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Identification of some herbaceous central sulawesi naturally spread plants potentially used as forage species

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Abstract

This study aims to seek promising plant species as forage crops through; collecting, identifying, and selecting herbaceous plant from different sites in Central Sulawesi. This descriptive study was conducted as a survey at two different elevations: lowlands (0-500 m above sea level); and highlands (> 1000 m ASL.). Plant specimens were prepared in accordance with herbarium standard process. Plant species was identified by the Indonesian Institute of Sciences at Cibinong Science Center. 'Promising species' were determined based on the herbage acceptance by goats. *Fourteen species of the study results were:* 7 lowland specimens consist of 3 legumes (*Alysicarpus nummularifolius*, *Desmodium heterocarpon*, and *Teramnus labialis*), 4 grasses (*Cenchrus brownie*, *Digitaria sanguinalis*, *Ischaemum barbatum*, and *Setaria verticillata*); and 7 highland specimens consist of 1 legume (*Uraria lagopodoides*), 1 Compositae (*Erigeron sumatrensis*), and 5 grasses (*Chionachne macrophylla*, *Digitaria setigera*, *Melinis minutiflora*, *Oplismenus compositus*, and *Setaria palmifolia*). In conclusion, there are 2 most promising grass species, namely *Cenchrus brownii*, and *Chionachne macrophylla*. In spite of its absence in acceptability test, the legume *Uraria lagopodoides* may also be considered as a potentially pasture species, therefore, the latter three species are interesting for further studies.

Keywords: grass, legume, lowland, highland, herbage acceptability

Introduction

Roughages, particularly forage origin, are the major feed for ruminants. Native grasslands still play an important role in ruminant livestock production in the tropics, however availability of agricultural land, especially for animal grassland is limited, so forage availability for livestock is also scarce both quantity and quality. On the other hand, Indonesia has a diversity of plant germ-plasma, either endemic species or that long adapted and naturalized which is unclear neither the native of origin nor its use aspect of livestock. Nevertheless, there is a limited information about the plant species that is well adapted to the local environment and that can be a forage source derived from the potential local native or naturalized plant species. Those situations call for the collection and identification researches as well as evaluation of plant germ plasma, which can encourage and become the solution of the above problems. The investigations therefore become urgent as an approach step on the usage of available plant germ plasma.

This research aims to find and identify potential plant species (local or introduced) that grows and spreads naturally in several locations in Central Sulawesi, which can probably be developed to support forage tenacity and herbivores development, particularly beef cattle in Central Sulawesi, and Indonesia in general. In detail, this research aimed: (a) collecting (making herbarium), (b) identifying (up to species level), and (c) doing a simple palatability test on livestock as a selection basic tool of promising plants which is probably developed becoming a forage source plant.

The framework of thought as this research background is started from the finding of a grass, *Panicum sarmentosum* Roxb., in its origin habitat that is in plant community underbrush in Tondo village (Amar, 2003) [2], indicating that the plant is shade tolerance, and adaptive on dry land. Some writers stated that the grass is only known as a weed (Watson and Dallwitz, 1999; Clayton *et al*., 2008) [49, 11], or as a herbal plant (Oudhia, 2010) [36]. The grass of *Panicum sarmentosum* is now proved to be successfully developed and integrated into coconut plantation (Tarsono *et al.*, 2009a; Tarsono *et al*,. 2009b) [47, 46]; and planted on dry land of Tondo village at Cv. Prima BREED farm. This is an example of a success story of a plant invention for forage which originally only grows and spreads naturally in Central Sulawesi.

Inventions of other germ plasmas which are adapted to shade are clearly needed to support intensification of land use of Integrated Farming System (IFS) models. Application of landuse intentification of the IFS model does not need land addition. The application of the IFS will be urgent when the agricultural land is limited. This shrinking agricultural land is clearly indicated by world population

growth, including Indonesia, which is inversely with the productive agricultural land area. The need of agricultural products of an Indonesian is only supported by the productive land that the area is far below the average of total ratio between the land and the population. A logic conclusion is that the ratio will be smaler in conjunction to the population growth because the land will not be larger. The integrated farming is a solution in facing limitations of land and forage availability.

Based on the above explanation, we conclude that; i) efforts on findings plant germ plasm are clearly needed urgently for enrichment and development of plants of forage source, and ii) there is a possibility in inventions of several plants that are natural adapted locally in Central Sulawesi, for the sake of forage plant development. The forage plant development is a very important matter that the low forage quality in Central Sulawesi leads to the low carcass quality and flesh weight as well so farmers' income is far away from the goal.

Materials and Methods

Study Sites

This study was an exploratory survey conducted at two different elevations, are classified as: i) lowlands (0 up to 500 m above sea level); and ii) highlands (more than 1000 m ASL.) in three selected districts of Central Sulawesi, i.e. Palu City, Poso, and Morowali. This is imitating approach used by Mansouri *et al*. 2020 [34] who had defined lowland and highland sites as less than 600 m and more than 1400 m above mean sea level, respectively. In addition to the different elevations, the two classified elevations above are differ in average annual air temperatures and total rainfalls (Table 1).

Table 1: The elevations, and main climatic characteristics (average air temperature and annual rainfall) of the areas of collecting specimens

City/ Districts	Study Sites/ the areas of collecting specimens	Altitude, range (m a.s.l.)	Climate Parameters	
			Air temperatures, (ºC)	Annual rainfall (mm)
Palu City	Tondo	100 – 122	27.8 (22 – 34)	935
Morowali	Bahoea, and Kolaka	410 – 422	26.5 (26 – 28)	1,188
Poso	Tambing, Wuasa, Alitupu, and Winowanga	1,100 – 1,665	18.5 (15 – 22)	>2,500

More about the areas of collecting specimens are presented in Table 3.

Collection of specimens

The research activities were collected and identifying collected herbaceous plant species that grows naturally and spreads in some locations in Central Sulawesi.

Sample collection was done on two stratifications of altitudes in 2 locations within Central Sulawesi region, that were: lowland region (altitude 0–500 m a.s.l.) represented by Tondo Village-Palu Valley and Morowali; and highland (altitude 1000–1700 m a.s.l.) represented by Tambing Lake area, and the highland Napu valley, in Distric Poso. The two regions were chosen intentionally (*purposive sampling*) considering that the regions are places for beef cattle development.

Collected specimens are plant species that indicated have been grazed or eaten or suggested to be eaten by any animals as a prediction that to be palatable by livestocks. Locations as collecting sites were (Figure–1):

1. Lowland represented by; Bahoea at sub-district Bungku Barat, Kolaka at sub-district Mori Atas (District of Morowali), and Tondo at sub-district Mantikulore (Palu City);
2. Highland represented by; Tambing, Wuasa, and Alitupu at North Lore, and Winowanga at sub-district East Lore (District of Poso).

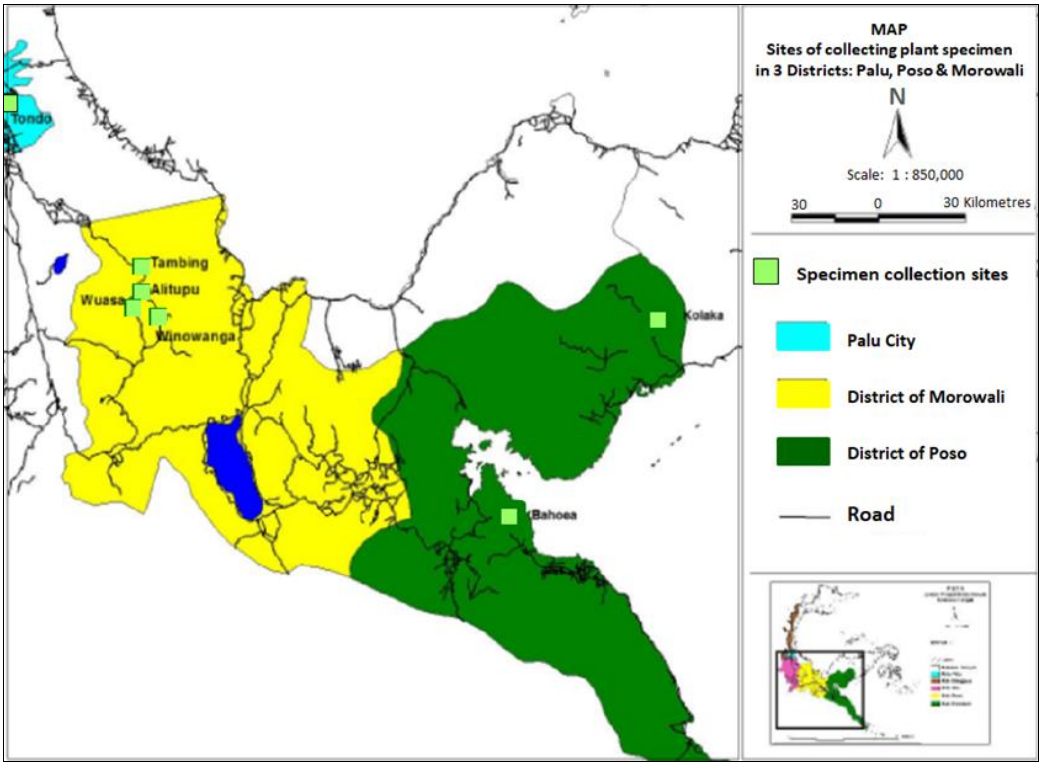

Fig 1: Locations of plant specimen collecting sites

Each of the collected plant specimens was filed in layers of folded newspapers, and bond in a wooden frame of plant press, following the standard procedure of herbarium preparation for plant identification **(**Anonymous, 2011**;** Seshagirirao, *et al*. 2016**)** [3, 40]. In the Animal Nutrition Lab of the Faculty of Animal Husbandry and Fishery, two herbarium specimens of each of the plant specimens were prepared for plant identification.

Plant identification and selection

Each specimen was made in the form of herbarium preparation equipped with field notes. Identification of plant species was done by the Centre of Biological Research, LIPI (*Lembaga Ilmu Pengetahuan Indonesia*/Indonesian Institute of Sciences), Cibinong Science Center, Jalan Raya Jakarta-Bogor, Km 46 Cibinong-16911 Indonesia. A simple acceptability test was undertaken in the Prima BREED Farm (a family farm) field in the Tondo Village for herbage of each collected plants. Finally, selection for 'new promising species' was done by qualitative discussion based on a literature review. The herbage acceptability by the local goat breed was graded by the indicators shown in the Table 2 below.

Table 2: Acceptability rating of herbage and indicators

Grade	Acceptability rating	Indicators
I	Excellent/very good	Eaten up greedily/voraciously
II	Good	Eaten most of the offered herbage
III	Fair /Satisfactory	Eaten approximately half of the offered herbage
IV	Poor	Eaten hesitately in small amount
V	Very Poor	Almost not eaten/rejected

Results and Discussion

Results of plant collection and identification

There are fourteen (14) collected plant specimens that have been identified to the species level. Botanical names (species and family) of the collected plant specimens are presented as from lowland (7 species), and from highland (7 species) sites.

Species from lowland sites

The research collected specimens from lowland are; 2 species from Morowali (representing lowland at the average altitude of 400 m a.s.l. = above sea level), and 5 specimens from Palu valley (representing lowland at the average altitude of > 100 m a.s.l.). Position of collection sites and botanical name (scientific name) of each specimen were presented in Table 3A.

Species from highland sites

There are also 7 specimens from high land, each; 5 specimens from Napu valley (representing high land at the average altitude of > 1000 m a.s.l.), and 2 specimens from location around the Lake Tambing (representing high land at the average altitude of > 1600 m a.s.l.). The information on these species is listed in Table 3B.

Herbage acceptability by local goat

Information on the herbage acceptability by the local goat breed is shown in the Table 4.

Discussion of promising new forage species

Species collected from lowland

Three legumes collected from low land sites are *Alysicarpus nummularifolius*, *Desmodium heterocarpon*, and *Teramnus labialis* (Table 3A). *Alysicarpus nummularifolius* is not indexed in Tropical Forage: an interactive selection tool, but it was mentioned as synonym of the indexed *Alysicarpus vaginalis* (L.) DC. (Cook, *et al*. 2020) [13], or *Alysicarpus vaginalis* var. nummularifolius (DC.) Kurian, *et al*. 2021; Kurian and Josekumar 2017) [31, 32].

Table 3: Botanical names of collected plant specimens from two altitude strata of locations in Central Sulawesi

No. of Specimen	Location altitude position	Species	Family
A	***Lowland***		
1	Bahoea, Bungku Barat 2º18'22"S; 121º 49'43"E; 410 meter (a.s.l.)	*Alysicarpus nummularifolius* (L.) DC.	Fabaceae
2	Kolaka, Mori Atas 1º3'39"S; 121º 6' 24" E; 422 meter (a.s.l.)	*Ischaemum barbatum* Retz.	Poaceae
3	Tondo, Palu 0º50'8"S; 119º53'37"E; 100 meter (a.s.l.)	*Teramnus labialis* (L.f.) Spreng.	Fabaceae
4	Tondo, Palu 1º3'39"S; 121º6'24"E; 122 meter (a.s.l.)	*Setaria verticillata* (L.) P. Beauv.	Poaceae
5	Tondo, Palu 1º3'39"S; 121º6 24"E; 122 meter (a.s.l.)	*Cenchrus brownii* Roem. & Schult.	Poaceae
6	Tondo, Palu 1º3'39"S; 121º6'24"E; 122 meter (a.s.l.)	*Digitaria sanguinalis* (L.) Scop.	Poaceae
7	Tondo, Palu 0º50'37"S; 119º54'36" E; 118 meter (a.s.l.)	*Desmodium heterocarpon* DC.	Fabaceae
B	***Highland***		
8	Tambing 0,1º19'24"S; 120º18'28"E; 1665 meter (a.s.l.).	*Melinis minutiflora* P. Beauv.	Poaceae
9	Tambing 0,1º19'24"S; 120º18'28"E; 1665 meter (a.s.l.)	*Setaria palmifolia* (J. Koenig) Stapf.	Poaceae
10	Wuasa 1º25'30"S; 120º19'42"E; 1105 meter (a.s.l.)	*Oplismenus compositus* (L.) Beauv.	Poaceae
11	Alitupu 1º25'25"S; 120º20'6"E; 1100 meter (a.s.l.)	*Digitaria setigera* Roth.	Poaceae
12	Wuasa 1º25'27"S; 120º19'58"E; 1104 meter (a.s.l.)	*Erigeron sumatrensis* Retz.	Compositae, or Asteraceae
13	Alitupu 1º25'27"S; 120º21'34"E; 1129 meter (a.s.l.)	*Chionachne macrophylla* (Benth.) Clayton	Poaceae
14	Winowanga 1º31'11"S; 120º24'2"E; 1120 meter (a.s.l.)	*Uraria lagopodoides* (L.) DC.	Fabaceae

Refer to many scientific publications, *A. vaginalis* is a well known forage legume (Skerman, *et al*. 1988; Hall and Walker, 2005; Bécquer, *et al*. 2016; Suarna, *et al.* 2019; Jelantik, *et al*. 2021) [41, 21, 4, 43, 26]. Palatability suggestion is not available from acceptability test on this species due to low above ground biomass found in the field, therefore,

there was insufficient harvested herbage sampel. It is not surprising as the nature of this small erect or spreading, procumbent legume (Cook, *et al*. 2020) [13] that grows in a wild uncontrolled environment. The second, *Desmodium heterocarpon* is also well know as a forage legume (see for instances Skerman, *et al*. 1988; Delamuta, *et al*. 2015; Salazar, *et al*. 2020; Joshi, *et al*. 2023) [41, 17, 39, 27], and it is listed in Tropical Forage index (Cook, *et al*. 2020) [13] as D. heterocarpon subsp. heterocarpon and D. heterocarpon subsp. ovalifolium. In this study, *D. heterocarpon* has suggested a good acceptability rate by goat (Table 4). The third legume, *Teramnus labialis* has also shown a good acceptability rate (Table 4), though has only marked as fairly palatable (Ouachinou, *et al*. 2018) [35], and it is listed by Cook, *et al*. (2020) [13]. This legume is already widely use as forage (Borroto, *et al*. 2007; Dayami, *et al*. 2013; Ouachinou, *et al*. 2018; Acosta, *et al*. 2021) [7, 15, 35, 1]. These three legumes have widely known and used as forage species.

Table 4: Herbage acceptance rates by local goat breed

No. of Specimen	Species	Acceptability rate
1	*Alysicarpus nummularifolius* (L.) DC.	n.a.
2	*Ischaemum barbatum* Retz.	Fair/satisfactory
3	*Teramnus labialis* (L.f.) Spreng.	Good
4	*Setaria verticillata* (L.) P. Beauv.	n.a.
5	*Cenchrus brownii* Roem. & Schult.	Good
6	*Digitaria sanguinalis* (L.) Scop.	Fair/satisfactory
7	*Desmodium heterocarpon* DC.	Good
8	*Melinis minutiflora* P. Beauv.	Poor
9	*Setaria palmifolia* (J. Koenig) Stapf.	n.a.
10	*Oplismenus compositus* (L.) Beauv.	Poor
11	*Digitaria setigera* Roth.	Poor
12	*Erigeron sumatrensis* Retz.	n.a.
13	*Chionachne macrophylla* (Benth.) Clayton	Excellent (Very good)
14	*Uraria lagopodoides* (L.) DC.	n.a.

The four grasses collected from lowland are *Cenchrus brownie, Digitaria sanguinalis, Ischaemum barbatum* and *Setaria verticillata*. *Cenchrus brownie* has shown a good palatability (Table 4), it is however not listed by Cook, *et al*. (2020) [13]. *C. brownie* has not been published as forage, but weed (Ghanizadeh and Harrington, 2019) [18], and Hambuckers, *et al*. (2021) [22] found that *C. brownie* is one among important seed producer plants as feed sources for an endemic endangered bird of the Andes in Bolivia. This suggested that this species provides edible biomass for anaimal. *C. brownie* has shown a good palatability in this reported study (Table 4). Secondly, *Digitaria sanguinalis* has only shown fair acceptability (Table 4) and is not listed by Cook, *et al*. (2020) [13]. However, *D. sanguinalis* has been known and used as a forage or pasture grass (Coffey, *et al*. 2005; Dillard, *et al*. 2018; Packialakshmi, *et al*. 2022) [12, 16, 37]. The third, *Ischaemum barbatum* is not listed in Tropical Forage index, neither considered as synonym to *I. ciliare* nor *I. timorense* (Cook, *et al*. 2020) [13]. Table 4 shows that herbage of this grass has fairly accepted by local goat. It is also hardly found publications on this species that suggested forage usage. The fourth, *Setaria verticillata* is neither listed in Tropical Forage index, nor indicated as synonym of any indexed Setaria by Cook, *et al*. (2020) [13]. Eventhough, *S. verticillata* has been known as *forage species* (Teka, *et al*. 2012; Brown and Ng'ambi, 2017; Harun, *et al*. 2022) [48, 8, 24].

It is concluded that none of the legumes above can be suggested as a new promising species. Fortunately, *C. brownie* is valuable to be considered as a potential grass species for uses as forage, and therefore need to be deeply studied.

Species collected from highland

Uraria lagopodoides was the only legume collected from highland site (Table 3B), though Suhadi, *et al*. (2018) [44] found this species in the lowland of Baluran National Park of between 5-20 meter altitudes above sea level. *U. lagopodoides* have been using as a traditional medicinal plant in Bangladesh, India, Africa and other countries (Ramaiah, *et al*. 2019) [38]. Kumar and Nuthakki (2014) [30] have confirmed the antidiarrhoeal properties of ethanolic extract of *U. lagopoides* which useful in the treatment of diarrhea. It is hardly found publication on *U. lagopoides* as forage or pasture species, but Khan, *et al.* (2023) [28] have suggested that it is one of the wild food plant among Pathans, Kohistanis, and Gujjars living in the highlands of the Hindukush, North Pakistan, and among highland pastoral societies in other parts of the Hindukush region. The latter publication may indicate the possible use of *U. lagopoides* as forage, but more indicators are hardly found, and unfortunately this study failed to show evident of acceptalility to goat (Table 4).

Other collected specimens (Table 3B) are: one from Family Asteraceae (*Erigeron sumatrensis*), and five grass species (*Chionachne macrophylla*, *Digitaria setigera*, *Melinis minutiflora*, *Oplismenus compositus*, and *Setaria palmifolia*). *Erigeron sumatrensis* was reported as a vicious invasion plant (Yang, *et al.* 2022) [50], and it was not included in the acceptability test (Table 4). While, the herbage of the *Chionachne macrophylla* grass has shown an excellent acceptability rate by goat (Table 4). This species has been listed in Plant Resources of South-East Asia (Lemmens and Bunyapraphatsara, 2003) [33]. It has hardly found in the publication as recognition for forage or pasture usages, but Jannink and Veeldkamp (2002) [25] has mentioned that *C. macrophylla* produces herbage of good, soft fodder of sufficient nutritive quality. Therefore, this grass is noticed as a valuable species to be popularized in uses for livestock, with necessitate further detail studies as the consequences. Secondly, *Digitaria setigera* has indicated low palatability (Table 4), but it is already known

as a forage grass that produces herbage with reasonable quality which contains 12.22% crude protein and more than 60% total digestible nutrients (Suwignyo, *et al*. 2017) [45]. The third grass, *Melinis minutiflora* is a well know as a pasture species (Skerman and Riveros, 1990; Cook, *et al*. 2020) [42, 13], which has surprisingly indicated low acceptability in this study (Table 4). Similarly, *Oplismenus compositus* has shown poor acceptability, although it has been known as source of animal feed, such for cattle (Bussmann, *et al*. 2011; Bireda and Yihune, 2020) [9, 5]. Gorade and Datar (2014) [19], however, listed *O. compositus* as a good fodder grass in palatability grade. Lastly, *Setaria palmifolia* has been known as a forage grass (Bora, *et al*. 1986; Gupta and Balaraman, 1988; Haque, *et al*. 2018; Khan, *et al*. 2021; Das, *et al*. 2022;) [6, 20, 23, 29, 14], but Choocharoen, *et al*. (2014) [10] suggested it has low palatability. Finally, it is highlighted that *Chionachne macrophylla* from upland sites could be suggested for more detailed studies as forage use.

Conclusions

Fourteen collected specimens have been identified to species level, consist of 7 species from lowland and 7 species from high land sites. Species from low land are: 3 legumes (*Alysicarpus nummularifolius*, *Desmodium heterocarpon*, and *Teramnus labialis*); and 4 grasses (*Cenchrus brownie*, *Digitaria sanguinalis*, *Ischaemum barbatum* and *Setaria verticillata*). Species from high land are: *Uraria lagopodoides* was the only legume; one from the Family Asteraceae (*Erigeron sumatrensis*); and five grasses (*Chionachne macrophylla*, *Digitaria setigera*, *Melinis minutiflora*, *Oplismenus compositus*, and *Setaria palmifolia*).

There are 2 most promising grass species, namely *Cenchrus brownii*, and *Chionachne macrophylla*. In spite of its absence in acceptability test, the legume *Uraria lagopodoides* however**,** may also be considered as a potentially pasture species. Therefore, there are three species might be suggested as potentially used as forage, and included for further studies.

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