= Drosera =

Drosera , commonly known as the sundews , is one of the largest genera of carnivorous plants , with at least 194 species . These members of the family Droseraceae lure , capture , and digest insects using stalked mucilaginous glands covering their leaf surfaces . The insects are used to supplement the poor mineral nutrition of the soil in which the plants grow . Various species , which vary greatly in size and form , can be found growing natively on every continent except Antarctica .

Both the botanical name (from the Greek ?????? : drosos = " dew , dewdrops ") and the English common name (sundew , derived from Latin ros solis , meaning " dew of the sun ") refer to the glistening drops of mucilage at the tip of each tentacle that resemble drops of morning dew .

= = Characteristics = =

Sundews are perennial (or rarely annual) herbaceous plants , forming prostrate or upright rosettes between 1 and 100 cm (0 @.@ 39 and 39 @.@ 37 in) in height , depending on the species . Climbing species form scrambling stems which can reach much longer lengths , up to 3 m (9 @.@ 8 ft) in the case of D. erythrogyne . Sundews have been shown to be able to achieve a lifespan of 50 years . The genus is so specialized for nutrient uptake through its carnivorous behavior , the pygmy sundew is missing the enzymes (nitrate reductase , in particular) that plants normally use for the uptake of earth @-@ bound nitrates .

= = = Habit = = =

The genus can be divided into several growth forms :

Temperate sundews : These species form a tight cluster of unfurled leaves called a hibernaculum in a winter dormancy period (= Hemicryptophyte) . All of the North American and European species belong to this group . Drosera arcturi from Australia (including Tasmania) and New Zealand is another temperate species that dies back to a horn @-@ shaped hibernaculum .

Subtropical sundews : These species maintain vegetative growth year @-@ round under uniform or nearly uniform climatic conditions .

Pygmy sundews : A group of roughly 40 Australian species , they are distinguished by miniature growth , the formation of gemmae for asexual reproduction , and dense formation of hairs in the crown center . These hairs serve to protect the plants from Australia 's intense summer sun . Pygmy sundews form the subgenus Bryastrum .

Tuberous sundews : These nearly 50 Australian species form an underground tuber to survive the extremely dry summers of their habitat , re @-@ emerging in the autumn . These so @-@ called tuberous sundews can be further divided into two groups , those that form rosettes and those that form climbing or scrambling stems . Tuberous sundews comprise the subgenus Ergaleium .

Petiolaris complex : A group of tropical Australian species , they live in constantly warm but sometimes wet conditions . Several of the 14 species that comprise this group have developed special strategies to cope with the alternately drier conditions . Many species , for example , have petioles densely covered in trichomes , which maintain a sufficiently humid environment and serve as an increased condensation surface for morning dew . The Petiolaris complex comprises the subgenus Lasiocephala .

Although they do not form a single strictly defined growth form , a number of species are often put together in a further group :

Queensland sundews : A small group of three species (D. adelae , D. schizandra and D. prolifera) , all are native to highly humid habitats in the dim understories of the Australian rainforest .

= = = Leaves and carnivory = = =

Sundews are characterised by the glandular tentacles , topped with sticky secretions , that cover their laminae . The trapping and digestion mechanism usually employs two types of glands : stalked

glands that secrete sweet mucilage to attract and ensnare insects and enzymes to digest them , and sessile glands that absorb the resulting nutrient soup (the latter glands are missing in some species , such as D. erythrorhiza) . Small prey , mainly consisting of insects , are attracted by the sweet secretions of the peduncular glands . Upon touching these , the prey become entrapped by sticky mucilage which prevents their progress or escape . Eventually , the prey either succumb to death through exhaustion or through asphyxiation as the mucilage envelops them and clogs their spiracles . Death usually occurs within 15 minutes . The plant meanwhile secretes esterase , peroxidase , phosphatase and protease enzymes . These enzymes dissolve the insect and free the nutrients contained within it . This nutrient mixture is then absorbed through the leaf surfaces to be used by the rest of the plant .

All species of sundew are able to move their tentacles in response to contact with edible prey . The tentacles are extremely sensitive and will bend toward the center of the leaf to bring the insect into contact with as many stalked glands as possible . According to Charles Darwin , the contact of the legs of a small gnat with a single tentacle is enough to induce this response . This response to touch is known as thigmonasty , and is quite rapid in some species . The outer tentacles (recently coined as " snap @-@ tentacles ") of D. burmannii and D. sessilifolia can bend inwards toward prey in a matter of seconds after contact , while D. glanduligera is known to bend these tentacles in toward prey in tenths of a second . In addition to tentacle movement , some species are able to bend their laminae to various degrees to maximize contact with the prey . Of these , D. capensis exhibits what is probably the most dramatic movement , curling its leaf completely around prey in 30 minutes . Some species , such as D. filiformis , are unable to bend their leaves in response to prey .

A further type of (mostly strong red and yellow) emergence has recently been discovered in a few Australian species (D. hartmeyerorum , D. indica) . Their function is not known yet , although they may help in attracting prey .

The leaf morphology of the species within the genus is extremely varied , ranging from the sessile ovate leaves of D. erythrorhiza to the bipinnately divided acicular leaves of D. binata .

= = = Flowers and fruit = = =

The flowers of sundews , as with nearly all carnivorous plants , are held far above the leaves by a long stem.This physical isolation of the flower from the traps was originally thought to be an adaptation meant to avoid trapping potential pollinators ; a recent study , however , indicated Drosera species attract distinct types of insects as pollinators and prey , with little overlap . Instead , the tall flower stalks probably help raise the flowers to a height where they are noticeable to pollinators . The mostly unforked inflorescences are spikes , whose flowers open one at a time and usually only remain open for a short period . Flowers open in response to light intensity (often opening only in direct sunlight) , and the entire inflorescence is also helitropic , moving in response to the sun 's position in the sky .

The radially symmetrical (actinomorphic) flowers are always perfect and have five parts (the exceptions to this rule are the four @-@ petaled D. pygmaea and the eight to 12 @-@ petaled D. heterophylla) . Most of the species have small flowers (< 1 @.@ 5 cm or 0 @.@ 6 in) . A few species , however , such as D. regia and D. cistiflora , have flowers 4 cm (1 @.@ 6 in) or more in diameter . In general , the flowers are white or pink . Australian species display a wider range of colors , including orange (D. callistos) , red (D. adelae) , yellow (D. zigzagia) or metallic violet (D. microphylla) .

The ovary is superior and develops into a dehiscent seed capsule bearing numerous tiny seeds . The pollen grain type is compound , which means four microspores (pollen grains) are stuck together with a protein called callose .

= = = Roots = = =

The root systems of most Drosera are often only weakly developed . Serving mainly to absorb water and to anchor the plant to the ground , the roots are relatively useless for nutrient uptake . A

few South African species use their roots for water and food storage . Some species have wiry root systems that remain during frosts if the stem dies . Some species , such as D. adelae and D. hamiltonii , use their roots for asexual propagation , by sprouting plantlets along their length . Some Australian species form underground corms for this purpose , which also serve to allow the plants to survive dry summers . The roots of pygmy sundews are often extremely long in proportion to their size , with a 1 @-@ cm (0 @.@ 4 @-@ in) plant extending roots over 15 cm (5 @.@ 9 in) beneath the soil surface . Some pygmy sundews , such as D. lasiantha and D. scorpioides , also form adventitious roots as supports . D. intermedia and D. rotundifolia have been reported to form arbuscular mycorrhizae , which penetrate the plant 's tissues .

= = Taxonomy and phylogenetics = =

The unrooted cladogram to the right shows the relationship between various subgenera and classes as defined by the analysis of Rivadavia et al. in 2002 . The monotypic section Meristocaulis was not included in the study , so its place in this system is unclear . More recent studies have placed this group near section Bryastrum , so it is placed there below . Also of note , the placement of the section Regiae in relation to Aldrovanda and Dionaea is uncertain . Since the section Drosera is polyphyletic , it shows up multiple times in the cladogram (*) .

This phylogenetic study has made the need for a revision of the genus even clearer .

= = Reproduction = =

Many species of sundews are self @-@ fertile ; their flowers will often self @-@ pollinate upon closing . Often , numerous seeds are produced . The tiny black seeds germinate in response to moisture and light , while seeds of temperate species also require cold , damp , stratification to germinate . Seeds of the tuberous species require a hot , dry summer period followed by a cool , moist winter to germinate .

Vegetative reproduction occurs naturally in some species that produce stolons or when roots come close to the surface of the soil . Older leaves that touch the ground may sprout plantlets . Pygmy sundews reproduce asexually using specialized scale @-@ like leaves called gemmae . Tuberous sundews can produce offsets from their corms .

In culture , sundews can often be propagated through leaf , crown , or root cuttings , as well as through seeds .

= = Distribution = =

The range of the sundew genus stretches from Alaska in the north to New Zealand in the south . The centers of diversity are Australia , with roughly 50 % of all known species , and South America and southern Africa , each with more than 20 species . A few species are also found in large parts of Eurasia and North America . These areas , however , can be considered to form the outskirts of the generic range , as the ranges of sundews do not typically approach temperate or Arctic areas . Contrary to previous supposition , the evolutionary speciation of this genus is no longer thought to have occurred with the breakup of Gondwana through continental drift . Rather , speciation is now thought to have occurred as a result of a subsequent wide dispersal of its range . The origins of the genus are thought to have been in Africa or Australia .

Europe is home to only three species : D. intermedia , D. anglica , and D. rotundifolia . Where the ranges of the two latter species overlap , they sometimes hybridize to form the sterile D. × obovata . In addition to the three species and the hybrid native to Europe , North America is also home to four additional species ; D. brevifolia is a small annual native to coastal states from Texas to Virginia , while D. capillaris , a slightly larger plant with a similar range , is also found in areas of the Caribbean . The third species , D. linearis , is native to the northern United States and southern Canada . D. filiformis has two subspecies native to the East Coast of North America , the Gulf Coast , and the Florida panhandle .

This genus is often described as cosmopolitan , meaning it has worldwide distribution . The botanist Ludwig Diels , author of the only monograph of the family to date , called this description an " arrant misjudgment of this genus ' highly unusual distributional circumstances (arge Verkennung ihrer höchst eigentümlichen Verbreitungsverhältnisse) " , while admitting sundew species do " occupy a significant part of the Earth 's surface (einen beträchtlichen Teil der Erdoberfläche besetzt) " . He particularly pointed to the absence of Drosera species from almost all arid climate zones , countless rainforests , the American Pacific Coast , Polynesia , the Mediterranean region , and North Africa , as well as the scarcity of species diversity in temperate zones , such as Europe and North America .

= = Habitat = =

Sundews generally grow in seasonally moist or more rarely constantly wet habitats with acidic soils and high levels of sunlight . Common habitats include bogs , fens , swamps , marshes , the tepuis of Venezuela , the wallums of coastal Australia , the fynbos of South Africa , and moist streambanks . Many species grow in association with sphagnum moss , which absorbs much of the soil 's nutrient supply and also acidifies the soil , making nutrients less available to plant life . This allows sundews , which do not rely on soil @-@ bound nutrients , to flourish where more dominating vegetation would usually outcompete them .

The genus , though , is very variable in terms of habitat . Individual sundew species have adapted to a wide variety of environments , including atypical habitats , such as rainforests , deserts (D. burmannii and D. indica) , and even highly shaded environments (Queensland sundews) . The temperate species , which form hibernacula in the winter , are examples of such adaptation to habitats ; in general , sundews tend to inhabit warm climates , and are only moderately frost @-@ resistant .

= = Conservation status = =

Although none of the Drosera species in the United States are federally protected , all are listed as threatened or endangered in some states . Additionally , many of the remaining native populations lie on protected land , such as national parks or wildlife preserves . Drosera species are protected by law in many European countries , such as Germany , Austria , Switzerland , the Czech Republic , Finland , Hungary , France , and Bulgaria . Currently , the largest threat in Europe and North America is habitat destruction for development projects , as well as the draining of bogs for agricultural uses and peat harvesting . In many regions , this has led to the extirpation of some species from parts of their former range . Reintroduction of plants into such habitats is usually difficult or impossible , as the ecological needs of certain populations is closely tied to their geographical location . Through increased legal protection of bogs and moors , as well as a concentrated effort to renaturalize such habitats , the threat to these plants ' survival might be curbed , although most species would remain endangered . The relatively unimpressive image of these plants , as well as their small , low growth , makes them difficult to protect . As part of the landscape , sundews are often overlooked or not recognized at all .

In South Africa and Australia , two of the three centers of species diversity , the natural habitats of these plants are undergoing a high degree of pressure from human activities . Expanding population centers (such as Queensland , Perth , and Cape Town) threaten many such habitats , as does the draining of moist areas for agriculture and forestry in rural areas . The droughts that have been sweeping Australia over the last 10 years also pose a threat to many species by drying up previously moist areas .

Those species endemic to a very limited area are often most threatened by the collection of plants from the wild . D. madagascariensis is considered endangered in Madagascar because of the large @-@ scale removal of plants from the wild for exportation ; 10 - 200 million plants are harvested for commercial medicinal use annually .

= = Uses = =

= = = As a medicinal plant = = =

Sundews were used as medicinal herbs as early as the 12th century , when an Italian doctor from the School of Salerno , Matthaeus Platearius , described the plant as an herbal remedy for coughs under the name herba sole . It has been used commonly in cough preparations in Germany and elsewhere in Europe . Sundew tea was especially recommended by herbalists for dry coughs , bronchitis , whooping cough , asthma and " bronchial cramps " . A modern study has shown that Drosera exhibits antitussive properties .

Culbreth 's 1927 Materia Medica listed D. rotundifolia , D. anglica and D.linearis as being used as stimulants and expectorants , and " of doubtful efficacy " for treating bronchitis , whooping cough , and tuberculosis . Sundews have also been used as an aphrodisiac and to strengthen the heart , as well as to treat sunburn , toothache , and prevent freckles . They are still used today in some 200 @-@ 300 registered medications , usually in combination with other herbal ingredients . Today , Drosera is usually used to treat ailments such as asthma , coughs , lung infections , and stomach ulcers .

Medicinal preparations are primarily made using the roots , flowers , and fruit @-@ like capsules . Since all native sundews species are protected in many parts of Europe and North America , extracts are usually prepared using cultivated fast @-@ growing sundews (specifically D. rotundifolia , D. intermedia , D. anglica , D. ramentacea and D. madagascariensis) or from plants collected and imported from Madagascar , Spain , France , Finland and the Baltics .

= = = As ornamental plants = = =

Because of their carnivorous nature and the beauty of their glistening traps , sundews have become favorite ornamental plants ; however , the environmental requirements of most species are relatively stringent and can be difficult to meet in cultivation . As a result , most species are unavailable commercially . A few of the hardiest varieties , however , have made their way into the mainstream nursery business and can often be found for sale next to Venus flytraps . These most often include D. capensis , D. aliciae , and D. spatulata .

Cultivation requirements vary greatly by species . In general , though , sundews require high environmental moisture content , usually in the form of a constantly moist or wet soil substrate . Most species also require this water to be pure , as nutrients , salts , or minerals in their soil can stunt their growth or even kill them . Commonly , plants are grown in a soil substrate containing some combination of dead or live sphagnum moss , sphagnum peat moss , sand , and / or perlite , and are watered with distilled , reverse osmosis , or rain water .

= = = Nanobiotechnology = = =

The mucilage produced by Drosera has remarkable elastic properties and has made this genus a very attractive subject in biomaterials research . In one recent study , the adhesive mucilages of three species (D. binata , D. capensis , and D. spatulata) were analyzed for nanofiber and nanoparticle content . Using atomic force microscopy , transmission electron microscopy , and energy @-@ dispersive X @-@ ray spectroscopy , researchers were able to observe networks of nanofibers and nanoparticles of various sizes within the mucilage residues . In addition , calcium , magnesium , and chlorine ? key components of biological salts - were identified . These nanoparticles are theorized to increase the viscosity and stickiness of the mucilage , in turn increasing the effectiveness of the trap . More importantly for biomaterials research , however , is the fact that , when dried , the mucin provides a suitable substrate for the attachment of living cells . This has important implications for tissue engineering , especially because of the elastic qualities of the adhesive . Essentially , a coating of Drosera mucilage on a surgical implant , such as a

replacement hip or an organ transplant , could drastically improve the rate of recovery and decrease the potential for rejection , because living tissue can effectively attach and grow on it . The authors also suggest a wide variety of applications for Drosera mucin , including wound treatment , regenerative medicine , or enhancing synthetic adhesives . Also of note , because this mucilage can stretch to nearly a million times its original size and is readily available for use , it can be an extremely cost @-@ efficient source of biomaterial .

= = = Other uses = = =

The corms of the tuberous sundews native to Australia are considered a delicacy by the Australian Aborigines . Some of these corms were also used to dye textiles , while another purple or yellow dye was traditionally prepared in the Scottish Highlands using D. rotundifolia . A sundew liqueur is also still produced using a recipe from the 14th century . It is made using fresh leaves from mainly D. capensis , D. spatulata , and D. rotundifolia .

= = Chemical constituents = =

Several chemical compounds with potential biological activities are found in sundews , including flavonoids (kaempferol , myricetin , quercetin and hyperoside) , quinones (plumbagin , hydroplumbagin glucoside and rossoliside (7 ? methyl ? hydrojuglone ? 4 ? glucoside)) , and other constituents such as carotenoids , plant acids (e.g. butyric acid , citric acid , formic acid , gallic acid , malic acid , propionic acid) , resin , tannins and ascorbic acid (vitamin C) .