A COMPARISON OF PREY CAPTURING EFFICIENCY BETWEEN TWO SPECIES OF SUNDEW, DROSERA LINEARIS AND DROSERA ROTUNDIFOLIA

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ABSTRACT

Members of the genus Drosera (sundews) are best known for their ability to capture insects in order to supplement low levels of nutrients (specifically nitrogen and phosphorus) present in the habitats in which they live. Two species, Drosera linearis (long-leaved sundew) and Drosera rotundifolia (round-leaved sundew), use the same basic mechanisms to capture prey, but differ in the shapes of their leaves and their preferred habitats. I aimed to determine whether one species was more efficient at capturing insects than the other, and if so, ascertain the reasons for such a disparity. In a rich fen in the northern lower peninsula of Michigan, I calculated percentages of leaves containing insects and counted the numbers of insects captured by these leaves per unit area for both species. D. linearis individuals had a higher percentage of leaves containing insects and caught an average of four times as many insects per leaf and 14.7 times as many insects per plant as D. rotundifolia. D. linearis was also 2.3 times more efficient at capturing insects than D. rotundifolia, calculated on the basis of leaf area. These results are most likely due to differences in the orientation and shape of leaves as well as differing levels of moisture, sunlight, and interspecific competition between microhabitats.

INTRODUCTION

Drosera linearis (long-leaved sundew) and Drosera rotundifolia (round-leaved sundew) coexist only in a few relatively small areas, one of which is in the fens of the Great Lakes Region (Slack 1979). The relationship between these two species is especially interesting because of their similarities in prey-capturing mechanisms, though they differ in structure and microhabitat preference. (For simplicity, all prey will be referred to as “insects” even though captured prey included other arthropods.)

Because of their mechanisms for capturing insects, Drosera and Pinguicula (Lentibulariaceae) can be categorized as “active fly-paper traps” (Slack 1979), because these species utilize tentacles (trichomes) tipped with a sticky substance to attract and immobilize insects, which land on them. Unlike their “passive fly-paper” counterparts, these species are also able to actively encompass their prey with their trichomes as well as with the margins of the leaf (Slack 1979). This is not necessarily a tactic used for securing prey; rather, the more trichomes that are in contact with the prey, the faster digestion and nutrient absorption occur (Slack 1979).
Drosera linearis has long slender leaves (~2.5 mm across), which are held erect and extend two to three cm into the air. It prefers the mineral-rich alkaline conditions of wet ground between hummocks in rich fens (Juniper 1989). Drosera rotundifolia has fewer, round leaves (~6 mm in diameter) that are spread flat in a rosette on the ground. It prefers the drier, more acidic areas created by Sphagnum beds on the tops of hummocks around the edges of fens as well as those scattered within (Thum 1986). Drosera rotundifolia is a shade-intolerant species that does not survive well with competing plants that reduce its access to sunlight (Stewart & Nilsen 1992). It is especially at a disadvantage in nutrient-rich areas where larger plants are more numerous. D. rotundifolia plants in the shade generally have larger leaves that are used to gather more sunlight (Thum 1989). Plants with larger leaves are also capable of capturing prey in larger numbers and of larger sizes (Schulze & Schulze 1990). Although there is no specific information on the effects of light levels on D. linearis, most members of Droseraceae are shade-intolerant (Juniper 1989). Because D. linearis tends to grow in the most open areas of fens, it is presumably even less shade-tolerant than D. rotundifolia.

This study was a comparison of insect-capturing efficiency between D. linearis and D. rotundifolia, taking into account both species’ relative abundances, leaf orientations, and surface areas. Results were used to better understand the differences between the structural adaptations and nutritional requirements of the two species.

METHODS & MATERIALS

Sampling was conducted in an interdunal swale just inland from Evergreen Beach on Lake Huron in southeastern Presque Isle Co., Michigan (NE ½ Sec. 21, T36N R4E) on 1 August and 4 August 2000. The swale was dominated by a rich fen comprised of marly soil where populations of Drosera linearis thrived. The fen contained scattered Sphagnum hummocks covered with Drosera rotundifolia and was surrounded by a cedar swamp beach ridge dominated by Thuja occidentalis, Abies balsamea, Picea mariana, Sphagnum capillifolium, and Sphagnum papillosum.

Samples were taken in relation to a 100-m north/south transect which extended nearly the length of the muddy soil in the bottom of the swale. Five ten-by-ten meter plots were oriented so that they included vegetation present in the marly areas as well as the hummocks and upland edges. Within each plot, I established two one-by-one meter subplots (one for each species). These subplots were chosen arbitrarily to ensure representative sample sizes. Three counts were made for both species within each subplot: 1) number of individuals, 2) total number of leaves and 3) number of leaves containing insects (“insect-leaves”). In addition, 10 insect-leaves were arbitrarily removed from each subplot. In cases where 10 insect-leaves were not present, five were taken instead.

To determine their potential insect-catching surface areas, the dimensions of these leaves were measured. For D. linearis, the length was determined as the distance of the leaf blade covered by trichomes and was multiplied by the width in the middle of the leaf to yield the surface area. For D. rotundifolia, diameters were measured and surface areas calculated assuming the shape of a leaf to be roughly circular. These values were divided by the average number of insects per insect-leaf for each species to give the average number of insects per mm² and then multiplied by the average leaf area to yield the total number of insects per leaf. To determine the total number of insects per plant, these values were multiplied by the average number of leaves per plant for each species. Using a dissecting scope, I counted the insects on these leaves and identified them to the ordinal level.
RESULTS

Kruskal-Wallis one-way analyses of variance were used to examine the significance of relationships between *D. linearis* and *D. rotundifolia* in the one square-meter subplots for: 1) the percentage of leaves containing insects (Fig. 1); 2) insects per insect-leaf (Fig. 2); and 3) insects per plant (Fig. 3). *Drosera linearis* plants had significantly larger percentages of leaves that contained insects compared to *D. rotundifolia* plants (*p* = 39.8, *n* = 10). On average, *D. linearis* insect-leaves contained about four times as many insects as those of *D. rotundifolia* (*p* = 39.8, *n* = 10) as well as 14.7 times as many insects per plant (*p* = 39.8, *n* = 10). Insects identified on leaves of both species included members of the orders Diptera, Hymenoptera, and Odonata (Reznik, personal communication).

The average surface area of *D. linearis* insect-leaves was 39 mm$^2$ (*n* = 27), compared to 21.2 mm$^2$ (*n* = 37) for insect-leaves of *D. rotundifolia*. The average...
FIGURE 3. Average Number of Insects per Insect-leaf in 1-m Subplots

FIGURE 4. Average Number of Insects per Plant
number of insects per mm$^2$ on \textit{D. linearis} insect-leaves was 0.087 ($n = 27$), which was 2.3 times greater than for those of \textit{D. rotundifolia} (0.038; $n = 37$).

\section*{DISCUSSION}

Not only did each insect-leaf of \textit{D. linearis} capture more insects than those of \textit{D. rotundifolia}, but \textit{D. linearis} plants also had a larger proportion of leaves containing insects, making \textit{D. linearis} much more efficient at capturing insects on a per-plant basis than \textit{D. rotundifolia}. Even when relative surface areas were considered in calculations, \textit{D. linearis} was still twice as effective.

There are several possible explanations for this relationship. First, it seems that \textit{D. linearis} is structurally better adapted for catching multiple insects on one leaf. This is related to the way that the margins and trichomes of the leaves curl inward around a captured insect. A \textit{D. rotundifolia} leaf curls inward and upward forming a cup-like shape, condensing the leaf and reducing the number of trichomes exposed to capture additional insects (Slack 1979). I observed that \textit{Drosera linearis} leaves pinch in from the sides, their trichomes folding inward in a lateral motion as well as rolling downward from the tip to the petiole, leaving a large portion of trichomes still available to catch additional insects. This is consistent with observations by Bopp and Weber (1981). Leaves of \textit{D. rotundifolia} are therefore adapted to capture only a few insects per leaf at a time, while those of \textit{D. linearis} are better equipped to capture additional insects while still digesting those already captured. Surface area, however, is probably not the best representation of a plant’s ability to catch insects. The highest densities of trichomes is around the margins of leaf, not in the middle (Slack 1979). Perhaps a more accurate measure of a leaf’s potential insect-capturing area would be margin length or even total number of trichomes.

Second, apart from a small population of \textit{Pinguicula vulgaris} (common butterwort), \textit{D. linearis} had virtually no competition for space in its microhabitat (nutrient-rich, alkali fens). In addition, the vertical orientation of leaves allowed it to capture flying insects easily. In contrast, \textit{D. rotundifolia} was competing for space with many larger species that probably reduced its access to flying insects (especially in rich fens) (Thum 1986). This would limit its prey to insects crawling on the ground (Schulze & Schulze 1990, Thum 1986). At the same time, \textit{D. linearis} would be limited to flying insects, as most crawling insects would not be present in standing or slow moving water (Schulze & Schulze 1990, Thum 1986). In fact, research conducted by Achterberg (1973) and Thum (1986, 1989) comparing the prey of \textit{Drosera rotundifolia} and \textit{Drosera intermedia} demonstrated that flying insects were captured far more often by \textit{D. intermedia} than by \textit{D. rotundifolia} and that the opposite was true for crawling insects. (\textit{Drosera intermedia} is similar to \textit{D. linearis} in its elongated, vertically-oriented leaves and preference for a wet, marly habitat. Because of these similarities, information on \textit{D. intermedia} can be used in this study as analogous data, to compensate for lack of information on \textit{D. linearis}.)

It is reasonable to assume that on the average, crawling insects weigh more than
flying insects. The total number of insects captured is less important than the total biomass of trapped prey; therefore, plants specializing in crawling prey could survive by consuming smaller numbers of insects. The low light conditions around the perimeter of the fen promoted larger leaves in *D. rotundifolia* which could have led to its capture of larger, but fewer insects (Schulze & Schulze 1990). In addition, because of the flattened orientation of its leaf rosettes, *D. rotundifolia* could benefit nutritionally from pollen grains and small leaf fragments which fall to the ground, making the capture of insects less important in supplementing low levels of nitrogen and phosphorus in the soil (Juniper 1989). Thum’s studies (1986, 1989) showed that while *D. intermedia* caught an average of 14 times as many insects as *D. rotundifolia* (consistent with the findings of this study for *D. linearis*), the total biomasses of the two species within the study area were equal. This meant that both species exhibited equal prey catching success when plant biomass was accounted for. Although plant biomass was not considered in this study, the same is most likely true for the relationship between *D. rotundifolia* and *D. linearis*. Simply because *D. linearis* captures more insects than *D. rotundifolia*, this does not suggest that *D. linearis* is any better adapted for survival. It must, however, in order to be successful, be better adapted for capturing more insects, because of the smaller size of its accessible prey and its limited access to alternate sources of nitrogen (pollen grains and leaf-fragments).

It should be noted that this study was conducted in a very specific and localized habitat and these results and conclusions may not apply to all areas in which *D. linearis* and *D. rotundifolia* coexist. In order to better understand the relationship between these two species, it is necessary to conduct further research in a variety of habitats, taking into account prey identity, biomass, nutritional value and plant biomass, as well as the length of leaf margins and numbers of trichomes.

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LITERATURE CITED


