Inventory and diversity of forages utilized by farmers raising goats in Halal way: The case of Region XII, Philippines

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Abstract

In small ruminant production, resource inventory is necessary. Among these, forage inventory and assessment are essential considering the fact that it is a major source of feedstuff for animals. In the Philippines, pioneering Halal goat research have been conducted in Region XII, however, forage inventory utilized in Halal goat production has not been done. This study aims to provide information on different species of plant utilized by goat raisers as forage. The study was conducted in 3 provinces of Region XII, namely North Cotabato, Sultan Kudarat and South Cotabato, and General Santos City. Four (4) municipalities/cities in each province were included in the assessment. Respondents in each area were selected based on the following criteria from the drafted Philippine National Standards for Halal goat production: a.) a believer of Islam b) with 5 to 24 breeder does; and c.) willingness of the farm owner to participate in the survey in addition to the established basic consideration for Halal goat raising. Respondents were interviewed using a semi-structured questionnaire. A total of 61 species of plants belonging to 19 families were utilized as forage by the respondents. Carabao grass (*Paspalum conjugatum* Bergius) is the most common species of forage with a relative abundance of 0.0949. This was followed by walis-walisan (*Sida acuta* Burm.*f.*) (0.0586), napier (*Pennisetum purpureum* Schum.) (0.0566), paragrass (*Brachiaria mutica* (Forssk.) Stapf.) (0.0566), ipil-ipil (*Leucaena leucocephala* (Lam.) de Wit-) (0.0545), and paragis (*Eleusine indica* (L.) Gaertn.) (0.0525). Higher diversity of forage species was recorded in Columbio, Sultan Kudarat based on the computed Simpson's Diversity (0.05322), Simpson's Index of Diversity (0.9468) and Shannon-Weiner Index (3.097). Differences in forage species diversity in all sampling sites were observed. Although all sampling sites are within one region, variability in land covers and climatic conditions can be attributed to species diversity difference.

Keywords: forage; inventory; diversity; goat; Halal

Introduction

Forages play an important role in livestock production. These are species of plants that provide food for grazing animals or plants that can be harvested for feeding for confined animals. Aside from livestock feed, forages also enhance diversity and wildlife habitat. Furthermore, they also provide soil ecosystem services (Allen et al., 2011). Forages are usually grasses or herbaceous legumes; however, some tree legumes are also utilized as forage like *Acacia* and *Leucaena* in the tropics (Muir et al., 2011). Most popular forage grasses cultivated include napier (*Pennisetum*), *Brachiaria* and *Panicum* species. Although there are similarities, species of forages grown and cultivated in any country and region varies depending on climate and livestock needs (Ghesquiere et al., 2010).

Despite being some of the most important plants globally, there has been limited research on forages compared to grains, fruits and vegetables (Capstaff & Miller, 2018). There is scarcity of information on different species of plants used as forage especially in the regional level. Grassland and rangeland utilized for goat raising comprise a large number of plant species that is potentially available as feed. The remote location of grassland and rangeland where goats are mostly reared is one of the main challenges in forage inventory (Brown & Thorpe, 2008).

Halal means "permissible" and, it is commonly being applied to as a preferred method of animal slaughter (Ibrahim 2011). The term is also used for food and products which are acceptable to individuals practicing Islam. In addition, this term is also applicable in animal rearing. Farouk et al. (2016) stated that Halal is not just the way animals are slaughtered but also includes how they are raised. In this study, the term Halal is used not as a breed but a practice of raising goats. The Philippine Halal products and services were at Php 5.52 billion or 8.73% of the country's total export in 2017. Currently, the Halal goat industry in the Philippines is still starting with minimal annual production. Pioneering Halal goat production research in the Philippines includes production protocols and quality assurance system development. In addition, basic considerations on Halal goat raising are also established. These include strategic grazing and housing system, health management and Shariah-compliant slaughtering procedures. In terms of strategic grazing, goats are only allowed to graze on clean pasture, free from anything considered unlawful with Muslim shepherd for at least 2 hours per day. Tethering and stall-feeding or full confinement are also allowed. Despite of these, resources, including forages, devoted for Halal goat production have not been assessed. Pasture areas and rangeland including species of plants utilized as forage are still undocumented. It can be noted that forage assessment is necessary because these animals are typically fed with locally available plant species which are highly variable in terms of quality and availability (PCAARRD, 2015).

This is an explorative research which aimed to gather information on species of plants utilized as forage for Halal goat production. The results of this study provide additional information on the limited number of literature on the species of plant utilized as forage. In addition, forage assessment is necessary considering the fact that Halal goat raisers are solely dependent on plants as feed for goats since there is no available Halal feed concentrate in the market.

Materials and Methods

Research design

Descriptive survey research design was used in this study to determine main challenges faced by Halal goat raisers in goat production in the three (3) provinces and one (1) city of Region XII in the Philippines.

Location of the study

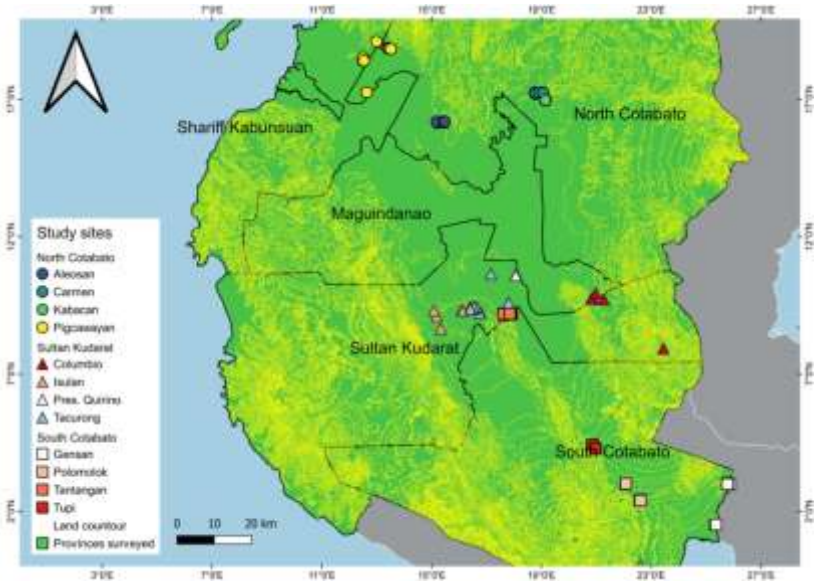
The study was conducted in selected areas of Region XII- Phillipines. Specifically, 3 provinces were considered namely North Cotabato, Sultan Kudarat and South Cotabato and 1 city- General Santos City. Four (4) municipalities in each province: North Cotabato- Pigcawayan, Aleosan, Carmen, and Kabacan; Sultan Kudarat- Columbio, Pres. Quirino, Tacurong, Isulan; South Cotabato- Tantangan, Tupi, Polomolok(Fig. 1).

Respondents and sampling procedures

Prior informed consent was sent to each municipality/city. Meetings with the Provincial Agricultural Officer, Municipal Agricultural Officers, livestock technicians and Barangay Chairpersons of the different barangays with highest concentration of goats were done to discuss the rationale of the study.

A total of 131 respondents were interviewed. Selection of respondents in each municipality was based on the following criteria from the drafted Philippine National Standards for Halal goat production: a.) a believer of Islam b) with 5 to 24 breeder does; and c.) willingness of the farm owner to participate in the survey in addition to the established basic consideration for Halal goat raising.

An on-farm assessment of resources included actual farm visitation and interview of respondents. Each respondent was interviewed on the species of plants they used as forage. Field assessment through quadrat method was also done to determine the number of individuals per species.



Data analysis

Each species was ranked based on the frequency the species was mentioned by all respondents. Species richness and relative abundance were determined and calculated, respectively. Shannon-Weiner Index, Simpson's Diversity (D) and Simpson's Index of Diversity (1-D) were used to determine the diversity of forage species in each site. Bray-Curtis Similarity Index was used to compare different sampling sites.

Results

Species of Forages

A total of 61 forage species belonging to 19 families were identified (Table 1.). Based on the results of the interview and field observation, carabao grass (*Paspalum conjugatum* Bergius c-Fig. 2a) is the most common species of forage with a relative abundance of 0.0949. This was followed by walis-walisan (*Sida acuta* Burm.*f*.-Fig. 2b) (0.0586), napier (*Pennisetum purpureum* Schum. Fig. 2c) (0.0566), paragrass (*Brachiaria mutica* (Forssk.) Stapf.-Fig. 2d) (0.0566), ipil-ipil (*Leucaena leucocephala* (Lam.) de Wit-Fig. 2e) (0.0545), and paragis (*Eleusine indica* (L.) Gaertn.- Fig. 2f) (0.0525).

Species with the least relative abundance include calliandra (*Calliandra calothyrsus* Meisn.), elepante (*Heliotropium indicum* L.), sampasampalukan (*Phyllanthus amarus* Schum. & Thonn.), physalis (*Physalis angulata* L.), Malaysian blue grass (*Setaria* sp.), anabiong (*Trema orientalis* (L.) Bl.) and kulutkulutan (*Urena lobata* L).

Diversity of forages

Table 2 shows the computed diversity indices for each sampling sites. Columbio had the highest number of species (n=27) followed by Polomolok (n=26), Pres. Quirino (n=23) and Tacurong (n=21). Areas with the least number of identified species were Tupi and Kabacan (n=8).

In terms of Simpson's Diversity (D), lower values were recorded in Columbio (0.05322), Pres. Quirino (0.06019) and Polomolok (0.06101). Higher values were recorded Tupi (0.1655), Kabacan (0.1331) and Pigcawayan (0.104). With this index, the higher value represents lower diversity and vice versa. The interpretation of Simpson's index of diversity (1-D) value is opposite with the values of Simpson's Index (D). Higher value indicates high diversity and lower value indicates low diversity. High diversity of forages based on Simpson's Index of Diversity (1-D) was recorded in Columbio (0.9468), Pres. Quirino (0.9398) and Polomolok (0.939) which confirms the result of Simpson's Index (D).

Higher value of Shannon Weiner Index (H') was recorded in Columbio with 3.097. This was followed by Polomolok (3.035) and Pres. Quirino (2.984). The least value was recorded in Tupi (1.894). Increasing values of this index indicates increasing richness and evenness, thus, increasing diversity.

Bray-Curtis distance-based analysis showed that Kabacan had unique species with similarity of 15% to all other sites (Fig. 3). A similarity of 53% was recorded between Tupi and Polomolok, and Pres. Quirino and Tangtangan. General Santos had a similarity index of 45% to Tupi and Polomolok. Between Tacurong and Pigcawayan, a similarity of 42% was recorded. Moreover, Pres. Quirino and Tantangan had a similarity index of 40% to Columbio. Species of forages in Aleosan was 37% similar with Carmen. Species recorded in Isulan was 32% similar to General Santos, Tupi and Polomolok. Isulan, General Santos, Tupi and Polomolok have species 32% similar to Pres. Quirino, Tantangan and Columbio. These areas have species 24% similar to Tacurong and Pigcawayan. Aleosan and Carmen have species 20% similar to other sampling areas except Kabacan.

Table 1. Identified species of forages utilized by Halal goat raisers in Region XII.

Species	Common Name	Family	Relative Abundance
1. Amaranthus spinosus L.	Uray	Amaranthaceae	0.0162
2. Arachis pintoi Krapov. & Greg.	Pinto peanut	Fabaceae	0.0162
3. Artocarpus heterophyllus Lam.	Langka	Moraceae	0.0283
4. Bambusa vulgaris Schard.	Bamboo	Poaceae	0.0040
5. Basella alba L.	Alugbati	Basellaceae	0.0040
6. Boerhavia erecta L.	Paanbalibis	Nyctaginaceae	0.0182
7. Brachiaria decumbens Stapf.	Signal grass	Poaceae	0.0081
8. Brachiaria mutica (Forssk.) Stapf.	Paragrass	Poaceae	**0.0566**
9. Calliandra calothyrsus Meisn.	Calliandra	Fabaceae	0.0020
10. Calopogonium mucunoides Desv.	Calopogonium	Fabaceae	0.0364
11. Chromolaena odorata (L.) King. & Rob.	Hagonoy	Asteraceae	0.0101
12. Cocos nucifera L.	Coconut	Arecaceae	0.0081
13. Commelina benghalensis L.	Commelina	Commelinaceae	0.0141
14. Corchorus olitorius L.	Saluyot	Malvaceae	0.0040
15. Cynodon plectostachyus (K.Schum.) Pilg.	Star Grass	Poaceae	0.0242
16. Cyperus rotundus L.	Mutha	Cyperaceae	0.0263
17. Dactyloctenium aegyptium (L.) Wiild.	Egyptian grass	Poaceae	0.0121
18. Desmodium cinereum (Kunth) DC	Rensonii	Fabaceae	0.0263
19. Dioscorea hispida Dennst.	Yam	Dioscoreaceae	0.0040
20. Echinochloa crus-galli (L.) P. Beauv.	Barnyard grass	Poaceae	0.0141
21. Elaeis guineensis Jacq.	African Oil Palm	Arecaceae	0.0101
22. Eleusine indica (L.) Gaertn.	Paragis	Poaceae	**0.0525**
23. Euphorbia hirta L.	Tawa tawa	Euphorbiaceae	0.0040
24. Flemingia macrophylla (Willd.) Merr.	Flemingia	Fabaceae	0.0101
25. Gliricidia sepium (Jacq.) Walp..	Kakawate	Fabaceae	0.0384
26. Gmelina arborea Roxb.	Paper Tree	Lamiaceae	0.0323
27. Heliotropium indicum L.	Elepante	Boraginaceae	0.0020
28. Imperata cylindrica (L.) Raeusch.	Cogon	Poaceae	0.0040
29. Indigofera tinctoria L.	Indigofera	Fabaceae	0.0141
30. Ipomoea aquatica Forssk.	Kangkong	Convulvulaceae	0.0081
31. Ipomoea batatas (L.) Lam.	Kamote	Convulvulaceae	0.0040
32. Ipomoea triloba L.	Morning glory	Convulvulaceae	0.0040
33. Leucaena leucocephala (Lam.) de Wit	Ipil-ipil	Fabaceae	**0.0545**
34. Mangifera indica L.	Mango	Anacardiaceae	0.0141
35. Manihot esculenta Crantz	Kamoteng-Kahoy	Euphorbiaceae	0.0040
36. Mikania micrantha Kunth	Kamkamote	Asteraceae	0.0040
37. Mimosa diplotricha Sauvalle	Sampinit	Fabaceae	0.0162
38. Mimosa pudica L.	Makahiya	Fabaceae	0.0303
39. Moringa oleifera Lam	Malunggay	Moringaceae	0.0040
40. Morus alba L.	Mulberry	Moraceae	0.0121
41. Murdannia nodiflora (L.) Brenan	Kulasi	Commelinaceae	0.0101
42. Musa paradisiaca L.	Banana	Musaceae	0.0222
43. Pennisetum purpureum x *P. glaucum*	Pakchong	Poaceae	0.0040
44. Panicum maximum Jacq.	Guinea grass	Poaceae	0.0081
45. Paspalum conjugatum P.J. Bergius	Carabao grass	Poaceae	**0.0949**
46. Pennisetum purpureum Schum	Napier	Poaceae	**0.0566**
47. Phyllanthus amarus Schum & Thonn.	Sampasampalukan	Phyllanthaceae	0.0020
48. Physalis angulata L.	Physalis	Solanaceae	0.0020
49. Pseudelephantopus spicatus (Juss. Ex Aubl.) Rohr.	Dilang baka	Asteraceae	0.0061
50. Rottboellia conchinchinensis (Lour.) Clayton	Angingay	Poaceae	0.0081
51. Saccharum spontaneum L.	Talahib	Poaceae	0.0081
52. Sandoricum koetjape (Burm.*f.*) Merr.	Santol	Meliaceae	0.0020
53. Sesbania grandiflora (L.) Pers.	Katurai	Fabaceae	0.0101
54. Setaria sp.	Malaysian Blue grass	Poaceae	0.0020
55. Sida acuta Burm.*f.*	Waliswalisan	Malvaceae	**0.0586**
56. Stylosanthes humilis Kunth	Stylo	Fabaceae	0.0061
57. Synedrella nodiflora (L.) Gaertn.	Cerbatana	Asteraceae	0.0141
58. Trema orientalis (L.)	Anabiong	Ulmaceae	0.0020
59. Trichanthera gigantea (Humb. & Bonpl.) Nees.	Madre de Agua	Acanthaceae	0.0182
60. Urena lobata L.	Kulutkulutan	Malvaceae	0.0020
61. Zea mays L.	Maize	Poaceae	0.0061

Figure 2. Common species of forages utilized by Halal goat raisers in Region XII. (a- *Paspalum conjugatum* Begius; b- *Sida acuta* Burm.*f.*; c- *Pennisetum purpureum* Schum.; d- *Brachiaria mutica* (Forssk.) Stapf.; e- *Leucaena leucocephala* (Lam.) de Wit; and f- *Eleusine indica* (l.) Gaertn.).

Table 2. Diversity Indices

Sampling Sites	n	D	1-D	H'
Columbio	27	0.05322	0.9468	3.097
Pres. Quirino	23	0.06019	0.9398	2.984
Tacurong	21	0.06167	0.9383	2.895
Isulan	18	0.07967	0.9203	2.719
General Santos	13	0.09667	0.9033	2.436
Tupi	8	0.1655	0.8345	1.894
Tangtangan	17	0.06778	0.9322	2.758
Polomolok	26	0.06101	0.939	3.035
Pigcawayan	18	0.104	0.896	2.539
Aleosan	17	0.06371	0.9363	2.799
Carmen	12	0.08876	0.9112	2.458
Kabacan	8	0.1331	0.8669	2.043

n= number of species, D=Simpson's Index, 1-D= Simpson's Index of Diversity, H'=Shannon Weiner Index

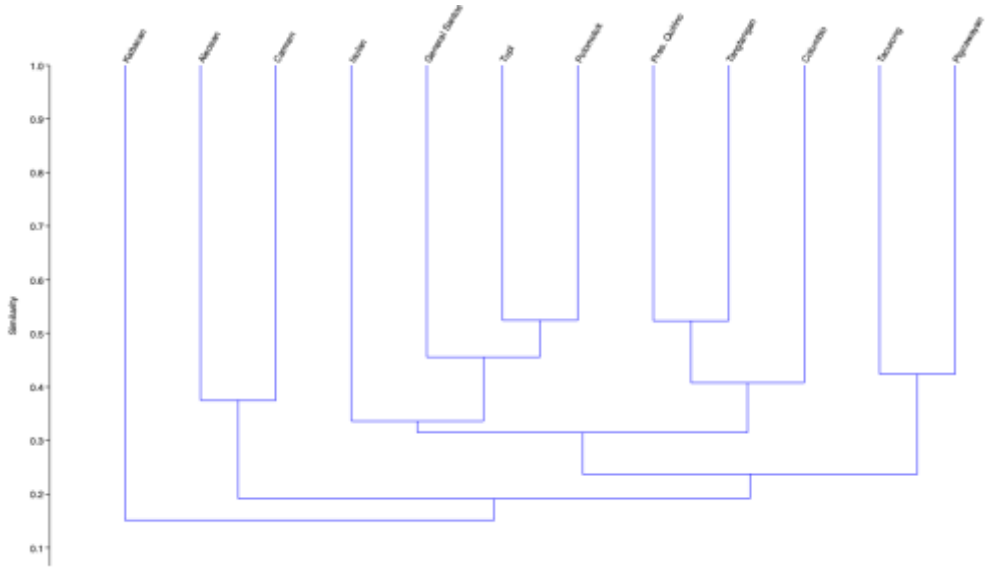


Figure 3. Bray-Curtis distance-based species similarity analysis of forages in all sampling sites

Discussion

Most common species of plant utilized as forage by Halal goat farmers in Region XII include carabao grass (*Paspalum conjugatum* Bergius), walis-walisan (*Sida acuta* Burm.*f.*), napier (*Pennisetum purpureum* Schum.), paragrass (*Brachiaria mutica* (Forssk.) Stapf.), ipil-ipil (*Leucaena leucocephala* (Lam.) de Wit) and paragis (*Eleusine indica* (L.) Gaertn.). In the study of Navarra (2019), *Paspalum conjugatum* is also commonly utilized as forage in BARMM (Bangsamoro Autonomous Region in Muslim Mindanao) together with *Brachiaria mutica, Leucaena leucocephala* and *Gliricidia sepium.* Bestil et al. (2014) stated that *P. conjugatum* has greater potential as ruminant feed, however, the quantity of forage that can be obtained from the species and its versatility to grow in marginal areas are the species' limitation when utilized as forage.

In most cases, *Brachiaria mutica, Leucaena leucocephala* and *Gliricidia sepium* are used for stall feeding while *Paspalum conjugatum* is grazed by goats in an open field. A list of feedstuffs for goat production have been established by Gerpacio and Castillo (1979) include napier grass (*Pennisetum purpureum*), paragrass (*Urochloa mutica*), star grass (*Cynodon plectostachyus*), Guinea grass (*Panicum maximum*), flemingia (*Flemingia macrophylla*), ipil-ipil (*Leucaena leucocephala*), centrosema (*Centrosema pubescens*), siratro (*Phaseolus atropurpureus*), calliandra (*Calliandra callothyrsus*), kakawate (*Gliricidia sepium*), pigeon pea (*Cajanus cajan*), mulberry (*Morus alba*) and rensonii (*Desmodium rensonii*).

It is only *Brachiaria mutica* that can adapt well in waterlogged areas among the *Brachiaria* species (Cardoso et al., 2013). Most of the sampling sites are located in low-lying areas wherein waterlogging is persistent. This provides the most plausible explanation on the abundance of this plant in sampling sites and its utilization as forage. The species can either be grazed or used in cut-and-carry system. In other areas, *B. mutica* can be made into hay or silage. Aside from forage, it can also be used to control erosion on river banks and steep slopes (Cook et al., 2005; Lansdown et al., 2013).

Napier is one of the improved and domesticated species of forage for livestock production. In commercial production, cultivation of napier throughout the year is possible under irrigated conditions. Napier is also known to have high protein content compared to other grasses and abundant moisture. These two characteristics are the reason for utilizing napier as an important feedstuff for dairy goats. Furthermore, excess supply of napier can be conserved primarily as silage (FFTC, 1998).

Leucaena leucocephala, together with *Gliricidia sepium*, are considered multipurpose forages. It is essential for farmers to select these species that can be used in several ways. These are not only protein-rich forages for ruminants but has other significant uses in the farm including fuel wood, fence, live post, shade, and wind breaks. Propagation of these species is easier, through stem cutting, and planting materials are readily available (Mangesho et al., 2017). In addition, *L. leucocephala* is also known to be well-adapted in different environmental conditions in the tropics. This species can maintain green leaf and remain productive throughout a long dry season (Dubeux et al., 2017).

Sida acuta has successfully invaded tropical regions as a contaminant in pasture seed. The tolerance of the species in a wide range of growing conditions enabled this plant to become established in pasture areas and rangelands. This species provides forage for herbivores within its geographical distribution (Williams & Baxley, 2006). Serra et al. (1997) observed that the species had relatively high mineral content in pastures grazed by

goats in the Philippines. Although it apparently exhibits some long-term toxicity (Furlan et al., 2008), cattle were observed to graze *S. acuta* to a limited extent (Egunjiobi, 1969).

According to Ecocrop (2019), *Eleusine indica* can be used as forage. It is palatable to livestock especially when young. However, it becomes tough at later stages of maturity. It can also be conserved into coarse hay or silage. *Eleusine indica* can also be used to treat fever in ruminants based on the observation of Pattanayak et al. (2017). This species is widely distributed in the tropical and subtropical regions and commonly found in disturbed lands, waste places, roadsides, open banks and in damp marshlands (Swarbrick et al., 1997). It is actually considered as weed especially in crop fields (Henty & Pritchard, 1975).

Based on the results, Halal goat farmers in Columbio utilized higher number of forage species. Diversity of forages is essential to expand options for use in smallholder goat farming to alleviate constraints like inadequate pasture. Most of the goat raisers in Columbio have wide rangelands in flat plains. It has been shown that grassland and/or rangeland exhibit various species of grasses and weeds (Tilman, 1993) which can be grazed by ruminants. Columbio is also bounded by hills with various backslopes. In the study of Guretzky et al. (2005), higher diversity of plant species especially weeds are observed in backslopes. The functional types of weed species may consist of annual grasses, sedges and other tree species.

Relative abundance and diversity of forage species vary not only among land covers like grasslands, woodlands, thickets, shrublands, and region but also among different climate. Forage differences, particularly grasses, can be attributed to climatic variability. Specifically, rainfall at different timescales has been noted to influence phenological vegetation parameters like germination, growth and seed production of plants (Holmgren et al., 2006). Although all sampling sites are within the same region, variability in climatic conditions can be also observed which affect differences in forage diversity.

In the case of Polomolok, goat raisers utilized available plant species within spaces of crop plantations. Goats are allowed in the crop plantation and consume weeds without damaging the crops. These weeds grow together with planted crops like oil palm and papaya. Perennial crop plantations also house different species of plants that can be utilized as feed for livestock (Speedy & Pugliese, 1992). Grazing animals reduce or eliminate the need for weed control wherein undesirable plants and weeds become forage for animal production. Biological weed control using animals offers a much better and cheaper alternative for herbicides (Tajjudin & Chong, 1991). Studies and observations made on animals grazing perennial crops have shown to increased yields of main crop (Iñiguez & Sanchez, 1991; Chen et al., 1991).

Conclusion A considerable number of plant species are utilized as forage by Halal goat raisers. Some are considered weeds and others are cultivated species. The result of the study implies that a wide range of plant species can be used as forage for small ruminant production. Other species have the potential to be propagated and cultivated as feed for goats. Diversity of forages can be affected by the presence of land covers and climatic conditions. Differences of forage diversity in all sampling sites can be attributed to these factors.

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