SEED STRUCTURE OF CARNIVOROUS PLANTS

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This report is the beginning of a study of the seed structure of carnivorous plants. For several years I have noticed that when one receives seed of a carnivorous plant one can't usually tell if the seed is from the plant that it is supposed to be from. There is usually no way of checking the species from the seed alone. The seed of most genera have not been studied extensively. However, the *Utricularia* of West Bengal and *Drosera* of North America have been drawn and studied extensively. Regional keys for these genera have been made. Seed of *Utricularia* of other areas has also been used to a great extent by Peter Taylor in distinguishing between species.

I decided this year to start drawing all of the seed that I had and to try to obtain as many more kinds as I could, so that these could be drawn too. I also have tried to collect as many descriptions of seed as I could find. Eventually I would like to combine all of the information known into one research paper. Also, I think that someday any seed of a carnivorous plant will be able to be keyed down by itself to the species or even the variety.

Materials and Methods

To start this project I have drawn all the seeds that I have obtained so far.* I also obtained as many descriptions of seed as I could find from various publications.

The seeds were first observed under a dissecting microscope. Then they were observed with a compound microscope using higher magnification. To view the opaque seeds with a compound microscope effectively, side lighting was used. The seeds were not soaked in water or pretreated in any way. The seeds were drawn to scale in pencil and later drawn over in black ink.

After making drawings of the exterior structure of seed, I dissected seed of each family that I had. I took the seed coat off the seed and stained it with I_2KI. The I_2KI stained the starch in the endosperm. I also took cross sections of seed and stained them with I_2KI as well. Utilizing these observations and those of others, I have made a key to distinguish between seeds of most of the genera of carnivorous plants.

In order to get information on seeds of carnivorous plants I used Lynn Macy's KWIC bibliography service and the library of SUNY at Albany. Many articles were obtained through the interlibrary loan service of SUNYA. In these publications I looked for descriptions of seed which are now included in this report.

Results

The seeds of carnivorous plants are quite different in their structure and morphology. The major difference between seeds of carnivorous plants is presence or absence of endosperm. The Family Lentibulariaceae (*Utricularia, Polypompholyx, Genlisea,* and *Pinguicula*) has no endosperm that can be readily seen in mature seed. All other carnivorous plant seeds have endosperm. In the Lentibulariaceae *Pinguicula* seed can be separated easily from the other three genera by external seed structure. All *Pinguicula* seed is scobiform. The other three genera have to be distinguished from each other by internal structure at this time. I think that they probably are different externally, too. The different species of *Utricularia* have seed of many different shapes and sizes. As a result I feel that all of these should be described before *Polypompholyx* and *Genlisea* are

*Patrick Dwyer's drawings could not be reproduced well; the drawings appearing with the article were done by Debbie Tolman and John Randall, students at the Univerty of North Carolina at Charlotte, from seed specimens sent to them by Patrick Dwyer. The caption information is from Patrick Dwyer.

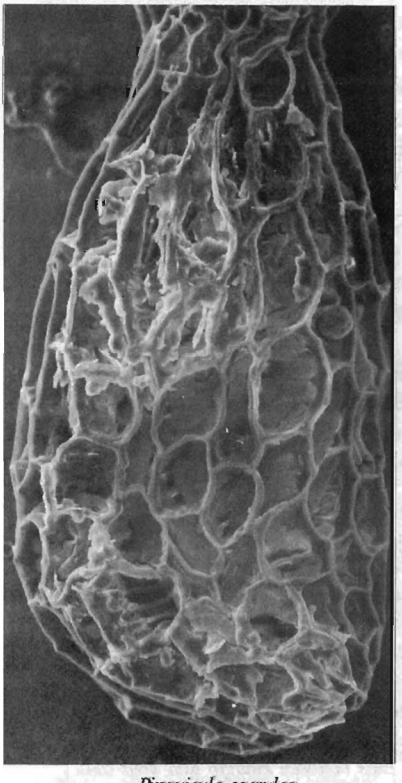
distinguished from them on external characters. In other words, they are too complex to generalize yet.

Among other carnivorous plants, *Drosera* is the largest group with the most variety between species. A small basal embryo in *Drosera* may be a difference from *Byblis* if *Byblis* does not have it. The differences between *Dionaea, Drosophyllum, Sarracenia, Darlingtonia, Heliamphora, Byblis* and *Nepenthes* are basically external characteristics and size. I really don't have enough information on *Cephalotus* to even include it in the key.

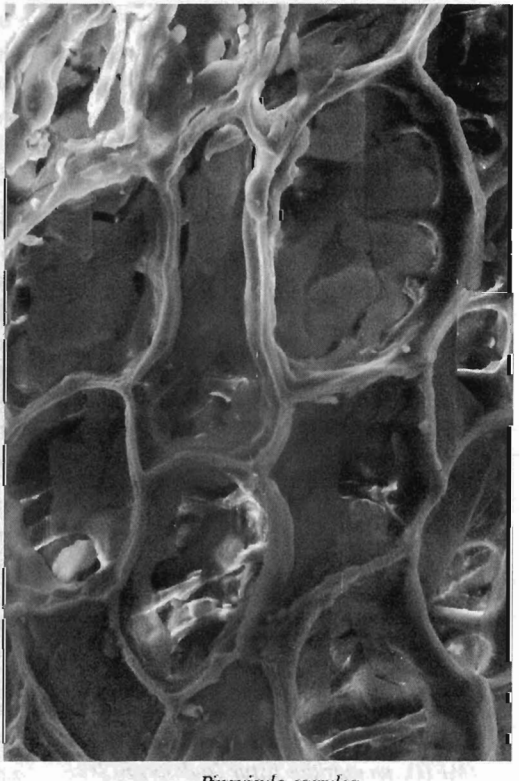
Within the genera the seeds that are hardest to distinguish between species are those of *Sarracenia* and *Nepenthes*. The seed of all of the species of *Sarracenia* are very similar. The structural characteristics and sizes of seed overlap from species to species. Donald Schnell informed me that the seeds of *Sarracenia* species vary in color, size, shape and external markings from season to season, and with the environmental factors that affect the plant. Dr. Baum suggested that perhaps there might be some colored chemical reactions which might distinguish the species of these seed. I was unable to find any reactions specific enough to be useful. However, I think this should be looked into further.

The other seed that I studied show differences in structure, size, or color from species to species. The *Utricularia, Polypompholyx, Drosera, Byblis,* and *Pinguicula* seeds all are distinguishable from species to species. *Pinguicula* seed is the hardest of these genera. They all look similar and have the same basic shape. Here size and color are more important than in the other genera.

I hope to study seeds of *Cephalotus* and *Heliamphora*, as well as more seed of the genera already listed. Maybe I will be able to get *Genlisea* and *Aldrovanda* seed also.



Pinguicula caerulea
Mag. 50×



Pinguicula caerulea
Mag 500×

SEM photomicrographs sent by Tom Story, 1112 Klengel St., Antioch, CA 94509.

KEY TO THE GENERA OF CARNIVOROUS PLANT SEED

1. Seed with endosperm, positive indication with I_2KI – (Sarraceniales) – 2.
1. Seed without apparent endosperm, negative indication with I_2KI – (Lentibulariaceae) – 9.
   2. Seed coat elongated at both ends, filiform, length usually greater than 5 mm (3 mm is smallest) – *Nepenthes*.
   2. Seed coat not elongated at ends, ovoid or obovoid; with only small extensions of seed coat, or none – 3.
      3. Seed winged, wings circling around the seed – *Heliamphora*.
      3. Seed not winged – 4.
         4. Seed with small projections or extensions of the seed coat, seed length around 3 mm – *Darlingtonia*.
         4. Seed without projections if around 3 mm in length or seed smaller than 3 mm – 5.
            5. Seed pyriform (pear-shaped) with thick wrinkled black seed coat, length about 3 mm – *Drosophyllum*.
            5. Seed with a smooth coat or smaller than 3 mm – 6.
               6. Seed ovate to pyriform with smooth black seed coat with minute pits, length about 3 mm – *Dionaea*.
               6. Seed smaller than 3 mm in length – 7.
                  7. Seed obovoid, areolate and sometimes tuberculate or bullate, length 1.1 mm – 2.5 mm, color from grey to brown, *Sarracenia*
                  7. Seed variously shaped, reticulate, papillose, pitted or smooth, color from brown to black, length from 0.25 mm – around 3.0 mm – 8.
                     8. Seed with basal embryo – *Drosera, Aldrovanda.*
                     8. Seed without basal embryo (? – this has not been seen or checked) – *Byblis.*
                        9. Seed length greater than width – often cylindrical or fusiform, the surface reticulated or pitted – *Pinguicula*
                        9. Seed variously shaped, sometimes winged, if cylindrical or fusiform then not reticulate or pitted. (This statement is based on a very small number of species. It may prove wrong with further investigation) – *Genlisea, Polypompholyx, Utricularia.*

The following differences between the genera of Lentibulariaceae were not observed by me. I attempted to see these features using tetrazolium stain. I will try again when I become more proficient with this chemical. All of these characteristics were found in the article by Farooq.

Pinguicula – embryo differentiated with root primodia, no micropylar endosperm haustorium (MEH), no nutritive tissue (endosperm) present.

Genlisea – embryo differentiated without root primordia, MEH within integument, nutritive tissue present (minute amount).

Polypompholyx – embryo undifferentiated, MEH enters funicle, nutritive tissue present (minute amount).

Polypompholyx – embryo undifferentiated, MEH enters funicle, nutritive tissue present (minute amount).

Utricularia – embryo undifferentiated, MEH is extra ovular, nutritive tissue is a single layer of cells between embryo and seed coat.

The following are descriptions that I found. Seed was drawn in many articles;

in some there was no description. I did not include those without written descriptions.

Aldrovanda vesiculosa L. (Europe, India, Japan, Africa) – minute, ellipsoidal, shining with a mucro at base, black (Ohwi, 1965).

Drosera affinis Welw. ex Oliver (Trop. Africa) – fusiform, testa reticulate with longitudinal and transverse ridges, 0.7-0.9 mm long and 0.2 mm broad (Laundon, 1959).

D. banksii R. Br. (Australia) – ovoid, about 1 mm long, black (Erickson, 1968).

D. binata Labill. (Australia, New Zealand) – linear with expanded membrane on each side (Erickson, 1968).

D. burkeana Planch. (S. Africa) – ovoid, testa smooth, 0.3-0.4 mm long and 0.15-0.2 mm broad, black (Laundon, 1959).

D. colombiana Fernandez-Perez (Colombia) – obovate to ellipsoid, base narrow, wrinkled, 0.4 mm long (Fernandez-Perez, 1965).

D. communis St. Hil. (Brazil, Colombia) – fusiform, 0.8-1.2 mm long and 0.3 mm wide (Fernandez-Perez, 1965).

D. emissa Diels. (Australia) – pitted and almost football shaped, grey (Erickson, 1968).

D. felix Steyermark & Smith (Venezuela) – ovoid, about 0.4 mm long and 0.2 mm wide (Steyermark & Smith, 1974).

Drosera fimbriata DeBuhr (Australia) – small, ovoid black (DeBuhr, 1975).

D. heterophylla Lindl. (Australia) – linear, curved in with a crook at one end (Erickson, 1968).

D. macrantha Lindl. (Australia) – linear (Erickson, 1968).

D. macrophylla Lindl. (Australia) – very small and round, black (Erickson, 1968).

D. madagascariensis D.C. (Madagascar, Trop. Africa) – fusiform, testa reticulate with longitudinal and transverse ridges, 0.7-0.9 mm long and 0.2 mm broad (Laundon, 1959).

D. marchantii DeBuhr (Australia) – linear, about 1 mm long, black (DeBuhr, 1975).

D. neesii Lehm. (Australia) – narrowly linear (Erickson, 1968).

D. paleacea D.C. (Australia) - striped and almost round (Erickson, 1968).

D. petiolaris R.Br. ex D.C. (Australia) – ellipsoid with small warts on each side (Erickson, 1968).

D. peltata var *nipponica* (Masam) Ohwi (Japan) – broadly elliptic, slightly attenuate at both ends, about 0.5 mm long with fine longitudinal and obsolete cross lines (Ohwi, 1965).

D. pilosa Exell et Laundon (Cameroons, Kenya, Tanzania) – ovoid, testa smooth, 0.3-0.5 mm long and 0.2 mm broad, black (Laundon, 1959).

D. platypoda Turcz. (Australia) – round, angled, and warty (Erickson, 1968).

Drosera pulchella Lehm. (Australia) – ellipsoid with minute dots and grooves, black (Erickson, 1968).

D. pusilla H.B.K. (Venezuela) – subglobose (Fernandez-Perez, 1965).

D. stricticaulis (Diels) O.H.S. (Australia) – broad and flat, curved like a flattened bean with a furrow along the middle of each side (Erickson, 1968).

D. sulphurea Lehm. (Australia) – narrowly linear (Erickson, 1968).

D. tenella H.B.K. (Argentina) – oblong (Fernandez-Perez, 1965).

D. whittakerii Planch. (Australia) – round and pitted, black (Erickson, 1968).

Cephalotus follicularis Labill. (Australia) – small, oval shaped, light brown (Mazrimas, 1976).

Heliamphora species Benth. (Venezuela) – large wing developed around seed (Uphof., 1936).

Nepenthes alata Blanco. (Philippines) – filiform, 8-10 mm long, nucleus with transverse wrinkles (Danser, 1928).

N. albo-marginata Lobb. (Malaysia, Sumatra, Borneo) – filiform, 15-22 mm long, nucleus transversely wrinkled (Danser, 1928).

N. ampullaria Jack. (Malaysia, Sumatra, Borneo, New Guinea) – filiform, 10-15 mm long, nucleus with minute prickles, slightly longitudinally wrinkled (Danser, 1928).

Nepenthes bongso Korth. (Sumatra) – filiform, 6-12 mm long, nucleus longitudinally

but hardly transversely wrinkled (Danser, 1928).

N. boschiana Korth. (Borneo) – filiform, about 12 mm long (Danser, 1928).

N. decurrens Macf. (Borneo) – up to 15 mm long (Danser, 1928).

N. ephippiata Dans. (Borneo) – filiform, 10-15 mm long, nucleus tuberculate-wrinkled (Danser, 1928).

N. gracilis Korth. (Malaysia, Sumatra, Borneo, Celebes) – filiform, 9-15 mm long, nucleus delicately prickly (Danser, 1928).

N. gracillima Ridl. (Malaysia) – filiform, about 8 mm long, nucleus strongly transversely wrinkled (Danser, 1928).

N. gymnamphora Nees (Sumatra, Borneo, Java) – filiform, 6-15 mm long, nucleus usually indistinctly transversely wrinkled (Danser, 1928).

N. hirsuta Hook. (Borneo) – filiform, 12-20 mm lng, nucleus transversely wrinkled (Danser, 1928).

N. maxima Nees. (Borneo, Celebes, Moluccas, New Guinea) – filiform, 10-20mm long, nucleus delicately transversely wrinkled (Danser, 1928).

N. mirabilis Druce. (Widespread over S.E. Asia and E. Indies) – filiform, about 12 mm long, nucleus slightly wrinkled and slightly prickled (Danser, 1928).

Nepenthes papuana Dans. (New Guinea) – filiform, 12-15 mm long, nucleus transversely wrinkled (Danser, 1928).

N. pectinata Dans. (Sumatra) – filiform (Danser, 1928).

N. rafflesiana Jack. (Malaysia, Sumatra, Borneo) – filiform, 10-12 mm long, nucleus and adjacent part of appendages delicately and shortly prickled (Danser, 1928).

N. rajah Hook. (Borneo) – filiform, 3-8 mm long, nucleus not or slightly wrinkled (Danser, 1928).

N. reinwardtiana Miq. (Malaysia, Sumatra, Borneo, Moluccas) – filiform, nucleus transversely wrinkled (Danser, 1928).

N. sanguinea Lindl. (Malaysia) – filiform, 12-15 mm long, nucleus strongly transversely wrinkled (Danser, 1928).

N. singalana Bec. (Sumatra) – filiform, 8-12 mm long, nucleus strongly transversely wrinkled (Danser, 1928).

N. spectabilis Dans. (Sumatra) – filiform, 12-18 mm long, nucleus strongly transversely wrinkled (Danser, 1928).

N. tobaica Dans. (Sumatra) – filiform, 8-15 mm long, nucleus transversely wrinkled (Danser, 1928).

N. treubiana Warb. (Sumatra, New Guinea) – filiform, nucleus transversely wrinkled (Danser, 1928).

N. veitchii Hook. (Borneo) – filiform, nucleus strongly transversely wrinkled (Danser, 1928).

N. villosa Hook. (Borneo) – filiform, 8-9 mm long (Danser, 1928).

Genlisea filiformis St. Hil. (Brazil, Venezuela, Guyana, Cuba, Colombia, Br. Honduras) – subpyramidal, 0.2 mm long, light brown (Fernandez-Perez, 1964).

Pinguicula agnata Casper (Mexico) – scobiform, cylindrical, alveolate (Casper, 1966).

P. albida Wright ex. Griseb. (Cuba) – scobiform, conical, ± 0.5 mm long and ±0.2 mm wide, reticulated (Casper, 1966).

P. antarctica Vah. (Chile, Argentina) – scobiform, cylindric-fusiform, 0.6-0.8 mm long and 0.2-0.26 mm wide, alveolate (Casper, 1966).

P. balcanica Casper (Bulgaria, Yugoslavia, Albania, Greece) – scobiform (Casper, 1966).

P. caerulea Walt. (N.C., S.C., Ga., Fla. – U.S.A.) – scobiform, oblong-conical ±0.5 mm long and 0.2-0.3 mm wide, alveolate (Casper, 1966); oblong or obpyramidal alveolate with 3-4 cross lines (Godfrey & Stripl., 1961).

P. calyptrata H.B.K. (Colombia, Ecuador) – scobiform, ellipsoid, alveolate (Casper, 1966).

P. chilensis Clos. (Chile, Argentina) – scobiform (Casper, 1966).

P. cladophila Ernst. = *P. casabitoana* Jimenez. (Cuba) – ellipsoid to fusiform, inauspicious, up to 1 mm long and 0.3 mm wide, with branches 1.5 mm long filled with complex irregularities (Casper, 1966).

Pinguicula colimensis McVaugh & Mickel (Mexico) – scobiform, minute (Casper, 1966).

P. crenatoliba D.C. (Mexico, Guatemala,

Honduras, El Salvador, Panama) – scobiform, ellipsoid, ±0.3 mm long and ±0.2 mm wide, alveolate (Casper, 1966).

P. crystallina Sibth. ex. Sibth. et Smith. (Cyprus) – scobiform (Casper, 1966).

P. cyclosecta Casper (Mexico) – scobiform (Casper, 1966).

P. elongata Benj. (Venezuela, Colombia) – scobiform, fusiform, 0.8-1 mm long and 0.2-0.27 mm wide, alveolate (Casper, 1966).

P. filifolia Wright ex. Griseb (Cuba) – scobiform, ±0.5 mm long, ±0.2 mm wide, reticulated (Casper, 1966).

P. heterophylla Benth. (Mexico) – scobiform, fusiform, oblong, ±1 mm long, ±0.55 mm wide, alveolate (Casper, 1966).

P. hirtiflora Ten. (Italy, E. Mediterranean) – scobiform, 0.5-1 mm long and 0.2-0.3 mm wide, alveolate (Casper, 1966).

P. involuta Ruiz et Pav. (Bolivia, Peru) – scobiform, ellipsoid, 0.4-0.6 mm long and 0.2-0.25 mm wide, alveolate (Casper, 1966).

P. jackii Barnh. (Cuba) – scobiform, ellipsoid, ±0.75 mm long and ±0.5 mm wide, verucose (Casper, 1966).

P. lignicola Barnh. (Cuba) – ellipsoid to fusiform, up to 0.5-0.8 mm long and 0.3 mm wide, with branches ±2 mm long filled with complex irregulates (Casper, 1966).

Pinguicula lilacina Schlecht et Cham. (Mexico) – scobiform, fusiform, 0.5-0.6 mm long and 0.2-0.25 mm wide, alveolate (Casper, 1966).

P. longifolia Ram. ex. D.C. (Spain, France, Italy) – scobiform, cylindrical, ±1 mm long and ±0.2-0.4 mm wide, alveolate (Casper, 1966).

P. moranensis H.B.K. (Mexico, Guatemala, El Salvador) – scobiform (Casper, 1966).

P. nevadensis (Lindbg.) Casper (Spain) – scobiform (Casper, 1966).

P. parvifolia Robinson (Mexico) – scobiform, alveolate (Casper, 1966).

P. ramosa Mijoshi ex. Yatabe (Japan) – scobiform (Casper, 1966).

P. variegata Turcz. (Siberia) – scobiform (Casper, 1966).

P. villosa L. (N. Boreal) – scobiform, reticulated (Casper, 1966).

Utricularia adpressa Salzm. ex. St. Hil. et Gir. (Br. Honduras, Venezuela, Guyana, Brazil, Trinidad) – globose with ± isodiametric reticulation (Taylor, 1967).

U. andongensis Hiern. (Guinea to Zambia and Angola) – verrucose, ovoid (Taylor, 1954).

U. aurea Lour. (India to Australia, Japan) – tabular prismatic and polygonal with slightly winged margins usually 1-2 layers thick, 829.6 microns long and 829.6 microns wide (Abraham & Subr, 1965).

Utricularia baouleensis A. Chev. (Trop. Africa, Madagascar, India, Philippines, Australia) – obovoid, epidermal cells finely striated and scrobiculate, 329 microns long and 174.2 microns wide (Abraham & Subr., 1965).

U. bifida L. (India to Australia, Japan) – obovoid, epidermal cells prominently striated and reticulate ending in blunt projections, 405.5 microns long and 261.3 microns wide (Abrahams and Subr., 1965).

U. caerulea L. (India to Australia, Japan) – obovoid, epidermal cells not striated, 256 microns long and 147 microns wide (Abraham & Subr.,1965).

U. chiribiquitensis Fernandez (Colombia, Venezuela) – globuse with ± isodiametric reticulation (Taylor, 1967).

U. chrysantha R.Br. (Australia, New Guinea) – minute, shining, yellow (Erickson, 1968).

U. dichotoma Labill. (Australia) – small and ovoid (Erickson, 1968).

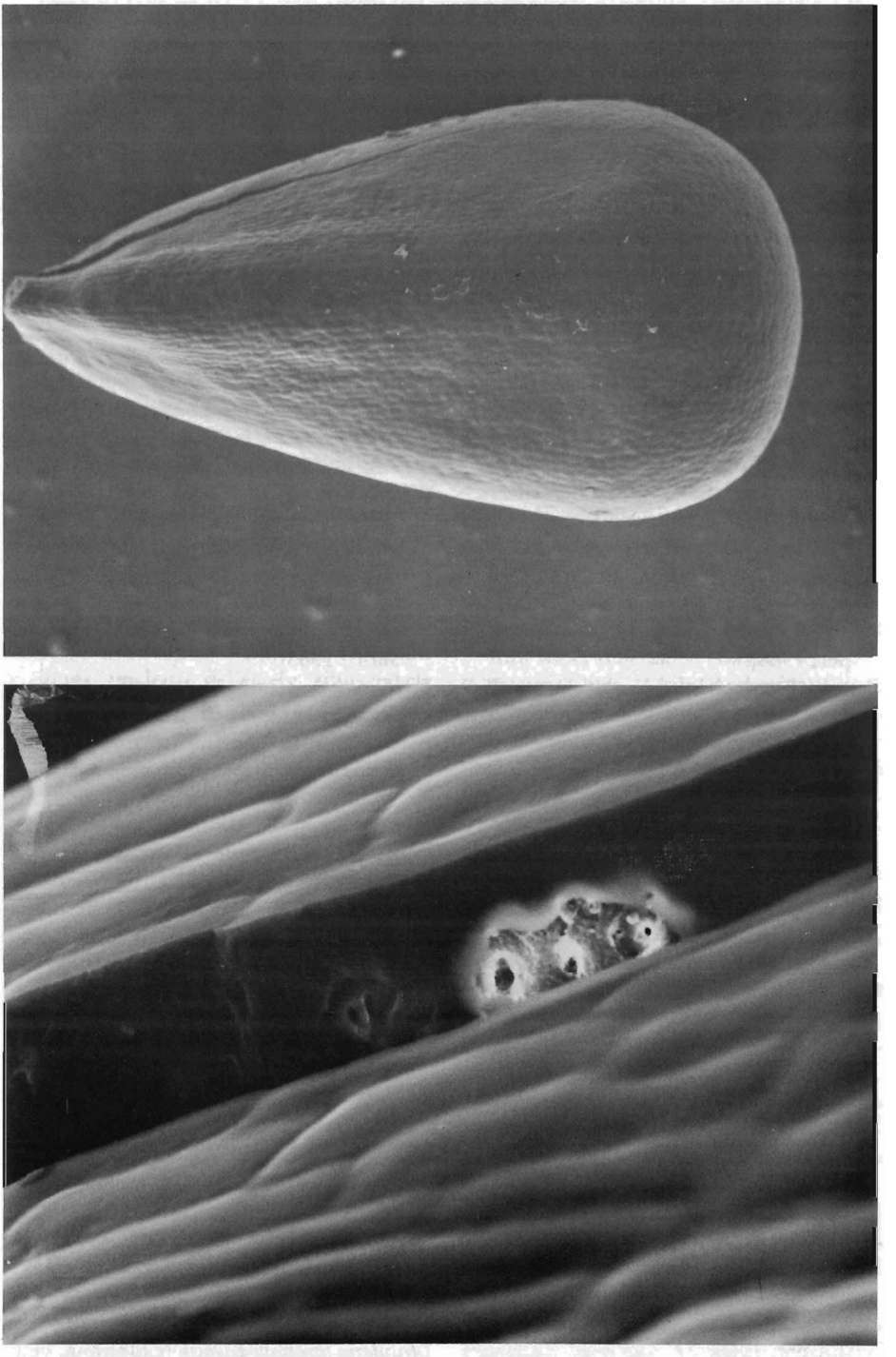
U. dimorphantha Makino (Japan) – angled with convex faces (Ohwi, 1965).

U. erectiflora St. Hil. & Gir. (Br. Honduras, Guyana, Venezuela, Brazil, Nicaragua, Colombia) – obliquely ovoid with prominent hilum, about 0.3 mm long, testa cells small and elongate (Taylor, 1975).

U. exoleta R. Br. (Africa to Australia, Japan, Spain, Portugal) – peltate bordered with a thin irregular wing (Erickson, 1968); lenticular with a crenulate corky wing, 1427 microns long and 1193 microns wide (Abraham & Subr., 1965).

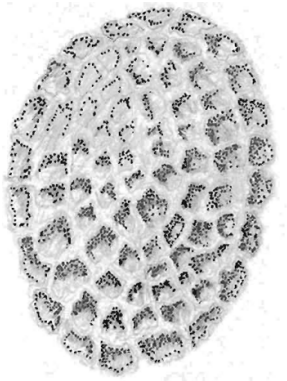
Utricularia fimbriata Kunth. (Colombia, Venezuela) – narrowly elliptical to globose, 0.2 mm long, transparent, brown (Fer-

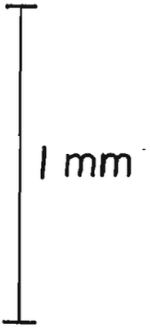
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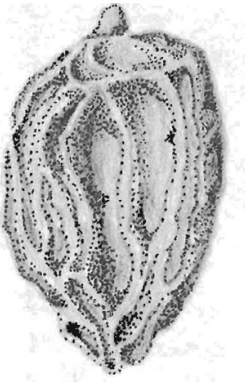


Dionaea muscipula Ellis Ex.L. (E. USA) – ovate to slightly pyriform, smooth shiny appearance with minute pits, around 3 mm in length, black.

Top: D. muscipula seed 75×. Bottom: 1200×. S.E.M. photos sent by Tom Story.



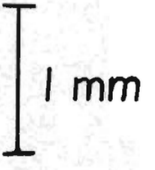




Byblis liniflora

Byblis gigantea





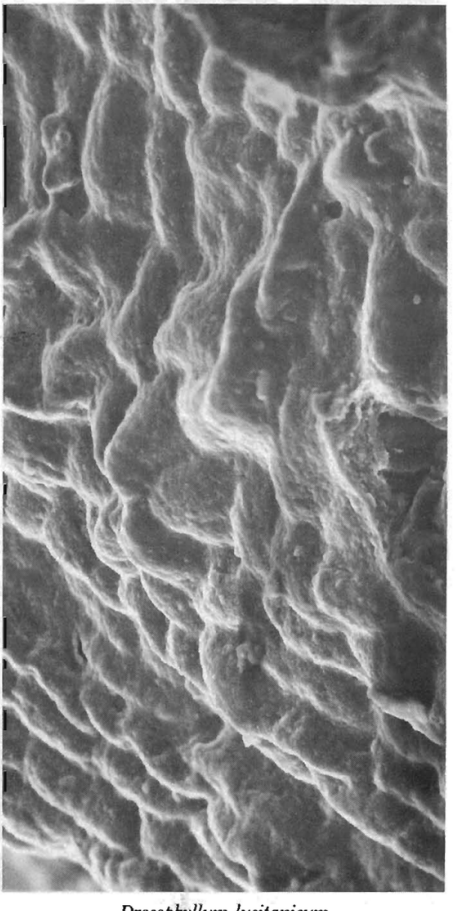
Drosophyllum lusitanicum

Drawings by Debbie Tolman

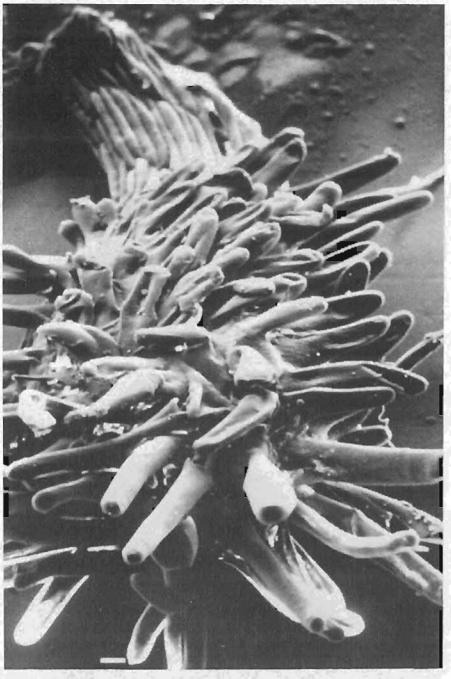
Byblis gigantea Lindl. (Australia) – irregularly ovate to elliptic, thick wrinkled seed coat, 1-1.5 mm, black.

Byblis liniflora Salisb. (Australia) – elliptic, reticulate seed coat, around 1 mm in length, black.

Drosophyllum lusitanicum Link. (Spain) – pyriform with a thick wrinkled seed coat, around 3 mm in length, black.



Drosophyllum lusitanicum
350×
photo sent by Tom Story

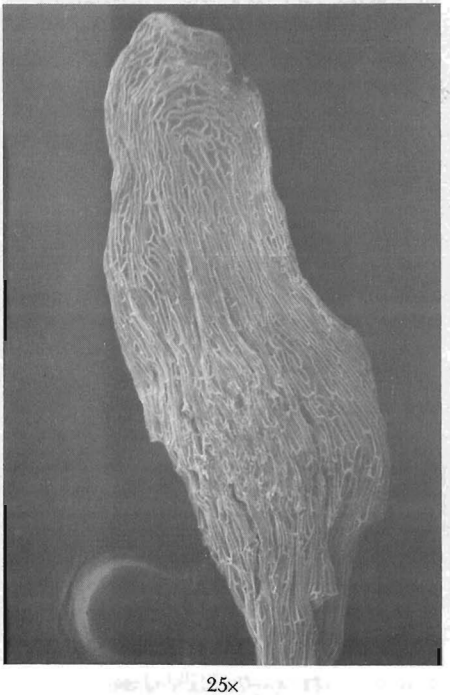


42×

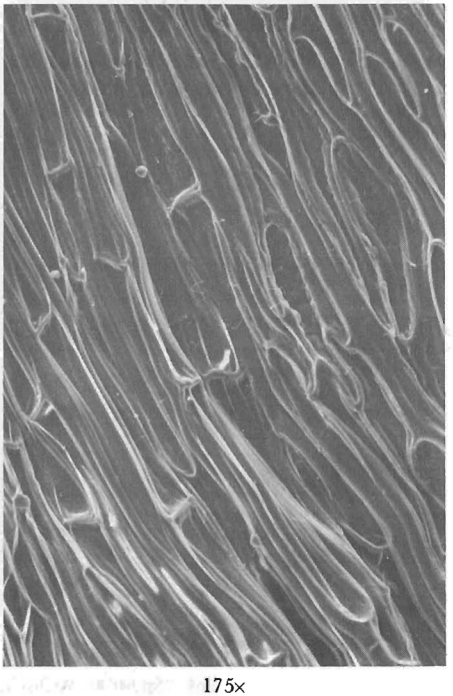


210×

Darlingtonia californica



25×



175×

N. pervielli

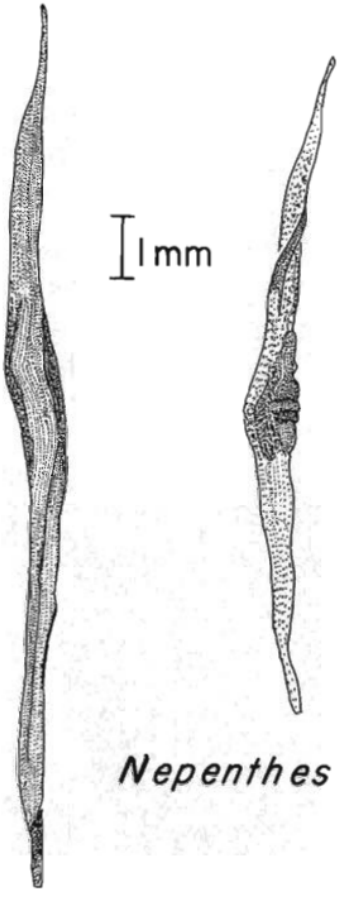
Photos sent by Tom Story

Left:
Darlingtonia californica Torr. (Ca., Oregon-USA) – elliptic with one end elongated and truncated, on the elliptic end there are long projections, seed length about 3.5 mm including projections, light brown.

Below from left:
Nepenthes mirabilis Druce. (S.E. Asia to Australia) – filiform, longitudinally striated, length around 14 mm, brown.

Nepenthes ventricosa Blanco. (Philippines) – filiform, longitudinally striated, nucleus transversely wrinkled, seed around 10 mm in length, brown.

Nepenthes macfarlanei Hemsl. (Malaysia) – filiform, longitudinally striated, nucleus transversely wrinkled, seed around 19 mm in length, brown.



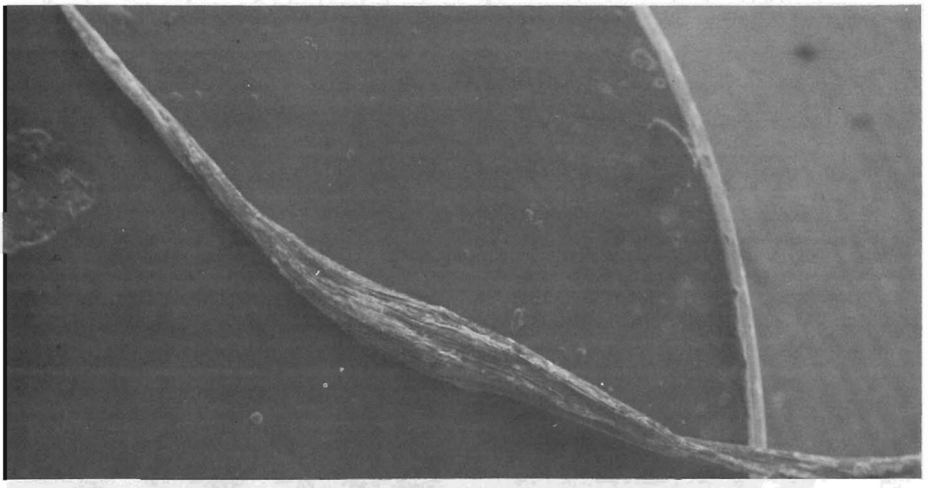
Nepenthes ventricosa



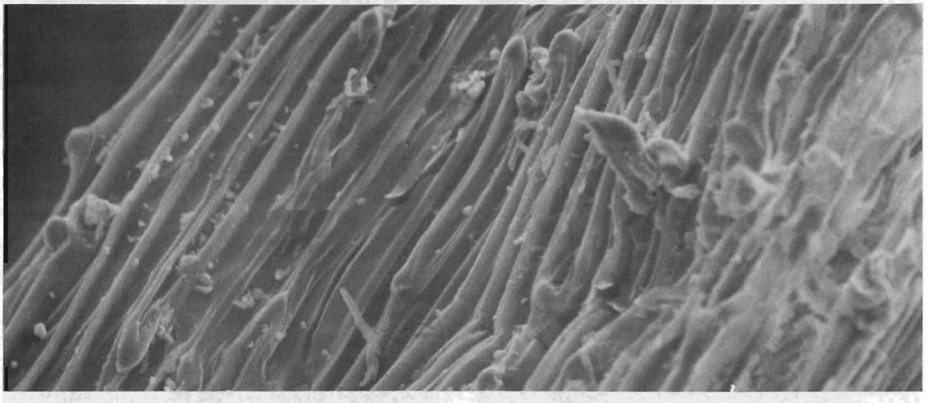
Nepenthes mirabilis

Nepenthes macfarlanei

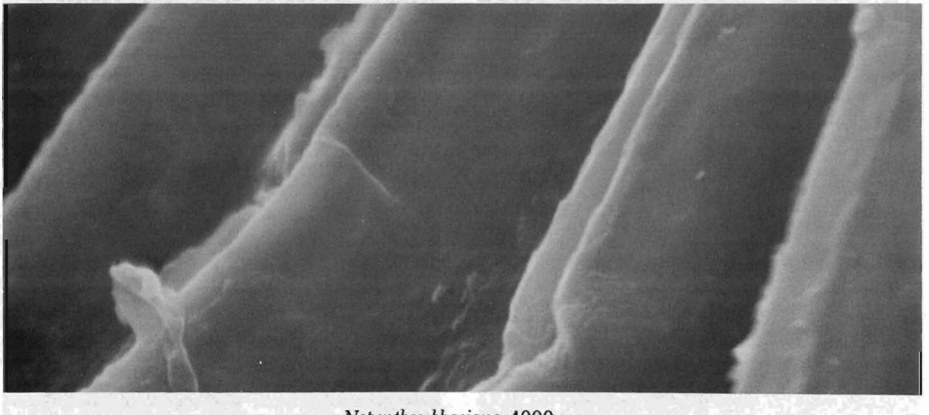
Drawings by John Randall



Nepenthes khasiana 20×



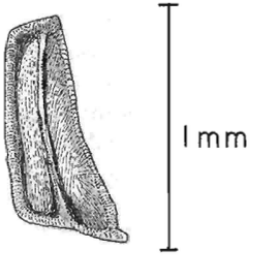
Nepenthes khasiana 400×



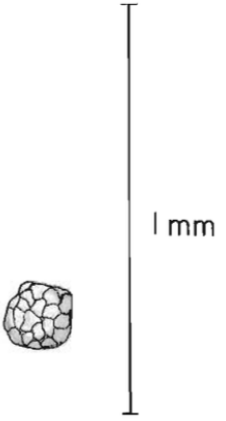
Nepenthes khasiana 4000×

Nepenthes khasiana Hook. (Assam, India) – filiform, longitudinally striated, length around 8 mm, dark brown.

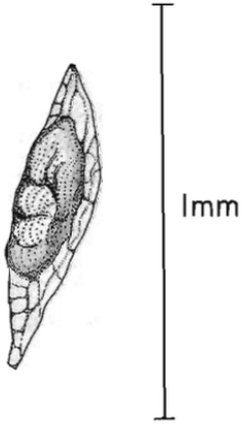
S.E.M. photos sent by Tom Story



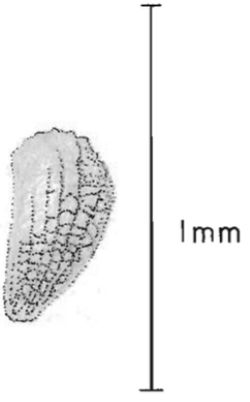
Utricularia longifolia



Utricularia nipponica



Utricularia endresii



Utricularia racemosa

Drawings by J. Randall and D. Tolman (*U. racemosa*)

Utricularia longifolia Gardn. (Brazil) – irregular, deltoid to oblong, heavily striated, length around 1.2 mm, winged, brown.

Utricularia nipponica = *Utricularia minutissima* Vahl. (India to Borneo, Australia, Japan, New Guinea) – minute, smooth, ovoid, wingless (Ohwi, 1965), reticulated, length around 0.1 mm, brown.

Utricularia endresii Reichb. (Central America – fusiform, three-angled, length around 1 mm, light brown.

Utricularia racemosa = *Utricularia caerulea* L. (India to Australia, Japan) – wingless (Ohwi, 1965), irregular, rhomboidal with striations, some shriveled, brown.

(Text continued from page 65)

nandez-Perez, 1964).

U. flexuosa Vahl. = *U. aurea* Lour. – flat and polygonal or almost circular (Khan, 1954).

U. foliosa L. (Florida to Argentina, Trop. Africa, Madagascar, Galapagos Islands) – lenticular, 2-2.5 mm in diameter with a narrow hyaline wing (Taylor, 1975).

U. fulva F. Muell. (Australia) – very small, ovoid (Erickson, 1968).

U. gibba L. (U.S.A.) – with a broad irregular

ring (Taylor, 1954).

U. hirta Klein ex. Link (India, Thailand, Indochina, Australia) – ovoid, seed coat without clavate projections and with a slightly wavy outline, 276.2 microns long and 207.5 microns wide (Abraham & Subr., 1965).

U. humboldtii R.H. Schomburgk (Venezuela) – circular, flat, with a reticulate hyaline wing (Taylor, 1967).

U. hydrocarpa Vahl. (Cuba to Brazil) – depressed globose, not winged (Taylor, 1967).

U. inflexa var. *stellaris* (L.) Taylor = *U. stellaris* L.F. (Trop. and S. Africa, Madagascar, Trop. Asia, Australia) – tabular, prismatic and polygonal with slightly winged margins usually 1-2 layers thick, 802.4 microns long and 802.4 microns wide (Abraham & Subr., 1965); prismatic, 0.5-0.7 mm wide, narrowly winged on all angles (Aston, 1973).

Utricularia jamesoniana Oliver (Ecuador, Guyana, Venezuela, Colombia, Antilles, Peru, Costa Rica, Panama) – narrowly cylindrical, about 0.3 mm long (Taylor, 1975).

U. juncea Vahl. (E. U.S.A., West Indies, Br. Honduras, Trinidad, N. Brazil, Colombia, Venezuela, Guyana) – subglobose, reticulated (Fernandez-Perez, 1964).

U. kimberleyensis Gardner. (Australia) – narrow and wrinkled (Erickson, 1968).

U. lateriflora R.Br. (Australia) – small, ovoid (Erickson, 1968).

U. leptoplectra F. Muell. (Australia) – twice (?) as long as broad, dark brown (Erickson, 1968).

U. micropetala Sm. (W. Trop. Africa) – ovoid, smooth with prominent hilium (Taylor, 1954).

U. multispinosa (Miki) Miki = *U. minor* L. (Europe, Asia, N. America) – winged, orbicular (Ohwi, 1965).

U. naviculata Taylor (Brazil, Venezuela) – lenticular (Taylor, 1967).

U. neottioides St. Hil. et Gir. (Brazil, Colombia) – elliptic (Fernandez-Perez, 1964).

U. nivea Vahl. = *U. caerulea* L. (India to Australia, Japan) – ovoid, seed coat with minute clavate projections, 223 microns long and 108.3 microns wide (Abraham & Subr., 1965).

Utricularia obtusa Sw. (West Indies, S. America, Trop. Africa) – more or less lenticular, about 1 mm wide with a pronounced hilium and an irregular corky wing (Taylor, 1975).

U. olivacea Wright ex. Griseb. (E. U.S.A., Cuba, Venezuela, Guyana, Brazil, Surinam) – not winged (Taylor, 1967).

U. pilosa (Makino) Makino (Japan, Korea) – obtusely 5 or 6 angled (Ohwi, 1965).

U. pubescens Sm. (Guyana, Venezuela, Colombia, Brazil, Trop. Africa, India) – smooth (Taylor, 1954).

U. pusilla Vahl. (Central and S. America, West Indies) – ovoid, about 0.35 mm long with about eleven longitudinal striations (Taylor, 1975).

U. pygmaea R.Br. (Australia) – dished in and winged about the edges (Erickson, 1968).

U. scandens Benj. (Trop. Africa, Madagascar, Trop. Asia, Australia) – ellipsoid, 324.4 microns long and 172.3 microns wide (Abraham & Subr., 1965).

U. scandens var. *schweinfurthii* Bak ex. Staphf. (Trop. Africa?) – ovoid, smooth with prominent hilium (Taylor, 1954).

U. singeriana F. Muell. (Australia) – shining, four times as long as broad, brown (Erickson, 1968).

U. spiralis Sm. (Trop. Africa) – globose, reticulate cells of testa isodiametric (Taylor, 1954).

Utricularia striatula Sm. (Trop. Africa, India to New Guinea) – glochidiate (Taylor, 1954).

U. stricticaulis Stapf ex. Gamble (India) – obovoid, epidermal cells finely striated and scrobiculate, 329 microns long and 174.2 microns wide (Abraham & Subr., 1965).

U. subulata L. (Nova Scotia to Argentina, Trop. Africa, Madagascar, Siam, Borneo, Portugal) – ovoid, about 0.25 mm long with about 15 longitudinal striations (Taylor, 1975).

U. tenuicaulis Miki = *U. australis* R.Br. (Trop. & S. Africa, Europe, Temp. Asia, Japan, Australia, Tasmania, New Zealand)–angled, truncate at the ends (Ohwi, 1965).

U. uliginosa Vahl. (India to Australia, Japan) –

nearly globular, appearing warty when dry, reticulate only when soaked (Erickson, 1968).

U. unifolia R. & P. (S. and C. America) – narrowly cylindrical, fusiform, 0.35-0.5 mm long (Taylor, 1975).

U. violacea R.Br. (Australia) – minute (Erickson, 1968).

U. yakusimensis Masam = *U. uliginosa* Vahl. – raised oblique striations (Ohwi, 1965).

Discussion and Summary

The seeds of carnivorous plants are quite distinctive generally. The main exceptions are within the species of *Sarracenia* and *Nepenthes*. All the others that I have seen appear to be distinguishable from each other. Hopefully a way will be found to distinguish the various species of *Sarracenia* and *Nepenthes* as well.

One of the major problems with this report is the proper naming of the seeds. I have had no way of checking most of them. I am currently trying to grow all of them. When they germinate it will be possible to tell whether I have the species that I thought I had. Others, like *Utricularia inflexa filiformis*, I never heard of before and I could not find a reference to the plant anywhere. It probably has another name. I will inform everyone if I find any mistakes in the names of the seeds.

I hope that the drawings and key are useful to people in some way. I would be quite happy to correspond with anyone interested in this subject and I would eagerly welcome any extra seed that people might like to donate. I think that some regional keys to species can be constructed soon while a single comprehensive key to all the species will take many years to finish.

Glossary

acute – forming an acute angle at base or apex

alveolae – small cavities as honeycombed

alveolate – honeycombed

apiculate – ending abruptly in a small, usually sharp tip

areolate – marked with areolae or small spaces

attenuate – gradually tapering to a very slender point

bullate – describing a surface with rounded elevations resembling blisters

caudate – having a tail-like terminal appendage

clavate – club-shaped, gradually increasing in diameter toward the summit

crateriform – having the form of a crater

crenulate – diminutive of crenate (with rounded teeth projecting at right angles to the edge)

deltoid – in the shape of an equilateral triangle

dentate – toothed along the margin, the apex of each tooth sharp and directed outward

ellipsoid – shaped more or less like a football or ellipse

elliptic – shaped like an ellipse

endosperm – a nutritive tissue developed in the embryo sac

epidermal cells – outermost layer of cells

filiform – threadlike

funicle – stalk of ovule, attaching it to placenta

fusiform – description of a solid body, thick near the middle and tapering to both ends

globose – spherical or almost spherical

glochidiate – barbed at the tip

hilium – scar or seed coat marking point of former attachment of seed to funicle

hyaline – thin and membranous, being transparent or translucent

isodiametric – having equal diameters

lanceolate – shaped like a lance head, much longer than wide and widest below the middle

lenticular – lens shaped

micropylar endosperm haustorium – ? (I was unable to find a definition for this anywhere)

micropyle – small opening in seed coat through which the pollen tube entered

mucro – a short, sharp, slender point

mucronate – tipped with a short, sharp, slender point

mucronulate – diminutive of mucronate

ob- – a prefix signifying in a reverse direction

oblong – descriptive of a flat organ broader than linear but maintaining its width for a considerable part of its length.

Also describing a solid object which is essentially cylindric or prismatic and therefore appears oblong when viewed from the side.

obtuse – blunt

-oid – blunta

-oid – suffix meaning "like" or similar to

orbicular – round and flat

ovate – descriptive of a flat organ widest below the middle and broader than lanceolate

papillae – projections

papillose – descriptive of a surface beset with short, blunt, rounded or cylindric projections

peltate – shieldlike, supported by a stalk attached near the center of the lower surface, like an umbrella with handle

polygonal – having the form of a plane with several angles

prismatic – of or resembling a prism

pyramidal – having the form of a pyramid (square base and four triangular sides meeting at a point)

pyriform – pear-shaped

reticulate – netted

rhombic – more or less diamond shaped

rhomboidal – having the shape of a three dimensional rhombic figure

rugose – describing a wrinkled surface

scobiform – having form and appearance of sawdust

scrobiculate – having small depressions, pitted

sigmoid – resembling the letter "S"

striate – marked with fine and usually parallel lines

sub- – a prefix meaning more or less or somewhat

tabular – flat

testa – seed coat, hardened integument

truncate – with the base or apex transversely straight or nearly so, as if cut off

tubercle – a minute swollen or tuber-like structure

tuberculate – bearing tubercules

verrucose – warty, covered on a surface with low, rounded protuberances

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Literature Cited

Abraham, V. and K. Subramanyam. 1965. "Studies on Seeds of Various Taxa of *Utricularia* Occurring in West Bengal." *Proc. of the Indian Academy of Sciences* 52B, pp. 97-102.

Aston, Helen. 1973. *Aquatic Plants of Australia.* Melbourne Univ. Press, Victoria, Australia.

Casper, S. Jost. 1966 "Monographic Der Gattung *Pinguicula* L." *Bibliotheca Botanica* Heft 127/128, Vol. 31.

Cruise, James E. and Paul M. Catling. 1974. "The Sundews (*Drosera* spp.) in Ontario." *Ontario Field Biologist* 28: 1-6.

Danser, B.H. 1928. "The Nepenthaceae of the Netherlands Indies." *Bulletin Jardin Bot. Buitenzorg*, Serie III, Vol. IX. Livr 3-4, pp. 249-437.

DeBuhr, Larry E. 1975. "Two New Species of *Drosera* From Western Australia." *Aliso* 8(3): 263-271.

Diels, L. 1936. "Droseraceae" in Engler, *Die Naturlichen Pflanzenfamilien* Band 17b:

Review of Recent Literature

Evert, D.S. 1957-58. *Dionaea* transplants in the New Jersey pine barrens. Bartonia 29: 3-4.

Steve Williams referred to this older paper to us and wondered if anyone had followed up on the several *Dionaea* plantings made by the author and others earlier (she reviews these to date of publication) in the pine barrens. Her observations at the time indicated considerable seedling activity at some of the locations. She only lists the locations very generally, so someone who knew her would have to do the follow-up. (DES)

Jansson, H. 1982. Predacity by nematophagous fungi and its relation to the attraction of nematodes. Microb. Ecol. 8: 233-240. *(Continued next page)*

766-784.

Erickson, Rica. 1968. *Plants of Prey*. Lamb Paterson Pty. Ltd., Western Australia.

Faroog, Mohd. 1964. "Studies in the Lentibulariaceae, I. The Embryology of *Utricularia Stellaris* Linn. F. var. *Inflexa Clarke*." Proc. Nat. Inst. Science of India 30B (5 & 6): 263-299.

Fernandez-Perez, Alvaro. 1964. "Plantas Insectivoras, I: Droseraceas de Colombia." *Caldasia* IX (43): 219-232.

Fernandez-Perez, A. 1965. "Plantas Insectivoras, II: Droseraceas de Colombia." *Caldasia* IX (41): 5-79.

Gleason, H.A. and Arthur Cronquist. 1963. *Manual of Vascular Plants of Northeastern U.S. and Adjacent Canada*. Van Nostrand and Reinhold Co., N.Y., N.Y.

Harms, H. 1936. "Nepenthaceae" in Engler, *Die Naturlichen Pflanzenfamilien* Band 17b: 728-765.

Harvey and Sonder. 1894. *Flora Capensis* Vol. I., L. Reeve & Co., Kent, England.

Khan, Reayat. 1954. "A Contribution to the Embryology of *Utricularia Flexuosa* Vahl." *Phytomorphology* 4: 80-117.

Laundon, J.R. 1959. "Droseraceae" – *Flora of Tropical East Africa*. Crown Agents, London, England.

Lloyd, Francis E. 1942. *The Carnivorous Plants*. Chronica Botanica. Waltham, Mass.

Mazrimas, J.A. 1976. "On Growing the Australian Pitcher Plant *Cephalotus*." *CPN*, V (1): 10-11.

McDaniel, Sidney T. 1971. "The Genus *Sarracenia* (Sarraceniaceae)." *Bull. Tall Timbers Research Station* No. 9.

Ohwi, Jisaburo. 1965. *Flora of Japan*. Smithsonian Institution, Washington, D.C.

Pietropaulo, James & Patricia. 1974. *The World of Carnivorous Plants*. R.J. Stoneridge. Shortsville, N.Y.

Steyermark, J.A. and L.B. Smith. 1974. "A New *Drosera* From Venezuela." *Rhodora* 76: 491-493.

Taylor, Peter. 1954. "Lentibulariaceae" in Hutchinson's *Flora of West Tropical Africa*, Vol. II. Crown Agents. London, England.

Taylor, P. 1967. "Lentibulariaceae, Botany of the Guayana Highland, Part VII." *Memoirs of the N.Y. Botanical Garden* 17: 201-228.

Taylor, P. 1975. "Lentibulariaceae." *Opera Botanica* Ser. B, No. 4: 9-21.

Uphof, J.C. 1936."Sarraceniaceae" in Engler, *Die Naturlichen Pflanzenfamilien* Band 17b: 704-727.

Wood, Carroll E., Jr. 1955. "Evidence for the Hybrid Origin of *Drosera anglica*." *Rhodora* 57: 105-130.

Wood, C.E., Jr. and R.K. Godfrey. 1957. "*Pinguicula* (Lentibulariaceae) in the Southeastern United States." *Rhodora* 59: 217-229.

Wynne, Francis E. 1944. "*Drosera* of Eastern North America." *Bulletin Torrey Botanical Club* 71 (2): 166-174.

Zeimer, R., J.A. Mazrimas and P. Taylor. 1974. "World Carnivorous Plant List." *CPN* Special Project Suppl. No. 1.