl. report) to 4 rooted crowns and 3 flowering stems when the site was visited in 2017 (Chris Newbold, unpubl. data 2017). Although covered by the late April 2017 flood waters, the population near the boat ramp at Graham Cave State Park rebounded throughout the summer, and the authors observed numerous rooted crowns on 29 August 2017. On 30 October 2017, a count by Lorie Volenberg yielded an impressive 114 rooted crowns. This population appears to be responding favorably to management by park staff, especially light mowing that does not remove rooted RBC plants but eliminates competitive vegetation.

On 25 April 2017, Volenberg discovered a sterile population of RBC at a new location at the park (Figure 1). Unlike other extant and historic sites, the population occurred along a mostly upland hiking trail directly adjacent to the mouth of Graham Cave, at an elevation of ~610 ft. A total of 40 rooted crowns were counted along a small area of trail in a Cedargap and Stulz soil

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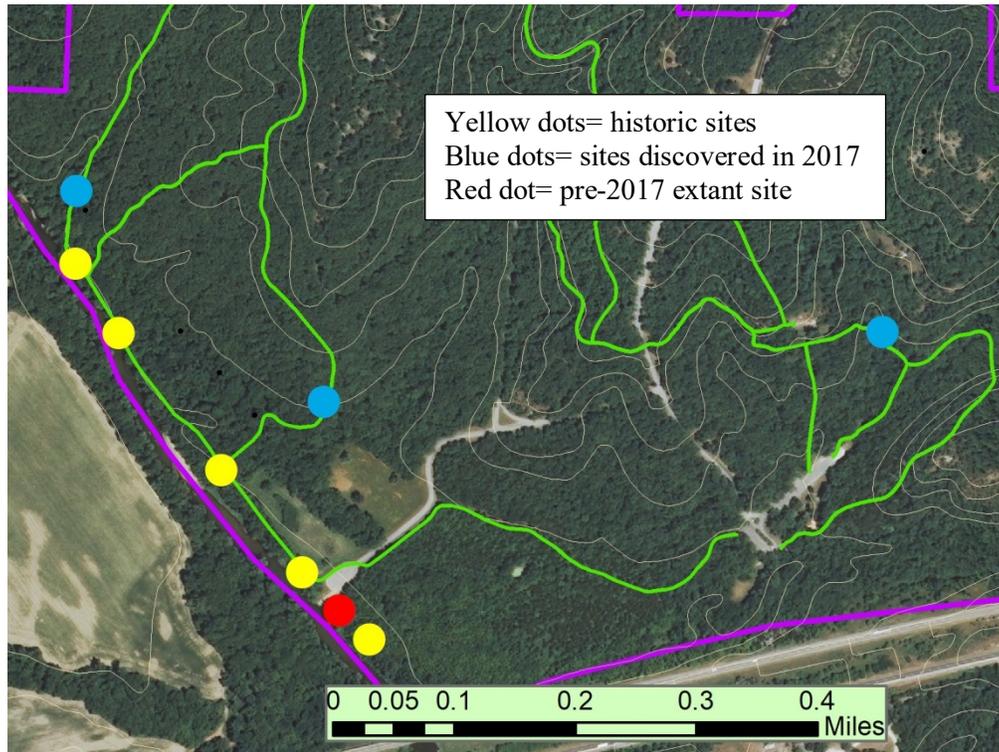
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that was formed from alluvium in an upland forest drainage way (Dennis Meinert, Missouri DNR unpub. report, 2009). Associates at this site included: *Asimia triloba*, *Carex grisea*, *Cubelium concolor*, *Impatiens* sp., *Elymus villosus*, *Leersia virginica*, *Similax* sp., and *Symphoricarpus orbiculatus*.

On 12 October 2017, a second upland population of 47 rooted crowns of *Trifolium stoloniferum* was found by Peter Hayes along a hiking trail southwest of the campground parking lot (Figure 2). The plants were scattered along an approximate 15 ft. section of the trail in a shaded woodland dominated by *Quercus alba* (Figure 3). Associates at this location included: *Asarum canadense*, *Carex jamesii*, *Celtis occidentalis*, *Cornus florida*, *Diarrhena obovata*, *Eupatorium purpureum*, *Leersia virginica*, *Oxalis* sp., *Parthenocissus quinquefolia*, *Persicaria longisetata*, *Phlox divaricata*, *Quercus imbricaria*, *Symphyotrichum* sp., *Ulmus rubra*, and *Viola sororia*. Species concepts and nomenclature in this report follow Yastkievych (1999, 2006, 2013).

The newest locations within Graham Cave State Park are in the Montgomery-Warren Oak Woodland/Forest Rugged Hills Land Type Association (LTA) as described by Nigh and Schroeder (2002). The LTA is in the Outer Ozark Border Subsection of the Ozark Highlands Section and is characterized by narrow, loess-covered ridges, steep slopes, and deep, narrow valleys. Most uplands are underlain by Mississippian and Devonian limestone, with the valleys consisting of Ordovician St. Peter Sandstone and Jefferson City-Cotter Dolomite (Nigh and Schroeder 2002). At Graham Cave the lower slopes with the new *Trifolium stoloniferum* locations are in sandy alluvium and colluvium below the St. Peter Sandstone formation and outcrops. The natural communities associated with these two new running buffalo clover populations are outside the Loutre River floodplain and are on the natural community border between dry-mesic sandstone woodland and mesic sandstone forest as described by Nelson (2005).

On 20 October 2017, the authors surveyed additional upland and bottomland sites within a half mile radius of the newest location and located yet another small population along a hiking trail that parallels the Loutre River (Figure 4). This site was approximately 0.25 mi. northwest of the hillside site, but within the riparian corridor of the Loutre River. Seven rooted crowns were located along the trail, approximately 10 feet lower in elevation than the hillside site. Associates at this site included *Acer sacharinum*, *Amphicarpaea bracteata*, *Celtis occidentalis*, *Cinna arundinacea*, *Fraxinus americana*, *Glechoma hederacea*, *Leersia virginica*, *Quercus imbricaria*, *Rubackia laciniata* var. *laciniata*, *Symphyotrichum* sp., and *Toxicodendron radicans*. The soil type for this location is identical to the description for the *Quercus alba* hillside (Dennis Meinert, Missouri DNR unpub. report, 2009) but the site appears within the Loutre River floodplain. All extant and historic locations of RBC at Graham Cave State Park are depicted in Map 1. Soils of historic locations of *Trifolium stoloniferum* at Graham Cave State Park have been defined as consisting of a coarse and loamy Kaintuck soil formed in alluvium of low floodplains and riverfront forests (Dennis Meinert, Missouri DNR unpub. report, 2009).



Map 1. Historic, pre-2017, and 2017 extant populations of *Trifolium stoloniferum* at Graham Cave State Park. Map provided by Bruce Schuette.

Field identification of sterile specimens of *Trifolium stoloniferum* can be extremely challenging, especially in separating this species from *Trifolium repens*. There are, however, field characters that can be used to distinguish the two species (Table 1). While the leaflets of *T. repens* often have noticeable chevron markings, many populations of this species lack this field mark. This character is also often hard to see when the leaflets are covered with mildew. Additionally, mildew can be present on leaflets of *T. stoloniferum* and can be mistaken as chevrons on the leaflets of some populations of *T. repens*. Some individuals use leaflet shape and size to distinguish *T. stoloniferum* from *T. repens* but we have found this to be an unreliable field mark due to the variation in leaflet shape and size of *T. stoloniferum*. Some of the larger, healthier populations of RBC have large leaflets but depauperate specimens of *T. stoloniferum* can have small leaflets that are amazingly close in size to leaflets of *T. repens*, especially those that lack the chevron markings typical of that species (Figure 5). While both species have stolons, leaves of *T. stoloniferum* are clumped forming “rooted crowns” and are often more scattered and less dense along the stolon than those of *T. repens* (Figure 6). The stolons of *T. stoloniferum* are often stouter than those of *T. repens* and there is often noticeable breakage or even dead stolons between rooted crowns (Figures 6, 7). The rooted nodes along the stolon of *T. repens* are often more numerous and most of the stolons remain intact, unbroken, and alive between plants (Figure 6). Additionally, the leaves arise singularly from the stolon on *T. repens*

rather than the often clumped arrangement on *T. stoloniferum*. Another main difference between the two species is the conspicuous pointed stipule that is at the base of leaf clump of *T. stoloniferum* that is perpendicular to the stolon (Figure 7). In *T. repens*, the stipules are membranous, inconspicuous, and are parallel to it (Figure 8). This condition can give the impression that the species lacks stipules (see Yatskievych 2013: plate 410, p. 155).

Table 1. Field characters to distinguish sterile material of *Trifolium stoloniferum* from *T. repens*.

SPECIES	PRESENCE OF CHEVRONS ON LEAFLETS	LEAF ARRANGEMENT	NUMBER OF NODES PER STOLON	STOLON CONDITION	STIPULE
<i>T. stoloniferum</i>	Absent	Leaves clumped, forming rooted crowns at nodes	Scattered	Stout and sometimes detached or dead	Long, pointed, and perpendicular to stolon
<i>T. repens</i>	Present or absent	Leaves singular on long pedicels	Numerous and more regularly spaced	Weak, alive and persistent	Inconspicuous, membranous; parallel to and enveloping the stolon

Given the known low seed production of *Trifolium stoloniferum* in Missouri (pers. obs. of authors and Newbold et al.), it is unknown what dispersal mechanism established RBC in these upland sites (see Map 1). It is possible that dispersal occurred via white-tailed deer (*Odocoileus virginianus*), eastern cottontail rabbit (*Sylvilagus floridanus*), or was human assisted.

The discovery of *Trifolium stoloniferum* at two upland sites in central Missouri increases the possibility that undiscovered sites of this species are yet to be found in Missouri. McKenzie and Newbold (2015) recommended surveying for this species on bottomland sites and in riparian corridors. These suggestions led to a survey by a well-qualified botanist in the late spring and early summer of 2016 in northcentral and northeastern Missouri. This survey failed to yield additional sites of RBC in Missouri (Newbold, pers. comm. 2017). We recommend that botanists search for *T. stoloniferum* along game trails, hiking trails, ATV trails, rights-of-ways and other disturbed areas in upland sites, despite the fact that most recent discoveries of RBC in Missouri have been by happenstance. Due to the short flowering period (typically early May-early June) of RBC, we also recommend searching when the species is in sterile condition. With practice and knowledge of the field marks noted above, *T. stoloniferum* can be separated from populations of *T. repens* that lack the characteristic chevrons on leaflets.

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FIGURES

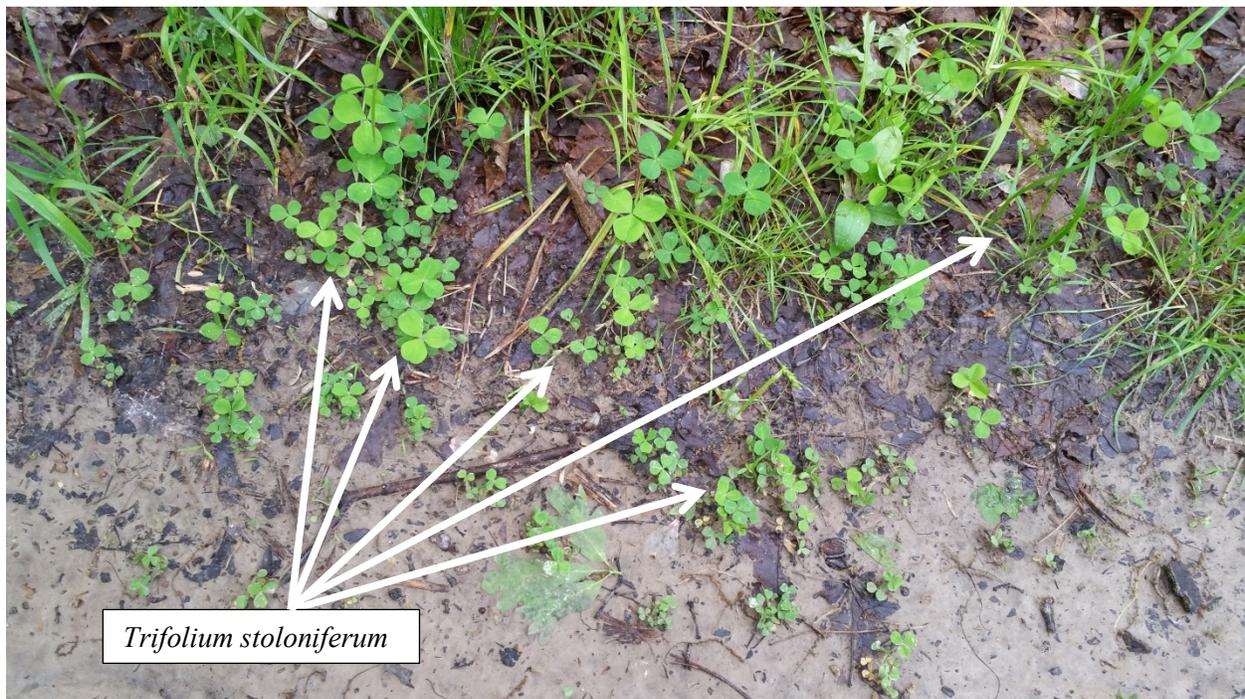


Figure 1. *Trifolium stoloniferum*, near mouth of Graham Cave, Graham Cave State Park, 4 May 2017. Photo by Paul McKenzie.

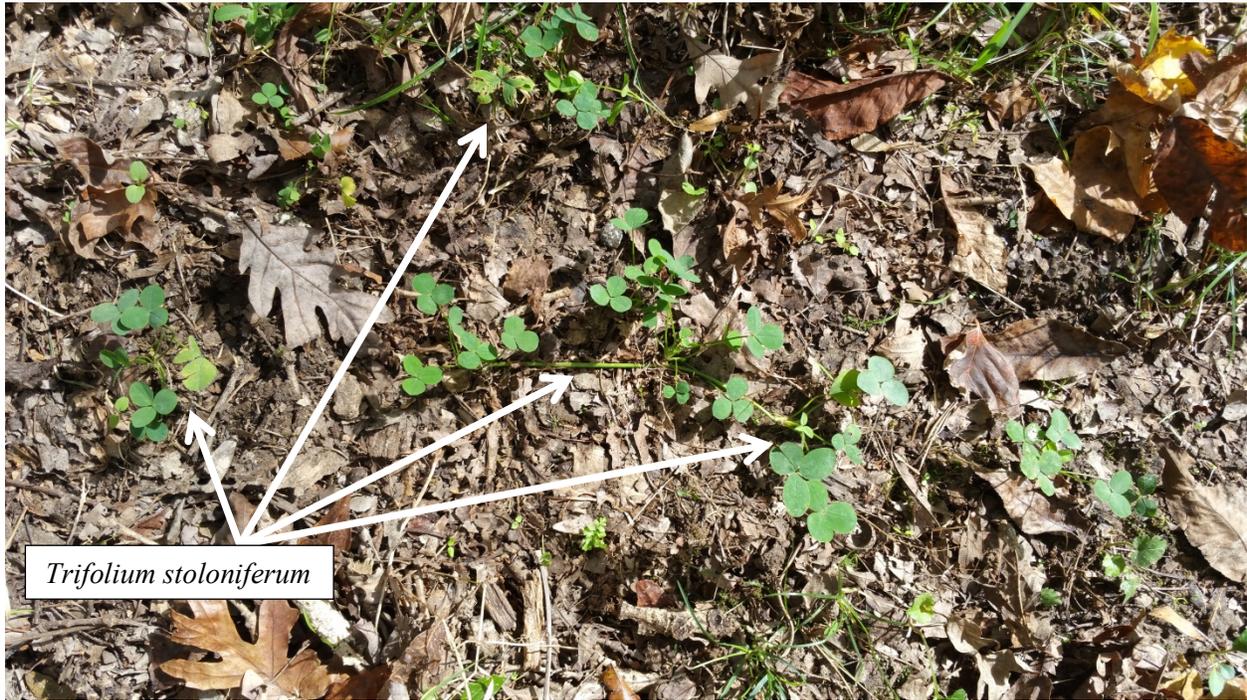


Figure 2. *Trifolium stoloniferum*, along hiking trail near campground, Graham Cave State Park, 20 October 2017. Photo by Paul McKenzie.



Figure 3. Overall habit of upland site for *Trifolium stoloniferum* in *Quercus alba* forest, near campground, Graham Cave State Park, 24 October 2017. Photo by Bruce Schuette.



Figure 4. *Trifolium stoloniferum*, along hiking trail paralleling the Loutre River, Graham Cave State Park, 24 October 2017. Photo by Paul McKenzie.

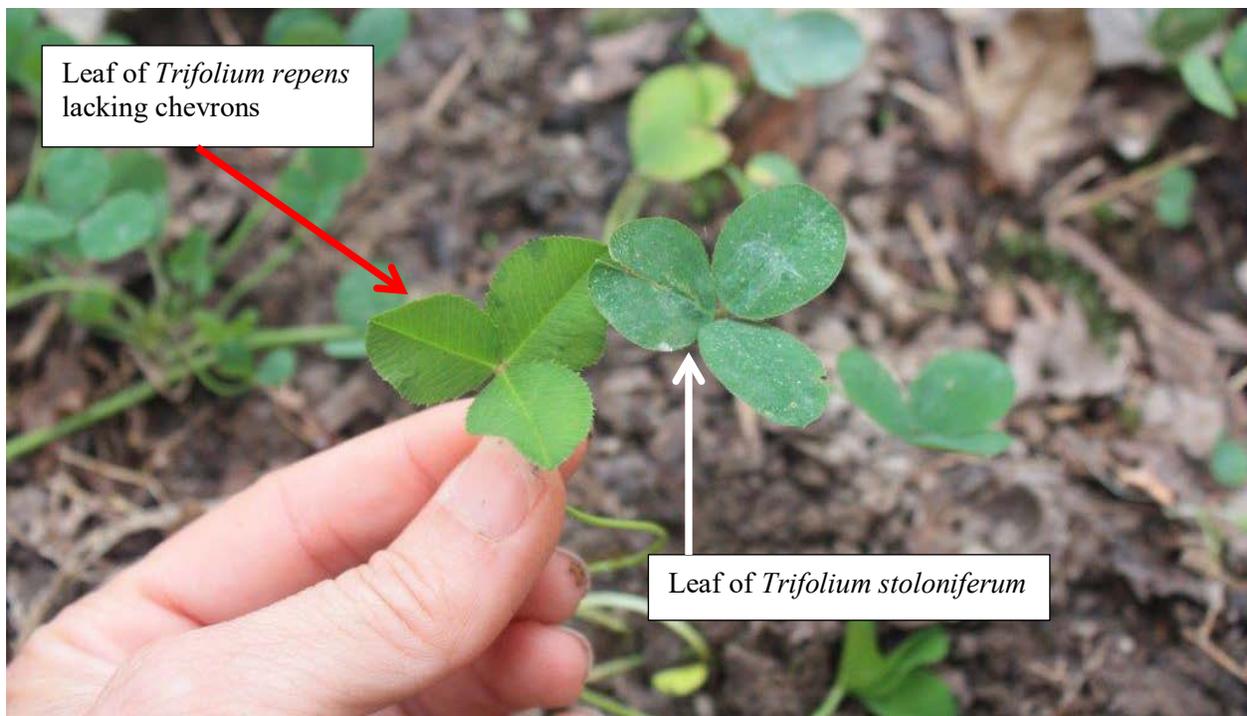


Figure 5. Similarity of leaf shape of *Trifolium repens* leaf lacking chevrons (left) and *Trifolium stoloniferum* (right). Graham Cave State Park, 2 November 2017. Photo by Lorie Volenberg.

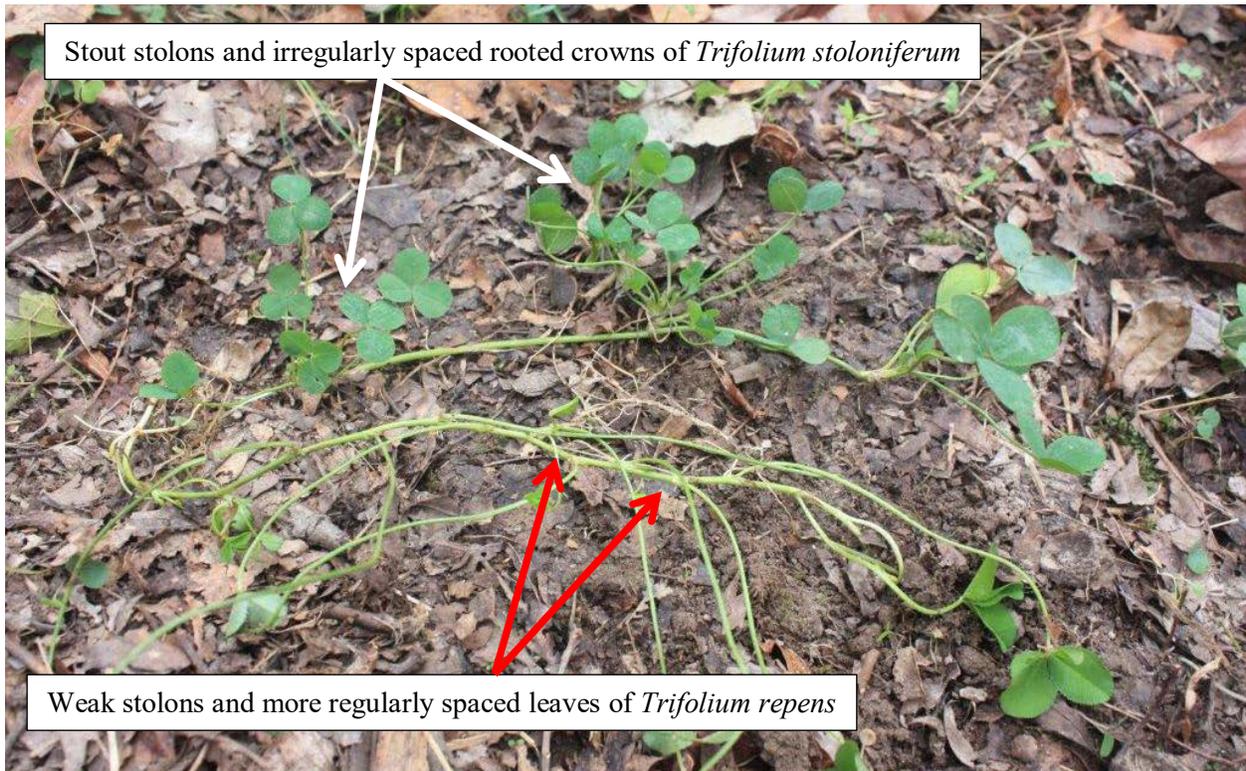


Figure 6. Side by side comparison of *Trifolium stoloniferum* (upper) and *T. repens* (lower), Graham Cave State Park, 2 November 2017. Photo by Lorie Volenberg.

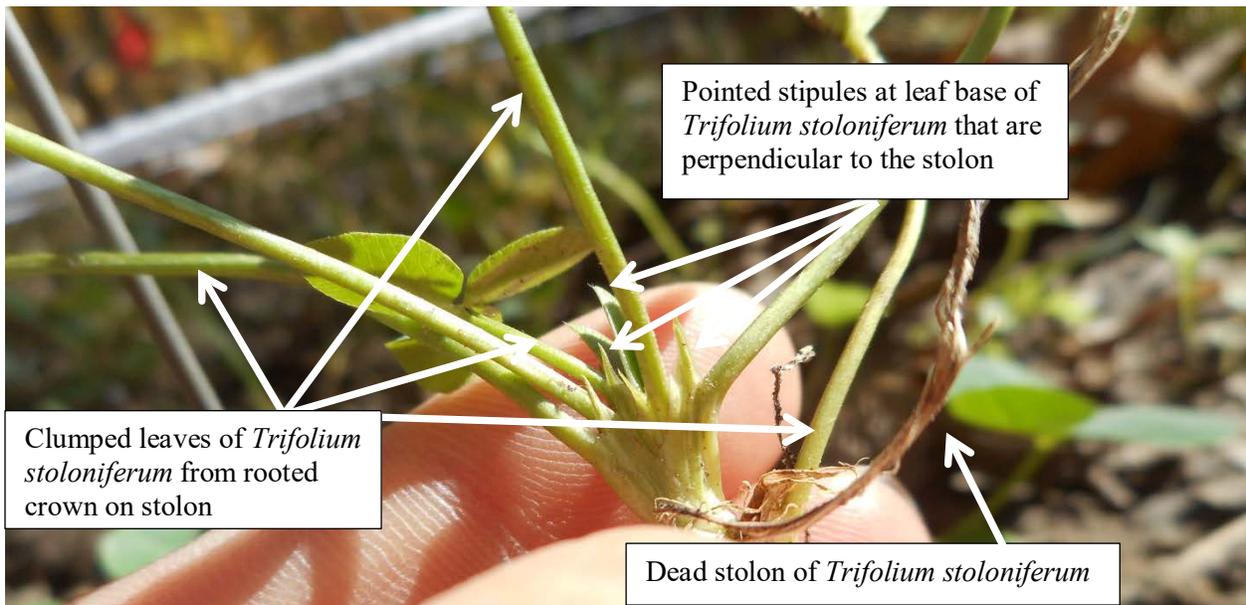


Figure 7. Stipules at leaf bases, clumped leaf arrangement, and dead stolon of *Trifolium stoloniferum*. Graham Cave State Park, 2 November 2017. Photo by Lorie Volenberg.

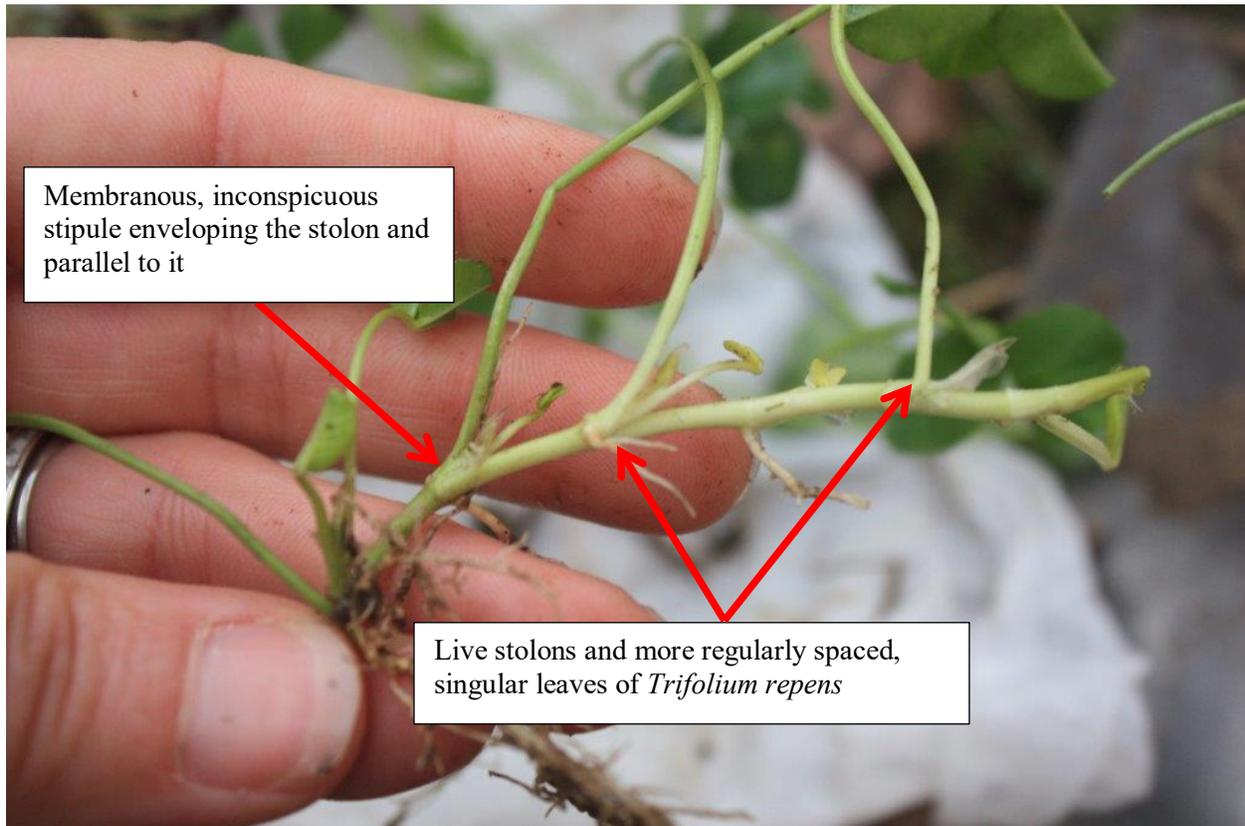


Figure 8. More regularly spaced leaves of *Trifolium repens*. Note inconspicuous, membranous stipule enveloping the stolon and parallel to it. Graham Cave State Park, 2 November 2017. Photo by Lorie Volenberg.