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Characters used in multivariate analyses of Vachellia × cedilloi, V. cornigera, and V. globulifera complex—1) Symmetry of stipular spine, 1 = symmetrical, 2 = asymmetrical. 2) Number of petiole glands, 1 = mostly solitary and at or just below the lower pair of pinna, 2 = 3–6 present along the petiole. 3) Shape of rachis gland, 1 = canoe-shaped, 2 = narrow volcano-shaped, 3 = columnar. 4) Pubescence of rachis gland, 1 = glabrous or nearly so with obvious striations, 2 = densely puberulent, striations not obvious. 5) Number of pairs of pinna on the largest leaves. 6) Distance between leaflets in mm. 7) Length of leaflet in mm.

8) Width of leaflet in mm. 9) Venation of leaflet, 1 = obvious, 2 = not obvious. 10) Shape of inflorescence, 1 = globose, 2 = short cylindrical, 3 = long cylindrical. 11) Length of inflorescence in mm. 12) Thickness of peduncle, 1 = 0.5–1.0 mm, 2 = 1.2–2.0 mm, 3 = >2.0 mm. 13) Apex of floral bract, 1 = tailed, 2 = circular. 14) Ratio of calyx:corolla lengths, 1 = nearly the same, 2 = 1.5–2 times longer. 15) Shape of calyx shape, 1 = cylindrical, 2 = cone-shaped. 16) Length of filament of stamen in mm.

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LAND SNAILS IN EPHEMERAL POOLS AT OTTINE SWAMP, GONZALES COUNTY, TEXAS

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ABSTRACT—We found five species of terrestrial land snails in dried ephemeral pools at Ottine Swamp, Palmetto State Park, Gonzales County, Texas. We recorded four species previously known (*Anguispira stronglyodes*, *Mesomphix friabilis*, *Olygyra orbiculata*, and *Rabdotus dealbatus*) and added a new occurrence (*Mesodon thyroidus*) to the list of species in the park.

RESUMEN—Se encontraron cinco especies de caracoles terrestres en los fondos secos de unos charcos efímeros en Ottine Swamp, Palmetto State Park, en el condado de Gonzales, Texas. Registramos cuatro especies conocidas anteriormente (*Anguispira stronglyodes*, *Mesomphix friabilis*, *Olygyra orbiculata* y *Rabdotus dealbatus*) y añadimos una nueva especie (*Mesodon thyroidus*) a la lista de especies en el parque.

We observed remains of land snails in a dried ephemeral pool in central Texas. Purposes of our study were to provide information on land snails, to list specific properties of soils and vegetation, and to complement available literature on snails as secondary indicators to identify vernal or ephemeral pools.

Our study area was the forest of Ottine Swamp, Palmetto State Park, Gonzales County, Texas. This swamp is ca. 80 ha and is between an oxbow lake and the San Marcos River. The most recent assessment of Ottine Swamp identified 11 types of wetlands and listed features such as spring-fed creeks, ash swamps, sphagnum marshes, lagoons, and ephemeral pools (Taber and Fleenor, 2005).

Because properties of soils, such as calcium and pH, limit distributions of land snails (Martin and Sommer, 2004), we collected soil and measured pH (at 22.5°C) using a SensION2 portable pH/ISE meter with a gel-filled Platinum Series pH electrode (Hach, Loveland, Colora-

do). Following methods of Burt (2004, 2011), a 1:1 mixture of soil (sifted through a number-10 sieve) and distilled water was prepared and mixed for 30 min. Water from the sample was vacuum filtered using an 8–12- μ m filter to remove suspended solids. Using a DR 3800 Spectrophotometer (Hach, Loveland, Colorado), we measured calcium carbonate using the calmagite colorimetric method 8030, nitrate-nitrogen using the dimethylphenol method 10206, potassium using the ammonium acetate method, and phosphorus using the ascorbic acid method 10209–10210 of Jones (2001). Salinity of water from the soil sample was measured using a Sodium Platinum Series Combination Electrode (Hach, Loveland, Colorado).

As they breakdown in ephemeral pools, leaves of oaks (*Quercus*) contribute tannin-lignin that potentially affects quality of water and invertebrates that live there. We placed 1 g of leaves from Shumard red oaks (*Quercus shumardii*) in 50 ml of distilled water and then into

indirect sunlight for 4 months to approximate natural conditions where water in ephemeral pools becomes tannic. A syringe fitted with a 0.45- μm filter was used to draw samples of water. We measured the tannin-lignin potential of samples using a DR 3800 Spectrophotometer and the tyrosine method 8193 of Jones (2001). To avoid possible interference from ferrous iron and sulfite, these two parameters were tested using the phenanthroline method 8146 and colorimetric method of Jones (2001), respectively.

We found the vegetation of the ephemeral pools to be overtopped by a canopy that consisted of sugarberry (*Celtis laevigata*), box elder (*Acer negundo*), black willow (*Salix nigra*), green hawthorn (*Crataegus viridis*), and red haw (*Crataegus mollis*) with a shrub component of black elderberry (*Sambucus nigra*), swamp dogwood (*Cornus foemina*), buttonbush (*Cephalanthus occidentalis*), and dwarf palmetto (*Sabal minor*). The vine present at all the pools was climbing hempvine (*Mikania scandens*). Non-woody plants included marsh buttercup (*Ranunculus septentrionalis*), blue flag (*Iris hexagona*), brookweed (*Samolus valerandii*), marsh purslane (*Ludwigia palustris*), warty arrowhead (*Sagittaria papillosa*), stingless nettle (*Boehmeria cylindrica*), large spikerush (*Eleocharis macrostachya*), turgid sedge (*Carex amphibola*), and basket grass (*Oplismenus hirtellus*).

We found five species of land snails (*Anguispira stronglyodes*, *Mesodon thyroideus*, *Mesomphix friabilis*, *Olygyra orbiculata*, and *Rabdotus dealbatus*) around margins of, and in, dried ephemeral pools with leaf litter dominated by Shumard red oaks. All specimens were shells on the surface of the leaf mat or just under the most recent seasonal leaf fall. Leaf litter was shallow and bleached, and condition of the decayed leaf mat indicated rapid breakdown.

The soil sample we analyzed was a grayish loam from the O and A horizons that lacked a well-developed organic layer (i.e., it contained little decayed leaf litter or plant matter). The pH was 6.7 and the sample was most similar to the range (5.6–7.3) reported for Navasota clay (Natural Resources Conservation Service, 2006). Soils in Ottine Swamp and Palmetto State Park reported by the Natural Resources Conservation Service (2006) include Bosque clay loam, Bosque-Tinn complex, Navasota clay, and Tinn clay from the frequent flooding of the San Marcos River. Conductivity of soil was 0.0 $\mu\text{S}/\text{cm}$, which is in the range of soils occurring along the river at and near the study site. Analyses of nutrients revealed 636 ppm calcium carbonate, 2.90 ppm nitrate-nitrogen, 200 ppm potassium, and 3.15 ppm phosphorus.

Tannin extracted from Shumard red oaks was 12.5 ppm. The pH of the solution from soil was 5.9. Tannins in natural ponds of an oak-chestnut (*Quercus-Castanea*), coastal-plain forest were 1.8–6.3 ppm (Randolf et al., 2006). In a study of 51 breeding ponds of amphibians,

Kutka and Bachmann (1990) reported tannin levels of 1.6–8.4 ppm.

Of the six species of land snails from Ottine Swamp and 12 others from Palmetto State Park listed by Taber and Fleenor (2005), we found four previously listed species and added a new occurrence, *M. thyroideus*, to the list. In our identifications, we distinguished *M. thyroideus* from *M. roemeri* by an elevated spire and rounded periphery of shell (Cheatum and Fullington, 1971: plate VI, figure 1). *Olygyra orbiculata* in central Texas may have thin outer lips (Ideker, 1979; Hubricht, 1985; Nekola, 2010); however, our specimens had thick outer lips.

Hubricht (1985) reported that *A. stronglyodes* may occupy a wide range of habitats, which may explain its ability to occur in tannic soils of Ottine Swamp. *Rabdotus dealbatus* is a calciphile attracted to places with episodic water, such as culverts (Hubricht, 1985; Nekola, 2010). *Mesodon thyroideus* is known from floodplains of large river valleys and woodlands with differing stages of decaying logs (Baker, 1939; Cheatum and Fullington, 1971), which exist in Ottine Swamp. *Mesomphix friabilis* is known from floodplains under leaf litter (Hubricht, 1985) as we found it. *Olygyra orbiculata* is a calciphile (Nekola, 2010), and unlike descriptions of habitats by Fullington and Pratt (1974) and Hubricht (1985), we found this species near water.

Although the five species we found in ephemeral pools are ubiquitous to Texas (Cheatum and Fullington, 1971, 1973; Fullington and Pratt, 1974; Hubricht, 1985; Kutac and Carun, 1994), their occurrence in floodplain soils that are tannic from litter in oak forests is notable. Tannins are toxic to land snails (Singh et al., 1996) and tannic leaf litter affects viability of eggs of snails (Barrientos, 1998; Coulis et al., 2009), similar to survival of amphibian embryos in vernal pools (Cook, 1983; Portnoy, 1990). Nekola (2010) reported that *R. dealbatus* and *O. orbiculata* only occur in neutral or calcareous soils. We found these two snails in soils of varying levels of nutrients. Calcium, nitrate-nitrogen, and potassium were high, and phosphorus was low. Dominant trees associated with the land snails we found (sweet pecan *Carya illinoensis*, American elm *Ulmus americana*, cedar elm *Ulmus crassifolia*, black willow *Salix nigra*, eastern cottonwood *Populus deltoides*, and sycamore *Platanus occidentalis*) supports placing our study site within the pecan-elm (*Carya-Ulmus*) forest of the east-central plains (Gould et al., 1960; McMahan et al., 1984).

Our study complements available literature on use of invertebrates, including snails, as secondary, indirect, or facultative indicators to identify vernal or ephemeral pools using facultative species or dry pool methods (Colburn, 2004; Colburn et al., 2007; Calhoun and de Maynadier, 2008). Whereas aquatic snails often are used as secondary indicators of ephemeral pools because of their facultative use of wetlands (i.e., not restricted to ephemeral pools to complete their life cycle), the five species we report have the

potential to be used similarly. Similar to aquatic snails, they can be in and along margins of dried pools and can exist in all hydroperiods and aquatic phases of ephemeral pools (Williams, 2005). Unlike the surrounding forest, the land snails we found were concentrated around the margin of the ephemeral pool either above or just below the leaf litter, which potentially can help to identify boundaries of vernal pools.

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