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The thread-leaf sundews *Drosera filiformis* and *Drosera tracyi*

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Introduction

The thread-leaf sundews of the Eastern North America are spectacular plants with erect, tall, filiform leaves. Backlit in the morning or evening light, their leaves burst with sunlight. There are two thread-leaf sundews (also known as dew-threads), known as either infraspecific taxa within *Drosera filiformis*, or as *Drosera filiformis* and *Drosera tracyi.* In this paper, I review their history of discovery, the details of their ranges, and the arguments regarding whether the two taxa should be treated as one species or two. I also describe the morphological differences between the two sundews. In total, this paper summarizes the current knowledge for this group, and also serves as a progress report on my continuing work on these plants.

A history of controversy

In 1808, Rafinesque described the thread-leaf sundew, *Drosera filiformis* Raf., which occurs on the Atlantic Coast of North America. The 1802 holotype he selected for this description is one of the oldest North American herbarium specimens housed in a North American herbarium (Sheviak 2010). In 1906, Diels noted that specimens from the USA's Gulf Coast were larger and greener, so he established for them the name *D. filiformis* var. *tracyi* Diels. In doing so, the name *D. filiformis* Raf. var. *filiformis* was created automatically (*i.e.*, an autonym) for the smaller, reddish thread-leaf sundew.

Diels obtained the varietal epithet "*tracyi*" from J.M. Macfarlane, who felt that the Gulf Coast plant should be treated as a new species ("*D. tracyi*"). While Diels disagreed, he did Macfarlane the courtesy of using his epithet, and even decorously noted "*Macfarlane msc. sub titulo speciei*" in the description for *D. filiformis* var. *tracyi* Diels. Schnell (2002) interpreted this Latin phrase to indicate that Macfarlane had an as-yet unpublished manuscript describing the plant as a new species—or at least intended to write such a manuscript!

Good intentions perhaps, but Macfarlane did not actually publish the name *Drosera tracyi* until his treatment of *Drosera* in Bailey's "The Standard Cyclopedia of Horticulture" (Macfarlane 1914; page 1077). Schnell (2002) argued that this publication did not constitute effective publication of the name "*D. tracyi*" because it was not accompanied by a Latin description. (The only Latin description for the plant was published by Diels, in the treatment for "*Drosera filiformis* var. *tracyi*." However, Macfarlane did not refer to the Diels description.) However, the Latin description requirement—as described by the ICBN (Article 36.1)—only applies to names described on or after 1 January 1935. Therefore, *D. tracyi* Macf. is entirely valid for those who wish to use it.

Thirty years later, Frances Wynne noted that the sundews in eastern North American have distinct seeds shapes and surface characteristics (Wynne 1944). Since the seeds of the two thread-leaf

sundews were identical, she followed Diels' perspective and treated them as two varieties of the same species. (She also established the name "*D. filiformis* var. *typica*," but this is a superfluous synonym for *D. filiformis* Raf. var. *filiformis* and should not be used.)

In the sixty-five years since Wynne's work, authorities have continued to disagree on whether to treat the thread-leaf sundews as one species or two. Gleason & Cronquist (1991) do not even recognize the two sundews as separate at the varietal level. (Oddly, the geographic distribution they describe for "*D. filiformis*" combines the range for both thread-leaf sundews, but their species description only fits the northern taxon's morphology and size.) Scientists who treat the thread-leaf sundews as varieties of one species include Kartesz (1994), Schnell (2002), and Schlauer (2002). Meanwhile authorities who treat them as two species include Clewell (1985), Godfrey & Wooten (1981), L. Mellichamp (pers. comm., 2010), and Sorrie (1998). Overall, in the last decade the two-species perspective has become dominant in floristic works—examples include The Biota of North America Program (BONAP.org), the Flora of North America (fna.org), The Flora of the Southern and Mid-Atlantic States (Weakley 2010), and NatureServe (NatureServe.org). Within the world of carnivorous plant enthusiasts, the tradition has typically been to follow the single-species perspective[1].

Molecular studies have been illuminating many aspects of *Drosera* phylogeny (Rivadavia *et al.* 2003), but they have not been applied to the matter of the thread-leaf sundews, and even if they were, would be unlikely to reveal much regarding these two closely related taxa.

My own perspectives of the two sundews have evolved over time. I long used the single-species approach (Rice 2006), but my interest in the Floridian "red" *D. filiformis* has caused me to revisit this carefully and in depth. After much consideration on this matter, I have switched to the two-species perspective. For simplicity, the rest of this paper will be presented using the two-species nomenclature.

The ranges of *Drosera tracyi* and *D. filiformis*

Drosera tracyi is native to an ever-shrinking range in the USA's Gulf Coast states (Figure 1). Much of its quoted habitat range is now purely of historical interest. Ranges below are based upon collections made or confirmed within the last ten years.

Florida: This state contains the bulk of the species' range. *Drosera tracyi* has been collected in every county of the panhandle (*i.e.*, the narrow, western extension of the state), from Wakulla and Leon Counties westward, with the apparent exception of Gadsen County (Sorrie 1998; Wunderlin & Hansen 2008).

Georgia: It was formerly known from Brooks, Calhoun, Cook, Grady, Lowndes, Thomas, and Worth Counties, but is apparently now extinct in them all (NatureServe 2008; Sorrie 1998). It is now only known from Colquitt County. Since it is known from only five or fewer occurrences in the state, it is considered critically imperiled by the Georgia Department of Natural Resources.

Alabama: It has been collected from Mobile, Baldwin, Washington, Escambia, and Covington Counties (BONAP 2010; Sorrie 1998; USDA 2010).

Mississippi: Known from Hancock, Harrison, Jackson, Stone, George, and Perry Counties (BONAP 2010; Sorrie 1998; USDA 2010).

Louisiana: A single poorly documented collection was made in 1907, putatively from an unspecified parish in Louisiana; if this information is correct, the plant is probably from St. Tammany or Washington Parish (Sorrie 1998). The Louisiana Natural Heritage Program tracks this species in

[1]This is no doubt at least partly because of the considerable authority and prominence Schnell has had with this audience. He was editor of Carnivorous Plant Newsletter from its inception to 1996.

Figure 1: A 2010 snapshot of the range of *Drosera tracyi*. Counties or parishes believed to currently maintain native populations are indicated by a black dot. Counties where it is believed *D. tracyi* has been extirpated are indicated by an empty circle. The question mark for the Louisiana site notes that it has not been confirmed that *Drosera tracyi* has ever occurred there.

their databases as a plant from St. Tammany Parish, but considers it to be presumably extinct in the state (LNHP 1999).

South Carolina: Reports in the literature for this plant in this state (*e.g.*, Wynne 1944) do not seem to be supported by voucher specimens.

Other sites: *Drosera tracyi* has been planted by horticulturists in California (Mendocino County). No doubt exotic plantings occur elsewhere in North America and around the world.

Drosera filiformis has a range which is strikingly different from that of *D. tracyi* for two reasons. First, instead of being strictly a USA Gulf Coast plant, it occurs primarily along the Atlantic Coast of North America (Figure 2). Second, instead of being largely continuous, its range is divided into four greatly separated segments: Nova Scotia (Canada), USA mid-Atlantic states, North Carolina, and Florida. The Nova Scotia range segment is only 20 km long. The mid-Atlantic range segment is 450 km southwest of the Nova Scotia sites, and spans more than 600 km of the Atlantic Coast. Approximately 450 km separates the mid-Atlantic range segment from the North Carolina segment, which itself is approximately 140 km in extent (county edge to county edge). Finally, 850 km separates the North Carolina segment from the Florida populations—a cluster of sites only 20 km across.

Unfortunately, the range of *D. filiformis*, like that of *D. tracyi*, is decreasing rapidly in extent and quality.

Canada Range Segment

Nova Scotia (Canada): *Drosera filiformis* was discovered in 1977 in Shelburne County (Sorrie 1998); peat studies indicate it has grown there for at least 4240 years (Landry & Cwynar 2005). Because of its great rarity—it is only known from five locations—it has been declared an endangered species by government agencies in both Nova Scotia and Canada (COSEWIC 1991; NSSRWG 2000). In fact, the presence of *D. filiformis* prevented one bog from being turned into a peat mining operation (Landry & Cwynar 2005).

USA Mid-Atlantic Range Segment

Massachusetts: It has been found in Plymouth, Barnstable, Nantucket, and Dukes Counties (Sorrie 1998; USDA 2010), although it is extinct at many of its former sites in the state.

Rhode Island: A single small population was recorded for Washington County in 1977, but it apparently dwindled to extinction around 1990 (Enser 2007; Sorrie 1998). It has been theorized (Sorrie 1998) that the populations in Rhode Island and Massachusetts might be short-term in nature—as new sites are opened by disturbance, *D. filiformis* propagules from other states may invade until the site becomes overgrown. Sorrie's suggestion of wind dispersal from the nearby (<150 km) New York populations seems less likely than transport by waterfowl from New York or Massachusetts. If this dispersal theory is correct, the natural human tendency to fragment habitat and prevent natural succession processes suggests that *D. filiformis* is unlikely to reestablish itself in Rhode Island and Massachusetts.

Connecticut: It has been found in New London and Hartford Counties, but these populations are probably extinct because of habitat change (Sorrie 1998). It is listed in Connecticut as a "probably extirpated" plant of Special Concern by the Connecticut Department of Environmental Protection (ct.gov/dep).

New York: It occurs only in Suffolk County on Long Island, and as such it is on the state's Rare Plant List (Sorrie 1998; Young 2010). Fortunately, at least one site is owned and protected by The Nature Conservancy (nature.org).

Figure 2: A 2010 snapshot of the range of *Drosera filiformis*. Counties believed to currently maintain native populations are indicated by a black dot. Counties where it is believed *D. filiformis* has been extirpated are indicated by an empty circle. Only native sites have been plotted. The question marks for the Delaware and Maryland sites note that it has not been confirmed that *Drosera filiformis* has ever occurred as a native at these locations.

New Jersey: Records include Monmouth, Ocean, Burlington, Camden, Atlantic, and Cape May Counties.
Maryland: It occurs in Charles County, and a non-native population has also been found in Prince Georges County (Shetler & Orli 2000; Sorrie 1998). The non-native planting casts some doubt upon the nativity of the Charles County site, but there is no certainty in this matter.
Delaware: Fernald (1931) indicated the presence of *D. filiformis* in Sussex County, but no voucher specimens have been found to support this claim (Sorrie 1998).

Carolinas Range Segment
North Carolina: It has been recorded from Bladen, Brunswick, Columbus, Duplin, Pender, Robeson, and Sampson Counties (NatureServe 2008; Sorrie 1998). It is apparently extinct in Brunswick and Pender Counties, and statewide has been reduced to as few as nine populations (Buchanan & Finnegan 2008; Sorrie 1998). Because of its rarity, the North Carolina Natural Heritage Program classifies it as a plant of "special concern," and recommends this status be elevated to "significantly rare" (Buchanan & Finnegan 2008).
South Carolina: Despite frequent reports of *D. filiformis* in South Carolina, no vouchers for the plant from this state have been located, nor is it recorded in regional surveys or Heritage databases (Schnell 2002; Sorrie 1998).

Florida Segment
Florida: Known from a cluster of sites in the Florida panhandle, as originally identified by Godfrey (1974). Currently, I know of two sites in Bay County and ten sites in Washington County. These sites are so close that they are easily connected by pollinating insects; no doubt propagules such as seed can be transported from site to site by waterfowl or even flooding. A single collection of a thread-leaf sundew from Liberty County (Apalachicola National Forest) was made in 1987 (Anderson 10436 FSU) with the notation "less robust than *D. tracyi*". Despite the small stature of this collection, other morphometric criteria indicate this collection is probably *D. tracyi* (Rice, in prep.). I returned to this site in 2010 but was unsuccessful in finding any thread-leaf sundews—woody vegetation had overgrown the area. Even if *D. filiformis* is found in this area, its nativity would be questionable since horticulturists have used various parts of Apalachicola as a dumping ground for non-native carnivorous plants.
Other sites: In addition to the questionably non-native population in Maryland, mentioned above, *D. filiformis* has been planted by horticulturists in numerous places, including California (Mendocino County: Rice 2002), Virginia (Caroline County: pers. observation), and West Virginia (Preston County: Breiding 1983; Sorrie 1998). *Drosera filiformis* has been collected in Pennsylvania (Fayette County: Morton & Speedy 2008), but the southern border of Fayette county is only 20 km from the West Virginia site, and so it is likely that the Pennsylvania record simply is another exotic planting. A single non-native planting of *D.* ×*hybrida* (=*D. filiformis* × *intermedia*) was recorded in California (Plumas County: Rice 2005) but it has probably been successfully eradicated. No doubt exotic plantings of thread-leaf sundews occur elsewhere in North American and around the world.

As seen in Figures 1 and 2, the ranges of the two species are dramatically different. The tiny amount of overlap region in Florida is not significant in light of the other, vastly greater differences. Interestingly, Sorrie (1998) notes that the pairing of two species, one being from the Gulf Coast and the other from the Atlantic Coast, is not unique to the thread-leaf sundews. This sort of pairing is repeated within other genera, *i.e.*, *Sabatia kennedyana* Fern. (Nova Scotia to South Carolina) and *S. foliosa* Fern. (South Carolina to Texas); *Coreopsis rosea* Nutt. (Nova Scotia to Georgia) and *C. nudata* Nutt. (Georgia to Louisiana). To this, we can add *Sarracenia purpurea* L. (Canada to Georgia) and *S. rosea* Naczi, Case & Case (Georgia to Mississippi).

Figure 3: *Drosera filiformis* growing on sandy flats in New Jersey (Ocean County).

Merge or split the thread-leaf sundews?

Should *Drosera filiformis* and *D. tracyi* be treated as two species, as two varieties, or even with no taxonomic recognition, as described near the beginning of this paper? The main points of discussion are three:

1) The two taxa are not particularly different on vegetative or floral characters;
2) The seeds of the two taxa are, essentially, identical;
3) Hybrids between the two species are possible and recorded in the wild (Rice 2010); furthermore they are fertile.

Can the two taxa easily be separated on gross morphological grounds? Clearly the plants have different pigmentations. As reviewed in Table 1 (from Sorrie 1998), *D. filiformis* is more deeply pigmented (Figure 3; reddish leaves, reddish tentacles, red gland heads) than *D. tracyi* (Figure 4; green leaves, green-white tentacles, red gland heads). But basing species distinctions on minor matters like pigmentation is inadequate. For example, it resulted in the erroneous separation of *D. brevifolia* Pursh into the white flowered "*D. leucantha* Shinners" and the pink-flowered "*D. annua* Reed" (Schnell 2002).

Further important characters that distinguish the two taxa are given in Table 1. In Tables 2 and 3, I present additional data from my own studies—Table 2 contains characters showing the entire range of values observed, while Table 3 shows the ranges as calculated by one-sigma variations around the group averages[2]. Some of the characters may not seem significantly different between the two

[2]The one-sigma range is a statistical measure; it contains about 68.2% of the values you are likely to encounter in a sample, and is a good way to specify the range of values you are likely to get when you measure a quantity.

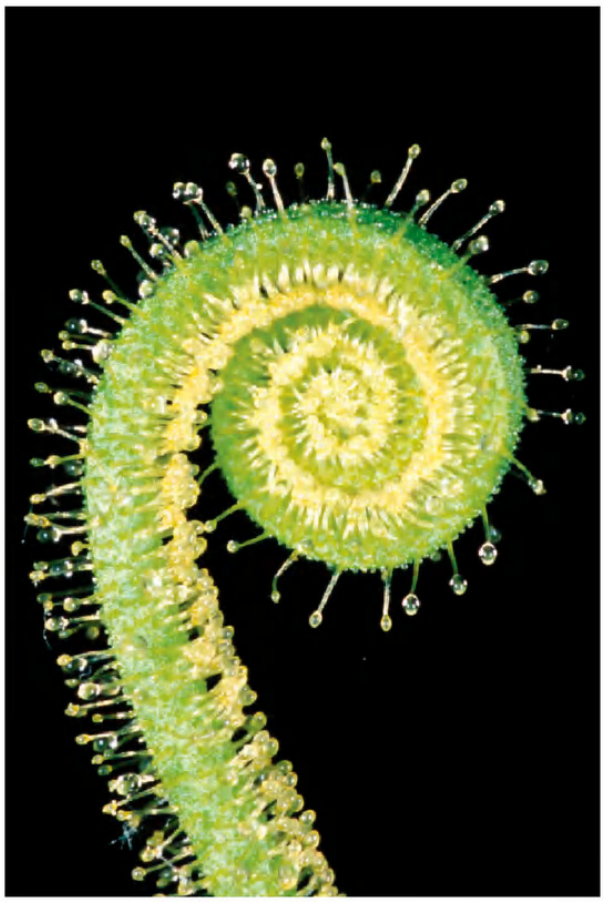

Figure 4: A close view of an unfurling leaf of *Drosera tracyi*.

Figure 5: The white-flowering, mutant form of *Drosera tracyi*.

species when you consider the total ranges shown in Table 2—for example the number of flowers per inflorescence can range from 4 to 21 for *D. filiformis* and 12 to 20 for *D. tracyi*. The overlap here is significant, but the one-sigma ranges in Table 3 do differ much more clearly, *i.e.*, 7-15 for *D. filiformis* and 13-19 for *D. tracyi*.

It is interesting that the tentacles of *D. filiformis* are longer than those of *D. tracyi*. The differences are particularly clear when normalized by the leaf width. The tentacle length/leaf width is 2.6-4.8 for *D. filiformis* and 0.9-2.3 for *D. tracyi*. Notice that, in this case, the smaller plant has the largest tentacles.

Similarly, the relative geometry of the leaves, expressed by the ratio of the total leaf length divided by petiole length is different for the two species: 18-110 for *D. filiformis* and 5.1-25 for *D. tracyi*.

Table 1: Characters used to distinguish *Drosera filiformis* and *D. tracyi*.[1]

Character	*Drosera filiformis*	*Drosera tracyi*
Leaf length	8-25 (30) cm	30-50 cm
Scape length	6-26 cm	25-60 cm
Petal length	0.7-1 (1.2) cm	1.2-1.7 (2) cm
Color of carnivorous glandular hairs	red to dark red	pale green
Color of living plant when backlit	reddish	white
Color of dried specimen	dark red to dark brown	pale greenish brown

[1]Data from Sorrie (1998).

Table 2: Characters used to distinguish *Drosera filiformis* and *D. tracyi*.[1]		
Character	*Drosera filiformis*	*Drosera tracyi*
	total range	total range
Leaf length	6-25 cm	24-34.5 cm
Petiole length[2]	1-16 mm	6-70 mm
Scape length	7.8-25 cm	28-47 cm
# of flowers	4-21	12-20
Tentacle length[3]	0.7-3.2 mm	0.8-2.5 mm
Tentacle/leaf width	1.3-6.7	0.7-3.8
Leaf/petiole	9.9-170	4.5-53

[1]Original data.
[2]The petiole is the nonglandular portion of the leaf, near the basal bud.
[3]Obtained by measuring the longest tentacles (including gland tip) near leaf midpoint (half-way up the leaf), avoiding tentacles that were obviously damaged or distorted by the preservation process.

In summary, I believe the data in Tables 1-3 support species recognition because the differences between *D. filiformis* and *D. tracyi* are not restricted to one or two characters. At least four independent characters are different: size of vegetative parts (leaves), size of flowers, leaf coloration, and the relative dimensions as expressed by tentacle/leaf and leaf/petiole ratios.

Ironically, the fact that the thread-leaf sundews are so different from other *Drosera* contributes to their being interpreted as a single species. The only other species in the genus even remotely similar in form is the South American *D. graminifolia* St. Hil. As a result, the differences between *D. filiformis* and *D. tracyi* seem less significant, when in fact they are considerable.

The second argument about the thread-leaf sundews is the observation that, in North America, all the *Drosera* species have seeds that are uniquely identifiable under a microscope (Wynne 1944). Shape and surface ornamentation allow for easy identification of every North America species. However, the thread-leaf species cannot be distinguished from each other on the basis of seed characteristics.

Table 3: Characters used to distinguish *Drosera filiformis* and *D. tracyi*.[1]		
Character	*Drosera filiformis*	*Drosera tracyi*
	(ave-1σ)—(ave+1σ)	(ave-1σ)—(ave+1σ)
Leaf length	9.7-17 cm	26-32 cm
Petiole length[2]	0-9 mm	11-44 mm
Scape length	8.9-19 cm	31-45 cm
# of flowers	7-15	13-19
Tentacle length[3]	1.3-2.4 mm	1.0-1.8
Tentacle/leaf width	2.6-4.8	0.9-2.3
Leaf/petiole	18-110	5.1-25

[1]Original data.
[2]The petiole is the nonglandular portion of the leaf, near the basal bud.
[3]Obtained by measuring the longest typical tentacles (including gland tip) near leaf midpoint (half-way up the leaf), avoiding tentacles that were obviously damaged or distorted by the preservation process.

This fact is undeniable, but is it significant? Elsewhere in the genus, seed coat is used only rarely to key species (Diels 1906; Lowrie 1987, 1989; Schlauer 1996). Perhaps one might devise a key based solely upon seed characteristics, but this is purely speculative. I argue that while it is undeniable that seed coats are distinct for most of the various species present in North America, it simply does not work for them all. In the same way, stipule characteristics can be used to identify many of the North American *Drosera*, but not all of them. Indeed, it is a very rare case that one encounters a botanical key that relies exclusively on one character. The fact that seed coats are different for many species of *Drosera* in North America is a useful and convenient tool in identification, but there is little evidence that it is a strong diagnostic for species variation across the genus, or even within section *Drosera*.

The final argument that these species should be lumped is based upon the observation that the two species can be hybridized, and the resulting progeny are fertile (Robinson 1981). Fertile hybrids between *D. filiformis* and *D. tracyi* have even been observed at a single site in the wild (Rice 2010). This is a powerful observation, and must be addressed completely.

As is commonly taught in school, interspecies infertility is a robust method of identifying separate species of vertebrate animals. But this metric is not as reliable in the plant world. Carnivorous plant enthusiasts are familiar with the fact that wild and cultivated fertile hybrids are common in *Heliamphora*, *Nepenthes*, and *Sarracenia* (Clarke; McPherson 2007; Rice 2006). Elsewhere in the wild and in horticulture, fertile hybrids are common in grapes, oaks, roses, tamarisk, violets, and countless other plant groups (Mabberley 1997). In some cases it is even possible to cross plants of different genera, resulting in fertile hybrid genera such as ×*Triticosecale* (=*Triticum* × *Secale*), ×*Fatshedera* (=*Fatsia* × *Hedera*), or even bizarre multigenera orchid hybrids such as ×*Brilliandeara* (= *Aspasia* × *Brassia* × *Cochlioda* × *Miltonia* × *Odontoglossum* × *Oncidium*).

Interspecific hybrids are frequent within *Drosera.* In horticulture, enthusiasts have produced the fertile hybrids *D. anglica* × *nagamotoi*, *D. burmannii* × *sessilifolia*, and *D. dielsiana* × *nidiformis* (Snyder 2000), and many others.

Drosera hybrids also occur in the wild. All the species in section *Lasiocephala* (*i.e.*, the "*petiolaris* complex") hybridize in the wild and in cultivation (Lowrie 1999). Additionally, natural populations of *D.* ×*sidjamesii* (=*D. omissa* × *pulchella*) have developed fertile, seed-setting plants (Lowrie & Conran 2007). Within section *Drosera*, hybrids are frequent; not only are they fertile in the case of the thread-leaf sundews, but fertile first-generation crosses have been observed involving Zambian species (Rivadavia, pers. comm., 2010). Natural hybrids such as *D. rotundifolia* × *linearis* and *D. rotundifolia* × *spatulata* are sterile in their first generation, but can apparently become fertile in subsequent populations *via* natural chromosome doubling, thus establishing *D. anglica* and *D. tokaiensis*, respectively (Schlauer 2010; Seno 2003).

Does interfertility mean the two thread-leaf sundews are the same species? I do not think so, but I believe that it indicates that the speciation (separation of the two species) is probably recent—Sorrie (1998) speculates that ancestral propagules of *D. filiformis* migrated northwards out of Florida after the Pleistocene (*e.g.*, approximately 12,000 years before present). It is currently a matter of pure speculation as to whether one species evolved from an ancient population of the other, or they both speciated from a common ancestor, or some other scenario.

There are many philosophies on what defines a species. I follow the traditional biological species concept, which is that "species are groups of actually or potentially interbreeding natural populations that are reproductively isolated from other such groups" (Mayr 1942). In the case of the thread-leaf sundews, we have two significantly morphologically different populations of plants, which occupy different ranges (and different habitat types within those ranges), and which are—for the most part—not exchanging genetic material. They are, simply, two different species. Those with

Figure 6: A familiar view of *Drosera tracyi*, backlit in the evening sunset (Liberty County, Florida).

different species concepts may come to different conclusions, and I do not fool myself into thinking I have had the last word on the subject of the two thread-leaf sundews. As Peter Taylor (1989) wrote, "Nothing is perfect, except perhaps the plants that we study and attempt to understand…."

Varieties, subspecies, or forms of thread-leaf sundews?

There are no infraspecific taxa identified for *D. tracyi*—the species is uniform in characteristics over its entire range. The only known variant is an anthocyanin-free specimen (see Figure 5) collected in Franklin County, Florida (Hummer 1998); this plant's novel mutation is expressed by its having white flowers and carnivorous gland-heads that are green instead of red. A name for this plant might be established at the rank of "*forma*," much like the analogous case with *Sarracenia rosea* f. *luteola*. However, current thought in botany is that names are best given to populations of plants that are evolutionary units: species, subspecies, and varieties. The "*forma*" rank is no longer considered of particular value. On the other hand, since such minor differences are appreciated by horticulturists, they can be named as cultivars, much like the green-flowered *Darlingtonia californica* has been named *Darlingtonia* 'Othello.'

Drosera filiformis is a distinctly different beast, however, since its range is fragmented into four separate populations, each of which may have developed different characteristics. In particular, carnivorous plant enthusiasts would very much like to hear of a new designation for the Floridian populations. I have been investigating this matter for several years, but a pronouncement along such lines would currently be premature and scientifically sloppy. I hope to settle this matter to my own satisfaction as soon as possible, but careful research efforts (herbarium loans, morphometric measurements, analyses, etc.) take time to conduct. Until the time that I feel comfortable publishing my

results, I recommend that horticulturists carefully maintain location information for their beloved plants, and strive to be patient!

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