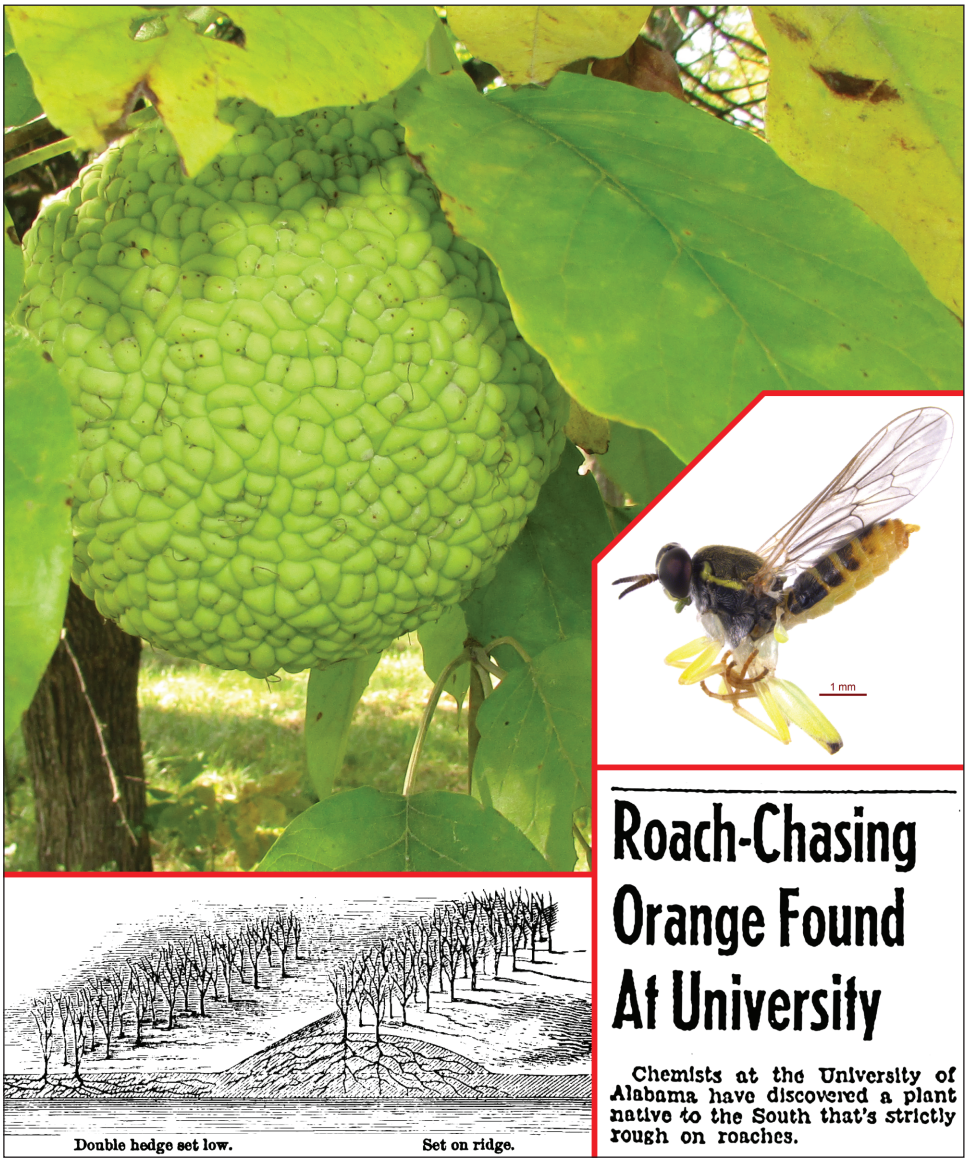
A Cultural and Entomological Review of the Osage Orange (*Maclura pomifera* (Raf.) Schneid.) (Moraceae) and the Origin and Early Spread of "Hedge Apple" Folklore



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Front Cover: Clockwise from top: Fruit ("hedge apple") of the Osage Orange (*Maclura pomifera*) (photograph © Michael Ferro); *Solva pallipes* fly reared from a hedge apple (photograph © Michael Ferro); article from the 30 October 1950 edition of the Tuscaloosa News that seemed to originate much of the folklore surrounding the Osage Orange; and illustration of suggested Osage Orange hedgerow planting configurations (taken from USDA Report of the Commissioner of Agriculture for the year 1868).

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A Cultural and Entomological Review of the Osage Orange (*Maclura pomifera* (Raf.) Schneid.) (Moraceae) and the Origin and Early Spread of "Hedge Apple" Folklore

Michael L. Ferro*

Abstract - *Maclura pomifera* (Osage Orange) is a singular tree with an extraordinary history. It was discussed by presidents, part of two national "manias", helped open up parts of the Midwest to early settlers, and was the subject of enduring entomological folklore ("a single fruit, known as a hedge apple, will drive cockroaches from a room within hours and keep them away for months"). The origin and early spread of the folklore have been discovered. A complete list of all arthropods (54 spp.) known to be associated with the tree is provided. Only a single insect species, *Solva pallipes* (Loew) (Diptera: Xylomyidae), had been previously reported from the fruit, but herein an additional 30 species from a survey of hedge apples from Missouri, Arkansas, and Louisiana are reported. Possible future applications of hedge apples, including the rearing of *S. pallipes* for entomophagy, supplemental nourishment for livestock, and/or biodiesel, are discussed.

"Outstanding Tree: not particularly outstanding"
Gilman and Watson (1994)

Introduction

Maclura pomifera (Raf.) Schneid. (Moraceae), most commonly called Osage Orange, has accumulated numerous common names: American Breadfruit, Bodark, Bodock, Bois d'arc, Bois Jaune, Bowdock, Bowdark, Bow-wood, Geelhout, Hedge, Hedge Apple, Horse Apple, Kansas Orange, Maclura, Mock Orange, Naranjo Chino, Osage, Osage Apple, Osage Plum, Osage Thorn, Palo de Arco, Prairie Hedgeplant, Rootwood, Wood of the Bow, and Yellow Wood (Conrad 1992, Gerwulf 2004, Starcraft 2013, Tarpley 2010, USDA 1869, Wynia 2011). See Austin (2004) for an additional 17 names, many in Native American languages, and USDA (2013) for eight more names in foreign languages. Synonyms include *Ioxylon pomiferum* Rafinesque, *Toxylon pomiferum* Rafinesque, *Joxylon pomiferum* Rafinesque, and *Maclura aurantiaca* Nuttall; see Smith and Perino (1981) for a complete list. The tree may be responsible for the name Ozark, which is probably a corruption of the French *Aux arcs*, a trading post so named because many *Bois d'arc* grew nearby (Barnett and Burton 1997, McKelvey 1955, Steyermark 1963, but see Brunvand 1996 for two possible alternative origins).

The Osage Orange belongs to the mulberry family (Moraceae), which also includes *Artocarpus altilis* (Parkinson) Fosberg (Breadfruit) and *Ficus* spp. (figs). It

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was once widespread in eastern North America, growing as far north as southern Canada (Barlow 2001, Schambach 2000). By the time of European exploration, it was restricted to the Red River drainage of Arkansas, Oklahoma, and Texas, and possibly small portions of Kansas, Louisiana, and Missouri (Barnett and Burton 1997, Diggs et al. 1999, Smith and Perino 1981, Weniger 1996). Osage Orange is a pioneer species with stout aposematically colored thorns on the lower branches (Rubino and McCarthy 2004), but higher branches may be unarmed and are used to create thornless cultivars (Pair 1992). The tree can be shaded out by climax species (Smith and Perino 1981), but naturally occurred in rare, pure stands called "bodark swamps" (Burton 1990). Osage Orange is remarkably hearty, but is host to two species of mistletoe (*Phoradendron serotinum* (Raf) M.C. Johnst. and *P. tomentosum* (Lam.) Griseb.; Burton 1990), and contracts several diseases, especially *Phymatotrichopsis omnivora* (Duggar) Hennebert (Cotton [Texas] Root Rot; Pezizales: Rhizinaceae); therefore it is not recommended for use in the root-rot-belt of Texas and Oklahoma (see Hepting 1971 for a complete list of diseases). The national champion Osage Orange is on the grounds of Patrick Henry's last home in Brookneal, VA, well out of its "native" range. The tree is approximately 300 years old, with a height of 18 m (60 ft), a spread of 26 m (85 ft), and a girth of 815 cm (321 in) (Hugo 2003).

Osage Orange fruit (Fig. 1), most commonly called hedge apples, are also known as green brains, hedge balls, horse apples, Irish snowballs, or monkey

Figure 1. Fully grown fruit of the Osage Orange, often referred to as a hedge apple.

balls (Ring 2006). The anachronistic fruits may be the result of coevolution with megafaunal seed dispersers (e.g., mammoths, giant ground sloths, etc.) and the reduced range of the tree may be the result of recent megafaunal extinctions (Barlow 2001, Brounaugh 2010, Donlan et al. 2006, Janzen and Martin 1981, Johnson 2009). Osage Orange is dioecious, and female trees produce a copious amount of fruit beginning at about 10 years of age. While no adequately referenced estimation of fruit production by the tree could be found, one author placed it at 450 kg (1000 lbs) per tree (Lipscomb 1992). Fruits are very large, 8–12 cm (~4 in) in diameter, average 450 g (1 lb) in weight (Smith and Perino 1981), and are bright green with a distinctive reticulated exterior. Intrigued by the smell, Queen Victoria is said to have tasted a hedge apple shown to her by William Hooker (Meehan et al. 1900). Horses, cattle, deer, squirrels, foxes, *Loxia curvirostra* L. (Red Crossbill), and *Colinus virginianus* (L.) (Bobwhite Quail) have been reported to eat the fruit (Carey 1994, Sternberg and Wilson 1995).

European Discovery

Osage Orange wood was highly prized for use as bows and clubs by Native Americans (see Austin [2004] for a detailed description of the tribes and trading practices) and may have been monopolized by a single tribe (Spiroan trader hypothesis; Schambach 2000), or not (Bruseth et al. 1995). Three expeditions sent by Thomas Jefferson to explore the west reported finding Osage Orange: the Dunbar and Hunter 1804 expedition into Arkansas, the Lewis and Clark 1804 expedition up the Mississippi, and the Freeman and Curtis 1806 expedition up the Red River (Barnett and Burton 1997, McKelvey 1955). In 1804 and 1807, Meriwether Lewis obtained cuttings of Osage Orange from plants cultivated by Pierre Chouteau in St. Louis, MO, and sent them to President Jefferson for propagation (Barnett and Burton 1997, Lawrence 1978). Those plants died soon after arrival (Smithsonian 2004) or are still alive today (Rogers 2009). The potential to use Osage Orange to create hedge fences was recognized by Dunbar and Hunter who recommended it to President Jefferson for that purpose (Smith and Perino 1981).

Everlasting Fence

Lack of adequate fences in the western plains was the "leak which prevents the filling up of our cup of bliss …" and the "… 'fretting leprosy' of the land". (Meredith 1951). Fencing was expensive; it cost 2–3 times the original cost of the land, had a higher value than the livestock, and in 1860 was considered the "greatest single form of capital investment in the country." (Danhof 1944). Fences were essential to protect crops not just from livestock but from the "land-shark" feral hogs (Lewis 1941).

Starting in the 1840s, Osage Orange was heavily promoted for use in hedge fences (e.g., Gage 1855), first by John S. Wright in the interest of growing the general economy and later by Johnathan B. Turner, who wished to establish public schools in Illinois (Barnett and Burton 1997, Sand 1991). Schools required sedentary

communities, which required good fences; see Lewis (1941) for a detailed history. Turner was convinced that "God designed Osage Orange especially for the purpose of fencing the prairies" (Sand 1991, Smith and Perino 1981). With the assurance that Osage Orange could grow a fence that was "horse high, hog tight, and bull strong" (Meredith 1951) "hedge mania" began, lasting from 1850 until the invention of barbed wire in 1874–1875 (Barnett and Burton 1997, Danhof 1944, Winberry 1979). Hedge fences of Osage Orange were approved as legal fences in some states (Missouri in 1869 for example; Beilmann 1938) and an industry of nurseries, seeds, seedlings, shippers, and planters spread across the South and Midwest (Barnett and Burton 1997, Danhof 1944, Winberry 1979). In 1855, 14,000 km (9000 mi) of hedges were planted in Iowa (Winberry 1979), and an estimated 300 million seeds, resulting in nearly 100,000 km (60,000 mi) of Osage Orange hedge, were expected to be planted in the US in 1869 (USDA 1869). Osage Orange hedges were planted as far away as Hawaii, where the only known hedge row has been recommended for removal (Starr et al. 2003), and Australia, where a newly discovered hedge row is considered a "significant historic heritage item" (Pickard 2006).

Some consider Osage Orange to be as important as the railroad, steel plow, and water-pumping windmill for the settlement of the Midwestern grasslands by European descendants (Barnett and Burton 1997). Reports and leaflets with detailed instructions on establishment and care of Osage Orange hedges were issued by the United States Government (Bonner and Ferguson 1974, Pinchot 1907, USDA 1869). However, in practice the "everlasting fence" (Downing 1847) required protection during establishment, was occasionally killed by harsh winters, and required yearly maintenance such as pegging down, pleaching, and plashing (Meredith 1951, Smith 1855, USDA 1869). Ultimately the cultural requirements of maintaining a hedge fence were seen as too great by many, and the mania subsided (Danhof 1944, Smith 1858: "Bad hedges are a nuisance to the eye, to the pocket, and to any farmer's crops.").

After the invention of barbed wire (inspired by Osage Orange thorns, as folklore has it; Conrad 1992), Osage Orange hedges were still planted and maintained as windbreaks, habitat for wildlife, and a source of fence posts (Austin 2004, Bates 1911, Harmon 1948). In the early 1900s, Osage Orange was one of the trees used in the US government program for afforestation of the sand hills region of Nebraska and Kansas (Bates and Pierce 1913). In 1934, because of the drought, dust storms, and depression, President Franklin Roosevelt established the Great Plains Shelterbelt (aka Prairie States Forestry Project) to create windbreaks and provide protection for crops on the Great Plains (Stoeckeler and Williams 1949). Osage Orange was greatly used in that project—more than 40% of all shelter belts planted in Kansas from 1865–1939 consisted of Osage Orange (63,400 km [39,400 mi]). After World War II, availability of bulldozers made removal of hedgerows and expansion of fields easier; however, the practice was not always seen as positive (Harmon 1948, McGraw and Davidson 1942, Steavenson et al. 1943). Post-war uses of the tree include urban planting, since it is rarely damaged by wind, drought, disease, ice, or pollution (Barnett and Burton 1997, Rhoads et al. 1980, Sternberg and Wilson 1995), and coal mine reclamation (Ashby and Kolar 1977, Vogel 1981).

Additional Uses

The wood of Osage Orange is extremely dense, strong, and reportedly the most decay-resistant wood in North America (Barnett and Burton 1997, Burton 1990, Cochran 1896: the wood was said to last "twenty years longer than rock"). It has been used to make artificial limbs, bows, bridge pilings, coopers wares, county boundary markers, foundation blocks, game calls, gates, grave markers, house blocks, insulator pins, machinery parts, mine timbers, police maces, parquet flooring, pulley blocks, smoking pipes, street paving blocks, telephone poles, and tree nails (Austin 2004, Beilmann 1938, Conrad 1992, Sand 1991, Smith and Perino 1981). Native Americans made cords with the fibers, made the roots into eyewash, made dye with the stem and bark of the roots (Austin 2004), and used juice from the fruit as an adhesive for war paint (McHargue 1915, Meehan et al. 1900). The fruit may have been consumed by Native Americans (Austin 2004) and freed slaves after the Civil War (presumably out of desperation; Meehan et al. 1900). Osage Orange was used by Charles Goodnight to make the first chuck wagon (Sand 1991) and was in great demand for rims, hubs, and spokes of wagon wheels before metal wheels were common (Barnett and Burton 1997, Smith and Perino 1981). It was also used for railroad ties and is still valued for fence posts. A single-row hedge produces about 6400 posts/km (4000/mi), and the posts are good for 40–60 years (Harmon 1948, Sand 1991). Osage Orange leaves were promoted as an alternative food source for *Bombyx mori* (L.) (Silkworm; Bombycidae) during the "silk mania" of the 1840s (Lewis 1941), and endorsed by many, including C.V. Riley, during the next silk mania of the 1880s (Davidson 1882), but, sadly, the resultant silk was deemed substandard (Bergmann 1940).

The biochemical attributes of Osage Orange have been well studied. Smith and Perino (1981) list 44 secondary constituents isolated from Osage Orange at the time of their review (see also McHargue 1915, Rowe and Conner 1979). The seed oil possesses appropriate qualities to be used as biodiesel fuel (Saloua et al. 2010) and in commercial applications such as cosmetic, pharmaceutical, and food products (Beal and Wenzel 1951, Saloua et al. 2009). The company Osage Health Care is currently trying to produce hair care products using oil and extract from Osage Orange seeds (Troute 2013). Yellow dye, called aurantine, was made from Osage Orange and used during World War I as a substitute for fustic (Matos 1916). Other pigments were also isolated, but all have been replaced by synthetic dyes (Smith and Perino 1981; Wolfrom et al. 1963, 1964).

The Osage Orange's resistance to insect attack has been the subject of much study. The extraordinary termite- and decay-resistance of the wood is probably provided by the antifungal agent oxyresveratrol (2,3',4,5'-tetrahydroxystilbene; Barnes and Gerber 1955, Rowe and Conner 1979). Osage Orange and *Taxodium distichum* (L.) Rich. (Bald Cypress; Cupressaceae) are the only two trees native to the temperate zone of North America with termite-resistant wood (Wolcott 1955). Wolcott (1953, 1957), using *Cryptotermes brevis* (Walker) (Isoptera: Kalotermitidae), gave Osage Orange wood a termite-resistance rating of 90 (or 92) out of 100. Root bark

contains macluroxanthone, osajaxanthone, and alvaxanthone, substances toxic to goldfish and mosquito larvae (Rowe and Conner 1979, Smith and Perino 1981).

General surveys have been made of the chemical constituents of hedge apples (Beal and Wenzel 1951, McHargue 1915), which were found to have antioxidant properties and contain a cardiac-active principle (Smith and Perino 1981, Waud et al. 1949). The chemicals Osajin and Pomiferin are responsible for antimicrobial activity in the fruit (Mahmoud 1981). Hedge apples have been rumored to be poisonous to farm animals, but feeding fruit to horses, cattle, and chickens and injection of fruit juice into guinea pigs, rabbits, and pigeons failed to produce toxic symptoms (Johnson et al. 1935).

Hedge apples have been tested for insect-repellent properties (Karr and Coats 1991). In a choice-box bioassay, with chambers separated by 20 cm (8 in), they tested repellency using *Blattella germanica* (L.) (German Cockroach). Repellency at concentrations of 10 and 100 ppm of raw fruit was no different from control tests, but at 1000 ppm it repelled 89% of individuals. Concentrations were expressed based on µg of material per cm^3 of the treated chamber, but in human-scale units, a cubic room 3 m (9 ft) to a side would require 27 kg (60 lbs) of hedge apples to achieve 1000 ppm concentration. In the same study, 94% of cockroaches were repelled from the treated chamber using pyrethrins at a rate of 10 ppm.

Studies of the repellent properties of fruit extracts have been conducted. The antimicrobial compounds osajin and pomiferin were purified from hedge apples and tested against *Sitophilus zeamais* Motschulsky (Maize Weevil; Coleoptera: Curculionidae). Neither showed repellent properties, but the weevil was repelled by methylene chloride extracts of the fruit (Peterson et al. 2000). Peterson et al. (2002) tested repellency of numerous extracts from hedge apples against *B. germanica.* Cockroaches were placed in a 12.5-cm (5-in)-diameter petri dish for 5 minutes and the time spent on treated and untreated sides was recorded. Several extracts were significantly repellent, the highest of which was hydrodistillate at 56.8%. Choice tests using various distillates and half or whole fruits over a distance of 40 cm (16 in) were conducted and showed some repellency, but none were as good as DEET (Ufkes and Grams 2007). Elemol, a component of hedge apple essential oil, was tested against *Culex pipiens* L. (Northern House Mosquito; Diptera: Culicidae) and had contact and residual repellency comparable with DEET over the three-hour test period (Schultz et al. 2006).

Hedge Apple Folklore

According to folklore, placing one hedge apple in a room will, within hours, drive all the pests from the room. The list of pests includes "roaches and water bugs" (St. Petersburg Times 1950a), "cockroaches, crickets, spiders, fleas, box elder bugs, and ants" (Ball 2000, Borecki 2002, Starcraft 2013), silverfish (Ring 2006), "Asian lady beetles" (Gerwulf 2004), mice (Jauron 1997), and even skunks and armadillos (Tarpley 2010). Based on testimonials submitted to the website www.hedgeapple.com (accessed 14 February 2014), a few hedge apples placed around a house will rid it of just about any animal pest imaginable and keep the

pests away for months. Sadly, no comment is given concerning their effectiveness at repelling politicians or telemarketers.

Despite the claims that "pioneers" or "settlers" used Osage Orange fruit to repel pests (Baumgardt 1972, Conrad 1992, Khater 2012, Pair 1992, Peterson and Coats 2001, Peterson et al. 2000, Sand 1991, Schultz et al. 2006), no report of such use could be found. Writing in 1804 to Thomas Jefferson, Meriwether Lewis stated, "An opinion prevails among the Osages, that the fruit is poisonous, tho' they acknowledge that they have never tasted it." However, he gave no indication that the fruit contained further repellent properties (Smithsonian 2004). During the Long Expedition, James (1823:333; also, see Woodman 2010) reported using hedge apple juice as a mechanical barrier (not a repellent) for protection from ticks:

> "The bark, fruit, &c. when cut into, exude a copious, milky sap, which soon dries on exposure, and is insoluble in water; containing, probably, like the milky pieces of many other of the urticae, a large intermixture of caotchouc, or gum elastic. Observing this property in the milky juice of the fruit, we were tempted to apply it to our skin, where it formed a thin and flexible varnish, affording us, as we thought, some protection from the ticks."

Nuttall (1865) gave a detailed description of the fruit and commented on its taste ("sweetish but insipid", "somewhat acrid") but mentioned no other use for it. Prior to 1950, publications promoting the tree or summarizing its use specifically mention the fruit, but make no mention of using the fruit to repel pests (Beilmann 1938, Downing 1847, Gage 1855, Harmon 1948, James 1823, McGraw and Davidson 1942, McHargue 1915, Osborne 1918, Pinchot 1907, Rogers 1917, USDA 1869). Tarpley (2010:187) attributes a quote about use of distillates from the fruit as an insect repellent to Cain (1944). The quote could not be found in Cain (1944), and the citation appears to be in error. Austin (2004), writing about the ethnobotanical uses of the tree, doesn't report any uses of the fruit as a pest repellent, except a reiteration of Peattie (1953), which is based on ideas of a recent origin (see below).

Folklore origin

The folklore of the extraordinary pest-repellent properties of Osage Orange fruit appears to have been born during October 1950. An article entitled "Roach-Chasing Orange Found At University" was published in the Tuscaloosa News (1950) (Appendix 1) on 30 October and versions of the article, syndicated by both the United Press and International News Syndicate, were published around the country from 29 October 1950 until at least 26 January 1951 (syndicated versions can be published before originals). Newspaper articles appeared in Alabama (Anniston Star 1950, Cullman Democrat 1950), Florida (St. Petersburg Times 1950a, b), Illinois (Edwardsville Intelligencer 1950), Indiana (Kokomo Tribune 1950), New York (Times Herald 1950, Troy Record 1950), Pennsylvania (Kane Republican 1950, Reading Eagle 1951), Texas (Lubbock Avalanche-Journal 1950, Baytown Sun 1950, Valley Morning Star 1951), and West Virginia (Charleston Daily Mail 1950), and probably many others. The magazine Newsweek (1950) also published a short article announcing the discovery.

The Tuscaloosa News (1950) reported that a chemist at the University of Alabama, George Toffel, claimed that a single Osage Orange fruit placed in a room would drive "roaches and water bugs" from the room within a few hours and that Toffel and his students were working to isolate the chemical that was responsible. As a result of the original and syndicated articles, Toffel reportedly received hundreds of letters from concerned homeowners (Tuscaloosa News 1951). A follow-up article two years after the original announcement, and the last known reference to Toffel's work with Osage Orange, stated: "He has satisfactorily isolated the repellent but has found that he is unable to keep the material active for over a period of six months." (Tuscaloosa News 1952).

George Mathias Toffel (28 January 1911–6 June 1993) was a professor of chemistry at the University of Alabama beginning in 1946 (Toffel 1995). Toffel was a gifted lecturer (Butler 1972) and was fondly remembered by students and family members (Smpctryphys 2007, 2008). Toffel was a pioneer in science education on TV and presented chemistry lessons on a television show called *Chemistry Can Be Fun* for the Alabama Educational Television System (Smpctryphys 2007, Tuscaloosa News 1957). The Director of the television sitcom *Seinfeld*, Tom Cherones, got his first job in television working on that show (UA News 2001).

Toffel was apparently an excellent chemist, and later tests have shown that Osage Orange fruit does have some limited insect-repellent qualities. However, his overzealous assertions may have resulted from a classic type-I error—mistaking correlation with causation; the fruit is only available in the fall (the announcement of his finding was published in late October) and only stays fresh through the winter ("But use only the fresh fruit, he warned." [Tuscaloosa News 1950]), at a time when pest insects are less frequently encountered.

The only known report of using hedge apples as a repellent of cockroaches, possibly prior to 1950, comes from Beal (1990). In a published acceptance speech for receiving the Distinguished Economic Botanist award for 1989, Jack Lewis Beal (1923–1998) states, "My grandfather had told me the story of how pieces of the fruit of the hedge-apple tree, *Malura* [sic] *pomifera*, could keep cockroaches away. So during my senior year I set about determining if this was true." Beal is referring to his senior year as an undergraduate in college, presumably 1949 or 1950, because he started graduate school in 1950 (ArchiveGrid 2014). It is entirely possible that the grandfather learned about repellent hedge apples from one of the many newspaper articles or from the Newsweek article announcing Toffel's discovery, and passed the news on to Beal. The proximity of the 1950 articles and the grandfather's "story" indicates the real possibility that they are causally related. Beal's collected papers are available at The Ohio State University and may shed some light on this sub-mystery #1 (ArchiveGrid 2014).

Folklore growth and development

After its birth in 1950, hedge apple folklore grew in at least three different directions (Fig. 2, Appendix 1). The first tendril is convoluted and adds many terms to the folklore. A blurb about the repellent properties of hedge apples appeared in a section called "Notes from a Nurseryman's Wife" in American Nurseryman

(1952). The author commented that the newspaper articles were the first she had heard of the cockroach-repellent properties of hedge apples. Six years later another blurb appeared in Missouri Botanical Garden Bulletin (Missouri 1958). It directly (but incompletely) referenced the American Nurseryman article, and provided the first use of "basement" and "closets" ("Mr. Pring as well as others at the Garden attest that a few hedge apples in the basement and closets have positive results.").

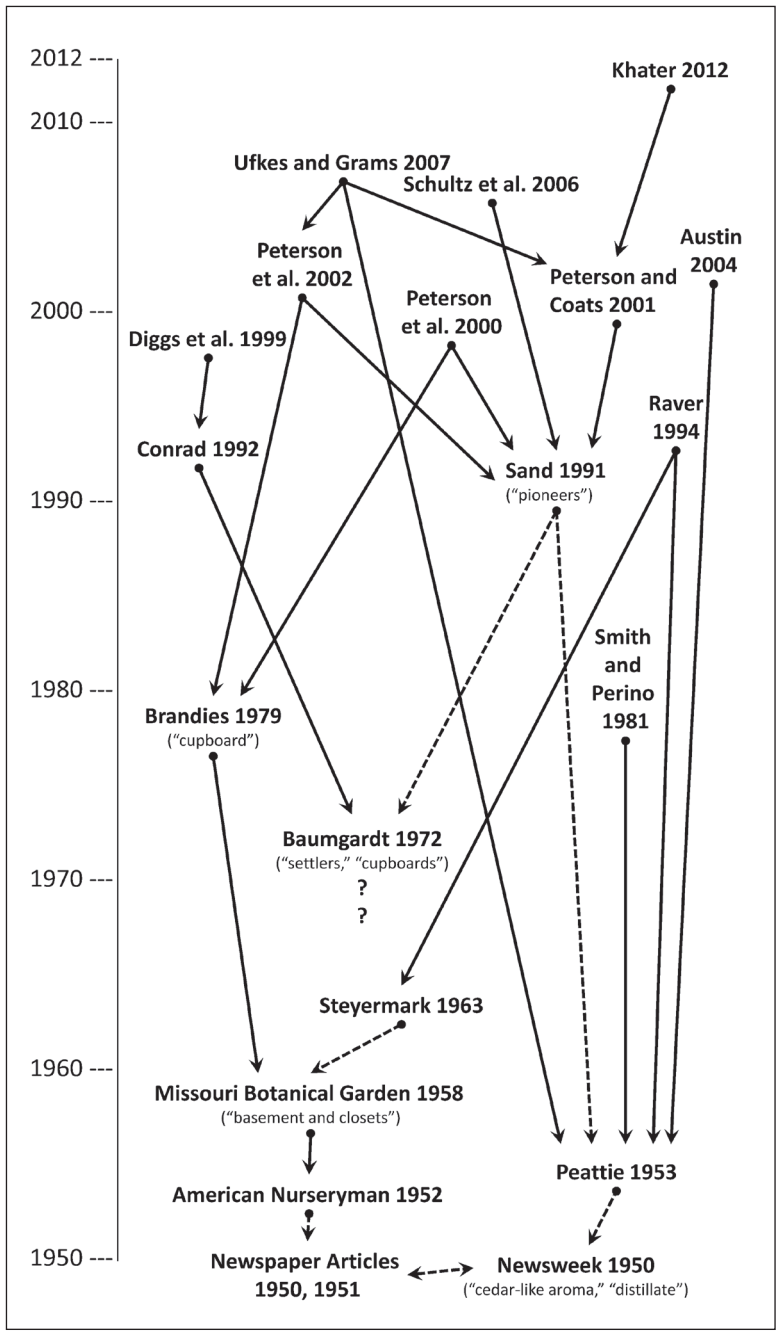


Figure 2. Origin and spread of hedge apple folklore. Solid lines represent specifically referenced relationships and dashed lines represent unreferenced but suspected relationships based on shared specific terminology. Words in parentheses represent terms introduced by the respective source.

Steyermark (1963) repeated "basement" and "closets" and almost certainly based his remarks on the Missouri Botanical Garden article. Brandies (1979) directly (but incompletely) referenced the Missouri Botanical Garden article from 21 years previous, and added the term "cupboards". After another 21+ years, Brandies (1979) was cited by Peterson et al. (2000, 2002).

The second tendril is only slightly more straightforward. Two weeks after the first newspaper articles, Newsweek (1950) ran an independently written article on Toffel's work. That article used the term "cedar-like aroma" and mentioned that an even stronger smelling "distillate" had been procured from the fruit. Anniston Star (1950) featured the Newsweek (1950) article, was the only newspaper to mention it, and appears to be a dead end. Peattie (1953) included information from Newsweek (1950) in his book on western trees. He used the terms "cedar-like aroma" and "distillate". Peattie was in turn cited by Smith and Perino (1981), was almost certainly a source used by Sand (1991) (she repeats "cedarlike aroma" and "stronger smelling distillate"), and was cited by Austin (2004), and Ufkes and Grams (2007). Peattie (1953) and Steyermark (1963) were both cited by Raver (1994), representing a combination of the (near) bases of the two main braches of the folklore (Fig. 2).

The idea of insect-repellent hedge apples in Baumgardt (1972) does not have a clear origin (sub-mystery #2): "The early white settlers depended upon it [Osage Orange] for enclosures, for fuel (it burns like hard coal), dyed their wool with it in lieu of Old World fustic, and kept cockroaches out of their cupboards with the fruits." Despite the scant information, two new terms were introduced: "cupboards" and "settlers". Baumgardt may have combined information from the newspaper article and the account of using hedge apple juice to guard against ticks by James (1823) to create the "settler" idea. There is no indication that Brandies (1979) got "cupboards" from Baumgardt (1972) and the term may have originated independently with both. Baumgardt (1972) is the first to imply that settlers used hedge apples to repel insects and was almost certainly used as a source by Sand (1991), who replaced "settlers" with "pioneers" and repeated "cupboards". Baumgardt (1972) was also (mis-)quoted by Conrad (1992), who in turn was cited by Diggs et al. (1999).

A myriad of websites and newspaper and magazine articles now perpetuate the repellency folklore on the internet and in print using various unreferenced recombinations of the elements above. In a rarely cited article in the Chicago Tribune, Cliff Meloan is quoted: "We found that hedge apples repel crickets. But it kills cockroaches, though not right away" (Phillips 1987). No follow up to this claim could be found, but the ability to kill cockroaches appears to be a new element of the folklore. Many newer articles (e.g., Spreyer 2003) directly or indirectly cited information from a webpage that detailed research by J. Coats and C. Peterson at Iowa State University (Iowa State University 1999). The story announced that new evidence had been found for the repellent properties of hedge apples. While that was technically accurate, there was no evidence that the degree of repellency demonstrated by Coats and Peterson approached that reported in the folklore.

Public Perception and "Evidence Illiteracy"

Only four sources in the literature reviewed provide an assessment of the folklore appropriate to the available evidence (Frazee 2009, Jauron 1997, Ring 2006, Sternberg and Wilson 1995), and the latter offers the best advice: "Folklore holds that the fruits repel roaches, but we suspect they are effective only if they happen to fall directly on one." Most sources presented the folklore as fact (e.g., Sand 1991) or provided a pseudo-balanced assessment of hedge apple repellent properties. For example, Raver (1994) provides seven positive pieces of evidence, including a personal testimonial, but only two cautionary statements ("don't have any double-blind studies", "Scientific information … is remarkably scarce …").

Meehan et al. (1893) used the discovery of the Osage Orange as an example of the practical benefits of "abstract science". I would like to use the spread and persistence of hedge apple folklore as an example of "evidence illiteracy". Individuals that perpetuate these beliefs seem to have a feeble ability to separate appropriate arguments and conclusive evidence from inappropriate arguments and inconclusive evidence (e.g., choice test with controls vs. anecdotal evidence). Within democratic nations, where citizens "steer the ship" through voting, donations, support of causes, etc., it is important that the public have at least a moderate education and a basic critical-thinking skillset. Literacy and mathematical understanding are seen as essential parts of modern society—they are taught in schools and understood to be necessary for the maintenance of our current quality of life. However, acquisition of knowledge and skills are of little use to an individual, or a society, where inappropriate arguments, misleading evidence, and logical fallacies are readily accepted and acted upon. The public needs to be taught not just how to acquire knowledge, but how to judge the quality of that knowledge. A full expansion of these ideas is beyond the scope of this paper.

Insects Associated with Osage Orange

If hedge apple folklore were accurate, Osage Orange would be virtually free of pests. However, a literature search revealed a total of 54 arthropod species that have been found feeding on Osage Orange (Table 1). Of those, 45 species exist within the native/recently expanded North American range, and nine species were found on trees planted well outside the native range, mostly in the Neotropics. No information is available on the frequency of infestation or the extent of damage caused by each species. One species, *Ceratomia hageni* Grote (Hagen's Sphinx; Lepidoptera: Sphingidae), is monophagous on Osage Orange (Robinson et al. 2010). The ant *Camponotus pylartes fraxinicola* M.R. Smith (Hymenoptera: Formicidae) was reported nesting in Osage Orange (Tynes and Hutchins 1964), but is not included in the list in Table 1.

To place the number of insect species associated with Osage Orange into appropriate context, a comparison with several other North American trees was performed using world-wide Lepidoptera (Robinson et al. 2010), Nearctic Buprestidae (Nelson et al. 2008), and Nearctic Cerambycidae (Linsley and Chemsak 1997) (Table 2). Comparable species were picked for a variety of reasons. *Quercus alba* L.

(White Oak; Fagaceae) and *Pinus taeda* L. (Loblolly Pine; Pinaceae) were selected because they are widespread eastern North American trees with a native range that overlaps that of Osage Orange. *Taxodium distichum* (L.) Rich. (Bald Cypress; Cupressaceae) was selected because it is the only other temperate North American tree with termite-resistant wood (Wolcott 1955). *Morus rubra* L. (Red Mulberry; Moraceae) was selected because it is the closest eastern North American relative to

Table 1. Arthropods reported feeding on Osage Orange. Species marked "yes" in the N.A. column are found within the native and expanded North American range of Osage Orange; range of species not found in North America is indicated. NeoT = Neotropical.

	Class/Order/Species	Part	N.A.	Citation
	Arachnida			
	Prostigmata			
	ERIOPHYIDAE			
1	*Tegolophus spongiosus* Styer	Leaves	Yes	Burton 1990, Styer 1975
	Prostigmata			
	TETRANYCHIDAE			
2	*Tetranychus canadensis* (McGregor)	Leaves	Yes	Burton 1990, Johnson and Lyon 1991
	Insecta			
	Hemiptera			
	APHIDIDAE			
3	*Aphis* (*A.*) *fabae* Scopoli	Leaves	Yes	Holman 2009
4	*Myzus* (*Nectarosiphon*) *persicae* (Sulzer)	Leaves	Yes	Holman 2009, Leonard et al. 1970
	COCCIDAE			
5	*Mesolecanium nigrofasciatum* (Pergande)	Twigs	Yes	Burton 1990, Starr et al. 2003
6	*Parthenolecanium corni* (Bouché)	Twigs	Yes	Burton 1990, Smith and Perino 1981, Starr et al. 2003
7	*Pulvinaria innumerabilis* (Rathvon)	Twigs	Yes	Burton 1990, Johnson and Lyon 1991, Starr et al. 2003
8	*Pulvinaria vitis* (Linnaeus)	Twigs	Yes	Cockerell 1893 (as *Pulvinaria maclurae*)
	DIASPIDIDAE			
9	*Abgrallaspis howardi* (Cockerell)	Leaves	Yes	Burke et al 1994; McDaniel 1969, 1974 (as *Hemiberlesia howardi*)
10	*Diaspidiotus ancylus* (Putnam)	Twigs/ Leaves	Yes	Burke et al 1994, McDaniel 1974
11	*Diaspidiotus bumelia* Ferris	Twigs	Yes	Burke et al 1994; McDaniel 1969, 1974
12	*Melanaspis tenebricosa* (Comstock)	Twigs	Yes	Burke et al 1994, McDaniel 1974
13	*Quadraspidiotus juglansregiae* Comstock	Twigs	Yes	Burton 1990, Starr et al. 2003
14	*Quadraspidiotus perniciosus* Comstock	Twigs	Yes	Burton 1990, Smith and Perino 1981, Starr et al. 2003
	Coleoptera			
	BOSTRICHIDAE			
15	*Xylobiops basilaris* (Say)	Wood	Yes	Burton 1990, Starr et al. 2003

Table 1, continued.

	Class/Order/Species	Part	N.A.	Citation
	CERAMBYCIDAE			
16	*Apriona cinerea* Chevrolat	Wood	India	Chatterjee and Thapa 1964, Singh and Prasad 1985
17	*Compsocerus violaceus* (White)	Wood	NeoT	Di Iorio and Farina 2009
18	*Desmiphora hirticollis* (Olivier)	Wood	Yes	Di Iorio and Farina 2009, Machado et al. 2012
19	*Dorcaschema alternatum* (Say)	Wood	Yes	Atkinson, T.H. (University of Texas Insect Collection, Austin, TX, pers. comm.), Burton 1990, Lingafelter 2007, Lingafelter and Horner 1993, Linsley and Chemsak 1997, Starr et al. 2003, Tavakilian and Chevillotte 2013
20	*Dorcaschema wildii* Uhler	Wood	Yes	Burton 1990, Lingafelter 2007, Linsley and Chemsak 1997, Starr et al. 2003, Tavakilian and Chevillotte 2013
21	*Dorcaschema cinereum* (Olivier)	Wood	Yes	Linsley and Chemsak 1997, Tavakilian and Chevillotte 2013
22	*Elaphidionoides parallelus* (Newman)	Wood	Yes	Linsley and Chemsak 1997, Tavakilian and Chevillotte 2013
23	*Elaphidionoides villosus* (Fabricius)	Wood	Yes	Linsley and Chemsak 1997, Tavakilian and Chevillotte 2013
24	*Euderces pini* (Olivier)	Wood	Yes	Giesbert and Chemsak 1997, Linsley and Chemsak 1997, Tavakilian and Chevillotte 2013
25	*Eupogonius pauper* LeConte	Wood	Yes	Linsley and Chemsak 1997, Tavakilian and Chevillotte 2013
26	*Heterachthes flavicornis* (Thomson)	Wood	NeoT	Di Iorio and Farina 2009
27	*Hyperplatys argentinus* (Berg)	Wood	NeoT	Di Iorio and Farina 2009, Machado et al. 2012
28	*Leptostylus transversus* (Gyllenhal)	Wood	Yes	Linsley and Chemsak 1997, Tavakilian and Chevillotte 2013
29	*Megacyllene caryae* (Gahan)	Wood	Yes	Burton 1990; Linsley and Chemsak 1997; Smith and Perino 1981; Starr et al. 2003; Webster and Mally 1897, 1898 (as *Cyllene picta* Drury)
30	*Neoclytus acuminatus acuminatus* (Fabricius)	Wood	Yes	Linsley and Chemsak 1997, Stein and Tagestad 1976, Tavakilian and Chevillotte 2013
31	*Neoclytus ypsilon* Chevrolat	Wood	NeoT	Di Iorio and Farina 2009
32	*Obrium maculatum* (Olivier)	Wood	Yes	Linsley and Chemsak 1997, Tavakilian and Chevillotte 2013
33	*Paromoeocerus barbicornis* (Fabricius)	Wood	NeoT	Di Iorio and Farina 2009
34	*Retrachydes thoracicus* (Olivier)	Wood	NeoT	Di Iorio and Farina 2009
35	*Urgleptes bruchi* (Melzer)	Wood	NeoT	Di Iorio and Farina 2009, Machado et al. 2012
36	*Urgleptes facetus* (Say)	Wood	Yes	Linsley and Chemsak 1997, Tavakilian and Chevillotte 2013

Table 1, continued.

	Class/Order/Species	Part	N.A.	Citation
37	*Prionus imbricornis* (L.)	Wood	Yes	Johnson and Lyon 1991
	CURCULIONIDAE: SCOLYTINAE			
38	*Phloeotribus frontalis* (Olivier)	Wood	Yes	Atkinson, T.H. (pers. comm.)
39	*Phloeotribus liminaris* (Harris)	Wood	Yes	Atkinson, T.H. (pers. comm.)
40	*Liparthrum squamosum* (Blackman)	Wood	Yes	Atkinson and Riley 2013, Blackman 1922, Bright 1968, Deyrup and Atkinson 1987, Wood 1982
41	*Cnesinus strigicollis* LeConte	Wood	Yes	Wood 1982
42	*Hypothenemus seriatus* (Eichhoff)	Wood	Yes	Wood 1982
	Lepidoptera			
	ARCTIIDAE			
43	*Hyphantria cunea* Drury	Leaves	Yes	Burton 1990
	LYMANTRIIDAE			
44	*Lymantria dispar* (Linnaeus)	Leaves	Yes	Robinson et al. 2010
45	*Orgyia leucostigma* (J.E. Smith)	Leaves	Yes	Robinson et al. 2010
	NOCTUIDAE			
46	*Peridroma saucia* Hübner	Leaves	Yes	Robinson et al. 2010
	NYMPHALIDAE			
47	*Marpesia chiron* (Fabricius)	Leaves	NeoT	Robinson et al. 2010
	PSYCHIDAE			
48	*Thyridopteryx ephemeraeformis* (Haworth)	Leaves	Yes	Robinson et al. 2010
	PYRALIDAE			
49	*Sericoplaga externalis* Warren	Leaves	Yes	Robinson et al. 2010
	SATURNIIDAE			
50	*Hyalophora cecropia* (Linnaeus)	Leaves	Yes	Robinson et al. 2010
	SPHINGIDAE			
51	*Ceratomia hageni* Grote	Leaves	Yes	Robinson et al. 2010
	TORTRICIDAE			
52	*Archips argyrospila* (Walker)	Leaves	Yes	Burton 1990, Smith and Perino 1981
53	*Platynota idaeusalis* (Walker)	Leaves	Yes	Robinson et al. 2010
	Diptera			
	XYLOMYIDAE			
54	*Solva pallipes* (Loew)	Fruit	Yes	Downing 1976, Smith and Perino 1981

Table 2. Comparison of phytophagous insect associates among widely distributed eastern North American tree species, including Osage Orange. WO = White Oak, LP = Loblolly Pine, BC = Bald Cypress, RM = Red Mulberry, and OO = Osage Orange.

	WO	LP	BC	RM	OO
Lepidoptera (Robinson et al. 2010)	172	30	21	3	9
Coleoptera: BUPRESTIDAE (Nelson et al. 2008)	27	7	4	0	0
Coleoptera: CERAMBYCIDAE (Linsley and Chemsak 1997)	13	1	6	25	14
Total	212	38	31	28	23

Osage Orange. Osage Orange had the fewest total insect associates (23 spp.), much lower than White oak (212 spp.), but it doesn't appear to have an abnormally low number of associates when compared to Loblolly Pine (38 spp.), Bald Cypress (31 spp.), or Red Mulberry (28 spp.).

The fly *Solva pallipes* (Loew) (Xylomyidae; Fig. 3) is the only insect reported from hedge apples (Downing 1976). No mention, general or specific, about the presence or absence of insects in hedge apples could be found in the literature. Despite the intense Osage Orange propagation during the mid-nineteenth century, hedge apples are generally not eaten by humans, and it is therefore understandable that any insects in hedge apples might be overlooked, provided they weren't damaging the seeds.

On 28 September 2013, a single hedge apple was collected on the campus of Louisiana State University (LSU), East Baton Rouge Parish, LA (30.4105°N,

Figure 3. Habitus of male *Solva pallipes* reared from hedge apple, Henry County, MO.

91.1778°W). The fruit yielded 38 insect specimens, representing 12 species (Table 3). Additional collections of fruit on campus by the author and B.H. Reily resulted in the collection of a further 79 insect specimens. In total, 20 species were collected at LSU from ~60 hedge apples checked sporadically during 28 September–10 October 2013. On 16 October 2013, ~100 hedge apples under ~30 trees were

Table 3. Insects collected from hedge apples. Collection site abbreviations: MO1 = Henry County, Missouri. MO2 = Texas County, MO. AR = Lawrence County, AR. LA = Louisiana State University campus, East Baton Rouge Parish, LA. Species marked with an asterisk (*) were present in the hedge apple found on 28 September 2013, Louisiana State University campus.

	Order/Family	Species	MO1	MO2	AR	LA	Trophic Role
	Dermaptera						
1	Anisolabididae	*Euborellia annulipes* Lucas	-	-	-	2	Saprophagous
	Hemiptera						
2	Anthocoridae	*Orius insidiosus* (Say)	1	-	-	-	Predator
3	Anthocoridae	*Xylocoris galactinus* (Fieber)*	-	-	-	1	Predator
	Coleoptera						
4	Corylophidae	*Sericoderus* sp.	1	-	-	-	Saprophagous
5	Curculionidae	*Conotrachelus posticatus* Boheman	-	-	-	2	Saprophagous
6	Elateridae	*Conoderus* sp.	-	-	-	1	Saprophagous
7	Monotomidae	*Bactridium* sp. *	-	-	-	3	Saprophagous
8	Nitidulidae	*Aethina tumida* Murray*	-	-	-	5	Saprophagous
9	Nitidulidae	*Carpophilus dimidiatus* (Fabricius)*	-	-	-	24	Saprophagous
10	Nitidulidae	*Carpophilus* sp.*	-	-	-	2	Saprophagous
11	Nitidulidae	*Epuraea ocularis* Fairmaire	-	-	-	3	Saprophagous
12	Nitidulidae	*Epuraea rufa* (Say)*	-	-	-	19	Saprophagous
13	Nitidulidae	*Stelidota coenosa* Erichson*	-	-	-	4	Saprophagous
14	Nitidulidae	*Stelidota geminata* (Say)*	-	-	-	15	Saprophagous
15	Nitidulidae	*Stelidota octomaculata* (Say)	-	-	-	2	Saprophagous
16	Nitidulidae	*Urophorus humeralis* (Fabricius)*	-	-	-	3	Saprophagous
17	Scarabaeidae	*Ataenius* sp.	1	-	-	-	Saprophagous
18	Scarabaeidae	*Pseudagolius bicolor* (Say)	2	-	-	-	Saprophagous
19	Staphylinidae	Athetini sp. 1	1	-	2	-	Saprophagous
20	Staphylinidae	Athetini sp. 2	-	-	1	-	Saprophagous
21	Staphylinidae	*Coproporus rutilus* (Erichson)*	-	-	-	6	Saprophagous
22	Staphylinidae	*Oxypoda* sp.	-	1	-	-	Saprophagous
23	Staphylinidae	*Rugilus* sp.	-	2	-	-	Predator
24	Staphylinidae	*Stenus* sp.	1	-	-	-	Predator
25	Staphylinidae	*Tachinus canadensis* Horn	21	-	-	-	Saprophagous
	Hymenoptera						
26	Figitidae		-	-	-	1	Parasitoid
	Diptera						
27	Drosophilidae	*Drosophila repleta* species group	-	-	-	1	Saprophagous
28	Drosophilidae	*Drosophila* sp.*	-	-	-	10	Saprophagous
29	Drosophilidae	*Zaprionus indianus* Gupta	-	-	-	3	Saprophagous
30	Phoridae	*Chonocephalus heymonsi* Stobbe*	-	-	-	1	Saprophagous
31	Xylomyidae	*Solva pallipes* (Loew)	500+	50+	50+	-	Saprophagous
	Total		8	3	3	20	

surveyed in Henry County, MO (N 38.423°, W 93.807°). A total of 29 specimens representing eight species were collected. In addition, several hundred xylomyid fly larvae were present in approximately half of all hedge apples surveyed at the Henry County site (Fig. 4). On 20 October 2013, specimens were collected from 15 hedge apples under one tree in Texas County, MO (N 37.1454°, W 92.1958°). Three beetle specimens, representing two species, and numerous xylomyid fly larvae were collected. That same day 10 hedge apples under two trees were surveyed in Lawrence County, AR (N 36.1964°, W 91.1674°) yielding three beetle specimens representing two species, plus numerous xylomyid fly larvae. Xylomyid fly

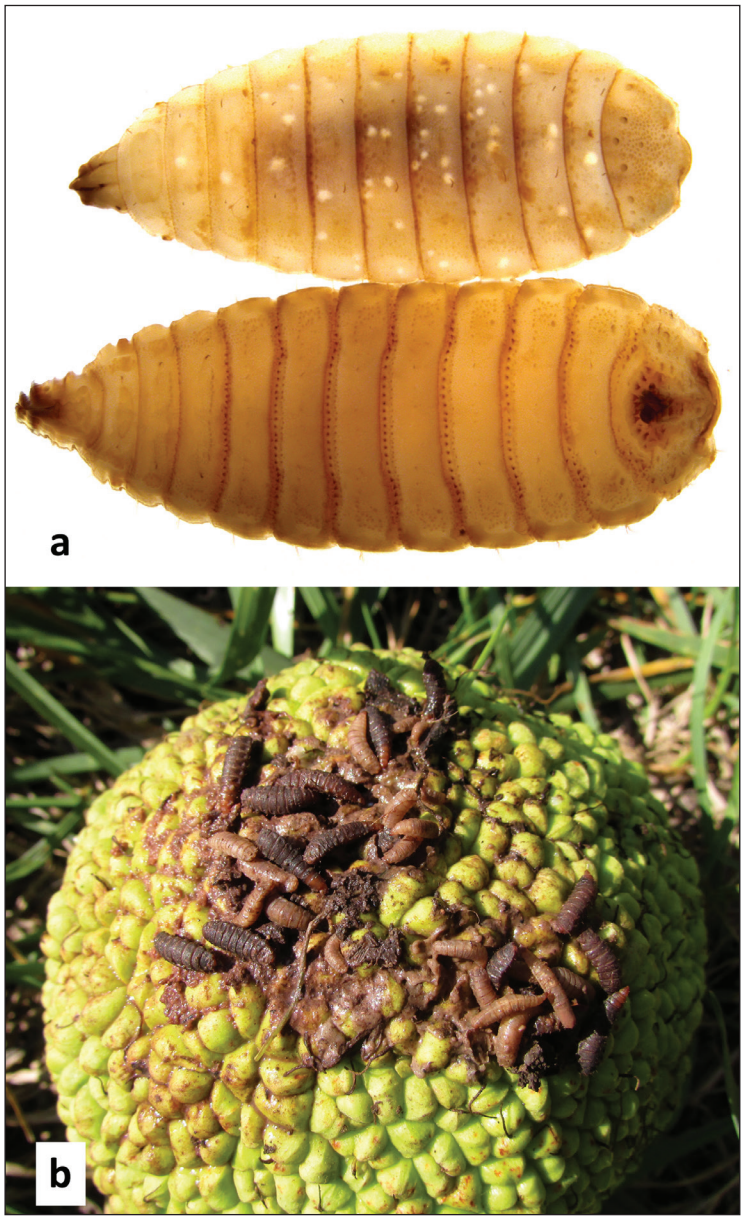


Figure 4. A) Final instar *Solva pallipes* larvae, top dorsal view, bottom ventral view; B) hedge apple rolled over (portion touching the ground exposed) with numerous *S. pallipes* larvae, Henry County, MO.

larvae from Missouri were reared and adults were identified as *Solva pallipes* using Webb (1984). Specimens are deposited in the Louisiana State Arthropod Museum (LSAM), LSU AgCenter, Baton Rouge, LA.

Solva pallipes is a widespread species that ranges from southern Canada, across the continental United States, and south to Panama (Webb 1984). Adults have been collected from January to November, with the majority collected in June and July. Immatures have been collected from *Populus deltoides* W. Bartram ex Humphry Marshall (Cottonwood), *Populus* × *canadensis* Moench (pro sp.) (*deltoides* × *nigra*) (Carolina Poplar), Osage Orange, Red Mulberry, and *Robinia pseudoacacia* L. (Black Locust) (Webb 1984). No indication of predation or parasitism of *S. pallipes* within hedge apples is indicated by the other species collected, as neither of the two predators collected with *S. pallipes* is known to eat flies.

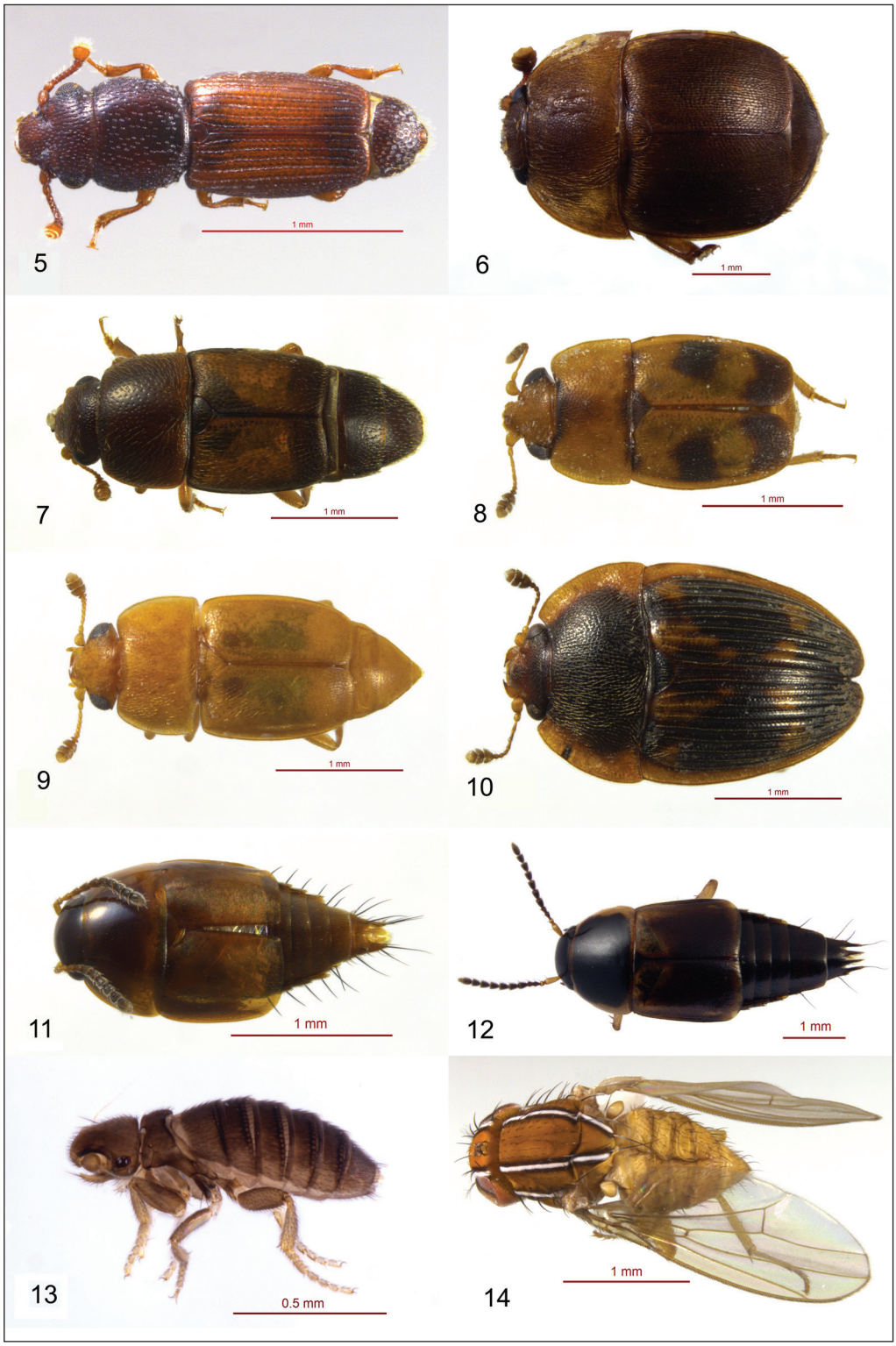
Except for *S. pallipes*, no other species was found at more than one site. Missouri and Arkansas sites were similar, in presence of *S. pallipes* and Staphylinidae, and absence of almost everything else. Louisiana was unique in lacking *S. pallipes*, but yielded four species of flies and members of four families of beetles not collected elsewhere, including nine species of Nitidulidae. Species of interest, including non-native species, rarely collected species, and species represented by a large number of individuals are illustrated in Figures 5–14. Four non-native species were collected on hedge apples in Louisiana: *Aethina tumida* Murray (Small Hive Beetle; Coleoptera: Nitidulidae; Fig. 6) (Hood 2004), *Carpophilus dimidiatus* (F.) (Corn Sap Beetle; Coleoptera: Nitidulidae; Fig. 7) (Parsons 1943), *Epuraea oculariis* Fairmaire (Coleoptera: Nitidulidae; Fig. 8) (Cline and Audisio 2011), and *Zaprionus indianus* Gupta (Diptera: Drosophilidae; Fig. 14) (van der Linde et al. 2006).

With the exception of *S. pallipes*, the other species collected from hedge apples appear to be opportunistic generalists and are probably not consistently found on hedge apples. In Missouri and Arkansas, species other than *S. pallipes* were virtually absent, less than one individual per 3–4 hedge apples. The results indicate that collection of insects in the fruit of Osage Orange across its historic and expanded range will probably yield a diverse and wide-ranging assortment of general saprophagous insects.

Future Practical Uses of Hedge Apples

While hedge apples are of no commercial use as insect repellents, they may have some use as insect attractants. Interest in raising insects as an alternative source

Figures 5–14 (following page). 5) *Bactridium* sp. (Monotomidae), rarely collected; 6) *Aethina tumida* Murray (Nitidulidae), non-native; 7) *Carpophilus dimidiatus* (F.) (Nitidulidae), non-native; 8) *Epuraea oculariis* Fairmaire (Nitidulidae), non-native; 9) *Epuraea rufa* (Say), numerous on hedge apples surveyed; 10) *Stelidota geminata* (Say), numerous on hedge apples surveyed; 11) *Coproporus rutilus* (Erichson) (Staphylinidae), numerous on hedge apples surveyed; 12) *Tachinus canadensis* Horn (Staphylinidae), numerous on hedge apples surveyed; 13) *Chonocephalus heymonsi* Stobbe (Phoridae), rarely collected; 14) *Zaprionus indianus* Gupta (Drosophilidae), non-native.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of protein for livestock, for human consumption, and even for use as biodiesel has greatly increased as people seek to create new resources or exploit existing resources more efficiently (van Huis et al. 2013). *Solva pallipes* is in the same superfamily, has a similar life history (nonpest, generalist detritivore) and immature form as *Hermetia illucens* L. (Black Soldier Fly; Diptera: Stratiomyidae). Research has indicated that *H. illucens* can be used to produce biodiesel (Li et al. 2011), and as supplemental food for fish, chickens, and swine (Sheppard 1992, Sheppard et al. 2002). A countertop appliance called Farm 432 was designed by Katharina Unger to facilitate rearing *H. illucens* on bio-waste (kitchen scraps). Larvae self-harvest and excess individuals (not needed to sustain the colony) are available for human entomophagy at a rate of approximately 500 g (1 lb.) per week (Unger 2014).

Hedge apples are a plentiful resource largely unused by humans and wildlife. Osage Orange is long-lived tree, resistant to insect attack, drought, breakage by ice, etc. and, once established, requires little to no inputs (e.g. water, pesticides, etc.). Widespread planting in the mid-nineteenth century and again in the mid-twentieth century failed to elicit outbreaks of pests or disease. Hedge apples are robust fruits that decompose slowly and could easily be collected with machinery once they fall to the ground.

The natural abundance of *S. pallipes* in hedge apples, and apparent lack of predators and parasites, indicates that research into conversion of hedge apple biomass into useable resources via *S. pallipes* biomass may be a profitable endeavor. No record of insects attacking the seeds was found. In fact, extraction of seeds is facilitated by allowing the seeds to "ripen" by storing them in a pile outdoors over winter (Bonner and Ferguson 1974). Presumably, *S. pallipes* only eats hedge apple pulp, leaving the seeds intact for additional uses such as production of biodiesel fuel (Saloua et al. 2010) or hair-care products (Troute 2013).

Conclusion

Few non-domesticated, non-pest organisms have had such a rich and varied relationship with humans as the Osage Orange. Folklore concerning the insect-repellent properties of hedge apples appears to have originated from a single source in 1950 and has been perpetuated with slight variation and additions to the present day. Research has shown that the folklore is inaccurate; however, hedge apples and hedge apple constituents have shown slight insect repellency in special cases. Relatively few arthropods are associated with the tree, but a wide variety of saprophagous insects have been found on the rotting fruit in low numbers. The Osage Orange may yet be involved in another national craze if the author's suggestion of extracting seeds from hedge apples and feeding the pulp of to the fly *Solva pallipes* for production of biodiesel and/or supplemental food for humans and livestock is adopted.

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Appendix 1. Foundational documents of hedge apple folklore.

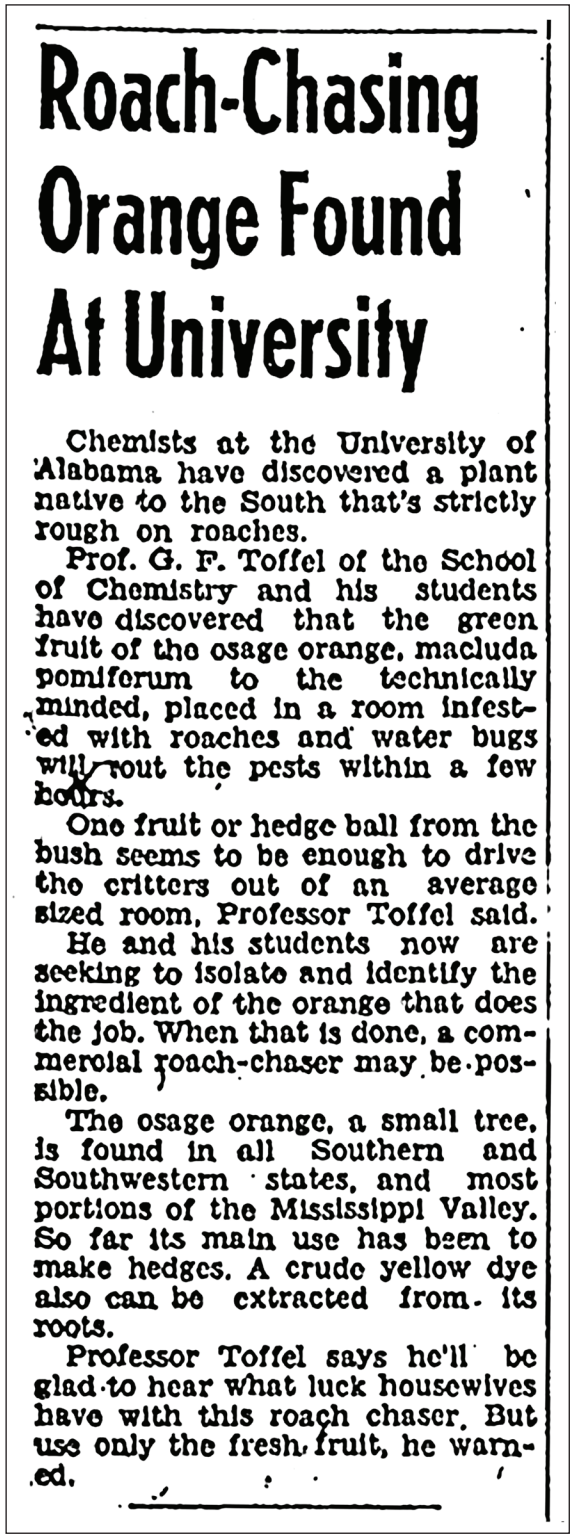
The oldest citations provided by contemporary publications commenting on hedge apple folklore were Brandies (1979), Peattie (1953), and Sand (1991), none of which provided adequate references for the origin of their information. Brandies (1979) only provided the clue "A bulletin from the Missouri Botanical Garden" as reference. Missouri Botanical Garden Bulletin is available online, and I found the article (Missouri 1958) relatively quickly. Missouri (1958) provided a partial citation for its source: "To quote an *American Nurseryman* writer …". The trade magazine American Nurseryman is only available in print form and discovery of the blurb (American Nurseryman 1952) required 14 hours of page-by-page searching in the library.

Sand (1991) offers no citations or even good clues (except in retrospect) concerning the origin of its information.

Peattie (1953) provided important details (“George Toffel”, “University of Alabama”) that assisted in discovery of relevant newspaper articles (several of which are only available in print form or behind a pay-wall online), but gave no indication of the relationship with the Newsweek (1950) article. Past editions of Newsweek are also only available in print form, and I only discovered the Newsweek (1950) article because of the Anniston Star (1950) article.

The foundational documents involved in the hedge apple myth were difficult to obtain and several are not available in electronic format. Piecing the literature together was only realistically possible through the use of modern resources such as search engines, databases, and online archives, plus the use of traditional library holdings. Tracing the (near?) complete history of hedge apple folklore represents an interesting case history in the origin and transmission of folklore over time.

Difficult to obtain primary documents are presented on the following pages.



Roach-Chasing Orange Found At University

Chemists at the University of Alabama have discovered a plant native to the South that's strictly rough on roaches.

Prof. G. F. Toffel of the School of Chemistry and his students have discovered that the green fruit of the osage orange, macluda pomiferum to the technically minded, placed in a room infested with roaches and water bugs will rout the pests within a few hours.

One fruit or hedge ball from the bush seems to be enough to drive the critters out of an average sized room, Professor Toffel said.

He and his students now are seeking to isolate and identify the ingredient of the orange that does the job. When that is done, a commercial roach-chaser may be possible.

The osage orange, a small tree, is found in all Southern and Southwestern states, and most portions of the Mississippi Valley. So far its main use has been to make hedges. A crude yellow dye also can be extracted from its roots.

Professor Toffel says he'll be glad to hear what luck housewives have with this roach chaser. But use only the fresh fruit, he warned.

1) The original newspaper article announcing the discovery of the repellent qualities of hedge apples. This short news items is apparently the origin of hedge apple folklore (Tuscaloosa News 1950).

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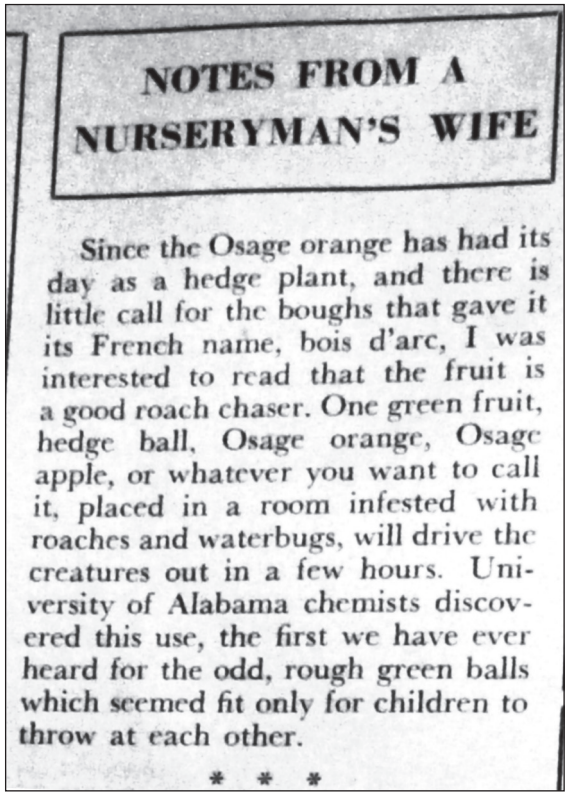

NOTES FROM A NURSERYMAN'S WIFE

Since the Osage orange has had its day as a hedge plant, and there is little call for the boughs that gave it its French name, bois d'arc, I was interested to read that the fruit is a good roach chaser. One green fruit, hedge ball, Osage orange, Osage apple, or whatever you want to call it, placed in a room infested with roaches and waterbugs, will drive the creatures out in a few hours. University of Alabama chemists discovered this use, the first we have ever heard for the odd, rough green balls which seemed fit only for children to throw at each other.

* * *

2) Brief piece from the American Nurseryman (1952).

[**Notes From A Nurseryman's Wife**

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(Note: this article uses the terms "waterbugs" and "roach chaser", both terms used in the original newspaper stories, but neither are used in the Newsweek (1950) article. Even though Newsweek (1950) and the newspaper articles were contemporary, this article seems to be based entirely on newspaper articles.)]

[p. 64]

HEDGE APPLES REPELL BUGS

THE hedge apple, the large, green, ball-like fruit of the Osage Orange tree, *Maclura pomifera*, is gaining a reputation as an insect repellant. To quote an *American Nurseryman* writer, "One green fruit, hedge ball, Osage orange, Osage apple or whatever you want to call it, placed in a room

infested with roaches and waterbugs, will drive the creatures out in a few hours," and he further states that such use was discovered by chemists at the University of Alabama.

In recent years there have been a number of reports of the effective use of hedge apples as a roach and waterbug exterminator. Mr. Pring as well as others at the Garden attest that a few hedge apples in the basement and closets have positive results.

Hedge apples drop throughout the fall and winter and the many trees at the Garden usually are quite productive.

3) Short note in the Missouri Botanical Garden Bulletin (1958).

[**Hedge Apples Repell Bugs**

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Roaches on the Run

Early planters in the South and Southwest grew thick, impenetrable hedges of scrubby Osage orange trees. And Indians used to make bows from the resilient wood. But until now there has been no use for the fruit itself—a venomous-green ball, slightly larger than an ordinary orange and woody inside.

This week it appeared that the Osage orange (known also as hedge apple) might yet do its bit for civilization. Prof. George M. Toffel, University of Alabama chemist, has found that Osage oranges drive away that most persistent of household pests, the cockroach. In his own apartment, which was heavily infested, he put one orange in each room except the living room. All the roaches promptly gathered in the living room. And when Toffel put an orange in that room too, the insects took off for next door.

Now trying, with the aid of some students, to concentrate the roach-repelling ingredient, Toffel guesses that it has something to do with the Osage orange's pleasant cedarlike odor. He has found that a stronger smelling distillate is just as effective as the fresh fruit.

4) Item from Newsweek (1950).

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