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Ecogeographic Survey and Collection of Forage Legumes in North Sulawesi, Indonesia

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A detailed ecogeographic survey of the north Sulawesi region of Indonesia for collection of forage legumes was undertaken during October, 1985. In all, 168 collections (population samples) of 11 legume genera were made from 89 sites differing in altitude, longitude, latitude, rainfall zone, pH, soil type and associated vegetation. Herbarium specimens were also made for all collections and passport data on several plant and ecological descriptors were recorded.

Collections of Pueraria phaseoloides, Desmodium heterocarpon, D. styracifolium *and* Uraria lagopodoides *from acidic soils and dry areas are of special significance. Some of the collections have promise as direct introductions or as parents in hybridisation programmes.*

The Indonesian archipelago is rich in genetic resources of native and introduced, naturalised forage plants. More recently, interest has been generated through the researches of CIAT, Colombia and CSIRO, Australia, in the forage value of species of *Desmodium* and *Pueraria* from Indonesia and other south-east Asian countries, for use in acid infertile soils. South-east Asia is considered a centre of origin and primary centre of differentiation of asiatic *Desmodium* species due to the presence of several related genera, and rich differentiation at the sub-generic and species level (Mehra, 1985). Similar is the situation regarding other forage legume species (Mehra and Magoon, 1974) which still grow wild under diverse agro-climatic situations in several islands of Indonesia. Therefore, eco-geographic survey was undertaken in north Sulawesi to locate vegetation sites likely to have one or more forage species. The information on legume genetic resources collected is presented.

PHYSIOGRAPHY AND AGRO-CLIMATE

North Sulawesi comprises of a long stretch of land mass, running parallel to the equator and lying between 121° to 126° East longitude and 0° to 2° North latitude. It has a central core of mountain ranges, varying in altitude and aspect and a coastal plain running along the long stretch of land both in the north and south. The rainfall pattern of north Sulawesi is highly influenced by the timing, duration and intensity of the north-west and south-east monsoons and the topographic and geographic features. While the whole north Sulawesi receives rain during both monsoon seasons, north-west monsoon brings more rain in the

northern coastal areas than the south-east monsoon. Similarly, in the southern coastal areas the rainfall is higher during the south-east monsoon. The north-west monsoon arrives in the northern part of north Sulawesi via the Celebes sea from the south China sea around November, the rainfall peak often falling in January (Poigar, Manado), beginning with the lowest rainfall in September and gradually increasing till January and then decreasing gradually till August-September. However, the southern coastal areas of north Sulawesi (Malibagu) receive high rainfall during the south-east monsoon season, the rainfall peak often falling in June and rainfall being lowest in November, gradually increasing from November to June.

In the valleys with a north-south direction, the rainfall is low throughout the year since these valleys are sheltered from both monsoons. In the central mountain ranges, the amount of rainfall varies according to the altitude and aspect during both monsoon seasons.

Climatic classifications should never be based on arbitrarily fixed thresholds, they should be natural (Papadokis, 1970). Furthermore, when the rainfall patterns are governed primarily by the occurrence of the monsoons with alternating dry and wet seasons and by the mountain formations which often lead to high intensity rainfall due to orographic lifting, rainfall classes (zones) should be based on the relative lengths of thc consecutive dry and wet months and on the rainfall intensity. Oldeman and Sjarifuddin (1977) felt that the amount of monthly rainfall should in turn be related to the plant-water requirement and recognised 18 agroclimatic zones in north Sulawesi, based on the consecutive wet (Wm) dry (Dm) months, being (i) A–1 (> 9 Wet (W) and <2 dry (D) months (m), (ii) B–1 (7–9 Wm and <2 Dm), (iii) C–1 (5–6 Wm and < 2 Dm), (iv) C–2 (5–6 Wm and 2–4 Dm), (v) D–1 (3–4 Wm and <2 Dm), (vi) D–2 (3–4 Wm and 2–4 Dm), (vii) E–1 (<3 Wm and <2 Dm) and (viii) E–2 (<3 Wm and 2–4 Dm). They used these criteria with 'consecutive' meaning the inclusion of not more than one month with 100–200 mm rainfall.

Rich variation occurs in the amount, distribution and timing of rainfall between the northern, central (mountain area) and southern (coastal) parts of north Sulawesi (Fig. 1). Therefore, eco-geographic survey and forage collection work should be taken along a travel route, covering different agro-climatic zones.

The major crops grown in north Sulawesi, in decreasing order are : bunded rice, corn, cassava, upland rice, sweet potato, peanut and soybean. Estate crops, especially coconut and cloves, are also dominant. Often corn and upland rice are inter-cropped with coconut.

GERMPLASM COLLECTION

Collections were made from 89 sites. The non-availability of the roads was the major limiting factor due to which western part of north Sulawesi could not be covered. However, it was possible to move across from north to south through the

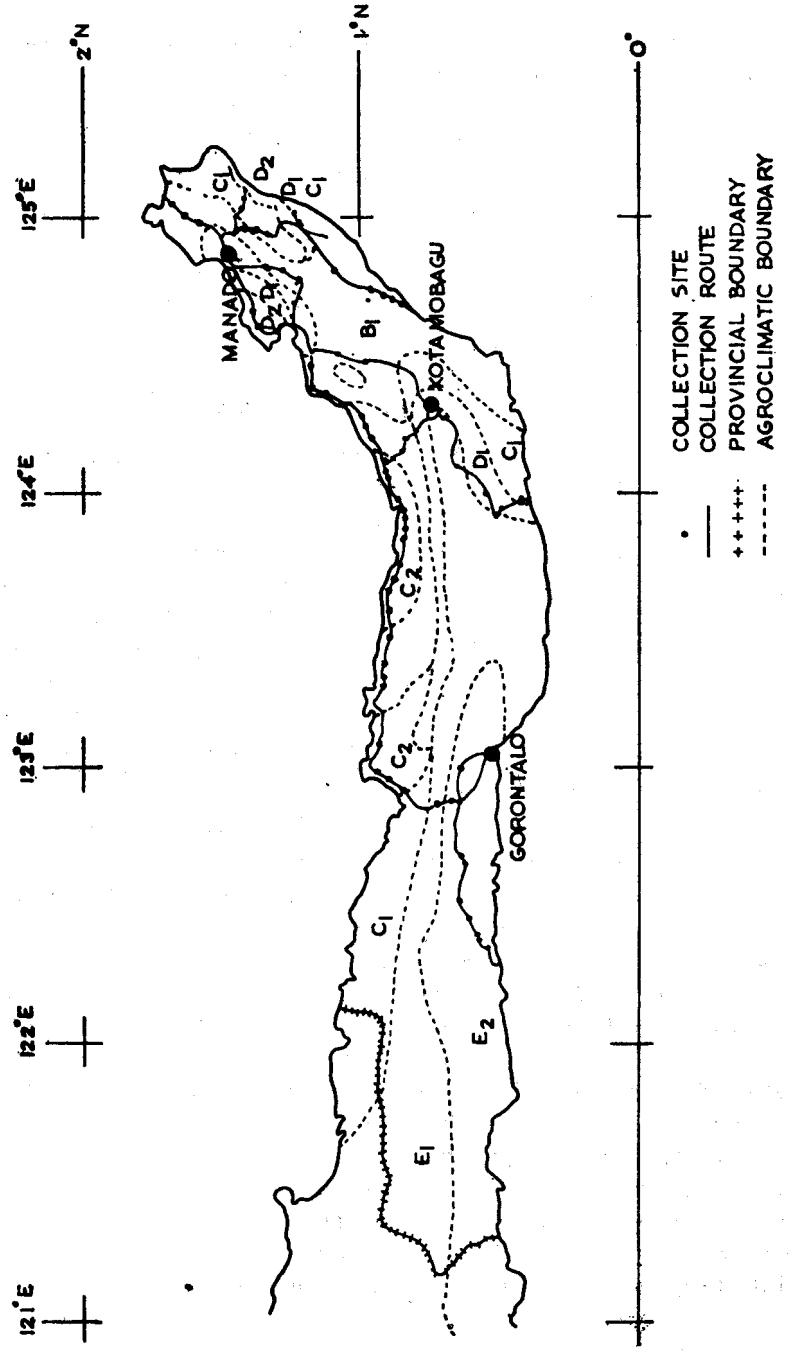
2°N
1°N
0°
125°E
124°E
123°E
122°E
121°E
MANADO
KOTA MOBAGU
GORONTALO
C1
D2
D1
C1
B1
C2
C2
D1
C1
C1
E2
E1
COLLECTION SITE
COLLECTION ROUTE
PROVINCIAL BOUNDARY
AGROCLIMATIC BOUNDARY

Fig. 1

mountain area along two routes. The dots on the collection route denote collection sites located at different altitudes and rainfall zones.

The objective of the collection mission was to conduct an eco-geographic survey and collection of forage legumes. The sites were selected at every 15–20 km based on the availability of the target species in the nearby forests and other areas, preferrably with some fallow land/abandoned land/edges of agricultural fields/coconut orchards/teak plantations, grasslands/grassy fields, roadside/roadside ridges, and protected/disturbed areas. The sampling sites were also selected in different edaphic and climatic zones so as to sample both geographic and micro-geographic components of variation, Population samples were taken and passport data recorded. The ripe seeds were collected from 25–50 plants. Herbarium specimens were prepared for all samples collected.

OBSERVATIONS AND CONCLUSIONS

During 15 days (5–19 October, 1985), 168 collections of 11 legume genera were made (Table 1) from 89 sites differing in one or more eco-geographic descriptors viz., altitude (0–700 m), longitude (122.20°E–125.06°E), latitude (0.21°N–1.40°N), rainfall zone (B–E), pH (4.5–8.5), soil type (silty, silty loam, loam, clay loam and clay), associated vegetation and geographic location. The collected samples (seeds) were deposited with CSIRO, Australia, CIAT, Colombia, Indonesian–Australian Animal Husbandry Programme, Ciawi, Indonesia and Lembaga Biologi Nasional, Bogor, Indonesia. The herbarium materials were deposited with Herbarium Bogoriensis along with the passport/site data. A set of material of interest to ICRISAT, India, was duplicated there. The passport data were sent to all receivers of collections.

Table 1 shows that population size of individual species was rare to abundant at specific sites. *Calopogonium mucunoides*, *Centrosema pubescens* and *Flemingia* sp. were frequent or abundant when present. Data were also recorded on the population frequencies of individual species along the entire collection route. *Aeschynomene americana*, *Alysicarpus* sp., *Calopogonium mucunoides*, *Desmodium heterocarpon*, *D. heterophyllum* and *Flemingia* sp. had localised distribution. *Centrosema pubescens*, *Desmodium gangeticum*, *D. laxiflorum* and *D. styracifolium* were distributed widely in entire north Sulawesi. *Pseudarthria viscida*, *Pueraria phaseoloides* and *Uraria lagopodoides* had localised distribution in north-south and south-eastern coastal areas. Table 2 shows that maximum number of species were collected from forest margins, while a few species were collected from agricultural fields/ricebunds. Several species occurred in more than one habitat. At individual sites, often more than one species occurred and such associated species are listed in Table 3. The field impressions based on eco-geographic survey of the target area and the actual sites for major components are given below :

1. *Aeschynomene americana* was distributed along Monado-Kotamobagu and Gorontalo-Talimuta route. This species has not naturalised in north Sulawesi

TABLE 1. LIST OF LEGUMES COLLECTED IN NORTH SULAWESI

Species	1	Range 2	3	4	5	6
Aeschynomene americana	5	5.0–7.0	120–660	B–E	1–6	1–4
Alysicarpus sp.	7	5.0–8.0	10–120	C–D	1–6	1–4
Calopogonium mucunoides	8	6.0–8.0	70–340	C–E	1–5	3–4
Centrosema pubescens	13	5.0–8.0	0–660	B–E	1–6	3–4
Desmodium gangeticum	46	5.0–8.5	10–650	B–E	1–3	1–4
D. heterocarpon	4	7.5–8.0	10–150	C–E	1–6	2–4
D. heterophyllum	6	5.0–7.0	20–640	B–E	1–6	2–4
D. laxiflorum	8	5.5–7.5	10–380	C–D	1–3	1–4
D. styracifolium	16	5.0–8.5	0–310	B–E	1–6	2–4
Desmodium sp.	4	6.5–8.0	20–380	C–D	0–1	1–2
Flemingia sp.	2	6.5–7.5	15–20	C	6	3–4
Indigofera sp.	1	6.5	0	C	1	3
Pseudarthria viscida	13	5.5–8.5	10–340	B–E	1–6	1–4
Psophocarpus palustris	1	6.5	130	E	4	1
Pueraria phaseoloides	14	4.5–8.5	0–700	B–E	1–6	2–4
Uraria lagopodoides	19	5.5–8.5	0–150	C–E	1–6	2–4
Unidentified	1	6.5	160	C	1	1

Columns 1 to 6 denote 1. Number of collections, 2. pH 3. Altitude (m) 4. Rainfall pattern 5. Seed ripening, and 6. Frequency.

TABLE 2. HABITAT OF LEGUME SPECIES AT COLLECTION SITES IN NORTH SULAWESI

Species	1	2	3	4	5	6	7	8	9
Aeschynomene americana	X	X				X	X		
Alysicarpus sp.	X					X			
Calopogonium mucunoides	X	X	X		X	X	X	X	X
Centrosema pubescens	X	X	X	X	X	X	X	X	X
Desmodium gangeticum	X	X				X	X	X	X
D. heterocarpon				X	X	X			
D. heterophyllum		X		X		X	X		
D. laxiflorum		X				X			
D. styracifolium	X	X		X		X		X	X
Desmodium sp.						X			
Flemingia sp.						X	X		
Indigofera sp.			X						
Pseudarthria viscida	X	X			X	X		X	X
Psophocarpus palustris								X	
Pueraria phaseoloides	X	X				X	X	X	X
Uraria lagopodoides	X	X	X		X	X		X	X

Columns 1 to 9 denote 1. Roadside, 2. Roadside ridges, 3. Agricultural fields, 4. Rice fields/bunds, 5. Grasslands, 6. Forest margins, 7. Clove plantations, 8. Coconut plantations, and 9. Others.

TABLE 3. LEGUME ASSOCIATIONS AT COLLECTION SITES IN NORTH SULAWESI

Legume species	Associated with															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1. *Aeschynomene americana*				X	X	X										
2. *Alysicarpus* sp.			X	X	X	X		X			X		X			X
3. *Calopogonium mucunoides*				X	X		X	X	X	X			X		X	X
4. *Centrosema pubescens*	X	X	X		X		X		X		X		X		X	
5. *Desmodium gangeticum*	X	X	X	X		X		X	X	X	X		X		X	X
6. *D. heterocarpon*		X			X			X	X							X
7. *D. heterophyllum*	X		X	X					X	X					X	
8. *D. laxiflorum*	X	X	X		X	X							X			X
9. *D. styracifolium*			X	X	X	X	X								X	X
10. *Desmodium* sp.			X		X		X									
11. *Flemingia* sp.		X		X	X								X			X
12. *Indigofera* sp.												X				
13. *Pseudarthria viscida*	X	X	X	X	X			X			X				X	X
14. *Psophocarpus palustris*														X		
15. *Pueraria phaseoloides*	X		X	X	X	X			X				X	X		X
16. *Uraria lagopodoides*	X	X	X		X	X		X	X		X		X		X	

Columns 1 to 16 denote species listed in sequence given above under legume species.

to the extent one finds it in south-east Sulawesi but where present it is locally abundant. Collections were made from four rainfall zones and represent samples from acidic soils/high altitudes,

2. *Alysicarpus* species occurred along the coastal, low altitude region from Inobonto to Kwandang, populations being rare to abundant. Collections were made from two rainfall zones and those differed in leafiness, branching, stem thickness, seed production and total biomass production.

3. *Calopogonium mucunoides* populations occurred frequently along the coastal area between Manado-Kotamobatu, with site density being frequent or abundant. Collections differed in branching, stem thickness, leaf size, soil cover, and production of seed/foliage/bio-mass.

4. *Centrosema pubescens* was widely distributed in north Sulawesi, mostly in the coastal areas, both in the north and south, and to a limited extent in the mountain areas. Collections were made from sites differing in pH, altitude and rainfall. Furthermore, collections were made from areas where rainfall peaks occurred in January (north coastal area) and in June (south-east coastal area). Collections varied in leafiness, leaf-stem ratio, total biomass and seed production, and in plant part pigmentation.

5. *Desmodium gangeticum* was widely distributed and collections were made daily along the entire travel route from sites differing in pH, altitude, rainfall, habitats and soil types. Populations were mostly in mid-ripening stage in the south and ripe or shedding stage in the north. The population size at indi-

vidual sites varied (being rare to abundant) and these occurred in several habitats alongwith other legumes (Table 3), both in the sunny and shady areas. Collections were made from both January and June peak rainfall zones. Two distinct morpho-types were identified. One type was erect, tall, with broad leaves, medium branching, very long inflorescences, pale yellow or white flowers, high-leaf stem ratio, high biomass production and high seed production, while other type had medium tall plants, decumbent with small or medium size leaves, highly branched, purple flowers and medium or low biomass production but with medium to high seed production.

6. *Desmodium heterocarpon* has a rare distribution in north Sulawesi, being present in the coastal areas with the population density being occasional to abundant at the collection sites. The plants were at early ripening stage in the northern region, but those in the southern coastal area had completed their ripening. Four collections were made from three rainfall zones but from alkaline habitats. The populations differed in growth habit, stem thickness, leaf size, leaf-stem ratio, forage production and seed yield.

7. *Desmodium heterophyllum* has rare distribution in both northern and southern coastal areas and collections were made from four rainfall zones. The population densities at most sites were abundant and varied in growth habit, leaf colour, leaf size, rooting at nodes, hairiness on plant parts, plant spread, leaf-stem ratio, forage and seed production.

8. *Desmodium laxiflorum* was collected mostly from acidic soils and from two rainfall areas. The population densities were rare to abundant. Variation was observed among collections in seed setting, leaf-stem ratio, plant height, branching, stem thickness and total biomass production. The populations occurred mostly in the shaded areas along the forest margins. Seed setting was abundant in areas with high insect populations.

9. *Desmodium styracifolium* was widely distributed along Kotamobagu-Molibagu, Isimu-Tilamuta, Pimpi-Antingola and Kema-Kombi travel routes, falling in the northern, south-central, north-eastern and mountain areas having different intensity and time of rainfall. The collection sites varied in pH, altitude and rainfall. In the Kotamobagu–Molibagu region where rainfall peak occurs in June, the seeds had already ripened, while in the north coastal area seeds were mostly in mid-ripening stage. The populations were rated as abundant in the Molibagu region and occasional or frequent elsewhere, and these differed in the stoloniferous habit, stem thickness, plant height and spread, leaflet size, leaf-stem ratio, total green matter and seed production. This species has much potential for use as forage plant in the acidic soils.

10. *Flemingia* sp. was distributed in few local pockets along the northern coastal area. Most populations had shed seeds. The plants were frequent or abundant at specific sites.

11. *Pseudarthria viscida* was widely distributed along Lolak-Antigola (north coastal) and Kema-Kombi area (south-eastern coastal), but in other areas it

occurred rarely. Collection sites varied widely in pH, altitude, rainfall and soil type. Populations were rated as frequent in the northern coastal area and as rare to frequent in other areas. Wide variation was observed in plant height, stem thickness, branching, leaf production, leaf-stem ratio and forage production, but seed production was high in all populations. This species merits evaluation for use as a sown pasture plant.

12. *Pueraria phaseoloides* occurred frequently between Isimu-Tilamuta, Poigar-Tanuwangko, Langoan–Belang, and Kema–Kombi regions, covering four types of rainfall zones and with rainfall peaks in January or June. A few collections made from acidic soils and comparatively drier climate, are of special significance. The populations were mostly abundant under coconut plantations and those seem to have been cultivated. Those occurring along the forest margins seem wild. Collection sites varied in altitude, pH and rainfall. Wide variation in total biomass production, stoloniferous habit, leaf-stem ratio and seed production was observed among collections. Seed setting was abundant in areas with high populations of pollinating insects.

13. *Uraria lagopodoides* was widely distributed along Poigar-Kwandung area of the northern coastal and between Isimu-Tilamuta area of south-western coastal regions, the collection sites varying in pH, altitude and rainfall. The population size was occasional to abundant and those in the northern coast were mostly in early ripening stage compared to those of the southern coastal area wherein most of the plants had already shed seeds. This species has much promise for use as forage plant in low rainfall areas. Variation was observed among populations in growth habit, plant height, stem thickness, branching, leaf size, leaf-stem ratio, forage production and seed yield.

AN OVERVIEW

Since the aim of the collection mission was to collect several forage legumes, the timing was early, medium or late for one or more species in one or more areas. Collections of forage legumes viz., *Pueraria phaseoloides*, *Desmodium heterocarpon*, *D. styracifolium* and *Uraria lagopodoides* from acid soils and dry areas are of special significance. Similarly, collections of several species from two rainfall peak (January, June) zones are of interest for use in specified rainfall zones.

It is hoped that these collections of forage legumes made from sites differing in pH, altitude, rainfall type and vegetation components would provide a basis to determine the ecologically and geographically related intra-specific genetic variability when these collections are eventually grown and evaluated in uniform environment. It is also hoped that some of these collections would be of use as straight introductions or as parents in the hybridisation programmes. The passport data of all collections supplied to CSIRO, Australia, have been deposited in CSIRO data base at Brisbane and information dealing with the collections from

specific latitude, longitude, altitude, rainfall type, soil type, pH level and plant characters can be obtained on request from CSIRO.

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