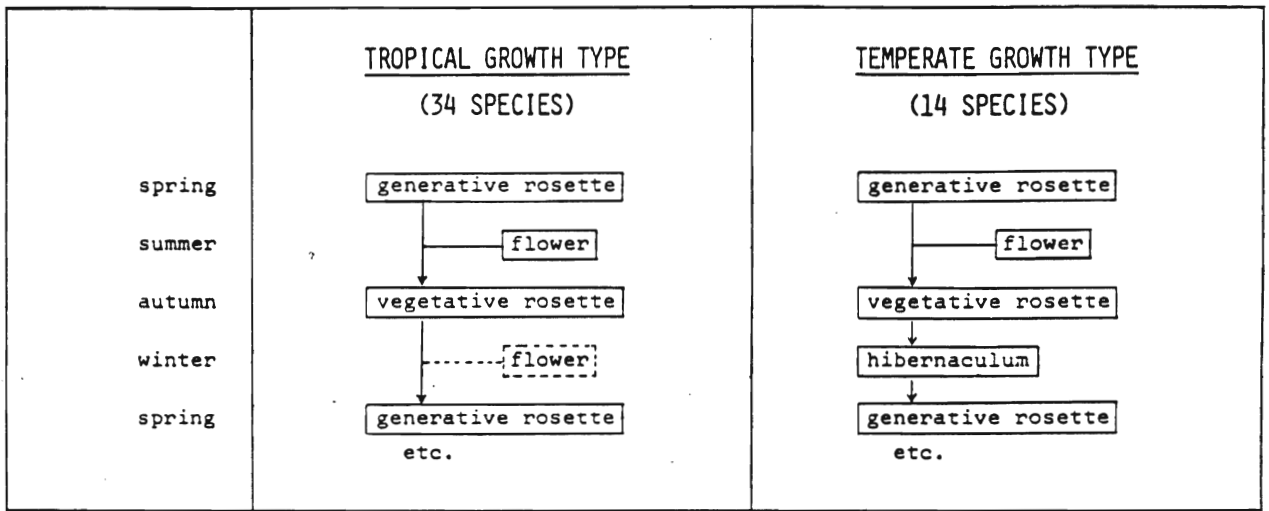
THE PINGUICULA SPECIES OF THE TEMPERATE GROWTH TYPE AND THEIR CULTIVATION

by Jürg F. Steiger

1. The two growth types of Pinguicula

There are two kinds of annual growth cycles in the genus Pinguicula - the tropical growth type and the temperate growth type (3). As shown in the upper part of fig. 1), the temperate growth type species are forming a winter bud (hibernaculum) each year at the end of the summer period. Such a stage is absent in the tropical growth type, where photosynthesis is also maintained during the cold season and where some species even have two flower periods annually (e.g. P. moranensis).
In both growth types the cycle generally begins with a first set of leaves followed by the flower (generative rosette). A second set of leaves is then developed during or after the seed stage (vegetative rosette). In the majority of species the shape and size of the leaves of the generative and vegetative rosettes are identical (homophyllous type - 33 species). In other species however the two rosettes are different (heterophyllous type - 15 species) and this heterophyllism is also present among 3 of the 14 hibernaculum-forming species. A growth type classification of the 48 Pinguicula species known today is given in fig. 1).



	TROPICAL GROWTH TYPE (34 SPECIES)	TEMPERATE GROWTH TYPE (14 SPECIES)
HOMOPHYLLOUS GROWTH TYPE Leaves of the generative and vegetative rosettes are of the same shape and size	**TROPICAL-HOMOPHYLLOUS GROWTH TYPE** P. agnata, P. albida, P. antarctica, P. benedicta, P. caerulea, P. calyptrata, P. chilensis, P. cladophila, P. crenatiloba, P. crystallina, P. filifolia, P. hirtiflora, P. involuta, P. ionantha, P. jackii, P. lignicola, P. lilacina, P. lusitanica, P. lutea, P. planifolia, P. primuliflora, P. pumila	**TEMPERATE-HOMOPHYLLOUS GROWTH TYPE** P. algida, P. alpina, P. corsica, P. grandiflora, P. leptoceras, P. macroceras, P. nevadensis, P. ramosa, P. variegata, P. villosa, P. vulgaris
HETEROPHYLLOUS GROWTH TYPE Leaves of generative and vegetative rosettes are of different shape and size	**TROPICAL-HETEROPHYLLOUS GROWTH TYPE** P. acuminata, P. colimensis, P. cyclosecta, P. elongata, P. gypsicola, P. heterophylla, P. imitatrix, P. kondoi, P. macrophylla, P. moranensis, P. oblongilcba, P. parvifolia	**TEMPERATE-HETEROPHYLLOUS GROWTH TYPE** P. balcanica, P. longifolia, P. vallisneriifolia

Fig. 1) Growth type classification in the genus Pinguicula (3,5,14)

2. Some general remarks on the temperate growth type species

Tropical growth type species are generally more popular among botanical gardens as well as among private growers than the temperate ones. Some tropical species (e.g. P. moranensis, P. gypsicola) are indeed very easy to cultivate in comparison to most temperate growth type species. This seems

somewhat paradox as one could argue that the temperate species are in dormancy for 4-8 months each year and have to be cared for only during the vegetation period in the remaining months while the evergreen species need uninterrupted care all the year through. Quantitatively this is true but the problems are mainly on the qualitative side - during their short vegetation period most of the temperate growth type species need highly specific growing conditions which are not easily reproducable in the usual kind of greenhouses unless an efficient cooling system is installed (see chapter 4). A further vital precondition for all northern species is sufficient soil moisture and air humidity. But also the hibernaculum stage is a very delicate one - up to now I have probably lost more material in the winter stage than during summer.

As no comprehensive literature on cultivation of northern Pinguiculas is available it may be useful to communicate some details referring to natural and artificial growth condidions. The following remarks are based upon the author's field studies and indoor experiments with Pinguiculas over many years. Up to the present successful cultivation is carried out since 3-18 years with 10 of the 14 temperate growth type species. Scanty material was also obtained of the remaining 4 species, but it either arrived in bad condition or cultivation was not yet successful to an extent which would allow sufficiantly valid comments (P. algida, P. balcanica, P. ramosa, P. variegata). For supplementary information climate maps, habitat descriptions, distribution maps and other literature data were consulted. Most helpful were some observations reported to me by epistolary communications.

The temperate growth type Pinguicula species are restricted to the northern hemisphere between 25°N (Himalaya, P. alpina) and 73°N (Greenland, P. vulgaris). Their vertical amplitude reaches from sea level (mostly arctic habitats: P. algida, alpina, macroceras , variegata, villosa and vulgaris) up to 4100 m = 13'450 f (P. alpina, Himalaya). P. nevadensis mounts up to 3200m = 10'500f (Sierra Nevada, Spain) and P. leptoceras to 3000m = 9840f (Swiss Alps)(3).

The diagram in fig. 2) shows an approximation of the preferred climate range for each species on the basis of their vertical amplitudes and north-south distribution (1-4,6,8-22 and 24-28). Certainly this diagram would discriminate more between different species by the addition of a third dimension indicating different general climate types (atlantic-pacific, mediterranean, continental etc.), as e.g. the arctic circle climate at the Norwegian coast is rather different from the arctic circle climate in central Siberia. Nevertheless the graph makes clear that e.g. P. nevadensis grows in much cooler conditions than P. vallisneriifolia, in relatively shorter summer day length than P. villosa and in a much narrower climate range than P. alpina, macroceras, vulgaris and others.

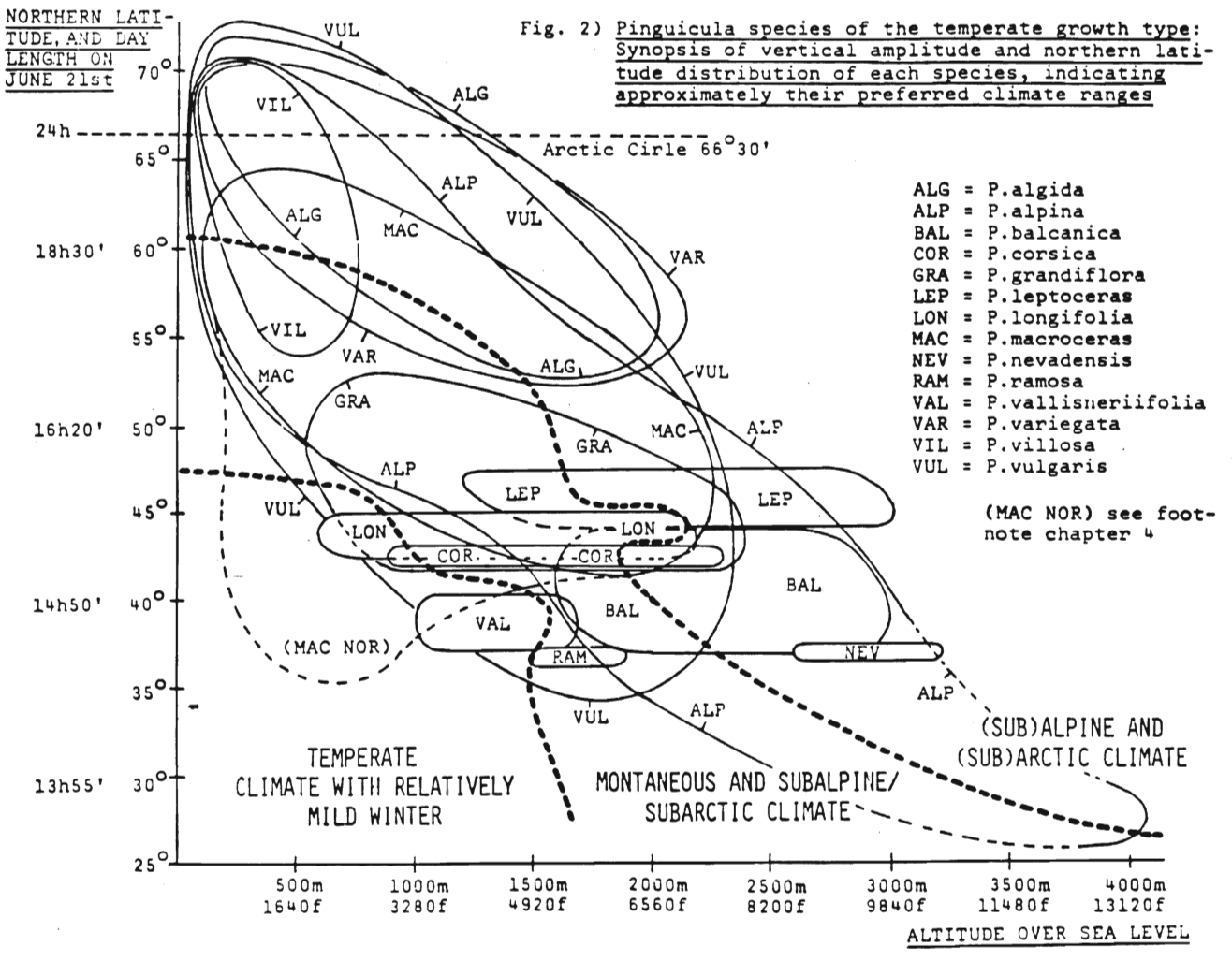


Fig. 2) Pinguicula species of the temperate growth type: Synopsis of vertical amplitude and northern latitude distribution of each species, indicating approximately their preferred climate ranges

3. The seasonal growth cycle

WINTER: All 14 temperate growth type species hibernate by means of a winter bud (hibernaculum). The smallest buds are found in P. villosa (diameter 2mm, length 6mm), the largest ones in P. vallisneriifolia (diameter 15-20mm, length 20-30mm). Fig. 4) shows a rosette of P. vulgaris in autumn with the hibernaculum already developed in the center (23). After the first frosts the leaves decay. In 12 species also the roots die in winter. Only in P. alpina and P. variegata (?) the roots are perennial(3). In some species little vegetative brood buds (gemmae) are formed with a length of about 2mm. Such gemmae are particularly numerous - up to 50 per specimen - in P. grandiflora (7) and P. corsica. I have observed several times at natural habitats of P. vulgaris that their winter buds were eaten by mice or snails, but some of the gemmae remained at place and formed new plantlets in spring. Winter buds of unusually large size often stem from specimen infected by Ustilago Pinguiculae. P. vallisneriifolia does not form gemmae but runners. Their connexions with the mother plant generally decay in winter.
Of great importance for the survival of the winter buds is the temperature. All 14 species grow at habitats with winter air temperatures occasionally or constantly below the freezing point. But for successful hibernation of Pinguicula it is vital to know that the winter soil temperatures are generally just at the freezing point or only very slightly below or above it, even if air temperatures are much below it. This is at least true for all habitats insulated by a thick layer of snow - only at habitats in northern continental climates the soil temperature may fall rather far below the freezing point (NE Siberia, NW Canada). Winter buds are frost resistant, but repeated freezing and thawing generally causes their death. In areas with frequent discontinuous autumn and spring frosts Pinguiculas therefore prefer microclimatic niches with smaller daily temperature oscillations. During the dormancy stage the soil substrate should be kept just damp, not soggy.
In room temperature the winter buds perish.

SPRING: When the snow has melted away or after the last frosts the new roots and a new rosette of leaves begin to develop out of the hibernaculum. Later on the same process begins with the gemmae, but under the leaves of the already developed large mother plant the majority of the tiny adventive pantlets are not viable, probably due to lack of light. In P. vallisneriifolia the 'gemmae' of the small runner off-shoots germinate in some distance (3-10cm) from the mother plant.
For propagation the gemmae may be removed from the hibernaculum and planted out separately.
If by any reason collection of Pinguiculas was not possible in autumn (see below), material may also be collected in spring, preferably before the rosettes are fully spread out.

SUMMER: All discussed species like moderate or cool summer temperatures with a relative air humidity of 60-100%. The required microclimatic conditions are rather specific for each species. The worst physical enemies for northern Pinguiculas are heat and dryness of soil and air. For some species a room temperature of 20°C (68°F) is already much to warm. It is better to keep Pinguiculas to shady than to sunny.
After the flower period the roots loose their ability of regeneration. Therefore mailing of these species is not recommended in summer unless plants are dug out together with enough surrounding substrate. The gemmae begin to develop already in summer. They originate in the axils of the outer leaves of the rosette.
Some species do not grow at places exposed to direct rainfall, while others are not delicate at all in this respect. To simulate the dew or fog of the natural habitat it is recommended to spray the plants each night very slightly with distilled water. Use spray nozzle producing very fine mist.
All species are occasionally or frequently exposed to wind.
Biological enemies of Pinguiculas are: snails, aphids and Ustilago Pinguiculae. Specimen infected by Ustilago (pollen violet instead of yellowish) shoud be thrown away. To avoid aphids substrate surface and leaves may be sprayed with an insecticide containing e.g. Rotenon, Pyrethrum and Piperonylbutoxide. Surprisingly Pinguiculas endure such treatment.
Foliar feeding: Twice a year the leaves are sprayed with a well shaked mixture of 40% white of an egg and 60% water.

AUTUMN: In autumn the winter bud begins to develop in the center of the rosette (fig. 4). In adult plants this process starts earlier than in young ones. In P. grandiflora the translation of the rosette into a hibernaculum was found to be induced by the combined effect of shortening days and falling night temperatures (7). Presumably this is true also for other species of the temperate growth type. I have experienced in different species that no winter buds are developed if plants are kept to warm in late summer and autumn. In this case the rosette continuously produces new leaves of increasingly smaller size for some weeks and then suddenly perishes.
Autumn is the best time for collecting and mailing temperate growth type Pinguiculas. The easiest way is to collect them in the beginning decay stage of the leaves. At that time it is still well possible to identify the rosettes among other mouldering plants, but the winter buds are already fully developed so that damage of the leaves or roots caused by collection are meaningless - exept in the species with hibernating roots (P. alpina and perhaps P. variegata).

4. Specific notes and data on cultivation

SOIL TYPE AND CLIMATE: Fig. 3) indicates the prefered soil type and - as a simplified summary of fig. 2) - the climate range for each temperate growth type species. The petrophilous species are almost exclusively restricted to wet, mossy and rain-protected niches of vertical or overhanging rocks. Some of the non-petrophilous species may occasionally also be found on rocks.

MIXED TROPICAL AND TEMPERATE PINGUICULA DRAWING BY DAVID KUTT

1. P. grandiflora
2. P. caudata
3. P. ionantha
4. P. primuliflora
5. P. planifolia
6. P. lusitanica
7. P. lutea
8. P. gypsicola

Fig. 4) Ping. vulgaris in autumn, with already developed hibernaculum in the center of the rosette

Fig. 7) Self-constructed cooled growth chamber for Pinguicula on the basis of a household deep-freezer

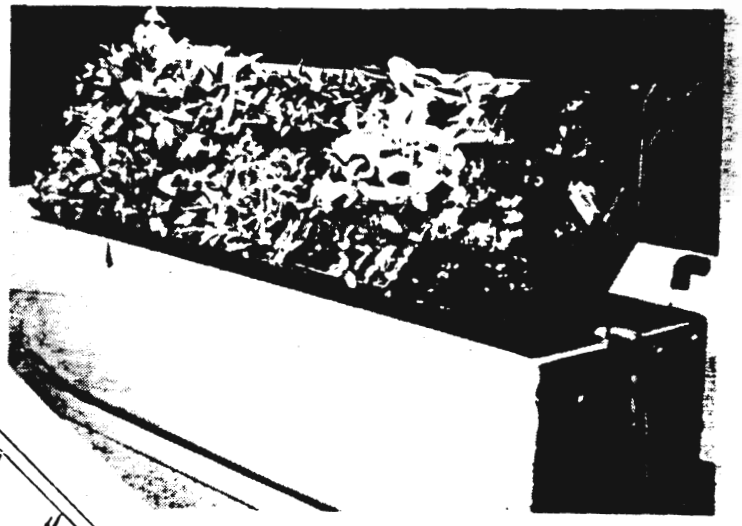
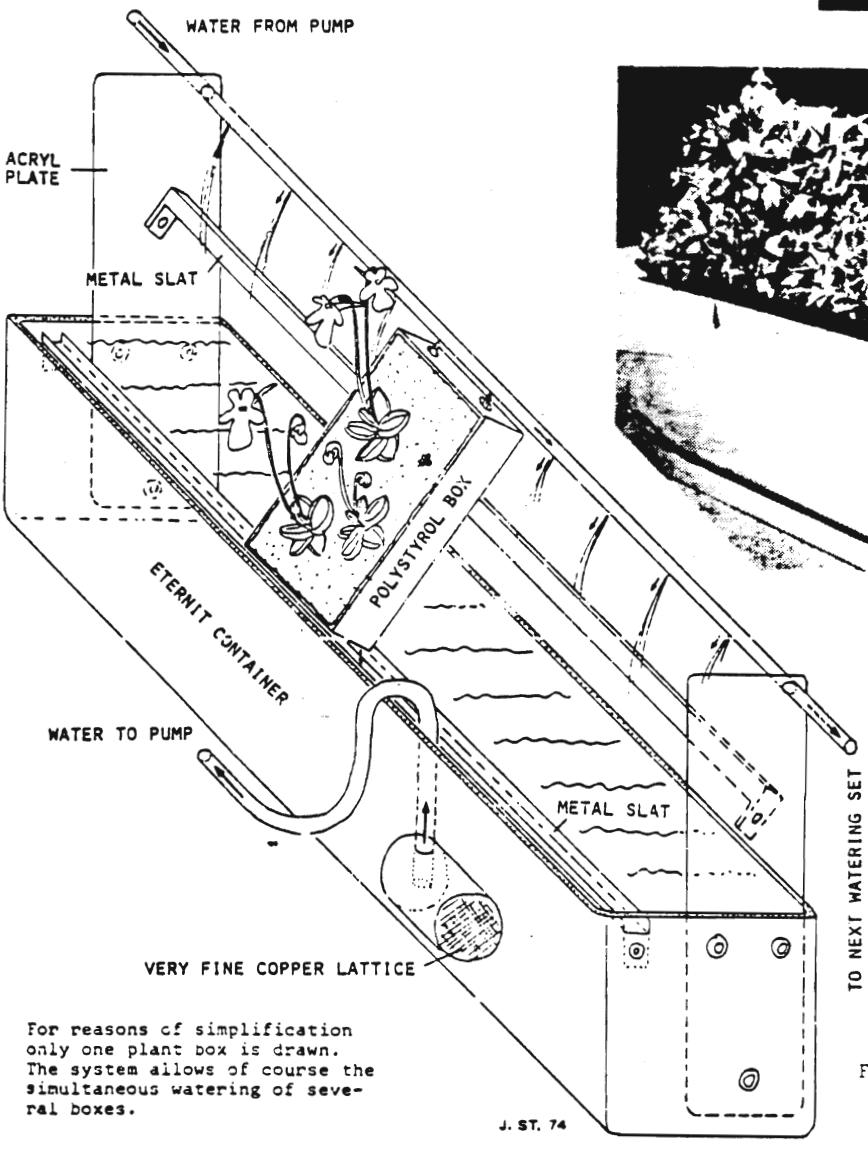


Fig. 5) Watering system for Pinguicula



For reasons of simplification only one plant box is drawn. The system allows of course the simultaneous watering of several boxes.

Fig. 6) Watering system for Pinguicula

GENERAL SOIL TYPE PREFERENCE ▽ / CLIMATE RANGE ▷		TEMPERATE CLIMATE WITH RELATIVELY MILD WINTER (MARITIME OR MEDITERRANEAN INFLUENCE) MID-SUMMER TEMPERATURE 15-30°C 59-86°F	MONTANEOUS AND SUBALPINE OR SUBARCTIC CLIMATE MID-SUMMER TEMPERATURE 10-20°C 50-68°F	(SUB)ALPINE OR (SUB)ARCTIC CLIMATE (TIMBERLINE ZONE OR COLDER) MID-SUMMER TEMPERATURE 5-15°C 41-59°F
PETROPHILOUS SPECIES	calciphobous	P. macroceras ssp. nortensis**	P. ramosa	
	calciphilous	P. vallisneriifolia*	P. longifolia ssp. longifolia*	
		P. longifolia ssp. caussensis* P. longifolia ssp. reichenbachiana*		
NON-PETROPHILOUS SPECIES	calciphobous			P. algida P. nevadensis* P. variegata P. villosa
			P. corsica*	
	calciphilous		P. grandiflora ssp. rosea P. grandiflora f. pallida	
	growing on different soils		P. grandiflora	P. balcanica P. leptoceras
			P. alpina P. vulgaris P. macroceras	

* Species which do not like to be exposed to direct rainfall ** See footnote

Fig.3) Prefered soil type and climate range of temperate growth type Pinguicula species

○ LIST OF PERTINENT DATA ON HABITATS AND ON CULTIVATION: The following list gives some habitat characteristics and some cultivation data concerning temperature, length of vegetation period and recommended soil mixture (see next three pages).
The figures are to be interpreted as follows: The column 'Winter Period' specifies how many months the hibernacula should be kept in a refrigerator at the indicated temperature. '3-5' does not mean 'march-may' but 'three to five months'. The column 'Vegetation Period' shows the analogous values for the summer season, with separate indications for mid-summer temperatures at night and day. The upper and lower values indicate the average temperature peaks which may occur for some few hours each day or night in mid-summer. Plants which are constantly kept at those upper or lower peaks values will not grow well. If daily temperature oscillations in the indicated range cannot be simulated, cultivation will succeed in most cases also by growing the plants at the mean temperatures indicated in brackets. Whenever possible it should be tried to achieve a night-day difference of some centigrades. In the first and last month of the vegetation period the mean temperature should be kept at the lower peak value of the mid-summer temperature. The column 'Soil Substrate' indicates the author's recommendations for the soil mixture, most of them based on personal cultivation experiences. This does not exclude that other substrate compositions will also be adequate. Most suitable for any species is of course the soil substrate from its natural habitat.
If cultivation is done under artificial light it is recommended to simulate the seasonal day length differences, particularly in autumn, as the development of the winter buds is dependent on the combined effect of falling temperature and shortening days. As mentioned above this is at least ascertained for P. grandiflora (7).

** A comparison of living material of P. macroceras from different habitats revealed that the specimen growing in northern California and southern Oregon are rather different from the 'typical' taxon of the (sub)alpine and (sub)arctic habitats in the northern distribution area. The holotypus originated from the Aleutian Islands. Provisionally I name the petrophilous population growing in Del Norte County (Cal.) and Josephine County (Oregon)

Pinguicula macroceras ssp. nortensis ssp.nov.

The chromosome number is 2n=32. A detailed description will be published separately.

CULTIVATION OF TEMPERATE GROWTH TYPE PINGUICULAS - LIST OF PERTINENT DATA

GENERAL REMARKS Distribution and Characteristics of Natural Habitat	VEGETATION PERIOD Months	Mid-Summer Temperatures Night	Day	WINTER PERIOD Months	Soil Temp.	SOIL SUBSTRATE
PETROPHILOUS SPECIES (ALPHABETICAL ORDER)						
PING. LONGIFOLIA SSP. CAUSSENSIS Main habitat: Gorges du Tarn (France), 400-1300m. Grows in windy gorges in the moss of shady, wet and overhanging limestone rocks, at locations protected from direct rainfall. Mediterranian climate type with dry summer and wet winter. Winter temperatures only occasionally below the freezing point. Flowering: April-July	7-9	12°-18°C (15°C) 54°-64°F (59°F)	15°-25°C (20°C) 59°-77°F (68°F)	3-5	+1°C 34°F	calcareous ⅓ marly limestone detritus ⅓ sand ⅓ perlite
PING. LONGIFOLIA SSP. LONGIFOLIA Central Pyrenees (France and Spain), 800-2200m. Grows on shady and wet vertical or overhanging limestone rocks in niches protected from direct rainfall. In higher regions frequent fogs (also in summer). Occasionally associated with P. alpina and P. grandiflora. Flowering: June-August	4-6	6°-14°C (10°C) 43°-57°F (50°F)	10°-20°C (15°C) 50°-68°F (59°F)	6-8	+1°C 34°F	calcareous ⅓ marly limestone detritus ⅓ sand ⅓ perlite
PING. LONGIFOLIA SSP. REICHENBACHIANA Roya Valley (France), 600m. Apuanian Alps and Abruzzian Alps (Italy), up to 1400m. Same habitat type as P. longifolia ssp. caussensis (see above). Flowering: April-July	7-9	12°-18°C (15°C) 54°-64°F (59°F)	15°-25°C (20°C) 59°-77°F (68°F)	3-5	+1°C 34°F	calcareous ⅓ marly limestone detritus ⅓ sand ⅓ perlite
PING. MACROCERAS SSP. NORTENSIS (see footnote) Northernmost California and southernmost Oregon (USA), 150-500m. Grows on shady rocks and on rocky bluffs of creeks and rivulets, in wet dripping crevices (Serpentine, mesozoic ultrabasic intrusives). Dry summer and wet winter. Flowering: April-June	7-9	12°-20°C (16°C) 54°-68°F (61°F)	17°-29°C (23°C) 63°-84°F (73°F)	3-5	+1°C 34°F	non-calcareous ½ granite or serpentine detritus ¼ black peat ¼ perlite
PING. RAMOSA Mt. Koshin and neighbouring mountains of the Nikko National Park (Japan), 1500-1900m. Grows in the needle tree girdle on mossy, shady, wet and vertical volcanic rock-cliffs, at places not exposed to direct rainfall. Frequent summer fogs. Flowering: June-July	4-6	6°-14°C (10°C) 43°-57°F (50°F)	10°-20°C (15°C) 50°-68°F (59°F)	6-8	+1°C 34°F	non-calcareous ½ volcanic detritus ¼ black peat ¼ perlite
PING. VALLISNERIIFOLIA Main habitat: Sierra de Cazorla (Spain), 1000-1700m Grows in the marly crevices of shady and soggy vertical or overhanging limestone rocks. No rain in summer, wet and mild winter (temperatures usually above the freezing point). Leaves very long (up to 30cm). Develops off-shoots (runners). Flowering: May-July	8-9	15°-20°C (18°C) 59°-68°F (64°F)	20°-30°C (25°C) 68°-86°F (77°F)	3-4	+3°C 38°F	calcareous ⅓ marly limestone detritus ⅓ sand ⅓ perlite
NON-PETROPHILOUS SPECIES (ALPHABETICAL ORDER)						
PING. ALGIDA Northern Siberia and northeastern Baikal area (USSR), sea level (arctic regions), 1500-2000m (Stanovoy Mountains). Grows in tundras and peat bogs, on bluffs of rivulets and on wet rocks. Cold winter. Flowering: July-August.	3-4	4°-8°C (6°C) 39°-46°F (43°F)	10°-16°C (13°C) 50°-61°F (55°F)	8-9	-3°C (?) 27°F (?)	non-calcareous ⅓ black peat ⅓ granite sand ⅓ perlite

GENERAL REMARKS Distribution and Characteristics of Natural Habitat	VEGETATION PERIOD Months	Mid-Summer Temperatures Night	 Day	WINTER PERIOD Months	 Soil Temp.	SOIL SUBSTRATE
PING. ALPINA Scandinavia and different higher moutain chains of Eurasia (Pyrenees, Alps, Karpates etc., Ural, Baikal region, Himalaya and Chinese mountains), 0-4100m. Grows in different kinds of bogs, on springy slopes and other moist places including wet bluffs and rocks. Habitats may vary from shady to full-sunny. Occasionally associated with P. grandiflora, P. longifolia ssp. longifolia, P. leptoceras and P. vulgaris, but advancing into dryer places than those. Perennial roots. Flowering: May-August	3-5	4°-12°C (8°C) 39°-54°F (46°F)	8°-20°C (14°C) 46°-68°F (57°F)	7-9	+1°C 34°F	different soils ⅓ black peat ⅓ sand ⅓ perlite
PING. BALCANICA Higher mountain chains of southeastern Europe: Dinaric Alps and Pindus Mountains (Yugoslavia, Albania, Bulgaria, Greece), 1900-2400m. Grows on springy slopes, in bogs, on peaty borders of creeks, in gorges and on wet rocks. Timber-line zone and above it. In calcareous as well as in acid soils. Relatively dry summer and wet winter. Flowering: June-August - VAR. TENUILACINIATA (Yugoslavia), preferably on wet rocks. More petrophilous than the typical form - SSP. PONTICA Pontic and Taurus mountains (Turkey), Caucasus (USSR), 1600-3000m. Same habitats as typical form but also below the timber-line	3-4	4°-10°C (7°C) 39°-50°F (45°F)	8°-16°C (12°C) 46°-61°F (54°F)	8-9	+1°C 34°F	different soils ⅓ black peat ⅓ sand ⅓ perlite
PING. CORSICA Corsica Island (France), 900-2400m. In the lower regions in half-shady springy places, in higher altitude also in full-sunny wet slopes. Ground: granite. Considerable variations of habitus according to altitude. Much snow or rain in winter but relatively dry summer. Flowering: May-August	4-6	6°-12°C (9°C) 43°-54°F (48°F)	8°-20°C (14°C) 46°-68°F (57°F)	6-8	+1°C 34°F	non-calcareous ⅓ black peat ⅓ granite sand ⅓ perlite
PING. GRANDIFLORA Western Jura (France, Switzerland), Pyrenees (Spain, France), Cantabrian mountains (Spain), southwestern Ireland. 600-2400m. Grows on sunny or half-shady places of wet meadows and springy slopes near cool creeks (continental habitats) and on peat bogs and 'raised moss' associations (Ireland), both on calcareous and granite ground. Occasionally associated with its f. pallida and with P. alpina, P. longifolia ssp. longifolia and P. vulgaris. Flowering: April-August	4-6	8°-14°C (11°C) 46°-57°F (52°F)	12°-20°C (16°C) 54°-68°F (61°F)	6-8	+1°C 34°F	different soils ⅓ black peat ⅓ limestone or granite detritus ⅓ perlite
PING. GRANDIFLORA F. PALLIDA Western Jura (France, Switzerland), associated with the typical form. On half-shady calcareous and very loamy slopes. Flowering: June-August A similar, almost white flowered form occurs in Ireland (Clare Co.), growing together with the typical species near calcareous springs which trickle slabs of bare limestone.	4-6	8°-14°C (11°C) 46°-57°F (52°F)	12°-20°C (16°C) 54°-68°F (61°F)	6-8	+1°C 34°F	calcareous ⅓ limestone detritus ⅓ loam ⅓ perlite
PING. GRANDIFLORA SSP. ROSEA Mountains near Grenoble (France). Shady or half-shady mossy places on slate or limestone. In this area the typical species does not occur (?). Flowering: June-July	5-6	8°-16°C (12°C) 46°-61°F (54°F)	14°-22°C (18°C) 57°-72°F (64°F)	6-7	+1°C 34°F	calcareous ⅓ limestone or slate detritus ⅓ loam ⅓ perlite

GENERAL REMARKS Distribution and Characteristics of Natural Habitat	VEGETATION PERIOD Months	Mid-Summer Temperatures Night	Day	WINTER PERIOD Months	Soil Temp.	SOIL SUBSTRATE
PING. LEPTOCERAS Alps (Austria, Switzerland, Italy, France), 1200-3000m. Sunny springy slopes, (sub)alpine bogs, glacier moraines and other moist places. Timber-line and above it. Habitats often exposed to wind. In the northern Alps preferably on granite ground, in the Maritime Alps also on calcareous soil. Occasionally associated with P. alpina or P. vulgaris. Flowering: June-August	3-4	4°-10°C (7°C) 39°-50°F (45°F)	8°-16°C (12°C) 46°-61°F (54°F)	8-9	+1°C 34°F	different soils ⅓ black peat ⅓ sand ⅓ perlite
PING. MACROCERAS Northern Pacific coastal area (Japan, Kamchatka Peninsula, Aleutian Islands, Alaska, Yukon, British Columbia, Washington, Montana, NE Oregon), 50-2300m. Grows in very different habitats: sunny springy slopes, wet meadows, glacier moraines and dripping rocks etc. On silicate as well as calcareous soils. Needle tree zone, timber-line and above it. Flowering: June-September	3-5	5°-13°C (9°C) 41°-55°F (48°F)	8°-18°C (13°C) 46°-64°F (55°F)	7-9	+1°C 34°F	different soils ⅓ black peat ⅓ sand ⅓ perlite
PING. NEVADENSIS Sierra Nevada (Spain), 2600-3200m. Grows in the alpine and nival zone in full-sunny springy slopes and other wet places, on silicate ground. Much snow in winter but only few summer-rain. Frequent mountain fogs. Flowering: July-August	3-4	4°-10°C (7°C) 39°-50°F (45°F)	8°-14°C (11°C) 46°-57°F (52°F)	8-9	+1°C 34°F	non-calcareous ⅓ black peat ⅓ granite sand ⅓ perlite
PING. VARIEGATA * Southern and eastern Siberia (USSR), from lowland (eastern regions) up to 1450-2200m (Baikal area). Grows in alpine sphagnum bogs, tundras and on mossy slopes and wet rocks. Timber-line and above it. Cold winter. Flowering: June-July	3-4	4°-8°C (6°C) 39°-46°F (43°F)	8°-16°C (12°C) 46°-61°F (54°F)	8-9	-3°C (?) 27°F (?)	non-calcareous ⅓ black peat ⅓ granite sand ⅓ perlite
PING. VILLOSA (Sub)arctic area of North America and Eurasia (but not occuring in Greenland, Iceland and Spitzbergen), 0-750m. Grows in Sphagnum bogs, hummocks and muskegs around pools and creeks, mainly in the timberline zone. Successful growth presumably only possible in long-day conditions (?). Flowering: June-August	3-4	6°-10°C (8°C) 43°-50°F (46°F)	8°-12°C (10°C) 46°-54°F (50°F)	8-9	-3°C (?) 27°F (?)	non-calcareous small and compact-tufted species of living sphagnum
PING. VULGARIS Eurasia, northernmost mountains of Africa, Iceland, Greenland, North America, 0-2300m. Grows almost in every biotop and in all sorts of soil minerals provided that moisture is sufficient and that the habitat is not too shady. Occasionally associated with P. alpina, P. grandiflora, P. leptoceras, P. lusitanica or P. villosa. Flowering: May-August - **F. ALBIDA and F. BICOLOR** May be found at different locations in central, northern and eastern Europe. Same habitats as the typical species.	4-6	7°-15°C (11°C) 45°-59°F (52°F)	10°-22°C (16°C) 50°-72°F (61°F)	6-8	+1°C 34°F	different soils ⅓ black peat ⅓ sand ⅓ perlite

* According to literature P. variegata has perennial roots (3). On the basis of hibernacula I received from Siberia I would assume that the roots decay in winter. However I am not shure whether the received material was really P. variegata - unfortunately it perished before identification was possible.

○ PLANT CONTAINERS: After several years of cultivation experiments - many were failures - I have found the following kind of containers most suitable: I utilize rectangular transparent polystyrol boxes of 17.5cm (L) x 12.5cm (B) x 4cm (H) as they are used by Ciba-Geigy Inc. for mailing pharmaceutical specimen. Then I rig up somewhat smaller 'boxes' by anticorrosive metal lattice (17cm x 11.5cm x 4cm, quadratic meshes with a diameter of about 13mm, wire diameter about 0.8mm), which are put into the polystyrol boxes. The inside of the metal lattice boxes themselves is lined with a nylon net of 1.5mm mesh diameter to prevent loss of smaller substrate particles. Now the soil mixture is filled into the net-coated lattice box up to its upper margin. Watering is done into the small interspace between lattice and polystyrol container - distilled water for the calciphobous species, tap water for the rest. The substrate should be wet but not soggy, the lattice box should generally not stand in water. Addition of water is necessary each 2-7 days, depending on temperature and air humidity. With this method all sides (even the downside) of the substrate 'block' are constantly exposed to air which reliably prevents any mold. For freeland experiments in natural bogs the lattice box with the plants may be lifted out of the polystyrol box and may be dug directly into the swampy soil, from where it is removable again at any time. The best results in home experiments were obtained by lifting the boxes into an inclination angle of about 45°. Watering is then done by a hose system connected with an aquarium filter pump (Eheim filter): Water can enter and leave the substrate by two wholes each on the upper and lower sidewall of the polystyrol box. The boxes themselves are installed above a rectangular water container (material: eternit or styropor). A timer ('Electro-Boy') is connected with the filter pump, allowing each full hour a watering period of 15 minutes. The filter material is charcoal and synthetic wadding. If fresh tap water is available this may be even better than the recirculating filter water system. However in some regions tap water may be too much chlorinated or too calcareous for some species.

○ SOIL SUBSTRATE: Whenever possible soil substrates from natural Pinguicula habitats should be used. If artificial mixture is necessary it is most suitable for the majority of species to mix fine black peat with sand of the preferred mineralic composition (lime, granite, serpentine, lava etc.) and ¼ to ⅓ volume parts of perlite. P. villosa grows almost exclusively on sphagnum. The petrophilous species require a more sandy soil with no or less peat. Thanks to the lattice box system described above I never had any problems of substrate rottennes in any soil mixture. To kill worms and other vermins I freeze and thaw the soil 2 or 3 times each for some days before using it (at -20°C/-4°F).

○ TEMPERATURE: For hibernation the winter buds and gemmae are stored in a household refrigerator just very little above the freezing point (+1°C/34°F). They are kept either in their lattice boxes or they are put into polystyrol jars of 5cm length and 4cm diameter stuffed with wet perlite and some milligrams of a fungicide/insecticide powder (e.g. Gesal, containing 5% malathion, 25% sulfur, 5% folpet, Ciba-Geigy Inc.). The seeds are kept dry and are stored between 1° and 10°C in small poystyrol boxes (40x40x15mm) after beeing powdered with a very small amount of the above named fungicide. In summer I keep the plants in a self-constructed cooled growth chamber: A usual household deep freezer (from which the cover must be removed) serves as 'chassis' for a wooden chamber of the same length and breadth and 90cm height. The chamber may be opened by two acryl glass front doors. The cover side of the chamber also consists of acryl glass. Above it two light sources are installed (see below). A propeller, connected with a timer, is fastened in the chamber to produce some air circulation from time to time. The northern plants are kept on shelves in the cool zone just some centimeters above the upper margin of the deep freezer. The adequate temperatures are found by lifting or lowering the shelves. The upper, warmer zones of the chamber serve for (sub)tropical species. Another possibility is to use an air conditioner, provided that it cools enough and that it doesn't dry up the air to much. Such equipment is more recommended for larger cultivation settings (e.g whole greenhouse compartments). Further suitable devices are cooled vitrines as they are used for food display in baker's and butcher's shops (such vitrines are available e.g. by Admiral Internat. Corp., Chicago).

○ LIGHT: Plants are grown either in daylight (bright but shady place at north facing window) or under Philips mercury lamp sources of the type HPLR-N (125 Watt). This light has a slight ultraviolet spectrum portion and almost no infrared so that the enlightened environment is hardly warmed up. The distance between light bulb and plants is 50-90cm. The distance between the lower bulb end and the acryl cover of the growth chamber is 6cm - a smaller interspace would cause the acryl to grow hot and to split.

○ PROPAGATION: Pollination is carried out with insect pins nr. 0 or 00 (brass or nylon heads). Pins contaminated by Ustilago-infected pollen are thrown away as well as the infected plants themselves. Seeds are sowed into the same substrate as used for the adult plants and into lattice boxes likewise. For regular sowing seeds may be mixed with very fine sand or peat dust. Gemmae are removed from the hibernacula in autumn or spring and cultivated mostly together with the seedlings. Some (sub)tropical species as P. gypsicola and P. moranensis may be propagated by means of leaf-cuttings. However this procedure is not applicable in any of the temperate growth type species. Another subtropical species, P. primuliflora, forms new plantlets at the tips of the adult leaves. Also this mechanism of vegetative propagation was not observed in the hibernaculum-forming species. A peculiarity amongst the temperate growth type species are the runners formed by P. vallisneriifolia. Their connexions with the mother plants generally decay in winter.

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6. References

1. Britton N.L. and Brown H.A., Illustrated Flora of the Northern United States, Canada and the British Possessions; The New York Gardens, Bronx Park N.Y. (1947), Vol.III, p.225-226
2. Casper S.J., On Pinguicula macroceras in North America; Rhodora, Vol.64 (1962), p.212-221
3. -- Monographie der Gattung Pinguicula; Bibliotheca Botanica, Vol. 127/128, Stuttgart (1966)
4. -- Die Gattung Pinguicula in Vorderasien; Wissensch. Ztschr. Friedr. Schiller Universität, Math.-Nat. Reihe, 19.Jg. Heft 3, Jena (1970), p. 275-292
5. -- Eine neue Pinguicula-Art aus Mexico; Feddes Repert., Band 85, Heft 1-2, Berlin (1974), p. 1-6
6. Contandriopoulos J., Recherches sur la flore endémique de la Corse et sur ses origines; Thèse Doct. Nr. 254, Faculté des Sciences Montpellier (1962), p.238-250
7. Heslop-Harrison Y., Winter Dormancy and Vegetative Propagation in Irish Pinguicula grandiflora; Proceed. of the Royal Irish Academy, Vol. 62, Section B, Nr.4 (1962), p.23-30
8. Hultén E., Flora of the Aleutian Islands; Bokförlags Aktiebolaget Thule, Stockholm (1937), p.302-304 and 307
9. -- Flora of Alaska and Yukon; C.W.K. Gleerup, Hakan Ohlsons Boktryckeri, Vol. VIII, Lund (1948), p.1422-1425
0. -- Atlas over Växternas utbredning i Norden; Generalstabens Litografiska Anstalts Förlag, Stockholm (1950), p.411-412
1. -- and Faegri K., Var Svenska Flora i Färg; AB Svensk Litteratur, Esselte AB Stockholm (1960), p. 251 and 545-546
2. -- Flora of Alaska and Neighboring Territories; California Stanford University Press (1968), p. 829-830
3. Котов М.І., Флора УРСР; Видавництво Академії Наук Української РСР, Київ, Том X (1961), с.58-61
4. Малышев Л.И. et al., in: Эндемичные Высокогорные Растения Северной Азии; Издательство "Наука", Новосибирск (1974), с.79 и 287-288
5. -- и Петроченко Ю.Н., Новые и Редкие Растения со Станового Нагорья; Новости Систематики Высших Растений, Издальство "Наука", Москва/Ленинград (1966), с.252-254
6. Miyoshi M., Notes on Pinguicula ramosa, sp. nov.; (Jap.) J. of Botany Vol.4 Nr.43 (1890) p.315-316
7. Моложников В.Н. и Худяркова Л.А., Влияние Некоторых Факторов Среды на Температуру Камбия Ствола и Корней Лиственницы; Сибирское Отделение Лимнологический Институт, Издательство "Наука", Москва (1969), с.228-237
8. Raup H.M., The Botany of Southwestern Mackenzie; Sargentia, VI, The Arnold Arboretum of Harvard University, Jamaica Plain (1947), p. 3,5,44-47,68-69,78-79,233 and plate 34
9. -- Phytogeographic Studies in the Peace and Upper Liard River Regions, Canada; The Arnold Arboretum of Harvard University, VI, Jamaica Plain (1934), p.198 and Fig. 1)
0. Ruffier-Lanche R., Notes de floristique alpine; Bulletin mensuel de la Société Linéenne de Lyon, 28me année Nr.8 (1959), p.265, 267-268
1. Scoggan H.J., Flora of Mannitoba; National Museum of Canada Bulletin Nr. 140, Series Nr.47 (1957), p. 492-493
2. Smith H.V., Michigan Wild Flowers; Cranbook Institute of Science, Bloomfield Hills, Mich., (1966), p. 355
3. Steiger J.F., Dauerkultur von Fettkraut (Pinguicula) und Sonnentau (Drosera) im eigenen Garten; Leben und Umwelt, 1960 Nr. 8, p.169-176
4. -- Die Unterscheidung der schweizerischen Pinguiculaarten; Beiträge zur Kartierung der Schweizer Flora, Nr.3, Bern (1970), p.1-8
5. -- Kapitel 'Pinguicula' in: Hess H. et al., Flora der Schweiz, Bd.3, Verlag Birkhäuser Basel/Stuttgart (1973), p.260-264
6. Steinhauser F. et al., Climatic Atlas of Europe; WMO/UNESCO Cartographia, Geneva (1970)
7. Yoshimura K., Studies on the chromosome number and caryotype of P. ramosa; J. of Jap. Bot., Vol.48 Nr.10 (1973), p.289-294
8. Ziemer R.R., Some field observations of Darlingtonia and Pinguicula; Carnivorous Plant Newsletter, Vol.II Nr.2 (1973), p.25-27