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GEOGRAPHICAL DISTRIBUTION AND CONSERVATION OF A RARE MEDICINAL PLANT *MUNRONIA PINNATA* (WALL.) THEOB. (MELIACEAE) IN SRI LANKA

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Key words: Munronia pinnata; Systematic survey; Meliaceae; Conservation; Cultivation; Medicinal plants.

Abstract

In the present study, distribution and abundance of *Munronia pinnata* (Wall.) Theob. in Sri Lanka were explored in 6 provinces, 7 districts, 68 Divisional Secretariat Divisions (DSD) and 395 Grama Niladari (GN) areas. Fifty three GN areas were identified as *M. pinnata* abundant areas. In 217 GN areas, the plant is found in small scale and in 65 GN areas it was rarely found. *M. pinnata* was not found in 8 DSDs. Ten new localities were found and three of them were in the wet zone. The highest diversity was found in Monaragala and Matale districts. Populations well adopted for a range of climatic conditions were observed in Madulla, Nilgala, Warakapola, Ritigala and Haldumulla. Monaragala, Wellawaya, Mathurata, Meemure and Kithulpe were identified as unique populations for conservation. Monaragala, Badulla and Matale appear to be the most suitable districts for commercial cultivation of *M. pinnata*. This is the first record of an extensive systematic survey on the distribution of *M. pinnata* in Sri Lanka.

Introduction

The Genus *Munronia* Wight. (Meliaceae), comprising 13-15 species, is naturally distributed in southern China, Vietnam, Myanmar, Java, Sri Lanka, India, Indonesia and the Philippines (Qi *et al*., 2003). Out of these, five species of *Munronia* are restricted to tropical Asia, and subtropical China, up to 1800 m and in Sri Lanka up to 700 m from the mean sea level (Dassanayake *et al.*, 1995; Peng and Bartholomew, 2008). *Munronia pinnata* (Wall.) Theob. is a rare medicinal plant species (Dassanayake *et al.*, 1995). According to the literature available, plants of *M. pinnata* with an array of variable phenotypic characters (3, 5, 7, 9 and 11 leaflets types) exist in various locations in Sri Lanka (Jayaweera, 1982; Dassanayake *et al.*, 1995). According to Hooker (1874), *M. pinnata* was an abundant and widely distributed plant in Sri Lanka in early days.

In Chinese and Sri Lankan traditional medicine, *Munronia* has been used since historic times for many ailments such as tuberculosis, cough, stomach-ache, sores, malaria, recurrent fever, dysentery and purification of blood (Jayaweera, 1982; Qi *et al*., 2003). Moreover, there are over 32 written recipes including 'Sudarshana Churna', 'Chandraprabha watee' and 'Denimba debatu adee kashaya' in Sri Lankan Ayurvedic

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Pharmacopeia, in which the entire plant of *M. pinnata* is used as the major ingredient of preparations used for above ailments (Anonymous, 1979). On the other hand *M. pinnata* is one of the most expensive plant materials (US$ 50-110/kg) used in traditional systems of medicine in Sri Lanka. Further almost all raw material requirements are obtaining from natural habitats due to lack of systematic cultivations, lack of information on cultivation and processing and lack of sufficient planting materials to establish commercial cultivation in Sri Lanka as well as elsewhere. Therefore, there is a tremendous pressure on this rare plant which might lead to extinction due to over exploitation.

Recording of existing populations in different locations with their abundance, identifying potential areas and morphotypes for cultivation, recognizing population/s for conservation and sustainable use of this valuable medicinal plant in traditional and Ayurveda medicine seem to be timely important issues. These data will certainly provide information needed to establish cultivations for sustainable use of *M. pinnata* in Sri Lanka. Information available on the distribution is very old and the most recent record is also more than 20 years old while some evidence are more than 100 years old (Dassanayake *et al.,* 1995). Therefore, attempts were made to investigate the present distribution and the abundance of *M. pinnata* in different localities in physically accessible areas of the country.

Materials and Methods

Island wide survey on the distribution: For administrative purposes, the country is divided into nine provinces and 26 districts. Each district has 3-7 Divisional Secretariat Divisions (DSD) and each DSD has many Gramaniladari divisions (GN). The GN division is the smallest administrative division in Sri Lanka. The present study was carried out during 2004-2007. The systematic survey comprises four stages as collecting information from available literature, collecting data from GN divisions using a questionnaire, visiting areas of the country where *M. pinnata* is available (guided by available literature) and gathering information by personnel communication with traditional practitioners of ayurveda.

Collecting information from available literature: A literature survey was carried out on the distribution of *M. pinnata* in Sri Lanka. Information was collected from literatures and databases, herbarium specimens deposited at Royal Botanical Garden Peradeniya, Sri Lanka and personal communication with personnel involved in traditional medical practices.

Collecting data from GN divisions: A systematic survey was carried out covering all DSDs of the country. A questionnaire for this survey was prepared and evaluated by trying out with 4-5 persons before giving the questionnaire to Gramaniladaris. The questionnaire was distributed among traditional ayurvedic doctors, cultivators and collectors of medicinal plants in each of the GN divisions through the government

administrative officer ("Gramaniladari") of the area. Completed questioners were collected through the same way and information was compiled.

Field visits: Field surveys were carried out by visiting various places, which were selected based on available literature and information collected through the questionnaire survey in different ecological regions of the country. Selected areas for field visits are given in Map 1. Distribution of *M. pinnata* as found in the present study was compared with data available in the literature (Appendix B) to mark populations for conservation as well as for places for cultivation.

Collection and maintenance of different populations: Out of the 16 locations listed in Table 3, plants from 13 locations were collected for the present study. Ten to twenty plants were collected from each location depending on the availability of plants. When there were only a few plants in a particular location, neighboring areas were searched for more plants without disturbing the existing population. Plants collected were brought to Industrial Technology Institute, Sri Lanka and potted in plastic or clay pots filled with a mixture of topsoil 1: compost 2: sand 1. Each sample was labeled using the respective notation and was maintained in the greenhouse for 5 years. Close observations were made during that period on the survival, growth performance, flowering and fruiting of each morphotype under normal day light and temperature $27^{o}C \pm 2$.

Collection of ecological data: The altitude, latitude and longitude of each population were measured using Global Positioning System (ETrex Vista Garmin Model). Soil samples were collected from each location using a soil auger to measure the soil pH. The agro-ecological region and rainfall data were adopted from Panabokke and Kannangara (1996).

Determination of the stomatal index: Stomatal index was calculated as described by Trease and Evance (2002) with slight modifications. End leaflet pieces of each population (5 × 5 mm) other than from extreme margin and midrib were warmed up in saturated chloral hydrate solution until they become transparent. Subsequently these were strained with 1% safranin in 50% ethanol and were made into temporary mounts using glycerin. Slides were examined under compound light microscope fitted with an eye piece micrometer. Counts were made of the number of epidermal cells and of stomata (two guard cells and ostiole being considered as a single unit) within the square grid. Successive adjacent fields were examined until about 400 cells have been counted. The stomatal index value for each population was calculated using standard formula given by Trease and Evance (2002).

$$\text{Stomatal index} = \frac{S \times 100}{E + S}$$

Where S = the number of stomata in a given area of leaf, E= the number of epidermal cells (including trichomes) in the same area of leaf.

Data analysis: The range of each variable/character was sub-divided and ranked, and then a numerical value was given to each level (Table 1). Using these numerical values, a data table (Table 2) for cluster analysis was prepared. Cluster analysis was done by using SPSS Version 10. Clusters were generated following Unweighted Pair Group Method with Arithmetic Means (UPGMA), which is an agglomerative clustering method.

Table 1. Parameters used in numerical analysis and ranking of their data (the ranks are given in parenthesis).

Parameter	Ranks given
1. Elevation (Ev)	< 100 m (1), 100 – 499 m (2), 500-1000 m (3), >1000 m (4)
2. Soil pH (pH)	5 -5.9 (1), 6 – 6.9 (2), >7 (3)
3. Agro-ecological region (AER)	IM (1), IL (2), WL (3), DL (4)
4. Rainfall (RF)	<45 (1), 45-60 (2), > 60 (3)
5. Soil type (ST)	RB/RBE (1), RYP (2)
6. Stomatal index (SI)	5.5 -6.4 (1), 6.5 -7.4 (2), 7.5 or more (3)

IM = Mid country intermediate zone; IL= Low country intermediate zone; WL= Low country wet zone; DL= Low country dry zone; RB/ RBE= Reddish brown/ Reddish brown earth; RYP Red yellow podzolic soils.

Table 2. Data matrix for analysis of ecological data (Ranking and notations are as in Table 1 and Table 3 respectively).

Character populations	Elevation	soil pH value	AER	Rainfall	Soil type	Stomatal index
Madulla	2	1	1	2	1	2
Monaragala	2	1	1	2	1	1
Nilgala	2	1	2	2	1	2
Warakapola	2	3	3	3	2	2
Ritigala	2	1	4	1	1	2
Kithulpe	3	3	2	2	2	1
Haldummulla	3	2	1	2	1	1
Wellawaya	2	2	2	2	1	3
Pallewela	1	2	3	3	2	2
Kuliyapitiya	1	1	3	2	2	1
Naula	2	1	1	1	1	2
Mathurata	4	2	3	2	2	1
Meemure	2	1	2	1	1	3

Results and Discussion

Island wide survey carried out using a questionnaire revealed that out of the 68 DSDs considered, *M. pinnata* could be naturally found in only 38 DSD divisions in Sri Lanka. *M. pinnata* was abundant in 395 GN divisions. In 217 GN Divisions it was found in small scale and in 65 it was found very rarely. The 38 DSDs are shown in Appendix A and list of places where *M. pinnata* had been recorded in literature as cited in the Handbook of Flora of Ceylon (Dassanayake *et al.,* 1995) is shown in Appendix B. Results of the present study on distribution and abundance of *M. pinnata* is presented in

Table 3. Different populations collected from different locations are shown in Plate 1. Areas recorded in the present study together with those recorded in literature are presented in Map 1. Presence/absence of flowering and fruiting of 13 populations are presented in Table 4.

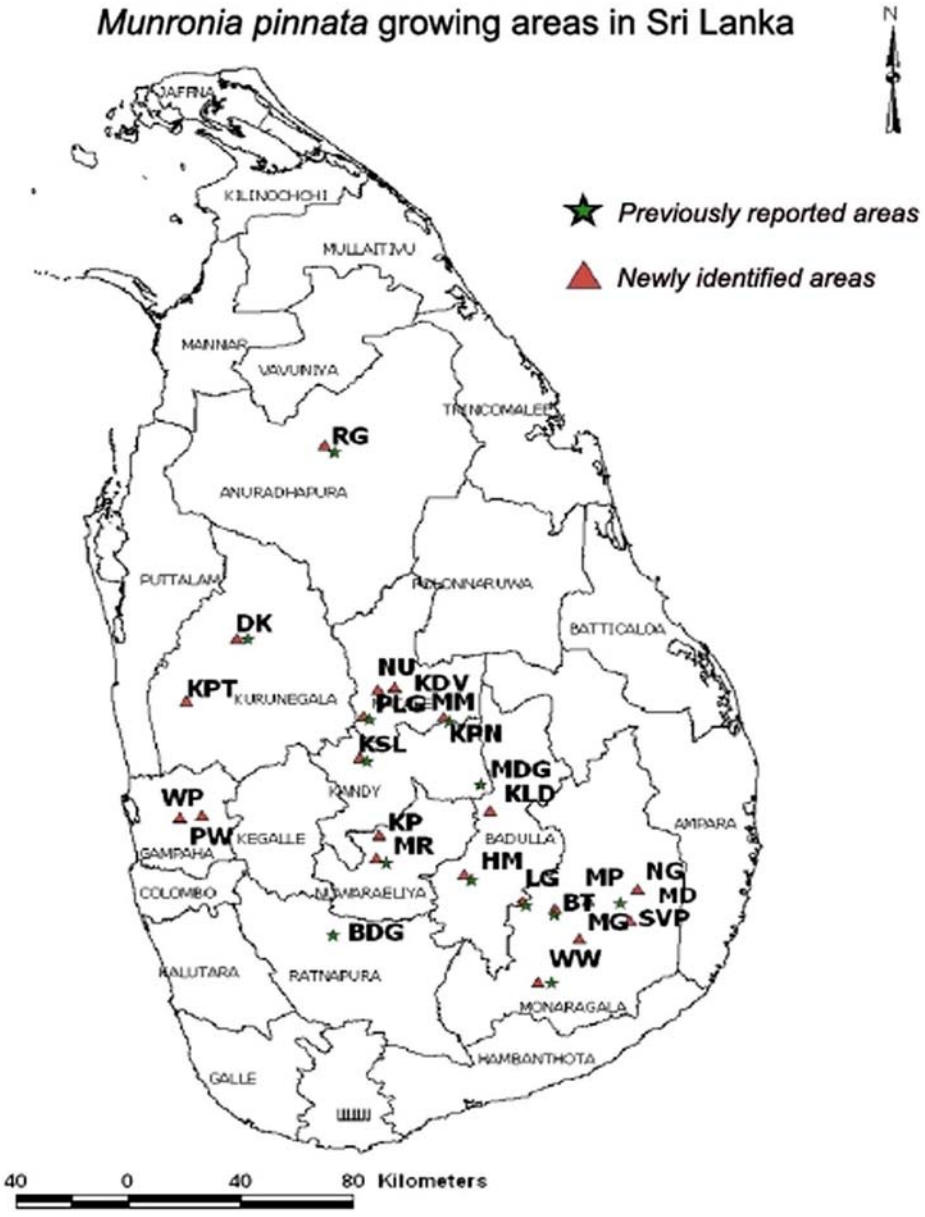
Table 3. Distribution and abundance of *M. pinnata* (Based on the present study)

Location	District	Province	Leaflet no.	Abundance*
1. Haldummulla (HM)	Badulla	Uva	3	A
2. Kalundewa**	Matale	Central	3/5	A
3. Kithulpe (KP)	Nuwaraeliya	Central	3	B
4. Koslanda	Badulla	Uva	3	B
5. Kuliyapitiya (KPT)**	Kurunegala	NW	5	B
6. Madulla (MD)**	Monaragala	Uva	3	A
7. Mathurata (MR)	Nuwaraeliya	Central	3	B
8. Meemure (MM)**	Matale	Central	5/7	A
9. Naula (NU)**	Matale	Central	5	A
10. Nilgala (NG)**	Monaragala	Uva	3	A
11. Pallegama**	Matale	Central	3	B
12. Pallewela (PW)**	Gampaha	Western	3	A
13. Ritigala (RG)	Anuradhapura	NC	5	A
14. Srivijayapura (MG)**	Monaragala	Uva	9/11	B
15. Warakapola (WP)**	Gampaha	Western	3	B
16. Wellawaya (WW)	Monaragala	Uva	7	A

*Abundance was estimated visually with relevant to the size of the populations A- abundant, B - only a very few plants available; **New localities found in the present study; NC- North central, NW- North western

Table 4. Flowering and fruiting performance of 13 morphotypes of *Munronia pinnata* under greenhouse conditions (Temp. 27 ±2 ^{o}C, Normal day length)

Populations	Performance	
	Flowering	Fruiting
Haldummulla	Normal	Normal
Kithulpe	Rare	No fruiting
Kuliyapitiya	Medium	Medium
Madulla	Normal	Normal
Monaragala	Rare	Very rare
Meemure	Rare	Very rare
Mathurata	Rare	No fruiting
Nilgala	Normal	Normal
Naula	Normal	Normal
Pallewela	Normal	Normal
Ritigala	Normal	Normal
Warakapola	Normal	Normal
Wellawaya	Rare	No fruiting



Map 1. Geographical distribution of *Munronia pinnata* in Sri Lanka (BDG- Balangoda; BT- Buttala, DK- Dolukanda; HM- Haldummulla; KPN- Kalupahana; KP-Kithulpe; KSL- Koslanda; KPT- Kuliyapitiya; KLD- Kundasale; LG - Lunugala; KDV- Kalundeva; PLG- Pallegama;MM- Meemure; MDG- Madugoda; MR- Mathurata; MG- Moneragala; MP – Muppane; MD- Madulla; NU- Naula; NG- Nilgala; PW- Pallewela; RG- Ritigala; SVP- Srivijayapura; WP- Warakapola, WW- Wellawaya)

However, in eight DSD divisions namely, Attala, Mundalama Matara, Pallepola, Baticalloa, Jaffna, Katana and Negombo, including 60 GN areas, *M. pinnata* was found neither growing naturally nor as in cultivation. Ten new localities were recorded in present survey and three of them were in the wet zone (Map 1). This plant had been reported only from dry and intermediate zones of the country.

Plate 1. Different morphotypes of *Munronia pinnata*, available in different locations in Sri Lanka. 1. Dambagalla, 2. Haldummulla, 3. Kalumdewa, 4. Kithulpe, 5. Kuliyapitiya, 6. Madulla, 7. Monaragala, 8. Meemure, 9. Mathurata, 10. Nilgala, 11. Naula, 12. Okadagala, 13. Pallewela, 14. Ritigala, 15. Warakapola, 16. Wellawaya.

During this survey, several localities with *M. pinnata* were found in Monaragala and Matale districts. Out of these two districts, the highest number of *M. pinnata*

morphotypes was found in Monaragala district, which comprises of four populations (two types of 3-leaflets, 7-leaflets and 9/11-leaflets types).

Out of 16 locations given in Table 3, 10 locations contained 3-leaflet types of *M. pinnata.* Populations bearing more than 3-leaflets were recorded only in five locations (Kalundewa, Naula, Ritigala, Kuliyapitiya and Meemure).

Normal growth was observed in all populations under greenhouse conditions. Flowering was rare and even when occurred, no fruiting was observed in five out of 13 populations under greenhouse conditions (Table 4). Flowering is one of the phenological processes influenced by external environmental factors especially temperature. Therefore difficulty observed in flowering in populations of KP and MR is quite acceptable as they were collected from Nuwaraeliya district which is in the hill country of Sri Lanka where the average temperature is around 20 ^{o}C. Furthermore, day length fluctuation is also higher in this area than that of the low laying areas of the country, where these plants were acclimatized in greenhouse. It indicates that conservation of these populations demands *in situ* conservation. If not they have to be grown in greenhouses under carefully controlled conditions. The morphotype collected from Meemure (Matale district) produced some flowers, but did not produce fruits. Since Meemure is isolated and surrounded from huge mountains it has its own microclimatic conditions. Therefore, this population may have adapted to these climatic conditions especially for flowering and fruiting. On the other hand population collected from Ritigala performed well producing flowers and fruits under normal greenhouse condition in Colombo. Although Ritigala is separated from wet and intermediate zones by dry plains, its isolation and high elevation has produced a unique climate with wet and intermediate characteristics. Hence Ritigala provides platform for 410 taxa of lower and higher plants. It shows that this population could easily be cultivated in areas with wet and intermediate characteristics. Geographical isolation must have restricted RG population to that area. Some populations collected from Monaragala and Matale performed well under climatic conditions of greenhouse in Colombo, while three of them namely, Monaragala, Wellawaya and Meemure did not. These populations bear 7-9 and 11-leaflets and are not common in other areas indicating that they may be genetically adapted to grow in these areas and their restricted distribution is not merely due to geographical isolation. *In situ* conservation seems to be the best method for these populations, but when ecological conditions were analyzed, these three clustered with the rest of the populations collected from Matale and Monaragala. It shows that there is a possibility for cultivation of these populations in other localities.

According to the analysis of ecological data (Fig. 1), *M. pinnata* growing in Sri Lanka could be separated into three main clusters such as 1. MD, NU, NG, MG, HM, WW, MM; 2. WP, PW, KPT; 3. RG, KP and MR. This indicates that MD, NU, NG, MG, HM, WW and MM require approximately the same climatic conditions compared to the other populations. These include plants collected from Badulla, Matale and Monaragala

districts. This group comprises of populations varying from 3, 5, 7 9 and 11 leaflet types. Flower and fruit setting of MG, WW and MM populations were very unsatisfactory under greenhouse conditions. These findings are very important in the conservation point of view as it shows the possibility of establishing large scale cultivation in areas where these populations do not exist naturally at present. Populations collected from Nuwara Eliya (KP and MR) formed a separate cluster which was collected from hilly areas with a cold climate. Their failure in producing flowers and fruits under low country conditions (Temperature around $27^{o}C \pm 2$) shows that they can be cultivated only in the areas with

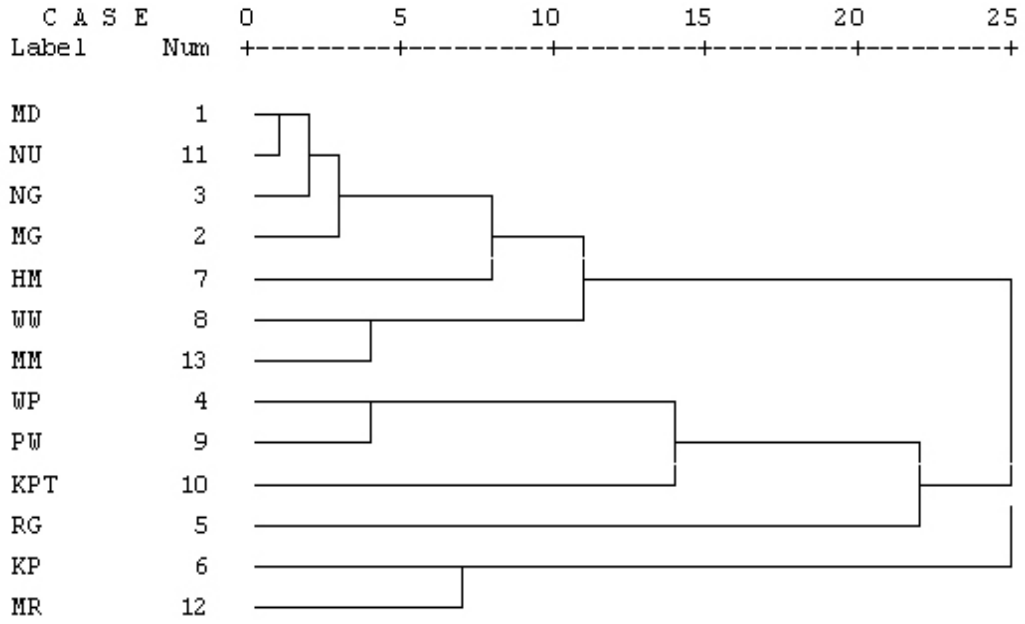


Fig. 1. A dendrogramme of ecological relationship of 13 *M. pinnata* populations (For abbreviations see Table 3).

similar environmental conditions. In the conservation point of view, they need special attention for survival. Population collected from Ritigala got separated from all three clusters. This is acceptable as the microclimate in this area is very specific and quite different from those of other locations. According to the present study, *M. pinnata* could be grown within a considerable range of ecological conditions including all three agro-ecological regions in the country and within a considerable range of altitude (30-1000 m). Moreover, studies on stomatal index of different populations did not show clear correlation with environmental factors or number of leaflets of different populations. Our findings are in agreement with the previous reports (Dassanayake *et al.*, 1995; Peng and Bartholomew, 2008), who pointed out that *M. pinnata*, was grown up to 700 m from mean sea level in Sri Lanka and up to 1800 m in China. Furthermore, Qi *et al.* (2003) and Peng and Bartholomew (2008) reported that *Munronia* species can grow in heights

varying from 200 m to 1800 m from mean sea level in China. Findings of the present study are in agreement with the previous work.

In order to conserve the medicinal plants ethnobotanical surveys are very useful (Chellaiah *et al.,* 2006; Bekalo *et al.,* 2009). The present study also highlights his important issue. The present study revealed that this rare and valuable medicinal plant could easily be cultivated in different parts of Sri Lanka under various climatic conditions. This opens up an avenue to establish large growing areas of *M. pinnata* in places where it has not been reported or cultivated before. This study was unable to find, *M. pinnata* in some of the localities reported earlier (Dassanayake *et al.,* 1995). Several reasons including urbanization, clearing forests for cultivation, natural disasters such as landslides and over-exploitation might have exerted unfavorable impacts on these populations, making them very rare or extinct in those localities.

Conclusion

This is the first record of an extensive systematic survey on the distribution of *M. pinnata* in Sri Lanka finding 10 new localities including three in the wet zone. It shows that this plant could be cultivated in the wet zone though it has been previously recorded only from the dry and intermediate zones. Matale, Badulla and Monaragala seem to be the most suitable districts to establish large scale cultivations of *M. pinnata.* Populations collected from Ritigala (RG) could easily be cultivated even in Colombo. This is quite promising as it was identified as a unique population for conservation with regard to morphology and molecular characters (unpublished data).

Six populations *i.e.* MD (Madulla), NU (Naula), NG (Nilgala), WP (Warakapola), RG (Ritigala) and HM (Haldummulla), were grown well, under a range of climatic conditions producing large number of flowers and fruits. However the ability to produce flowers and seeds of the morphotypes KP, MR, MG, WW and MM are very low and hence there should be a special conservation plan for them particularly, otherwise they might be extinct from the country soon.

Appendix A. DSDs of *M. pinnata.*

1. Ahatuwewa	11. Horowpathana	21. Mawathgama	31. Polgahawela
2. Alawwa	12. Ibbagamuwa	22. Medagama	32. Polpithigama
3. Anamaduwa	13. Kaluthara	23. Mihintala	33. Rasnayakepura
4. Bammunukotuwa	14. Katupotha	24. Morawewa	34. Raththota
5. Bibile	15. Kebithigollewa	25. Naula	35. Ududaddawa
6. Dambulla	16. Kotawehera	26. Nikaweratiya	36. Wariyapola
7. Dankotuwa	17. Kurunegala	27. Palagala	37.Kulama
8. Galgamuwa	18. Laggala	28. Pallegama	38. Wellawaya
9. Gomarankadawela	19. Madulla	29. Palugaswewa	
10. Hambanthota	20. Mallawapitiya	30. Pannala	

Appendix B. Locations of *M. pinnata* previously recorded (Dasanayake *et al.*, 1995).

Haldummulla (1986)*	Kalupahana (1987)*	Madugoda (1990)	Ritigala (1887,1905, 1971,1973,1975)*
Balangoda (1906)	Katharagama (1897)	Mathurata (1883)*	Wadinagala (1975)
Buttala*(N/A)	Kundasale (1987)* (N/A)	Mediwaka (1990)	Wellawaya (1906)*
Dammenthenna (1987)	Laggala 1987*	Muppene (1928)	Uma Oya (1883)
Doluwa (1972)	Lunugala (1888)*N/A		

Those marked with * were visited during this study

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References

Anonymous, 1979. Ayurveda Pharmacopeia **1**. Part (2). Department of Ayurveda, Colombo, Sri Lanka. p.121.

Bekalo, T.H., Woodmatas, S.D. and Woldemariam, Z.A. 2009. An ethnobotanical study of medicinal plants used by local people in the lowlands of Konta Special Woreda, southern nations, nationalities and peoples regional state, Ethiopia. J. Ethnobiol. Ethnomed. **5**:26.

Dassanayake, M.D., Fosberg, F.R. and Clayton, W.D (eds) 1995. A Revised Handbook to the Flora of Ceylon. Vol. **9**. Amerind Publ. Co. Ltd. New Delhi, India, pp. 230-239.

Hooker, J.D. 1874. Flora of British India. Vol. **1**. London, pp. 540-569.

Jayaweera, B.M.A. 1982. Medicinal plants (Indigenous and exotic) used in Ceylon, Part **4**. National Science Council, Sri Lanka p. 59.

Muthu, C., Ayyanar, M., Raja, N. and Ignacimuthu, S. 2006. Medicinal plants used by traditional healers in Kancheepuram district of Tamil Nadu, India. J. Ethnobiol. Ethnomed. **2:** 43.

Panabokke, C.R. and Kannangara, R.P. 1996. Agro-ecological regions of Sri Lanka: Map 2. Survey Department of Sri Lanka.

Peng, H. and Bartholomew, B. 2008. *Munronia*. *In*: Theobald, W. and Burmah, M. (eds), Flora of China **11:** 118-119.

Qi, S.-H., Chen, L., Wu, D.G., Maa, W.-B. and Luoa, X.-D. 2003. Novel tetranortriterpenoid derivatives from *Munronia henryi*. Tetrahedron **59**: 4193-4199

Trease, W.C. and Evance, D. 2002. Pharmacognosy. Elsevier LTD, New York pp. 545-546.

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