Genetic Resources Communication

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No. 20, 1993

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GRC

AUSTRALIA

ISSN 0159-6071
ISBN 0 643 05336 0

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SUMMARY

Accessions of 10 of the lesser known species of the tropical legume genus *Macroptilium* were grown under glasshouse and field conditions to identify the extent of variation within the collection.

Despite the sometimes poor representation, the presence of certain plant characteristics together with geographical origin, and in some cases the results of initial evaluation studies, suggest that at least some of these species may have potential as pasture legumes. Two plant characteristics which may indicate adaption to grazing were encountered. Tuberous root formation was relatively widespread in *M. affine*, *M. fraternum*, *M. gibbosifolium* and *M. panduratum*, and amphicarpy was found in *M. panduratum* and many accessions of *M. gracile*. Two species, *M. gibbosifolium* and *M. gracile*, were extremely variable in both morphology and flowering time. One species, *M. martii*, despite being well represented, exhibited almost no morphological variation. Preliminary evaluation suggested that further collection of *M. affine* and Brazilian forms of *M. panduratum* should be considered a priority.

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Keywords: genetic resources, distribution, forage legumes.

Published by: CSIRO Division of Tropical Crops and Pastures, 306 Carmody Road, St. Lucia, QLD 4067, Australia

Diversity and forage potential of some *Macroptilium* species

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INTRODUCTION

Williams (1983) listed two options for pasture improvement, the first being to change the plant's environment by management, and the second being to change the plant. If the second of these options is to be embraced, then it is important to know what species and varieties are available for incorporation into plant improvement programs either by plant breeding or by selection of material from the assembled gene pool (Williams 1983). The selection of germplasm for evaluation or for inclusion in plant breeding programs is usually based on a combination of plant characteristics and plant geography (Burt *et al.* 1979). Characteristics such as the ability to root at the nodes and the development of a dense low crown might indicate that a particular accession or group of accessions has potential as pasture plants tolerant of heavy grazing. Environmental adaptation such as frost and drought tolerance, or the preference for particular soils, might also encourage incorporation into species evaluation studies.

The genus *Macroptilium* has to date provided three tropical forage cultivars, *M. lathyroides* cv. Murray, an annual forage plant, *M. atropurpureum* cv. Siratro, a twining perennial legume adapted to the sub-humid tropics and sub-tropics, and *M. gracile* cv. Maldonado. Although cv. Murray is rarely used commercially in Australia, cv. Siratro is still being used as a component in permanent sown pastures today, 30 years after commercial release (Oram 1990). Commercial seed stocks of cv. Maldonado are not yet available.

Despite the success of these species, others have been largely ignored as a source of pasture legumes. *M. bracteatum, M. erythroloma* and *M. martii* have been included in several evaluation studies in Queensland and elsewhere since 1960 (e.g. Cameron *et al.* 1984; Cameron 1989). Nowhere have they shown potential as permanent pasture species. Other species such as *M. gibbosifolium*, *M. fraternum* and *M. affine* have been included in a small number of evaluation studies at a limited number of sites. Even *M. gracile*, from which cv. Maldonado has recently been released in the Northern Territory, has only been evaluated to a limited extent.

In recent years the diversity and numbers in the collection of *Macroptilium* held by the Australian Tropical Forage Genetic Resources Centre (ATFGRC) and in other tropical forage germplasm centres, have increased considerably as a result of more intensive plant collecting throughout the Americas.

This paper describes the extent of variation in the collections of the lesser known species of the legume genus *Macroptilium* currently held at the ATFGRC, and reports plant characteristics and geographical information for these species. The studies described in this paper also provided an opportunity to report plant attributes or features which are not reported elsewhere in the literature. Two such attributes, amphicarpy and tuber formation, may have important roles in determining species persistence under grazing.

The taxonomy of *Macroptilium*, as with many tropical legumes, is confused. Even in this case where reviews of the genus have been recently published (Barbosa-Fevereiro 1988; Marechal *et al* 1978), there remain some areas which require clarification. According to recent treatments, the genus includes 16 species.

Three species were excluded from the study. The best represented species in the collection, *M. atropurpureum*, is currently under study by others and will be reported elsewhere. *M. bracteatum* and *M. lathyroides* have been evaluated over many years, and in the case of *M. bracteatum*, without identification of potential cultivars. *M. lathyroides*, although widely used as an annual forage legume on clay soils in the past, was not considered to be of interest because of lack of persistence in grazed pastures.

MATERIALS AND METHODS

The information presented here has been accumulated from field and glasshouse culture undertaken as part of the Centre's germplasm regeneration and description program.

Initially, the collection of *M. gibbosifolium* was grown as spaced plants at the Samford Research Station (Lat.27^{0}22'S Long.152^{0}53'E) in 1982-83. Seedlings were raised in peat cups in a glasshouse and transplanted into a cultivated seedbed in the field in December 1982, at about the five leaf stage.

In 1986, accessions of all species of *Macroptilium* in the ATFGRC collection, with the exception of those previously identified as *M. atropurpureum*, *M. bracteatum* and *M. lathyroides*, were grown in 20cm pots in a glasshouse at the Samford Research Station. Seed was pregerminated and then sown at four plants per pot into a peat/sand potting medium to which a balanced fertiliser mix had been added. Twining plants were trained onto stakes. A set of accessions was selected for field growing at the same site in 1987-88. Herbarium specimens were taken of all accessions included in both the field and glasshouse studies, for taxonomic classification.

Available passport data for all accessions included in this study are given in Appendix 1. The locations of collection sites of the accessions are mapped to show plant distribution (Figures 1-3).

SPECIES ATTRIBUTES

M. affine (1 accession, Figure 1)

This perennial species is represented in the ATFGRC collection by only one accession (CPI 92609) which was collected in Ecuador. As Piper (1926) noted, this species is very similar to *M. atropurpureum*. Attributes of note include its strong perennation and regrowth from a tuber, and a large number of stems originating from the crown as regrowth. From observations of seed production in the field and in the glasshouse, unlike *M. atropurpureum* it may be an outbreeder, or perhaps require tripping, since no fertile pods have been observed in the glasshouse (in the absence of insects). This accession warrants further evaluation as a forage species.

M. erythroloma (23 accessions, Figure 1)

This twining species has been collected from dry to sub-humid regions of sub-tropical South America, southern Brazil and Argentina with three accessions from Colombia. Evaluation studies in Queensland have consistently shown this species to have poor persistence and little value as a permanent pasture legume.

M. fraternum (22 accessions, Figure 2)

This species originates from sub-tropical South America. Accessions held by ATFGRC have been collected from a narrow geographic range in the northern Argentinian provinces of Salta and Jujuy (Latitude $23^{0}6$'S to $24^{0}6$'S) where they were commonly a component of pastures grazed by either cattle or horses on soils with pH ranging from 6.3 to 7.8. Average annual rainfall at the collecting sites ranged from 500 to 1000mm and altitude from 1000 to 2100 metres. This species is extremely uniform with a prostrate habit, small orange flowers, lanceolate leaflets with no lobing of the lateral leaflets, fine stems and characteristic long yellow hairs on the stems and petioles. The only diversity observed during this study was in time to flowering. Accessions of this species have the ability to root at the nodes and form tubers.

Although the origin and habit of these collections suggest some agronomic potential in south-east Queensland, this species has not persisted in evaluation studies to date despite encouraging results in the first season of experiments. The origin of this species suggests that it may be better suited to high altitude tropics and sub-tropics such as the New England Tableland and the Granite belt of south-east Queensland and northern New South Wales in Australia, the Ethiopian and Kenyan Highlands and sub-tropical South Africa.

M. gibbosifolium (syn. *M. heterophyllum*) (28 accessions, Figure 2)

This well represented perennial species has been collected from the southern United States and Mexico, with one accession from Guatemala and one from Honduras (Lat. 14^{0}N to 32^{0}N). Rainfall at the collection site ranged from 300mm to 1300mm per annum and altitude from 1200 to 2500 metres. All accessions have a prostrate habit with the ability to root at the nodes and form large tuberous tap roots. All accessions appear to be insect pollinated as they do not set seed under glasshouse conditions. The collection shows considerable variation in leaflet shape and indumentum, dry matter production and flowering time with the northern accessions being the first to mature and the southern accessions, which are also from the more humid environments, being late flowering. Collection notes indicate that this species is tolerant of heavy grazing. Once again the combination of plant habit and passport data suggest that this species warrants further evaluation in sub-tropical regions.

M. gracile (syn. *M. longepedunculatum*) (52 accessions, Figure 3)

Following the review of Barbosa-Fevereiro (1988) this species includes material held by this centre and others under the name *M. longepedunculatum*. This extremely variable species is widely distributed throughout the tropical Americas from northern Mexico to Minas Gerais in southern Brazil. The collection can be divided into two distinct groups based on the ability to set below-ground or geocarpic seed. Within both of these groups there is considerable variation in both morphological and agronomic attributes including leaf shape, dry matter production, and flowering time.

The amphicarpic variant is perennial and is represented by collections from the extremes of latitude for the species and has been collected from many sites in between these extremes. Rainfall at the sites of collection ranged from as low as 250mm in Baja California to 1600mm in Chiapas. The accessions from the most arid environments were the earliest maturing. Several accessions however did not produce any, or very little, aerial seed but set large quantities of geocarpic seed. Soil pH for this group was in the range of 4.0 to 8.5.

Accessions of the other variant were, in most cases, annuals which produced large quantities of aerial seed. This group has already shown some potential as a pasture legume with one accession, CPI 62158, having been released in the Northern Territory as cv. Maldonado. This group, although having a similar southern limit to the amphicarpic group, has been less commonly collected in the north with the most northern accession being from Oaxaca in southern Mexico. Soil acidity at the site of collection for three members of this group ranged from pH 4.0 to pH 5.0. These accessions from very acid soils should be included in any acid soil evaluation studies in humid and sub-humid tropical environments.

M. martii (15 accessions, Figure 2)

The collection of this annual species is morphologically uniform. R.L. Burt and B.C. Pengelly (unpublished data) found that the only variable attribute was the degree of crown branching as measured in a spaced plant experiment at Lansdown Research Station near Townsville (Lat. $19^0$40'S, Long. $146^0$51'E). All accessions were collected from disturbed sites over a range of soil types (not clays or sands) in the semi-arid regions of north-east Brazil in the provinces of Bahia and Pernambuco, with two accessions from the state of Rio Grande de Norde. It also occurred in grazed caatinga but was never dominant under these conditions (Burt *et al.* 1979). Although included in a number of evaluation studies in northern Australia, this annual has shown little potential (Cameron *et al.* 1984; Cameron 1989). *M. martii* is specific in its rhizobium requirements (Bushby *et al.* 1984).

M. panduratum (10 accessions, Figure 3)

This species includes the material which Burkart (1952) published as *M. geophilum* and which has to date been held in this centre and in others under that name. All accessions of this species in the ATFGRC collection originated from the northern Argentinian states of Salta and Jujuy (Lat. 24°15'S to 25°12'S). Rainfall at the sites of collection ranged from 450 to 600 mm. Soils were typically neutral to alkaline (pH 7.2 to 8.3) and high in fertility (R. Reid pers. com.). All accessions are amphicarpic with the aerial pods having 6-10 seeds whilst the underground pods, which are papery in texture, have only one or two seeds. The specimen illustrated by Burkart (1952) clearly shows the large tubers formed by this species and all collections grown in this study were tuberous-rooted. Apart from differences in flowering time, there appears to be little variation within this collection. Of more interest would be the more tropical material from north-eastern Brazil which we have not been able to evaluate. This species, like *M. martii*, is specific in its rhizobium requirements (Bushby *et al.* 1984).

M. prostratum (1 accessions, Figure 1)

This species is represented by only one accession from northern Argentina, an example of one of the two variants recognised in this species. CPI 25865 is prostrate in habit, with entire linear leaflets. This accession has only been grown under glasshouse conditions, where seed production has been poor.

M. psammodes (2 accessions, Figure 1)

M. psammodes is represented by two accessions, CPI 39098 from Paraguay, where it was collected from a low altitude and CPI 74870 from northern Argentina. There is no evidence that this species produces tubers. CPI 39098 has persisted well on light soils in a recent evaluation study at Narayen Research Station in south eastern Queensland. The same accession has persisted at several sites in the Gympie district on sandy and clay soils and average annual rainfall from 800 to 1250 mm (B. Cook pers. com.). A feature of this accession is its ability to develop very strong roots at the nodes, and although being persistent, dry matter production has been quite low. Results to date suggest that this accession should be further evaluated in the sub-tropics. CPI 74870 is also prostrate in habit, but has not persisted in evaluation studies.

M. sabaraense (1 accessions, Figure 1)

This species is represented by only one accession (CPI 93068) which was collected from Minas Gerais, Brazil. The performance of this accession at Samford was poor and it produced little dry matter.

DISCUSSION

The gene pool of some of the species discussed here is very small; three species, *M. affine*, *M. prostratum* and *M. sabaraense* are each represented by one accession only, and *M. psammodes* by two. A further three species, *M. monophyllum*, *M. pedatum* and *M. supinum*, are not represented at all in this collection. There is a need to expand the collections of these species, and although it is risky to generalise on the basis of one or two accessions, it appears that *M. affine* offers some potential as a forage plant and should be a high priority for plant collecting. Obtaining accessions of Brazilian forms of *M. panduratum* is also a high priority.

M. gracile is well represented in the collection. This species has been collected from a wide range of environments and, given that one accession has already been released in the Northern Territory (cv. Maldonado), deserves more widespread evaluation. The occurrence of both amphicarpic and aerial seeding members suggests this species especially requires taxonomic review.

Amphicarpy can be seen as an adaptive mechanism useful in enhancing survival under limiting conditions or resources (Koller and Roth 1964), since the cost in terms of energy of producing subterranean seed is considerably less than that incurred in producing aerial seed (Schemske 1978). The occurrence of this attribute in such a geographically diverse group of plants as *M. gracile* and the fact that the species was often collected from heavily grazed sites (R. Reid pers. com.), suggests that this species warrants more widespread evaluation.

Although *M. bracteatum* was excluded from the study, several accessions which were previously unidentified, or incorrectly identified, were confirmed as *M. bracteatum*. Three such accessions were distinctive in having white flowers, and more importantly from an agronomic viewpoint, large tubers which the more common morphotype of this species lacks. The presence of tubers is usually associated with strong perennation and the presence of this attribute suggests that *M. gibbosifolium*, *M. affine* and the three accessions of *M. bracteatum* which possess this character may have potential as permanent pasture legumes. Similarly the species and accessions which have shown the ability to root at the nodes, *M. fraternum*, *M. gibbosifolium*, *M. panduratum* and *M. psammodes* might be of interest.

ACKNOWLEDGMENTS

We are indebted to Dr. S.F. Smith of the Smithsonian Institution for his valuable assistance in the identification of many of the species included in this study.

REFERENCES

Barbosa-Fevereiro, V.P. (1988) *Macroptilium* (Bentham) urban do Brasil (Leguminosae - Faboideae - Phaseoleae - Phaseolinae). *Arquivos do Jardim Botanica do Rio de Janeiro* **28**:109-180.

Burkart, A. (1952) Una notable especie nueva de *Phaseolus* del noroeste Argentino (*Ph. geophilus* n.sp.). *Darwiniana* **10**:19-25.

Burt, R.L., Isbell, R. and Williams, W.T. (1979) Strategy of evaluation of a collection of tropical herbaceous legumes from Brazil and Venezuela I. Ecological evaluation at the point of collection. *Agro-Ecosystems* **5** : 99-117.

Bushby, H.V.A., Date, R.A. the late Norris, D.O. and Panitz, R.B. (1984) Rhizobium screening for a range of crop and pasture legumes: Lists of strains of rhizobium and host legumes forming effective nitrogen fixing associations. *Genetic Resources Communication No. 7.* CSIRO Division of Tropical Crops and Pastures, Brisbane.

Cameron, A.G., Miller, I.L., Harrison, P.G. and Fritz, R.J. (1984) A review of pasture plant introduction in the 600 - 1500mm rainfall zone of the Northern Territory. *Technical Bulletin No. 71.* Department of Primary Production, Darwin.

Cameron, A.G. (1989) A review of pasture plant introduction in the 600 - 1500mm rainfall zone of the Northern Territory 1981 - 1985. *Technical Bulletin No. 144.* Department of Primary Industry And Fisheries, Darwin.

Koller, D. and Roth, N. (1964) Studies on the ecological and physiological significance of amphicarpy in *Gymnarrhena micrantha* (Compositae). *American Journal of Botany* **51**:26-35.

Marechal, R., Mascherpa, J. and Stainer, F. (1978). Etude taxonomique d'un groupe complexe d'especes des genres *Phaseolus* et *Vigna* (Papilionaceae) sur la base de donnees morphologiques et polliniques, traitees par l'analyse informatique. *Boissiera* **28**:151-157.

Oram, R.N. (1990) Register of Australian Herbage Plant Cultivars. 3rd Edn. (CSIRO Melbourne.)

Piper, C.V. (1926) Studies in American Phaseolinae. *Contributions from the United States National Herbarium* **22**:347-519.

Schemske, D.W. (1978) Evolution of reproductive characteristics in *Impatiens* (Balsaminaceae): The significance of cleistogomy and chasmogamy. *Ecology* **59**:596-613.

Williams, R.J. (1983). In: J.G. McIvor and R.A. Bray (eds) 'Genetic Resources of Forage Plants'. (CSIRO Melbourne.)

Appendix 1. Passport data for Macroptilium accessions.

Species	Acc. Num.	Site	Prv.	Country	Lat.	Long.	Alt. (m)	pH	Reaction	Rain (mm)
affine	92609	30KM.QUITO,SAN ANTONIO		ECUADOR	14.00S	78.30W				
erythroloma	27405	FAZ."JACARECATINGA",NR VALPARAISO	SP	BRAZIL	21.16S	50.54W				
erythroloma	34590	RIO MOGI,NR RINCAO	SP	BRAZIL	21.40S	48.05W				
erythroloma	34591	RIO MOGI NEAR RINCAO	SP	BRAZIL	21.40S	48.05W				
erythroloma	34744	NOVA CAMPINAS	SP	BRAZIL	22.54S	47.06W				
erythroloma	34747	QUARRY,MATAO	SP	BRAZIL	21.36S	48.20W				
erythroloma	37659	246KM.SANTA CRUZ - COCHABAMBA	COC	BOLIVIA	17.30S	65.03W	2266			
erythroloma	37685	CAMIRI AIRPORT	SC	BOLIVIA	17.45S	63.14W	150			
erythroloma	39090			BRAZIL						
erythroloma	40195	LA PAZ - CHULUMANI	LP	BOLIVIA	16.26S	67.50W	1740			
erythroloma	40196	OPPOSITE HOTEL,CHULUMANI	LP	BOLIVIA	16.22S	67.30W	3000			
erythroloma	40196A	OPPOSITE HOTEL,CHULUMANI	LP	BOLIVIA	16.22S	67.30W				
erythroloma	40218	5KM.E SAMAIPATA	SC	BOLIVIA	18.08S	63.51W	1700			
erythroloma	49752	FAZ."JACARECATINGA",NR VALPARAISO	SP	BRAZIL	21.16S	50.54W	350		B	1100
erythroloma	53184	PATOS DE MINAS	MG	BRAZIL	18.35S	46.32W				
erythroloma	54824	FAZ.BACURI	SP	BRAZIL	23.00S					
erythroloma	75368			ARGENTINA						
erythroloma	76974			BRAZIL						
erythroloma	78443	2KM.N S S. DE JUJUY	JUJ	ARGENTINA	24.00S	65.48W	1260			890
erythroloma	78456	POCOS DE CALDAS	MG	BRAZIL	21.48S	46.33W	1350			1500
erythroloma	79845	65KM.CALI - BUENAVENTURA	VAL	COLOMBIA	3.42N	76.50W				800
erythroloma	81299	PARQUE CHAQUENO ORIENTAL	SAL	ARGENTINA						800
erythroloma	81371	14.5KM.S SANTANDER - POPAYAN	CAU	COLOMBIA	3.10N	76.30W	1200			1500
erythroloma	92529	90KM.CALI - POPAYAN	CAU	COLOMBIA	2.38N	76.30W	1630			1600
fraternum	27761	SAO GABRIEL	RS	BRAZIL	30.24S	54.20W				
fraternum	27762	VACARIA	RS	BRAZIL	28.31S	50.52W				
fraternum	78447	2KM.W SALTA	SAL	ARGENTINA	24.46S	65.28W	1325	6.3	A	690
fraternum	78448	10KM.W SALTA	SAL	ARGENTINA	24.46S	65.33W	1350			700
fraternum	78449	25KM.N SALTA - S.S.DE JUJUY	SAL	ARGENTINA	24.36S	65.24W	1500	6.5	A	1000
fraternum	78450	42KM.S S S.DE JUJUY - SALTA	JUJ	ARGENTINA	24.34S	65.05W	1350	6.3	A	1000
fraternum	78451	18KM.S S S.DE JUJUY - SALTA	JUJ	ARGENTINA	24.35S	65.50W	1250	7.7	C	650
fraternum	78452	15KM.SE S.S.DE JUJUY - PERICO	JUJ	ARGENTINA	24.12S	65.40W	1000	7.2	B	700
fraternum	78453	14KM.SW S.S.DE JUJUY	JUJ	ARGENTINA	24.13S	65.49W	1660		B	1000
fraternum	78454	20KM. S S.DE JUJUY - TUMBAYA	JUJ	ARGENTINA	24.02S	65.54W	1620	7.0	B	900
fraternum	78455	2KM.VOLCAN - S.S.DE JUJUY	JUJ	ARGENTINA	23.57S	65.41W	2100	7.8	C	500
fraternum	78636	JUJUY	JUJ	ARGENTINA						
fraternum	78637	JUJUY	JUJ	ARGENTINA						
fraternum	78638	JUJUY	JUJ	ARGENTINA						
fraternum	78639	LOZANO - JUJUY	JUJ	ARGENTINA						
fraternum	78640	ARROYO HONDO	JUJ	ARGENTINA						
fraternum	78641	RIO BLANCO	JUJ	ARGENTINA	24.11S	65.48W				
fraternum	78642	VOLCAN	JUJ	ARGENTINA	23.57S	65.41W				
fraternum	92590	CERRILOS	SAL	ARGENTINA	24.55S	65.30W				

Species	Acc. Num.	Site	Prv.	Country	Lat.	Long.	Alt. (m)	pH	Reac-tion	Rain (mm)
fraternum	92600	CERRILOS	SAL	ARGENTINA	24.55S	65.30W				
fraternum	92601	CERRILOS	SAL	ARGENTINA	24.55S	65.30W				
fraternum	92605	GRAND BURG	SAL	ARGENTINA						
gibbosifolium	36631	53KM.GUATEMALA CITY - QUEZALTENANGO	CHM	GUATEMALA	15.52N	91.12W	2166			
gibbosifolium	37316	TEGUCIGALPA - ZAMORANO	FRM	HONDURAS	14.02N	87.05W	1766			
gibbosifolium	90373	SANTA RITA MOUNTAINS	ARZ	USA	32.00N	111.00W				
gibbosifolium	90386	PAJARITO MOUNTAINS,SANTA CRUZ COUNTY	ARZ	USA	32.10N	111.00W				
gibbosifolium	90387	PENA BLANCA - RUBY,SANTA CRUZ COUNTY	ARZ	USA	31.30N	111.15W				
gibbosifolium	90388	SANTA RITA MOUNTAINS	ARZ	USA	32.00N	111.00W	1900			
gibbosifolium	90389	SANTA RITA MOUNTAINS	ARZ	USA	32.10N	111.00W				
gibbosifolium	90390	45KM.W NOGALES	ARZ	USA	31.30N	111.20W				
gibbosifolium	90412	25KM.NW NOGALES	ARZ	USA	31.30N	111.12W	1250	6.0	A	440
gibbosifolium	90414	HANK YANK RUIN,SYCAMORE CANYON	ARZ	USA	31.29N	111.13W	1200	6.5	A	440
gibbosifolium	90442	22KM.N TULA AT SAN BARTOLO	HID	MEXICO	20.16N	99.30W	2000	7.2	B	500
gibbosifolium	90442A	22KM.N TULA AT SAN BARTOLO	HID	MEXICO	20.16N	99.30W				
gibbosifolium	90447	9KM.S TULA	HID	MEXICO	20.00N	99.25W	2200	7.2	B	600
gibbosifolium	90448	10KM.E TEXCOCO	HID	MEXICO	19.30N	99.10W	2500	7.0	B	700
gibbosifolium	90480	30KM.E SAN MIGUEL ALLENDE	GUA	MEXICO	20.55N	100.30W	2000	7.2	B	500
gibbosifolium	90483	5KM.E SAN MIGUEL ALLENDE	GUA	MEXICO	20.55N	100.42W	2000	7.2	B	500
gibbosifolium	90483B	5KM.E SAN MIGUEL ALLENDE	GUA	MEXICO	20.55N	100.42W				
gibbosifolium	90741	13KM.SE FRESNILLO	ZAC	MEXICO	23.10N	102.50W	1950	7.5	C	450
gibbosifolium	90760	60KM.N CHIHUAHUA	CHH	MEXICO	29.27N	106.18W	1550	7.0	B	320
gibbosifolium	90762	68KM.W CHIHUAHUA	CHH	MEXICO	28.29N	106.37W	1750	5.8	A	350
gibbosifolium	90768	25KM.W CUAUHTEMOC	CHH	MEXICO	28.29N	107.12W	2100	6.5	A	385
gibbosifolium	90773	4KM.E GUERRERO	CHH	MEXICO	28.31N	107.31W	2000	6.0	A	500
gibbosifolium	90777	32KM.S PARRAL	CHH	MEXICO	26.40N	105.35W	1750	6.0	A	460
gibbosifolium	90783	23KM.GUANAJUATO - DOLORES	GUA	MEXICO	21.05N	101.12W	2300	5.5	A	800
gibbosifolium	91130	14KM.W TELOLOAPAN - CUIDAD ALTIMIRANO	GRO	MEXICO	18.26N	99.55W	1450	8.0	C	1150
gibbosifolium	91144	27KM.W TELOLOAPAN - CUIDAD ALTIMIRANO	GRO	MEXICO	18.27N	100.00W	1450	6.5	A	1000
gibbosifolium	91177	56KM.MEXICO - OAXTEPEC	MOR	MEXICO	19.06N	99.02W	2000	6.0	A	1100
gibbosifolium	91222	74KM.MEXICO CITY - CUERNAVACA	MOR	MEXICO	19.00N	98.59W	1900		A	1300
gracile	104738		ATL	COLOMBIA						
gracile	107159	13.9KM.PALENQUE - EMILIANO ZAPATA	CHI	MEXICO	17.35N	91.55W	50			2025
gracile	33497	PUNTA DE MATA,7KM.W JUSEPIN	MON	VENEZUELA	9.47N	63.39W	75	4.5	A	
gracile	33498	EL TEJERO	MON	VENEZUELA			75	4.5	A	
gracile	34435	BURRELL BOOM		BELIZE			9	5.0	A	
gracile	37203	BETWEEN LEON - MANAGUA	LEO	NICARAGUA	12.15N	86.37W	66			
gracile	38288	CARACAS -MARACAY		VENEZUELA	10.28N	67.12W	450			
gracile	40206	EXPT.STN.,NR PENTECOSTES	CE	BRAZIL	3.49S	39.18W				
gracile	40207	EXPT.STN.,NR PENTECOSTES	CE	BRAZIL	3.49S	39.18W				
gracile	40208	FAZ."CANHOTINHA",25KM.S QUIXERAMOBIM	CE	BRAZIL	5.22S	39.22W				
gracile	51368		PE	BRAZIL						
gracile	54826	UMIRIM,100KM.W FORTALEZA - SOBRAL	CE	BRAZIL	3.40S	39.21W	150		A	900

Species	Acc. Num.	Site	Prv.	Country	Lat.	Long.	Alt. (m)	pH	Reac-tion	Rain (mm)
gracile	55751	60KM.IBOTIRAMA - SEABRA	BA	BRAZIL	12.20S	42.50W	450		A	620
gracile	55763	5KM.CHITRE - PEDASI		PANAMA	7.56N	80.23W	50			1000
gracile	62158	HATO EL FRIO,180KM.W SAN FERNANDO DE APURE	APU	VENEZUELA	7.44N	68.57W			A	1300
gracile	67650	12KM.SW EL PROGRESO NR SANSARE	EP	GUATEMALA	14.50N	90.08W	250			
gracile	68835	SANTA MARTA	MAG	COLOMBIA	11.18N	74.10W				
gracile	78635	FAZ."LONGA",120KM.NE TERESINA	PI	BRAZIL	4.40S	42.00W			A	
gracile	78635A	FAZ."LONGA",120KM.NE TERESINA	PI	BRAZIL	4.40S	42.00W				
gracile	78635B	FAZ."LONGA",120KM.NE TERESINA	PI	BRAZIL	4.40S	42.00W				
gracile	84999	22KM.N CABO SAN LUCAS - TODOS SANTOS	BCS	MEXICO	23.02N	110.00W	250	6.5	A	250
gracile	90915	3KM.W LA CRUZ	SIN	MEXICO	23.53N	106.53W	10			700
gracile	91089	6KM.S ESCUINAPA	SIN	MEXICO	22.50N	105.50W	50	6.5	A	1000
gracile	91094	10KM.W ESCUINAPA	SIN	MEXICO	22.49N	105.55W	10	6.0	A	1000
gracile	91101	3KM.N ROSARIO	SIN	MEXICO	23.00N	105.53W	50	6.5	A	1000
gracile	91106	6KM.W CONCORDIA	SIN	MEXICO	23.16N	106.03W	140	6.5		1000
gracile	91157	43KM.W TELOLOAPAN - C ALTIMIRANO	GRO	MEXICO	18.26N	100.12W	1100			1000
gracile	91329	6KM.W TONALA	CHI	MEXICO	16.09N	93.49W	20	6.5	A	1600
gracile	91337	8KM.SW NILTEPEC - LOS TULES	OAX	MEXICO	16.19N	94.35W	10	7.5	C	960
gracile	91340	MICROONDAS L T 10KM.SW NILTEPEC	OAX	MEXICO	16.19N	94.35W	30	4.0	A	960
gracile	91347	LOS TULES	OAX	MEXICO	16.19N	94.35W	30	4.0	A	960
gracile	91446	20KM.S CAMPECHE - CHAMPOTON	CAM	MEXICO	19.44N	90.40W	10	8.0	C	1080
gracile	91449	39KM.S CAMPECHE - CHAMPOTON	CAM	MEXICO	19.35N	90.40W	3	8.5	C	1080
gracile	91485	16KM.N MERIDA - PROGRESSO	YUC	MEXICO	21.10N	89.39W	10	8.5	C	700
gracile	91490	6KM.W PROGRESSO	YUC	MEXICO	21.19N	89.41W	3	8.5	C	425
gracile	92525	8KM.SANTA MARTA - RIOHACHA	MAG	COLOMBIA	11.18N	74.02W	20			
gracile	92526	51KM.CARIMAGUA - PT CARRENO	VIC	COLOMBIA	4.08N	73.01W	175			2200
gracile	92527	PUERTO CARRENO	VIC	COLOMBIA	6.08N	69.27W	125			2000
gracile	92528	277KM.CARIMAGUA - PT CARRENO	VIC	COLOMBIA	5.20N	70.33W	170			2100
gracile	92530	SANTA ISABEL DO MORO	GO	BRAZIL	11.36S	50.37W	200			
gracile	92531	4KM.W PALOMINO - SANTA MARTA	MAG	COLOMBIA	11.15N	73.39W				
gracile	92532	21KM.EL TIGRE - ANACO	ANZ	VENEZUELA	8.54N	64.20W	220			1100
gracile	92533	49KM.W MATURIN	MON	VENEZUELA	9.47N	63.33W	100			1200
gracile	92535	FAZ."LONGA",120KM.NE TERESINA	PI	BRAZIL	4.40S	42.00W	85			1200
gracile	92536	20KM.N SANTA ISABEL DO ARAGUAIA	GO	BRAZIL	5.55S	48.22W				
gracile	92542	4KM.SW CAICO	RN	BRAZIL	6.23S	37.02W	160			500
gracile	92667	2KM.N SANTA MARTA	MAG	COLOMBIA	11.18N	74.10W	1400			1000
gracile	92684	20KM.SE SANTA MARTA - SAN LORENZO	MAG	COLOMBIA	11.15N	74.07W	390	6.0	A	1100
gracile	92711	26KM.E SANTA MARTA - RIOHACHA	MAG	COLOMBIA	11.18N	74.06W	200	6.0	A	1200
gracile	92723	18KM.SANTA MARTA - BARRANQUILLA	MAG	COLOMBIA	11.10N	74.12W	50	6.0	A	800
gracile	93084	30KM.JANAUBA - JAIBA	MG	BRAZIL	15.48S	43.24W	550			
gracile	93092	54KM.JANAUBA - ESPINOSA	MG	BRAZIL	15.38S	43.00W	600			
martii	49780	SENTO SE,BAHIA	BA	BRAZIL	9.41S	41.16W				
martii	55781	20KM.PETROLINA - RECIFE	PE	BRAZIL	9.10S	40.15W	370		B	400
martii	55782	20KM.PETROLINA - RECIFE	PE	BRAZIL	9.10S	40.15W	370		C	400

Species	Acc. Num.	Site	Prv.	Country	Lat.	Long.	Alt. (m)	pH	Reac-tion	Rain (mm)
martii	55783	PETROLINA AIRPORT	PE	BRAZIL	9.22S	40.30W	370		A	383
martii	55784	4KM.CABROBO - BELEM DE SAO FRANCISCO	PE	BRAZIL	8.30S	39.16W	400		A	400
martii	55785	3KM.S CROSSRD.,21KM.PETROLINA - CASA NOVA	PE	BRAZIL	9.30S	40.35W	380			400
martii	55786	15KM.PETROLINA - CASA NOVA	PE	BRAZIL	9.28S	40.35W	380		B	400
martii	55787	20KM.SW IACU	BA	BRAZIL	12.48S	40.17W	230		A	550
martii	55788	60KM.IBOTIRAMA - SEABRA	BA	BRAZIL	12.19S	42.53W	450		A	620
martii	55789	14KM.IBOTIRAMA - SEABRA	BA	BRAZIL	12.13S	43.00W	450			720
martii	55790	13KM.LIVRAMENTO DO BRUMADO - BRUMADO	BA	BRAZIL	13.50S	41.51W	500			620
martii	92540	45KM.SW CURRAIS NOVOS	RN	BRAZIL	6.28S	36.42W	340			550
martii	92541	4KM.SW CAICO	RN	BRAZIL	6.23S	37.02W	160			500
martii	Q10026	ITAPETIM	PE	BRAZIL	7.24S	37.10W				
martii	Q10037	ITAPETIM	PE	BRAZIL	7.24S	37.10W				
panduratum	18556	GUEMES	SAL	ARGENTINA						
panduratum	78435	13KM.E COLONEL MOLDES	SAL	ARGENTINA	25.16S	65.20W	1140	8.3	C	450
panduratum	78436	15KM.E COLONEL MOLDES	SAL	ARGENTINA	25.16S	65.22W	1140			450
panduratum	78437	14KM.S SAN PEDRO	JUJ	ARGENTINA	24.20S	65.00W	830	8.0	C	600
panduratum	78438	8KM.PERICO - S.S.DE JUJUY	JUJ	ARGENTINA	24.15S	65.15W	1000	7.2	B	600
panduratum	78439	27KM.S PALOMITAS - METAN	SAL	ARGENTINA	25.12S	65.02W	900	8.0	C	470
panduratum	78440	1KM.E EL QUEBRACHAL	SAL	ARGENTINA	25.21S	64.02W	300	7.7	C	500
panduratum	81300	8KM.SE JOAQUIN V GONZALEZ,PARQUE CHAQUENO OCCIDENT	SAL	ARGENTINA	25.04S	64.02W				500
panduratum	81301	8KM.SE JOAQUIN V GONZALEZ,PARQUE CHAQUENO OCCIDENT	SAL	ARGENTINA	25.04S	64.02W				500
panduratum	92592	SAN JUANCITO	JUJ	ARGENTINA	24.20S	64.55W				
prostratum	25865	4KM.N SAN JUSTO	SF	ARGENTINA	30.45S	60.42W				
psammodes	39098	ESTANCIA"YACARE",100KM.S OF ASUNCION		PARAGUAY	25.58S	57.14W	180			
psammodes	74870		COR	ARGENTINA						
sabaraense	93068	9KM.MONTES CLAROS - JANAUBA	MG	BRAZIL	16.36S	43.48W	675			

Figure 1. Location of collection sites of accessions of:

■ *M. affine*
▲ *M. erythroloma*
□ *M. prostratum*
● *M. psammodes*
◇ *M. sabaraense*

Figure 2. Location of collection sites of accesions of:

◇ *M. fraternum*
▲ *M. gibbosifolium*
■ *M. martii*

Figure 3. Location of collection sites of accessions of:

■ *M. gracile* (amphicarpic)
▲ *M. gracile* (aerial seeding)
◇ *M. panduratum*