BUKTI KORESPONDENSI

ARTIKEL JURNAL INTERNASIONAL BEREPUTASI

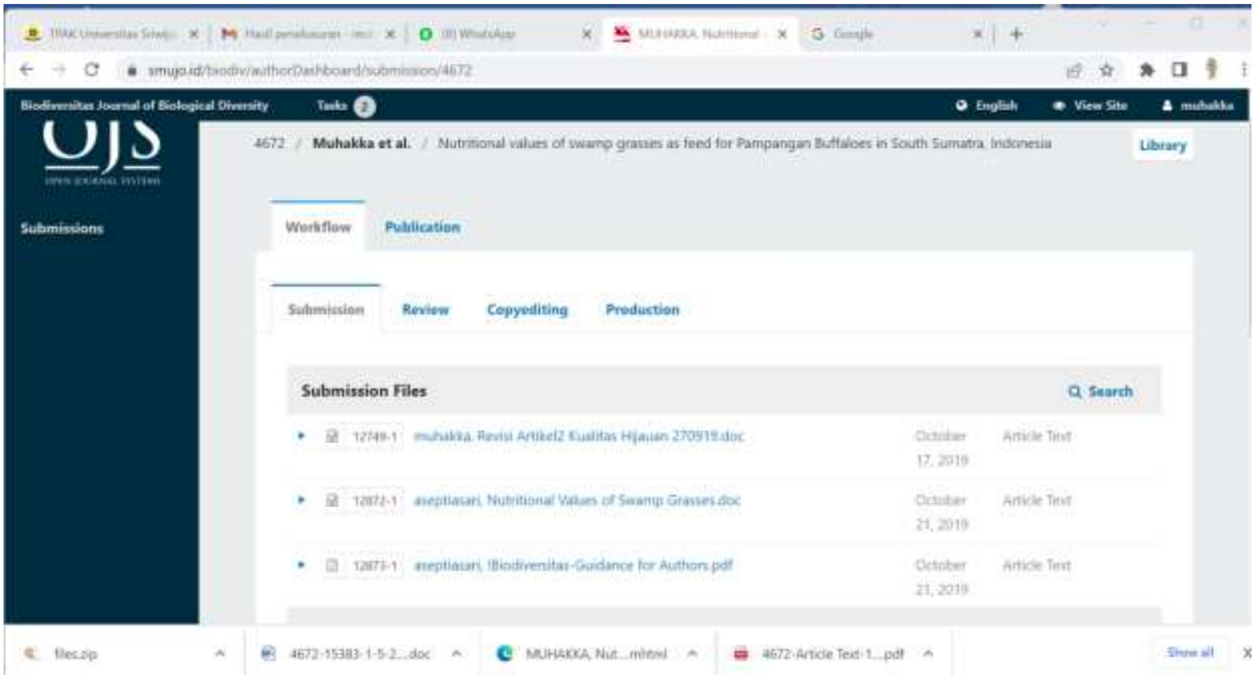
Judul Artikel : Nutritional values of swamp grasses as feed for Pampangan Buffaloes in South Sumatra, Indonesia.

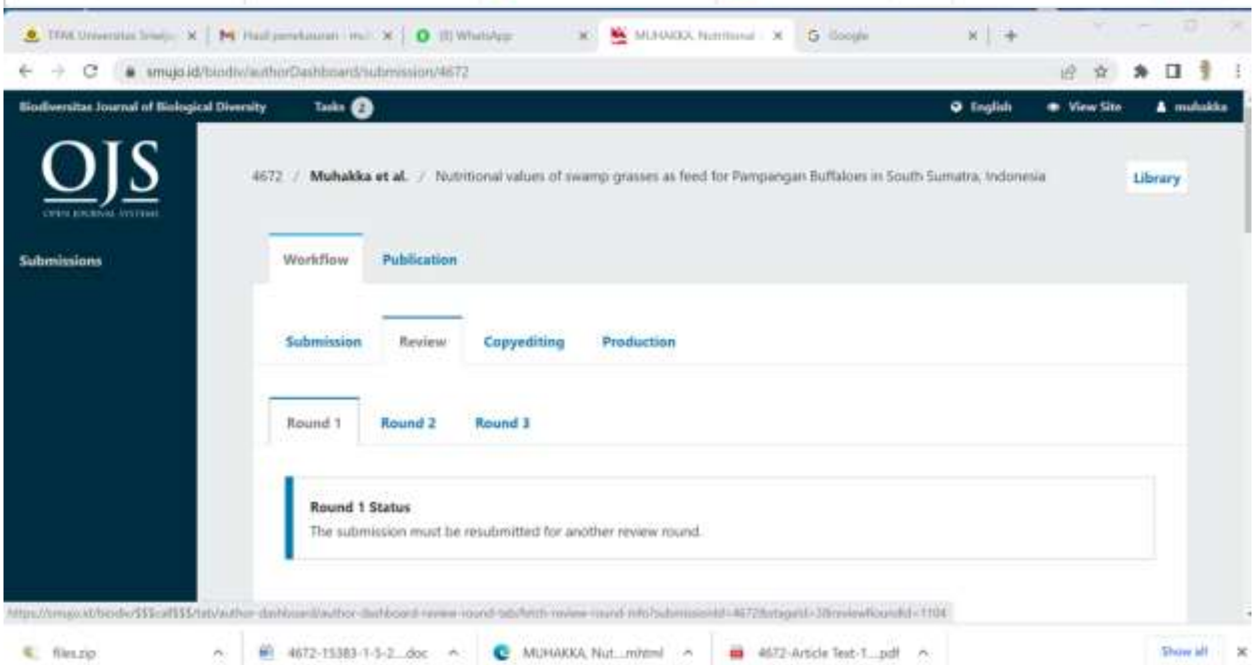
Jurnal : Biodiversitas, 2020 Volume 21 (3): 953-961

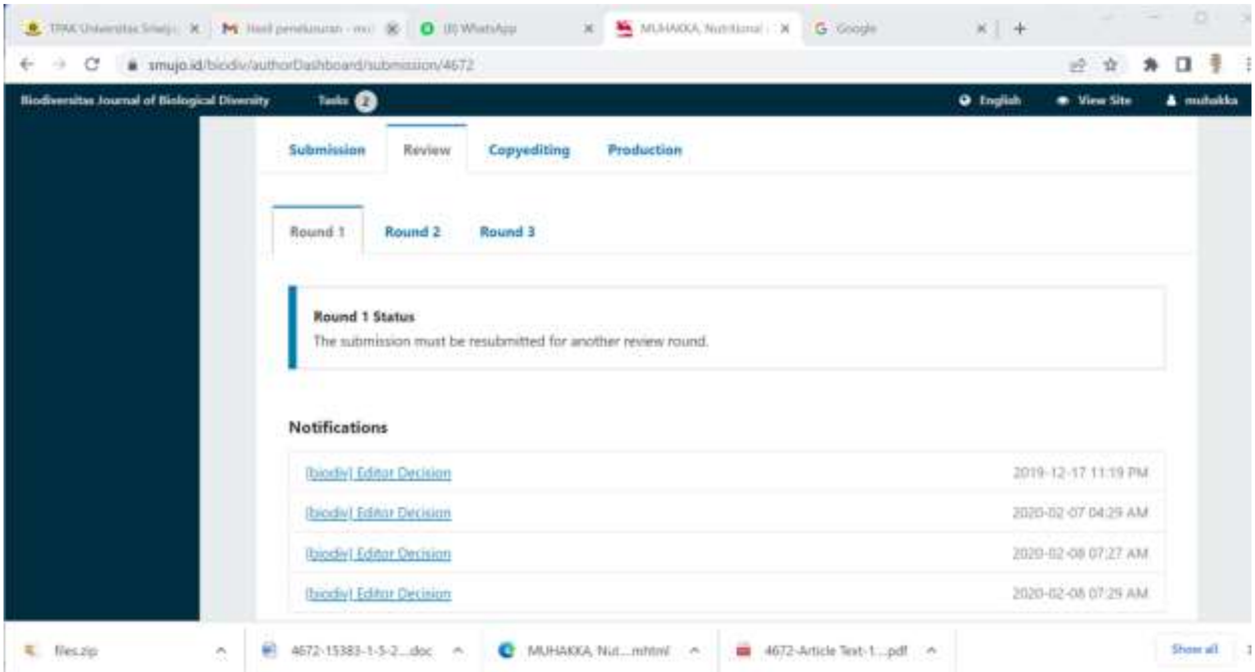
Penulis :

No.	Perihal	Tanggal
1.	Bukti konfirmasi submit artikel dan artikel yang disubmit	17 Oktober 2019
2.	Bukti konfirmasi review dan hasil review pertama	17 Desember 2019
3.	Bukti konfirmasi submit revisi pertama, respon kepada reviewer, dan artikel yang diresubmit	23 Desember 2019
4.	Bukti konfirmasi review dan hasil review kedua	7 Februari 2020
5.	Bukti konfirmasi submit revisi kedua, respon kepada reviewer, dan artikel yang diresubmit	8 Februari 2020
6.	Bukti konfirmasi submit revisi ketiga, respon kepada reviewer, dan artikel yang diresubmit	8 Februari 2020
7.	Bukti konfirmasi artikel accepted	8 Februari 2020
8.	Bukti konfirmasi artikel published online	1 Maret 2020

1.Bukti Konfirmasi Submit Artikel dan Artikel yang Disubmit (17 Oktober 2019)


smujo.id/biodiv/authorDashboard/submission/4672
Biodiversitas Journal of Biological Diversity
Tasks 2
English
View Site
muhakka
OJS
Submissions
4672 / Muhakka et al. / Nutritional values of swamp grasses as feed for Pampangan Buffaloes in South Sumatra, Indonesia
Library
Workflow
Publication
Submission
Review
Copyediting
Production
Submission Files
Search
12749-1 muhakka, Revisi Artikel2 Kualitas Hijauan 270919.doc
October 17, 2019
Article Text
12872-1 aseptiasari, Nutritional Values of Swamp Grasses.doc
October 21, 2019
Article Text
12873-1 aseptiasari, !Biodiversitas-Guidance for Authors.pdf
October 21, 2019
Article Text
files.zip
4672-15383-1-5-2....doc
MUHAKKA, Nut....mhtml
4672-Article Text-1....pdf
Show all


smujo.id/biodiv/authorDashboard/submission/4672
Biodiversitas Journal of Biological Diversity
Tasks 2
English
View Site
muhakka
OJS
Submissions
4672 / Muhakka et al. / Nutritional values of swamp grasses as feed for Pampangan Buffaloes in South Sumatra, Indonesia
Library
Workflow
Publication
Submission
Review
Copyediting
Production
Round 1
Round 2
Round 3
Round 1 Status
The submission must be resubmitted for another review round.
files.zip
4672-15383-1-5-2....doc
MUHAKKA, Nut....mhtml
4672-Article Text-1....pdf
Show all


smujo.id/biodiv/authorDashboard/submission/4672
Biodiversitas Journal of Biological Diversity
Tasks 2
English
View Site
muhakka
Submission
Review
Copyediting
Production
Round 1
Round 2
Round 3
Round 1 Status
The submission must be resubmitted for another review round.
Notifications
[biodiv] Editor Decision
2019-12-17 11:19 PM
[biodiv] Editor Decision
2020-02-07 04:29 AM
[biodiv] Editor Decision
2020-02-08 07:27 AM
[biodiv] Editor Decision
2020-02-08 07:29 AM
files.zip
4672-15383-1-5-2....doc
MUHAKKA, Nut....mhtml
4672-Article Text-1....pdf
Show all

COVERING LETTER

Dear **Editor-in-Chief,**

I herewith enclosed a research article,

Title:

Nutritional Values of Swamp Grasses as Feed for Pampangan Buffaloes in South Sumatera Indonesia

Author(s) name:

MUHAKKA[1,♥], RUJITO AGUS SUWIGNYO[2], DEDIK BUDIANTA[3], YAKUP[2]

Address

(Fill in your institution's name and address, your personal cellular phone and email)

[1]Department of Animal Husbandry, Faculty of Agriculture, Sriwijaya University, Jl. Palembang-Prabumulih Km. 32 Inderalaya 30662, South Sumatera, Indonesia, Tel/Fax. +62-711-581106. ♥email: muhakka@fp.unsri.ac.id
[2]Department of Agronomy, Faculty of Agriculture, Sriwijaya University, Inderalaya 30662, Indonesia
[3]Department of Soil Science, Faculty of Agriculture, Sriwijaya University, Inderalaya 30662, Indonesia

For possibility publication on the journal:

(fill in *Biodiversitas* or *Nusantara Bioscience* or *mention the others*)

Biodiversitas

Novelty:

(state your claimed novelty of the findings versus current knowledge)

Several nutrient content of swampland forage have been found for Pampangan buffalo.

Statements:

This manuscript has not been published and is not under consideration for publication to any other journal or any other type of publication (including web hosting) either by me or any of my co-authors.

Author(s) has been read and agree to the Ethical Guidelines.

List of five potential reviewers

(Fill in names of five potential reviewers **that agree to review your manuscpt** and their **email** addresses. He/she should have Scopus ID and come from different institution with the authors; and from at least three different countries)

1. Prof. Dr. Ir. Luki Abdullah, M.ScAgr (email: lukiabdullah@gmail.com)
2. Prof. Dr. Ir. I. Komang G. Wiryawan (email: kgwiryawan61@gmail.com)
3. Prof. Dr. Ir. Latief Toleng, M.Sc (email: latief.toleng@yahoo.com)
4. Dr. Ir. Yun Alwi, S.Pt., M.Sc (email: alwiyun@unja.ac.id)
5. Dr. Drs. Sarno, M.Si (email: sarno_klaten65@yahoo.co.id)

Place and date:

Palembang, October 17th, 2019

Sincerely yours,

(fill in your name, no need scanned autograph)

MUHAKKA

Nutritional Values of Swamp Grasses as Feed for Pampangan Buffaloes in South Sumatra Indonesia

MUHAKKA[1,♥], RUJITO AGUS SUWIGNYO[2], DEDIK BUDIANTA[3], YAKUP[2]

[1]Department of Animal Husbandry, Faculty of Agriculture, Sriwijaya University, Jl. Palembang-Prabumulih Km, 32 Inderalaya, Ogan Ilir 30662, South Sumatra, Indonesia, Tel/Fax. +62-711-581106. ♥email: muhakka@fp.unsri.ac.id
[2]Department of Agronomy, Faculty of Agriculture, Sriwijaya University, Jl. Palembang-Prabumulih Km, 32 Inderalaya, Ogan Ilir 30662, South Sumatra, Indonesia
[3]Department of Soil Science, Faculty of Agriculture, Sriwijaya University, Jl. Palembang-Prabumulih Km, 32 Inderalaya, Ogan Ilir 30662, South Sumatra, Indonesia

Manuscript received: 17 10 2019 (Date of abstract/manuscript submission). Revision accepted: .... 2019.

Abstract. This study was aimed at determining the types and quality of vegetations in swamp area which could be used as sources of roughage for Pampangan buffaloes in South Sumatera. In this descriptive study. Results showed that, the highest crude protein and ether extract contents, 20.56 and 2.92%, respectively were found in Kemon air *(Neptunia olerancia)*. The highest ash content of 25.19% was found in Kasuran *(Cyperus digitatus)*. The lowest fiber content (11.01%) was found in Cecengkehan *(Ludwigia hyssopifolia)* which also had the lowest content of NDF (40.64%). Hemicellulose content was found to be highest (37.14%) in Bento rayap*(Leersia hexandra)*. The lowest ADF (23.66%) and lignin (14,84%) contents were found in Telepuk gajah *(Nymphaea lotus)*. Kemon air *(Neptunia olerancia)* was found to have the lowest content (27.08%) of cellulose. It was concluded that the swamp vegetations found in this study consisted of 17 types of grasses (89.47%) and 2 types of legumes (10.53%). Kasuran *(Cyperus digitatus)* and Cecengkehan *(Ludwigia hyssopifolia)* were found to have the best nutritional values. Dominant and palatable vegetations with good nutritional values which were potential to be used as sources of roughage for *Pampangan* buffaloes were Kumpai tembaga *(Hymenachne acutigluma)*, Kumpai padi *(Oryza rupifogon)*, Kumpai minyak *(Hymenachne amplexicaulis*, Are bolong *(Polygonum barbatum)*, and Purun tikus *(Eleocharis dulcis)*.

Key words: Nutritional value, Swamp grass, Feed, Pampangan buffalo.

INTRODUCTION

The availability of roughage as the main feed for ruminant animals depends considerably on seasons. During rainy season, it is abundant and during dry season the availability of grasses and legumes is lacking. Limited supply of roughage may hamper productivity including reproductive performance of ruminant animals including buffaloes.

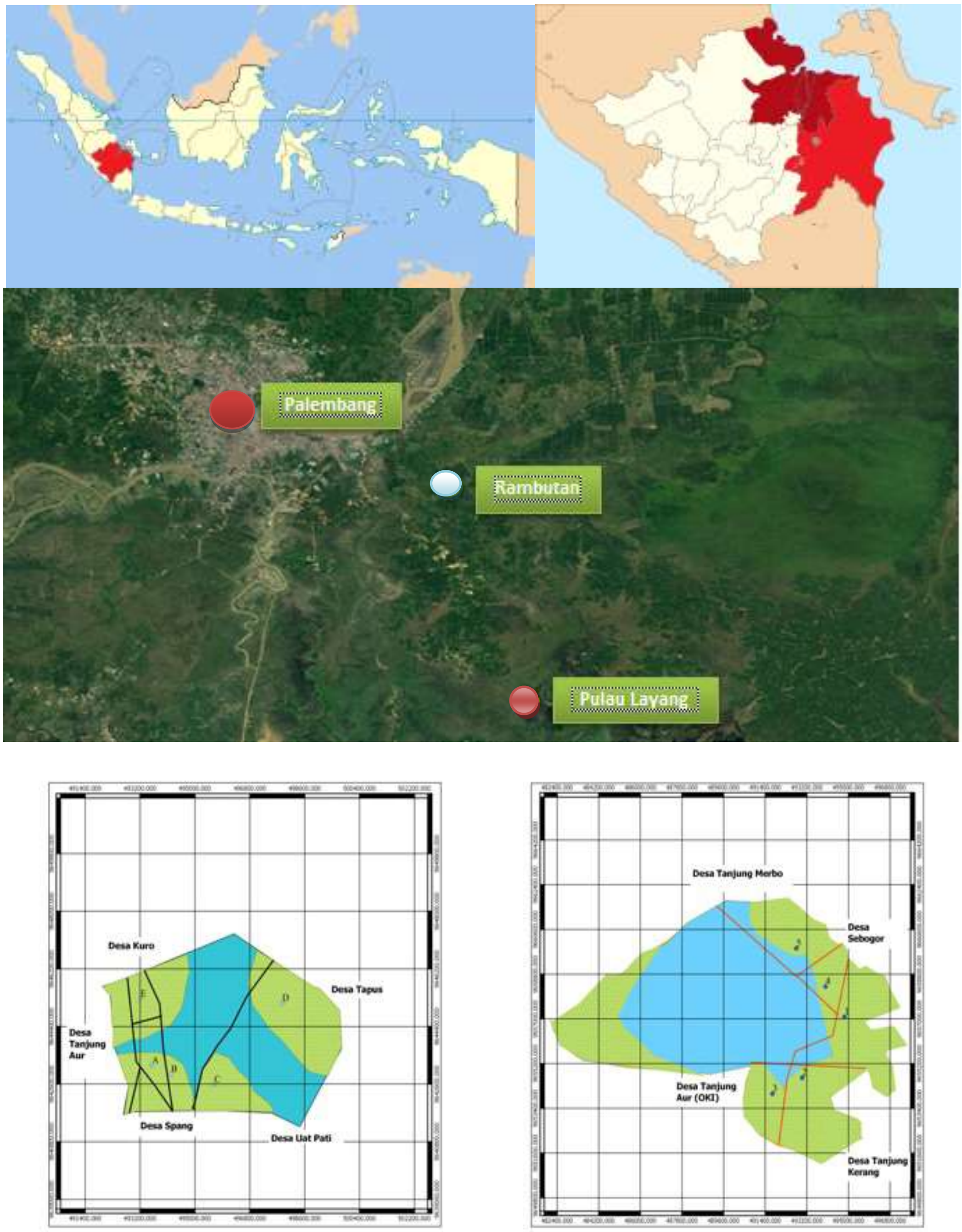
In South Sumatera Pampangan buffalo is a potential germplasm which needs to be preserved and developed. There were 37,405 heads of Pampangan buffaloes in 2016 and this population increased by 3.97% to 38,952 heads in 2017. In 2017, of this population, 11,150 heads (28.63%) and 2,227 heads (5.72%) were found in Ogan Komering Ilir Regency and Banyuasin Regency, respectively (Statistik Peternakan Sumsel, 2017). The population and productivity of *Pampangan* buffaloes need to be improved and for this purpose, feed is an important factor to consider. Pampangan buffaloes feed mostly on roughage from swamp and/or grassland to meet their maintenance and reproductive needs.

In Indonesia, there are 13.27 million hectares of lowland swamp areas. Only 4 million hectares of these areas has been developed and cultivated by the community and private sectors (2.6 million hectares) and the government assistance (1.3 million hectares) (BPS, 2010, Mulyani and Sarwani, 2013). In Sumatera, the largest lowland swamp area of 2.98 million hectares is found in South Sumatera but only 298,189 hectares of it has been utilized (BPS Sumatera Selatan, 2014). In order to utilize the potential swamp area as a feed source for Pampangan buffaloes, a study on vegetations as sources of roughage in lowland swamp areas that include vegetation identification and nutritional quality determination needs to be conducted.

In the previous study, some swamp grasses including Kumpai minyak grass (*H. amplexicaulis)* (Rostini et al., 2014**;** Muhakka et al., 2015), *I. rugosum* and *L. hexandra* (Ali et al., 2012) were identified. However, many more swamp vegetations have not been identified. This study was conducted to identify the types and nutritional values of vegetations that could be used as sources of roughage feed for Pampangan buffaloes in South Sumatera. This information was important to support the productivity improvement of Pampangan buffaloes as a germplasm in South Sumatera.

MATERIALS AND METHODS

This study was a descriptive study to assess the types and nutritional values of vegetations which were the dominant and palatable as sources of roughage feed for Pampangan buffaloes. Vegetation samples were taken from grazing areas of Pampangan buffaloes in Rambutan Village and Pulau Layang Village, South Sumatra from April to Juni 2017. Vegetation samples for nutrient analysis were obtained by following these procedures: (1) vegetation collection was done based on estimated growth age (young age, medium age, and old age based on physical appearance), (2) collected samples of each vegetation was composited, and (3) samples were chopped into small sizes, homogenized. For each vegetation, 1 kg sample was taken by random to the laboratory for oven drying at 105ºC until constant weight was obtained and dry matter content was determined. Samples were then ground for nutrient content determination by using proximate and Van Soest analyses (Syarifuddin and Wahdi, 2010).



A **B**

Figure 1. Research location in South Sumatera, Indonesia, **A.** Pulau Layang Village, Pampangan Sub-district, Ogan Komering Ilir District, South Sumatra, **B.** Rambutan Village, Rambutan Sub-district, Banyuasin District, South Sumatra (Muhakka et al., 2019)

Measured parameters

Proximate Analysis

Crude protein, fiber, ether extract, and ash contents were determined based on the procedures of AOAC (1990).

1. *Crude Protein*. Nitrogen (N) content was determined by using a Kjehdahl method. In this analysis, sulphuric acid with a catalyst and a heating process. The organic matter of samples was then oxidized by sulfuric acid and nitrogen was changed into an ammonium sulfate form. The remaining sulfuric acid was neutralized by NaOH until the solution became basic. Ammonium sulphate was then distilled in an acid medium to obtain the quantitative amount of N. As the average protein contains 16% nitrogen, a factor 100% : 16% = 6.25 was used to obtain the value of crude protein (crude protein = N% x 6.25).
2. *Fiber*. Filtered fat-free sample was used in fiber content determination. 1.25% sulfuric acid solution was added into the sample and the mixture was heated for about 30 minutes before the residue was filtered. 1,25% NaOH solution was added into the precipitate and the mixture was heated for about 30 minutes. The mixture was then filtered and the precipitate was washed, dried, and weighed. This precipitate was burnt and the ash was weighed. The difference between the weight of precipitate before it was burnt and the weight of the ass was referred to as fiber content.
3. *Ether Extract*. Dry matter sample was extracted with diethyl ether for 5 hours. In the end of the extraction process, ether evaporated and the remaining material was referred to as fat.
4. *Ash*. The third part of dry matter sample was weighed and burnt in a crucible at 550ºC for 8 hours.

Van Soest Analysis

NDF, ADF, hemicellulose, cellulose, and lignin contents were determined by using a Van Soest method (1982).

1. Neutral Detergent Fiber (NDF). *a* gram of sample was put in a beaker glass. 50 ml NDS solution was added into the beaker before the mixture was heated for an hour. The mixture was then filtered by using a vacuum pump and a filter glass which was previously weighed (*b* gram). The mixture was then washed with hot water and acetone before it was dried in an oven and let cool in a desiccator. Finally, it was weighed as *c* gram. NDF content was calculated by using the following formula:

$$\%\ NDF = \frac{c - b}{a} \times 100\%$$

2. Acid Detergent Fiber (ADF). *a* gram of sample was put in a beaker glass. 50 ml ADS solution was added into the beaker before the mixture was heated for an hour. The mixture was then filtered by using a vacuum pump and a sintered glass filter which was previously weighed (*b* gram). The mixture was then washed with hot water and acetone before it was dried in an oven and let cool in a desiccator. Finally, it was weighed as *c* gram. Cellulose content was calculated by using the following formula:

$$\%\ cellulose = \frac{c - d}{a} \times 100\%$$

4. Hemicellulose. Hemicellulose content was calculated as a difference between NDF and ADF contents as follows.

$$\%\ Hemicellulose = \%\ NDF - \%\ ADF$$

5. Lignin. Cellulose residue (*d* gram) was burnt in a furnace at 500-600ºC for 3 hours. After that, it was left to cool and weighed (*e* gram). Lignin content was calculated by using the following formula:

$$\%\ Lignin = \frac{d - e}{a} \times 100\%$$

Data Analysis

The data obtained were used directly to describe the nutritional value of the swamp vegetations that could be used as a roughage source. These data were then combined with those of *in vitro* digestibility as the basis for drawing the conclusion (Syarifuddin and Wahdi, 2010).

RESULTS AND DISCUSSION

Results

Results of soil analysis showed that soil at the study site had low fertility level and was highly acidic. It also had very high organic C and total N contents, medium level of exchangeable-K and N contents, very low Ca and Mg contents, medium P content, and very high CEC level (Table 1).

Table 1. Properties of soil at the study site

	Pulau Layang		*Rambutan*	
Parameter	**Value**	**Remark**	**Value**	**Remark**
pH H_2O (1 : 1)	5.10	Low	4.41	Very low
pH KCl (1 : 1)	4.39	Very acidic	3.99	Very acidic
Organic C (g/kg)	57.66	Very high	36.14	Very high
Total N (g/kg)	3.64	Very high	2.19	Very high
Available P/Bray I (mg/kg)	11.70	Medium	2.25	Very low
Exchangeable K (cmol/kg)	0.63	Medium	0.45	Medium
Na (cmol/kg)	0.65	Medium	0.65	Medium
Ca (cmol/kg)	1.95	Very low	0.73	Very low
Mg (cmol/kg)	0.45	Very low	0.32	Very low
CEC (cmol/kg)	65.25	Very high	43.50	Very high
Exchangeable Al (cmol/kg)	1.84		2.37	
Exchangeable H (cmol/kg)	0.74		0.88	
Texture:				
Sand (%)	47.08		46.64	
Ash (%)	31.11		27.18	
Clay (%)	21.81		26.18	

Source: Laboratory of Soil Chemistry, Biology, and Fertility, Soil Department, Faculty of Agriculture, Sriwijaya University (2017).

Nutrient Contents of Lowland Swamp

Crude protein, fiber, ether extract, and ash nutrient contents of lowland swamp vegetations found in this study are listed in (Table 2).

Table 2. Crude protein, fiber, ether extract, and ash contents (%) of lowland swamp vegetations

Latin Name	Local Name	Crude Protein	Fiber	Ether Extract	Ash
Catharanthus roseus	Tapak dara	15.20	11.18	1.29	12.53
Cyperus digitatus	Kasuran	15.31	14.76	1.42	25.19
Digitaria fuscescens	Kerak Maling/Pasiran	12.00	15.64	1.24	16.26
Eichhornia crassipes	Eceng gondok	8.61	20.66	0.84	14.22
Eleocharis dulcis [P]	Purun tikus	8.22	25.72	0.48	15.13
Eleocharis dulcis [R]	Purun tikus	6.63	24.52	1.69	10.24
Hymenachne acutigluma) [P]	Kumpai Tembaga	6.86	30.26	2.22	7.88
Hymenachne acutigluma [R]	Kumpai Tembaga	10.96	23.73	1.77	10.30
Hymenachne amplexicaulis [P]	Kumpai Minyak	9.21	21.91	2.82	13.96
Hymenachne amplexicaulis [R]	Kumpai Minyak	12.00	15.64	1.24	16.26
Hymenachne sp	Kumpai Merah	8.52	21.20	1.30	12.88
Ipomoea aquatica	Kangkung merah	8.95	14.34	2.24	10.39
Leersia hexandra	Bento rayap	5.35	27.57	2.06	5.63
Ludwigia hyssopifolia	Cecengkehan	12.07	11.01	1.66	9.09
Neptunia olerancia	Kemon air	20.56	15.03	2.92	7.31
Nymphaea lotus	Telepuk Gajah	13.22	11.45	2.84	10.30
Oryza rupifogon [P]	Kumpai Padi	7.93	23.30	1.60	16.25
Oryza rupifogon [R]	Kumpai Padi	10.41	21.59	2.49	11.92
Polygonum barbatum	Are Bolong	7.53	16.60	1.57	8.40
Rhynchospora corymbosa	Berondong	5.26	22.27	1.48	14.84
Sesbania exasperata	Mutiara	18.27	11.22	1.86	19.47

Source: Laboratory of Dairy Nutrition, Department of Nutrition and Feed Technology, IPB (2017).
Notes: [P] : Grass in Pulau Layang Village; [R] : Grass in Rambutan Village.

The NDF and ADF contents of vegetations found in this study were about 40.65–79.47% and 23.66–60.33%, respectively. Lowland swamp vegetations were found to have hemicellulose and cellulose contents ranging from 7.73 to 37.14% and 5.24 to 27.08%, respectively. Lignin contents of lowland swamp vegetations ranged from 14.84 to 43.09% (Table 3).

Table 3. Composition of fiber fractions of green vegetations in lowland swamp: NDF, ADF, Hemicellulose, Cellulose, and Lignin (%).

Latin Name	NDF	ADF	Hemicellulose	Cellulose	Lignin
Catharanthus roseus	47.79	39.67	8.12	16.96	22.71
Cyperus digitatus	58.90	36.93	21.97	5.24	31.68
Digitaria fuscescens	65.43	33.56	31.87	12.11	21.45
Eichhornia crassipes	62.77	41.83	20.94	10.22	31.60

Eleocharis dulcis [P]	69.57	49.83	19.74	21.80	28.04
Eleocharis dulcis [R]	75.73	54.91	20.82	19.71	35.20
Hymenachne acutigluma [P]	75.89	50.60	25.29	12.25	38.34
Hymenachne acutigluma [R]	64.72	46.38	18.34	16.01	30.37
Hymenachne amplexicaulis	65.31	38.92	26.39	8.29	30.63
Hymenachne sp	60.14	28.40	31.74	8.64	19.76
Ipomoea aquatica	41.40	26.17	15.23	6.32	19.85
Leersia hexandra	79.47	42.33	37.14	25.88	33.92
Ludwigia hyssopifolia	40.64	32.91	7.73	8.39	24.52
Neptunia olerancia	62.31	45.44	16.87	27.08	18.36
Nymphaea lotus	46.05	23.66	22.39	8.82	14.84
Oryza rupifogon [P]	71.13	60.33	10.80	17.23	43.09
Oryza rupifogon [R]	65.49	46.19	19.30	14.96	31.24
Polygonum barbatum	61.27	48.46	12.81	20.28	28.18
Rhynchospora corymbosa	65.29	44.64	20.65	16.08	28.56

Source: Biotechnology Assessment Laboratory, Center for Biotechnology Research, Indonesian Institute of Sciences (LIPI), Cibinong, Bogor (2017).

Notes: [P] : Grass in Pulau Layang Village; [R] : Grass in Rambutan Village.

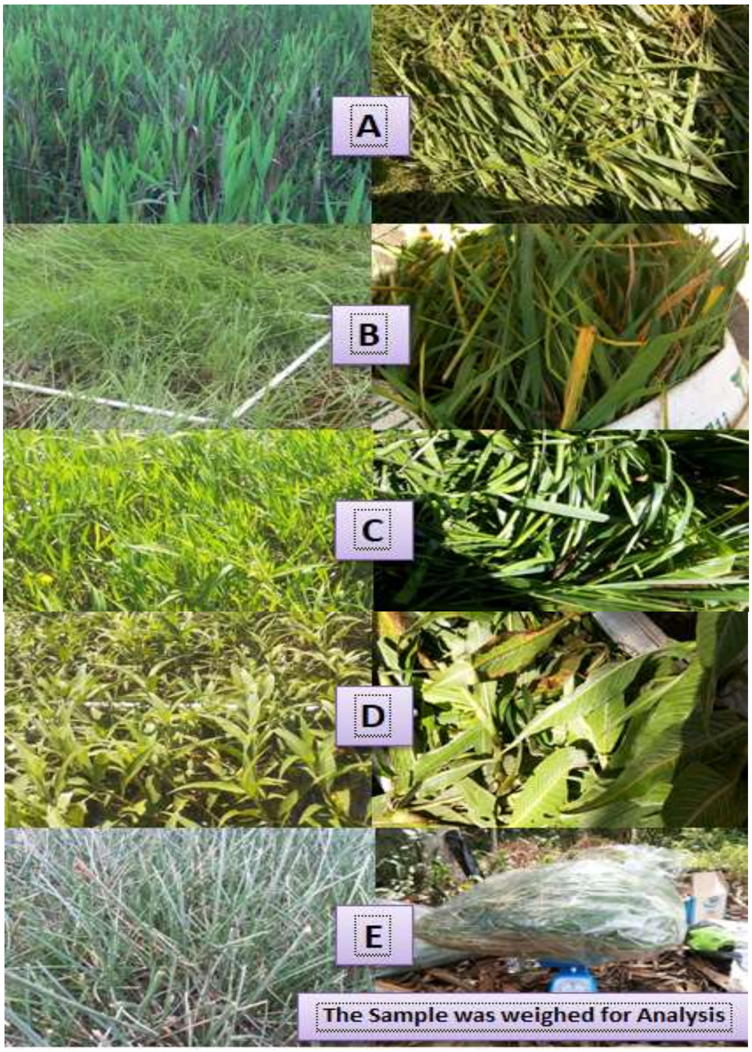


Figure 2. Dominant and palatable swamp roughages with good nutrient contents included. **A**. *Hymenachne acutigluma*, **B**. *Oryza rupifogon* **C**. *Hymenachne amplexicaulis*, **D**. *Polygonum barbatum*, and **E**. *Eleocharis dulcis*.

Discussion

Crude Protein Content

Results showed that the crude protein contents of swamp green vegetations ranged from 5.26% to 20.56% with the lowest value (5.26%) was found in Berondong grass (*R. corymbosa*) and the highest (20.56%) was found in Kemon air legume (*N. olerancia*). Kasuran grass (*C. digitatus*) had the highest crude protein content (15.31%) (Table 2). This high nutritional value of Kasuran grass was suspected as caused by the fact that most of this grass was found to grow in the area of buffalo pens where the soil was rich in organic matter. However, the growth of this grass was not dominant as it mostly occured in rainy seasons.

Kumpai minyak (*H. amplexicaulis*), Kumpai padi (*O. rupifogon*), Kumpai tembaga (*H. acutigluma*), and Purun tikus (*E. dulcis*) were found as the dominant palatable grasses containing 12.00, 10.41, 10.96, and 8.22% crude protein, respectively. Results of this study were not too different from those obtained by Rostini et al. (2014) who reported that Kumpai minyak and Pipisangan had protein contents of 10.88 and 15.92%, respectively. Crude protein (CP) contents of these swamp grasses in Pulau Layang and Rambutan Villages were closed to those of prime grasses including 9.11-12.8% CP of *elephant* grass (*P. purpureum*) (Santos et al., 2013; Dahlan and Iskandar, 2013; Rahman et al., 2014), 12.4% CP of *elephant* grass hay, 11.1% CP of *elephant* grass silage, 11.4% CP of king grass hay, and 10.2% CP of king grass silage (Santoso and Hariadi, 2008). Other vegetations even had higher CP contents including Kumpai tembaga *(H. acutigluma)* with 10.96% CP, Tapak dara (*C. roseus*) 15.20%, Telepuk gajah (*N. lotus*) 13.22%, Cecengkehan (*L. hyssopifolia*) 12.07%, Kasuran *(C. digitatus*) 15.31%, and Kumpai minyak (*H. amplexicaulis)*[R] 12.0% (Table 2). CP contents of vegetations in this study were also higher than those of nature grasses found in coffee plantation areas (6.95%) and pastoral areas (6.65%) in Wulanggitang District, East Flores Regency as reported by Kleden et al. (2015). Meanwhile, CP content of grasses in lowlands was 8.41% (Rochana et al., 2016; Maswada and Elzaawely, 2013).

This high protein content was suspected to be caused by the fact that soil organic C and total N contents in the study site were also high, namely 36.14-57.66 and 2.19-3.64 $g.kg^{-1}$, respectively (Table 1). Soil organic C and total N contents affected protein content in plants. Four swamp grasses including Kasuran (*C. digitatus*), Tapak dara (*C. roseus*), Telepuk gajah (*N. lotus*), and Cecengkehan (*L. hyssopifolia*) and a legume, Kemon air (*N. olerancia*) were found to be the lowland swamp vegetations having the highest N contents of 15.31,15.20, 13.22, 12.07, and 20.56%, respectively.

Fiber Contents

Fiber contents of lowland swamp green vegetations ranged from 11.01 to 30.26% with the lowest content found in Cecengkehan (*L. hyssopifolia*) and the highest in Kumpai tembaga *(H. acutigluma* [P]*)*. Four vegetations including *Cecengkehan* (*L. hyssopifolia*), Tapak dara (*C. roseus*), Mutiara legume (*S. exasperata*), and Telepuk gajah (*N. lotus*) were found to have the lowest fiber contents of 11.01, 11.18, 11.22, and 11.45%, respectively (Table 2). These results were almost similar to those found by Ali et al. (2012) who reported that the fiber contents of roughage in a pasture ranged from 7.20 to 34.98%. These researchers found that the fiber content of Bento rayap (*Leersia hexandra*) was 27.40% which was very close to that (27.57%) of the same vegetation in this study. Meanwhile, Rostini et al. (2014) reported that the fiber contents of swamp vegetation in South Kalimantan ranged from 14.84 to 29.35% with the lowest content found in Hadangan (*Paspalum sp*) and the highest in Dadangsit (*L. adscendens*). These figures were lower than those found by Kleden et al. (2015) who revealed that nature grasses in a coffee plantation area and a pasture in Wulanggitang, East Flores contained 34.57 and 35.59% of fiber. They also found that the lowest fiber content was found in *L. peploides* and the highest in *I. rugosum*. Fiber contents reported by Kleden et al. (2015) were higher that the results reported by Ahmed *et al*. (2013) with a fiber content of 29.32% in *D. aegyptium* plants. A previous study showed that fermented *I. rugosum*, *H. amplexicaulis*, and *O. rifipogon* had fiber contents of 29.27, 29.57, and 33.07%, respectively (Muhakka et al., 2015).

The fiber content of Eceng gondok (*E. crassipes*) in this study (20.66%) was lower than those found by Hossain et al. (2015), Tham and Uder (2015), and Make et al. (2016). In addition, the fiber content of Eceng gondok (*E. crassipes*) in this study was lower than those of *Azolla*, another water plant, ranging from 13.19 to 16.54% (Kathirvelan et al., 2015; Anitha et al., 2016) and 9.25 to 13.25% (Ahmed et al., 2016). These fiber contents of *Azolla* equalled to those of Cecengkehan (*L. hyssopifolia*) (11.01%), Tapak dara (*C. roseus*) (11.18%), Mutiara legume (*S. exasperata*) (11.22%), Telepuk gajah (*N. lotus*) 11.45%, and Kangkung merah (*I. aquatica*) (14.34%) found in this study. Fiber contents of swamp green vegetations found in this study indicated that they were potential to be used as feed for Pampangan buffaloes.

Ether extract contents

Lowland swamp vegetations in this study were found to have ether extract (EE) contents of about 0.48-2.92%. The lowest EE content was found in Purun tikus (*E. dulcis*) while the highest was found in Kemon air legume *(N. olerancia*). Four vegetations of lowland swamp including Telepuk gajah (*N. lotus*) (2.84% EE), Kumpai minyak (*H. amplexicaulis*) (2.82% EE), Kumpai padi (*O. rupifogon*) (2.49% EE), and Kangkung merah (*I. aquatica* Forsk) (2.24% EE) were revealed to have the highest ether extract contents (Table 2). Results of this study were lower than those found by Rostini et al. (2014) reporting about 0.61–3.67% of EE contents in swamp vegetations in South Kalimantan with the lowest found in Pipisangan (*L. hyssopifolia*) and the highest in Padi hiang (*O. rufigopon spotanea*). EE contents of lowland swamp vegetations were 1.40–1.91% for grasses and 1.36–2.95% for legumes (Asep et al., 2012) and those of grasses in a pasture for buffaloes in Pulau Moa were 1.95–2,41% (Eoh, 2014). In other studies, grasses in a natural pasture in North *Lore*, Poso Regency had EE contents of 2.12–2.34% (Damry, 2009) and those in Sabana Timur Barat pasture in rainy season to the end of dry season had an average EE content of 1.91% (Manu, 2013). A study by Se'u et al. (2015) revealed an EE content of 1.07% in grasses in a pasture in Timor Tengah Selatan Regency. Another work by Kleden et al. (2015) showed that vegetations in a natural pasture and a coffee plantation area had EE contents of 1.23 and 1.35%, respectively.

Vegetations found in this study had EE contents equaled to those of prime grasses including *elephant* grass (*P. purpuperum*) and *king* grass (*P. purpureophoides*) preserved in the form of hay and silage. *Elephant* grass hay and silage had EE contents of 1.9 and 2.6%, respectively while those of king grass had EE contents of 1.6 and 2.4%, respectively (Santoso and Hariadi, 2008; Ukpabi et al., 2015). EE contents of some species of ruminant roughages were found to be about 1.2–4.1% (Ahmed et al., 2013). Dominant swamp roughages including Kumpai minyak (*H. amplexicaulis*) and Kumpai padi *(O. rupifogon)* had EE contents of 2.82 and 2.49%, respectively and they were palatable and potential to be used as feed for Pampangan buffaloes.

Ash Contents

Ash contents of green vegetations in lowland swamp ranged from 5.63 to 25.19%. Four types of vegetations with the highest ash contents included Kasuran (*C. digitatus*) (25.19%), Mutiara legume (*S. exasperata*) (19.47%), Kumpai minyak (*H. amplexicaulis*) (16.26%), and Kumpai padi (*O. rupifogon* ^{P}) (16.25%). Meanwhile, Bento rayap *(L. hexandra)* was found to have the lowest ash content of 5.63% (Table 2). Ash contents of vegetations found in this study were higher than those of swamp vegetations in South Kalimantan of 2.18- 3.28% during high tidal season and 3.23-9.83% during low tidal season (Rostini et al., 2014). *Elephant* grass (*P. purpureum*) was indicated to have varied ash contents of 4.4% (Dahlan and Iskandar, 2013), 0.95-1.1% (Ukpabi et al., 2015), 9.59% (Nuhuyanan, 2010), and 18% (Araica et al., 2009). Meanwhile, the ash content of grasses in lowland areas ranged from 6.32 to 8.91% (Richmond et al., 2015; Mako et al., 2016; Norman et al., 2013; Maswada et al., 2013). Alam *et al.* (2015) found that *B. mutica* had an ash content of 4.20-4.89% and rice straw had 6.63%.

Roughages were found to have average ash contents of 7.28% in a pasture for buffaloes in Pulau Moa (Eoh, 2014), 9.82–10.14% in Lore Utara, Poso Regency (Damry, 2009), 11.51% in a pasture during the rainy season until the end of dry season in Sabana Timur Barat (Manu, 2013), and 8.11 and 8.22% in a natural pasture and a coffee plantation area, respectively (Kleden et al., 2015). Differences in these ash contents were suspected to be caused by differences in plant species (internal factor) and environmental differences, particularly seasonal differences (external factor). In a dry season, pH levels in lowland swamp areas were found to be 3.9-4.8 causing a decreased supply of nutrients, especially total N and K, to the soil. This decreased supply of nutrients led to lowered nutrients contained in plants (Rostini et al., 2014). This was in line with what was stated by Gutteridge and Shelton (1994) that nutrient content in plants was affected by soil nutrient content. In addition, in acidic soil condition, activities of Fe, Al, and Mn increased which might cause in toxicity in plants (Tjondronegoro and Gunawan).

NDF and ADF Contents

Neutral Detergent Fiber (NDF) depicts plant cell walls consisting of hemicellulose, cellulose, and lignin. NDF is part of fiber which is not dissolved in neutral detergent representing the component of fiber undissolved in plant cell wall materials. NDF content of a feed affects the ability of ruminant animals to consume feed. Acid Detergent Fiber (ADF) represents parts of plant cell wall bond to cellulose and lignin. ADF content is related to energy content and higher ADF content results in lowered digestible energy content (Van Soest, 1982).

The NDF and ADF contents of vegetations found in this study were about 40.65–79.47% and 23.66–60.33%, respectively. Lowest NDF contents were found in Cecengkehan (*L. hyssopifolia*) (40.65%), Kangkung merah (*I. aquatica*) (41.40%), Telepuk gajah (*N. lotus*) (46.05%), and Tapak dara (*C. roseus*) (47.79%). In contrast, highest NDF content of 79.47% was found in Bento rayap (*L. hexandra*). Lowest ADF contents were found in Telepuk gajah (*N. lotus*) (46.05%), Kangkung merah *(I. aquatica)* (26.17%), Kumpai merah (*Hymenachne sp*) (28.40%), Cecengkehan (*L. hyssopifolia*) (32.91%). Meanwhile, the highest ADF content of 60.33% was found in Kumpai padi *(O. rupifogon* ^{P}*)* (Table 3). NDF and ADF contents of vegetations found in this study were lower than those of Asep et al. (2012) who reported that the NDF contents of swamp green vegetations in a pasture for buffaloes were about 91.73–93.45% in grasses and 68.11–90.93% in legumes and the ADF content of grasses was 51.6-86.8%. it was shown in other studies that NDF and ADF contents of roughages in a pasture during the rainy season to the end of the dry season in Sabana Timur Barat were on average 65.9 and 43.29%, respectively (Manu, 2013). Vegetations in a natural pasture and a coffee plantation area had NDF contents of 74.89 and 72.37% and ADF contents of 57.22 and 55.15%, respectively (Kleden et al., 2015). Meanwhile, swamp vegetations in South Kalimantan had average NDF and ADF contents of 55.97 and 37.87%, respectively, during high tidal season and 81.44 and 60.86% respectively, during low tidal season (Rostini et al., 2014).

NDF and ADF contents of roughages in BPTU-HPT Padang Mengatas area were found to be 75.62 and 45.96%, respectively in rain season and 69.35 and 38.66%, respectively in dry season (Muhajirin et al., 2017). NDF and ADF contents of Eceng gondok (*E. crassipes* in this study were 62.77 and 41.83%, respectively. These figures were close to those of *water hyacinth* (*E.crassipes*) plants studied by Tham (2015) with NDF and ADF contents of 63.9 and 34.68% and by Tham and Uden (2015) with NDF and ADF contents of 52.1 and 30.7%, respectively. Other studies conducted by Ahmed et al. (2016), Anitha et al. (2016), and Nampoothiri (2017) showed that *Azolla sp* had NDF and ADF contents of 53.8-54.85% and 36.57-37.0%, respectively. Meanwhile, NDF and ADF contents of *elephant* grass (*P. purpureum*) were found to be 55.8 and 46.5% (Dahlan and Iskandar, 2013) and 84.25 and 64.07% (Nuhuyanan, 2010), respectively. These figures equaled to the NDF and ADF contents of Kumpai tembaga (64.72 and 46.38%), Kumpai minyak (65.31 and

38.92), and Are bolong (61.27 and 48.46%). This indicated that, lowland swamp vegetations had fiber fraction nutritional quality which was not less than that of prime grasses including *elephant* grass and *king* grass.

In this study, NDF and ADF contents of lowland swamp vegetations were 40.65– 79.47% and 23.66%–60.33%, respectively. These figures were still within the ranges of NDF and ADF contents of prime grasses such as *elephant* grass (*P. purpureum*) which had NDF and ADF contents of 55.8 and 46.5% (Dahlan and Iskandar, 2013) and 84.25 and 64.07% (Nuhuyanan, 2010), respectively. In rumen, NDF degradation is higher than that of ADF as NDF contains hemicellulose fraction which is more soluble (Church and Pond, 1986). NDF content has a negative correlation with its degradation rate (Varga et al., 1983) and higher NDF content decreases dry matter digestibility of feed (NRC, 1988). Cellulose is an ADF component which is easy to digest while lignin is hard to digest as it contains double bonds. Higher lignin content decreases feed digestibility (Sutardi et al., 1980).

Hemicellulose and Cellulose Contents

Lowland swamp vegetations were found to have hemicellulose and cellulose contents ranging from 7.73 to 37.14% and 5.24 to 27.08%, respectively. Four green vegetations with highest hemicellulose contents were Bento rayap (*L. hexandra*) (37.14%), Kerak maling (*D. fuscescens*) (31.87%), Kumpai merah (*Hymenachne sp.*) (31.74%), and Kumpai minyak (*H. amplexicaulis*) (26.39%). In contrast, lowest hemicellulose content was found in Cecengkehan (*L. hyssopifolia*) (7.73%). Highest cellulose contents were found in Kemon air (*N. olerancia*) (27.08%), Bento rayap (*L. hexandra*) (25.88%), Purun tikus (*E. dulcis*) (21.80%), and Are bolong (*P. barbatum*) (20,28%). Meanwhile, Kasuran (*C.digitatus*) had the lowest cellulose content of 5.24% (Table 3). Results of this study were in line with those of a study conducted by Asep et al. (2012) who reported the hemicellulose and cellulose contents of lowland swamp green vegetations ranging from 7.89 to 31.55% and 30.85 to 63.35%, respectively. They also found that Kumpai padi (*O.rupifogon*) had 31.55% hemicellulose content which was higher than those of Kumpai padi (10.80- 19.30%) found in this study (Table 4). Swamp vegetations in South Kalimantan had hemicellulose contents of 0.65-25.85% in high tidal season and 5.37-40.09% in low tidal season. Cellulose contents in high and low tidal seasons were about 20.07-34.03% and 7.90- 38.31%, respectively (Rostini et al., 2014). Various water plants including Azolla, which was used as animal feed, had hemicellulose and cellulose contents of 10.20 and 12.76% (Nampoothiri, 2017), 1.15-10.20% and 12.76% (Nampoothiri, 2017), respectively. Roughages in BPTU-HPT Padang Mengatas had hemicellulose and cellulose contents of 29.79 and 33.62% in rain season and 30.69 and 31.64% in dry season, respectively (Muhajirin et al., 2017). *Elephant* grass (*P. perpureum*) was found to contain 21.18% hemicellulose and 43.32% cellulose (Nuhuyanan, 2010) and 35.3% cellulose (Dahlan and Iskandar, 2013). In a study conducted by Archimede et al. (2010), hay was found to have 37.7% hemicellulose and 35.7% cellulose. Based on the above findings, it was suggested that hemicellulose (7.73– 37.14%) and cellulose (5.24–27.08%) contents of lowland swamp vegetations in this study were within normal ranges and these vegetations were potential to be used as feed for Pampangan buffaloes.

Lignin Contents

Lignin contents of lowland swamp vegetations ranged from 14.84 to 43.09%. Four vegetations including Telepuk gajah (*N. lotus*), Kemon air (*N. olerancia*), Kumpai merah (*Hymenachne sp.*), and Kangkung merah (*I. aquatica*) were found to have the lowest lignin contents of 14.84, 18.36, 19.76, and 19.85%, respectively, while the highest lignin content of 43.09% was found in Kumpai padi (*O. rupifogon* ^{P}) (Table 3). Lignin contents in this study were higher than that obtained by Rostini et al. (2014) who reported the lignin contents of swamp vegetations in South Kalimantan were about 2.8-17.59% in high tidal season with that of Kumpai minyak as the lowest and that of *Beberasan* as the highest and 10.06-61.12% in low tidal season with that of *Beberasan* as the lowest and that of Kumpai minyak as the highest. Lignin contents of Kumpai padi (*O. rupifogon* ^{R}) (31.24%) and Kumpai padi (*O. rupifogon* ^{P}) (43.09%), Bento rayap *(L. hexandra)* (33.92%), and Eceng gondok *(E. crassipes)* (31.60%) (Table 3) found in this study were higher those of Kumpai padi (18.27%) and Bento rayap *(L. hexandra)* (17.96%) found by Asep et al. (2012) and Eceng gondok *(E. crassipes)* (8.17%) found by Tham (2015). In other studies *Azolla* was found to have lignin contents of 5.7% (Ahmed et al., 2016) and 28.24% (Nampoothiri, 2017). Meanwhile, lignin contents of *elephant* grass were found to be 15.37% (Nuhuyanan, 2010) and 11.2% (Dahlan and Iskandar, 2013).

Differences in lignin contents in green vegetations are suspected to be caused by differences in plant species, plant ages, and environmental factors including seasons (rain or dry season), tidal seasons, and fertility levels of the soil where the vegetations grow. In cell walls, cellulose is bond with hemicellulose and lignin. Lignin cannot be digested by the animals and its atomic proportion is different from other carbohydrates as it contains carbon and nitrogen of only 1-5%. Hemicellulose consists of pentose, hexose, uronic acid, and pectin substance. Pectin is a carbohydrate which is composed of aronic acid, galactose, arabinose, xylose, and methanol. Cellulose is degradable by microorganisms and functions as the source of volatile fatty acids. Young grasses (roughages) contain less than 5% lignin and 80% of their cellulose is degradable. On the contrary, in old roughages, lignin content may reach up to 10% causing a decrease in cellulose digestibility by up to 50% (Prawirokusumo, 1994).

Based on the results of the study, it was concluded that:

1. The highest protein (20.56%) and crude fat (2.92%) contents were found in Kemon air *(Neptunia olerancia)*. The highest ash content (25.19%) was found in Kasuran *(C. digitatus)* while the lowest (11.01%) was found in

Cecengkehan *(L. hyssopifolia)*. The lowest NDF content (40.64%) was found in Cecengkehan *(L. hyssopifolia)* and the highest hemicellulose content (37.14%) was found in Bento rayap. Telepuk gajah had the lowest ADF (23.66%) and lignin (14,84%) contents. Kemon air contained the highest cellulose level of 27.08%.

2. The best nutritional values were found in Kasuran *(C. digitatus)* and Cecengkehan *(L. hyssopifolia)*.
3. Dominant and palatable swamp roughages with good nutrient contents included Kumpai tembaga *(H. acutigluma),* Kumpai minyak *(H. amplexicaulis),* Kumpai padi *(O. rupifogon),* Are bolong *(P. barbatum)*, and Purun tikus *(E. dulcis)*.

ACKNOWLEDGEMENTS

The author expresses his deepest gratitude to the Rector of Sriwijaya University through the Chair of the Institute for Research and Community Services funding this research in accordance with the Competitive Leading Research Contract of Sriwijaya University Number: 988 / UN9.3.1 / PP / 2017, dated 21 July 2017.

REFERENCES

Ahmed HA, Ganai A.M, Beigh YA, Sheikh GG, Reshi PA. 2016. Performance of growing sheep on *Azolla* based diets. Indian J. Anim. Res. 50 (5): 721-724.
Alam MR, Haque MM, Sumi KR, Ali MM. 2015. Proximate composition of para-grass *(Brachiaria mutica)* produced in integrated fish-fodder culture system. Bang. J. Anim. Sci. 44 (2): 113-119.
Ali AIM, Sandi S, Muhakka, Riswandi. 2012. Kualitas hijauan pakan di rawa lebak padang penggembalaan kerbau pampangan. Prosiding InSINAS 2012. 307-312.
Anitha KC, Rajeshwari YB, Prasanna SB, Shree JS. 2016. Nutritive evaluation of azolla as livestock. Journal of Experimental Biology and Agricultural Sciences. 4(6): 670-674.
AOAC (Association of Official Analytical Chemists). 1990. Official Methods of Analysis. 15th ed., Washington, DC.
Araica BM, Sporndly E, Sanchez NR, Norell L, Sporndly R. 2009. Silage quality when Moringa oleifera is ensiled in mixtures with elephant grass, sugar cane and molasses. Grass and Forage Science. 64: 364-373.
Archimede H, Gonzales-Garcia E, Despois P, Etienne T, Alexandre G. 2010. Subtitution of corn and soybean with green banana fruits and Gliricidia sepium forage in sheep fed hay-based diets: effects on intake, digestion and growth. Journal of Animal Physiology and Animal Nutrition. 94 (2010): 118-128.
Brazle FK, Kilgore GI, Fauzett MR. 2000. Effect of season on grazing native-grass pastures. The Profesional Animal Scientist. 16: 15-28.
BPS (Badan Pusat Statistik). 2010. Direktorat Jendral Tanaman Pangan. *Luas lahan rawa di Indonesia*. Departemen Pertanian. Jakarta.
BPS (Badan Pusat Statistik) Provinsi Sumatera Selatan. 2014. Sumatera Selatan dalam Angka 2014.
Church DC, Pond WG. 1986. Digestive Animal Physiologi and Nutrition. 2nd. Prentice Hell a Devision of Simon and Schuster Englewood Clief, New York.
Dahlan I, Iskandar MNZ. 2013. Use of plantain peels (Musa paradisiaca) as a fibrous feed substitute for napier grass (Pennisetum purpureum) in rusa deer (Cervus timorensis ratio under captivity. J. Anim. Sci. 3 (9): 472-480.
Damry. 2009. Produksi dan kandungan nutrisi hijauan padang penggembalaan alam di Kecamatan Lore Utara Kabupaten Poso. Jurnal Agroland. 16 (4): 296-300.
Eoh M. 2014. Kapasitas tampung dan komposisi zat-zat makanan padang penggembalaan ternak kerabau di Pulau Moa. Agrinimal. 4 (2): 77-82.
Gutteridge RC, Shelton HM. 1994. The Role of Forage Tree Legumes in Cropping and Grazing System. The Tropical Grassland Society of Australia Inc.
Hossain MdE, Sikder H, Kabir MdH, Sarma SM. 2015. Nutritive value of water hyacinth *(Eichhornia crassipes).* Online Journal of Animal and Feed Research. 5 (2): 40-44.
Kathirvelan C, Banupriya S, Purushothaman MR. 2015. Azolla-an alternate and su tainable feed for livestock. International Journal of Science Environment. 4 (4): 1153-1157.
Kleden MM, Ratu MRD, Randu MDS. 2015. Kapasitas tampung hijauan pakan dalam areal perkebunan kopi dan padang rumput alam di Kabupaten Flores Timur Nusa Tenggara Timur. Jurnal Zootek 35 (2): 340-350.
Mako AA, Akinwande VO, Anurudu NF, Ogunwole OA. 2016. Evaluation of nutritive value of water hyacinth *(Eichhornia crassipes)* and guinea grass *(Panicum maximum)* mixture as animal feed in the tropics. 2016. Bull. Anim. Hith. Prod. Afr. (64): 463-473.
Manu AE. 2013. Produktivitas padang penggembalaan sabana Timor Barat. Jurnal Pastura. 3 (1): 25-29.
Maswada HF, Elzaawely AA. 2013. Nutritive value of Stipagrostis lanata (Forssk.) de winder as a feed for livestock. Asian Journal of Crop Sciences. 5 (2): 216-221.
Muhakka, Suwignyo RA, Budianta D dan Yakup. 2019. Vegetation analysis of no-tidal swampland in South Sumatra, Indonesia and its carrying capacity for Pampangan buffalo pasture. Journal Biodiversitas. 20 (4): 1077-1086.
Muhakka, Wijaya A, Ammar M. 2015. Nutritional dried matter, crude protein and crude fiber on lowland tidal grass fermented by probiotic microorganisms for use bali cattle feed. Journal Animal Production. 17 (1): 24-29.
Muhajirin, Despal, Khalil. 2017. Pemenuhan kebutuhan nutrien sapi potong bibit yang digembalakan di Padang Mengatas. Buletin Makanan Ternak.104 (1): 9-20.
Mulyani A, Sarwani M. 2013. Karakteristik dan potensi lahan sub optimal untuk pengembangan pertanian di Indonesia. Jurnal Sumber daya Lahan. 7 (1): 47-55.
Nampoothiri VM. 2017. Aquatic plants and marine waste as animal feed. Sch.J. Agric.Vet. Sci. 4 (6): 249-254.
Norman HC, Master DG, Barrentt-Lennard EG. 2013. Halophytes as forage in saline landscapes: Interaction between plant genotipe and environment change their feeding value to ruminants. Environmental and Experimental Botany. 92 (2013): 96-109.
NRC. 1988. Nutrition Reguirement of Beef Cattle. 6th. Rev. Ed. National.
Nuhuyanan LE. 2010. Pengaruh pemberian wafer rumput gajah dengan perekat fermented moter liquor (FML) dan tetes (molasses) terhadap konsumsi pakan, kecernaan zat-zat makanan dan kenaikan berat badan sapi bali jantan. Jurnal Ilmu Peternakan. 5 (2): 111-117.
Prawirokusumo S. 1994. Ilmu Gizi Komperatif. BPFE., Yogyakarta.

Rahman MM, Abdullah RB, Wan Khadijah WE, Nakagawa T, Akashi R. 2014. Feed intake and growth performance of goats affered napier grass *(Pennisetum purpureum)* supplemented with concentrate pellet and soya waste. Sain Malaysiana. 43 (7): 967-971.

Richmond AS, Wylie ARG, Laidlaw AS, Lively FO. 2015. Methane emissions from beef cattle grazing on semi-natural upland and improved lowland grasslands. Animal. 9 (1): 130-137.

Rostini T, Abdullah L, Wiryawan KG, Karti PDMH. (2014). Production and nutrition potency of swamp local forage in South Kalimantan as ruminant feed. Glob. J. Anim. Sci. Livestock Prod. Anim. Breed. 2 (2):107-113.

Santoso dan Hariadi BTj. 2008. Komposisi kimia, degradasi nutrien dan produksi gas metana in vitro rumput tropika yang diawetkan dengan metode silase dan hay. Media Peternakan 31(2): 128-137.

Se'u VE, Karti PDMH, Abdullah L. 2015. Botanical composition, grass production, and carrying capacity of pasture in Timor Tengah Selatan District. Journal Media Peternakan 38(3):176-182.

Statistik Peternakan Sumatera Selatan. 2014. Dinas Peternakan Provinsi Sumatera Selatan Tahun Anggaran 2015.hal:14.

Sutardi T, Pratiwi SH, Adnan A, Nuraini S. 1980. Peningkatan pemanfaatan jerami padi melalui hidrolisa basa, suplementasi urea dan belarang. Bull. Makanan Ternak. 6 Bogor.

Tham HoT. 2015. Utilisation of water hyacinth as animal feed. Nova Journal of Engineering and Applied Sciences. 4 (1): 1-6.

Tham HoT, Uden P. 2015. Effect of fresh water Hyacinth (Eichhornia crassipes) on intake and digestibility in cattle fed rice straw and molasses-urea cake. Nova Journal of Engineering and Applied Sciences. 4(1): 1-8.

Tjondronegoro AD, Gunawan A. 2000. Beberapa jenis gulma di lahan pasang surut pada tingkat kemasaman tanah yang berbeda. Prosiding Seminar Nasional. P. 247-254.

Van Soest PJ. 1982. Nutritional Ecology of the Ruminant: Ruminant Metabolism, Nutritional Stategies the Cellulolytic Fermentation and the Camisthy of Forages and Palm Fiber. Cornell University O & B Books Inc. USA.

Varga GA, Hoover WH. 1983. Rate and extent of NDF of feedstuff in-situ. J. Dairy. Sci. 66:2109.

SUBMISSION CHECKLIST

Ensure that the following items are present:

The first corresponding author must be accompanied with contact details:	**Give mark (X)**
• E-mail address	x
• Full postal address (incl street name and number (location), city, postal code, state/province, country)	x
• Phone and facsimile numbers (incl country phone code)	x

All necessary files have been uploaded, and contain:

• Keywords	x
• Running titles	x
• All figure captions	
• All tables (incl title and note/description)	x

Further considerations

• Manuscript has been "spell & grammar-checked" Better, if it is revised by a professional science editor or a native English speaker	x
• References are in the correct format for this journal	x
• All references mentioned in the Reference list are cited in the text, and vice versa	x
• Colored figures are only used if the information in the text may be losing without those images	
• Charts (graphs and diagrams) are drawn in black and white images; use shading to differentiate	

Nutritional Values of Swamp Grasses as Feed for Pampangan Buffaloes in South Sumatra Indonesia

Abstract. This study was aimed at determining the types and quality of vegetations in swamp area which could be used as sources of roughage for Pampangan buffaloes in South Sumatera. In this descriptive study. Results showed that, the highest crude protein and ether extract contents, 20.56 and 2.92%, respectively were found in Kemon air *(Neptunia olerancia)*. The highest ash content of 25.19% was found in Kasuran *(Cyperus digitatus)*. The lowest fiber content (11.01%) was found in Cecengkehan *(Ludwigia hyssopifolia)* which also had the lowest content of NDF (40.64%). Hemicellulose content was found to be highest (37.14%) in Bento rayap*(Leersia hexandra)*. The lowest ADF (23.66%) and lignin (14,84%) contents were found in Telepuk gajah *(Nymphaea lotus)*. Kemon air *(Neptunia olerancia)* was found to have the lowest content (27.08%) of cellulose. It was concluded that the swamp vegetations found in this study consisted of 17 types of grasses (89.47%) and 2 types of legumes (10.53%). Kasuran *(Cyperus digitatus)* and Cecengkehan *(Ludwigia hyssopifolia)* were found to have the best nutritional values. Dominant and palatable vegetations with good nutritional values which were potential to be used as sources of roughage for *Pampangan* buffaloes were Kumpai tembaga *(Hymenachne acutigluma)*, Kumpai padi *(Oryza rupifogon)*, Kumpai minyak *(Hymenachne amplexicaulis*, Are bolong *(Polygonum barbatum)*, and Purun tikus *(Eleocharis dulcis)*.

Key words: Nutritional value, Swamp grass, Feed, Pampangan buffalo.

INTRODUCTION

The availability of roughage as the main feed for ruminant animals depends considerably on seasons. During rainy season, it is abundant and during dry season the availability of grasses and legumes is lacking. Limited supply of roughage may hamper productivity including reproductive performance of ruminant animals including buffaloes.

In South Sumatera Pampangan buffalo is a potential germplasm which needs to be preserved and developed. There were 37,405 heads of Pampangan buffaloes in 2016 and this population increased by 3.97% to 38,952 heads in 2017. In 2017, of this population, 11,150 heads (28.63%) and 2,227 heads (5.72%) were found in Ogan Komering Ilir Regency and Banyuasin Regency, respectively (Statistik Peternakan Sumsel, 2017). The population and productivity of *Pampangan* buffaloes need to be improved and for this purpose, feed is an important factor to consider. Pampangan buffaloes feed mostly on roughage from swamp and/or grassland to meet their maintenance and reproductive needs.

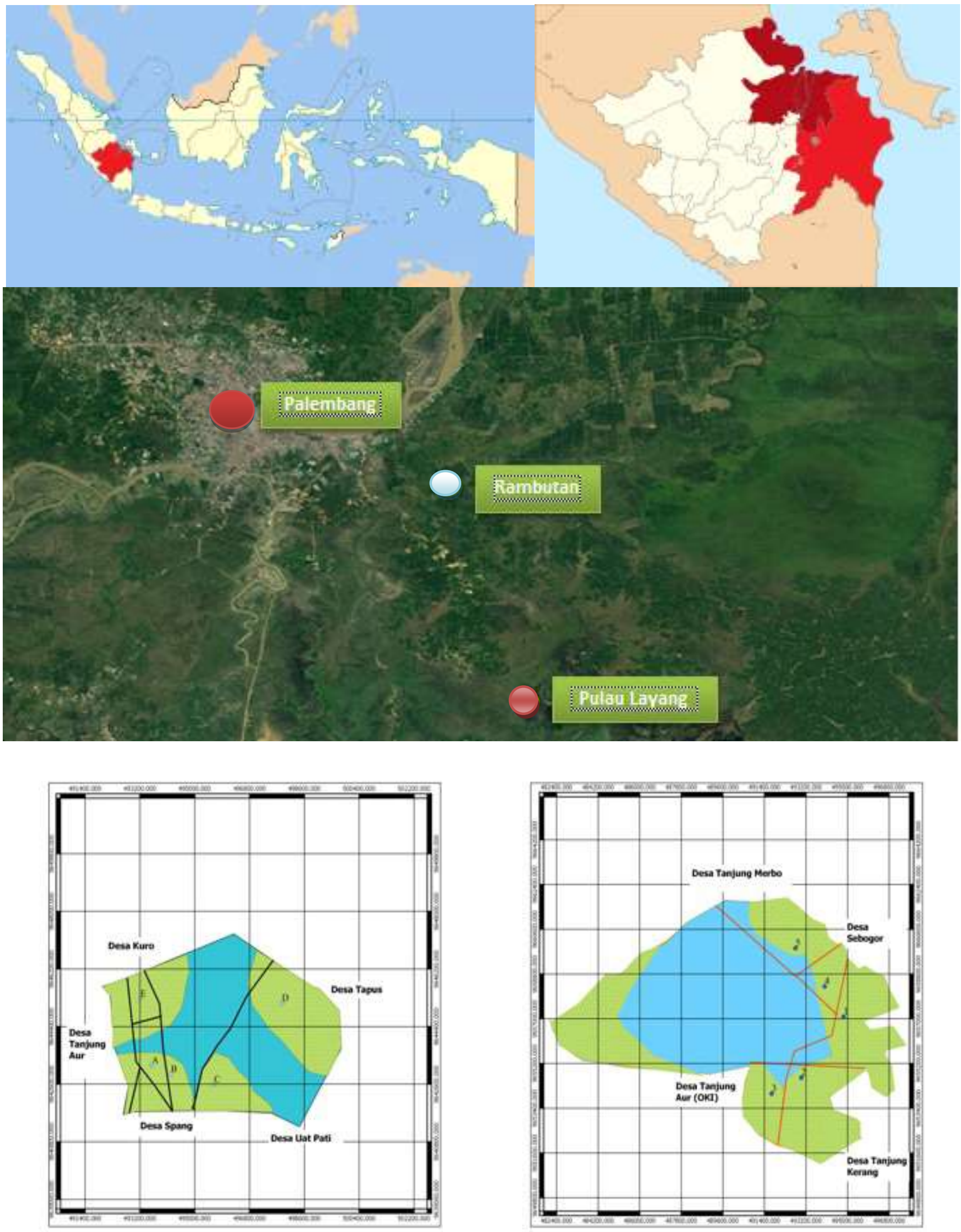
In Indonesia, there are 13.27 million hectares of lowland swamp areas. Only 4 million hectares of these areas has been developed and cultivated by the community and private sectors (2.6 million hectares) and the government assistance (1.3 million hectares) (BPS, 2010, Mulyani and Sarwani, 2013). In Sumatera, the largest lowland swamp area of 2.98 million hectares is found in South Sumatera but only 298,189 hectares of it has been utilized (BPS Sumatera Selatan, 2014). In order to utilize the potential swamp area as a feed source for Pampangan buffaloes, a study on vegetations as sources of roughage in lowland swamp areas that include vegetation identification and nutritional quality determination needs to be conducted.

In the previous study, some swamp grasses including Kumpai minyak grass (*H. amplexicaulis)* (Rostini et al., 2014**;** Muhakka et al., 2015), *I. rugosum* and *L. hexandra* (Ali et al., 2012) were identified. However, many more swamp vegetations have not been identified. This study was conducted to identify the types and nutritional values of vegetations that could be used as sources of roughage feed for Pampangan buffaloes in South Sumatera. This information was important to support the productivity improvement of Pampangan buffaloes as a germplasm in South Sumatera.

MATERIALS AND METHODS

This study was a descriptive study to assess the types and nutritional values of vegetations which were the dominant and palatable as sources of roughage feed for Pampangan buffaloes. Vegetation samples were taken from grazing areas of

Pampangan buffaloes in Rambutan Village and Pulau Layang Village, South Sumatra from April to Juni 2017. Vegetation samples for nutrient analysis were obtained by following these procedures: (1) vegetation collection was done based on estimated growth age (young age, medium age, and old age based on physical appearance), (2) collected samples of each vegetation was composited, and (3) samples were chopped into small sizes, homogenized. For each vegetation, 1 kg sample was taken by random to the laboratory for oven drying at 105^{o}C until constant weight was obtained and dry matter content was determined. Samples were then ground for nutrient content determination by using proximate and Van Soest analyses (Syarifuddin and Wahdi, 2010).



A **B**

Figure 1. Research location in South Sumatera, Indonesia, **A.** Pulau Layang Village, Pampangan Sub-district, Ogan Komering Ilir District, South Sumatra, **B.** Rambutan Village, Rambutan Sub-district, Banyuasin District, South Sumatra (Muhakka et al., 2019)

Measured parameters

Proximate Analysis

Crude protein, fiber, ether extract, and ash contents were determined based on the procedures of AOAC (1990).

1. *Crude Protein*. Nitrogen (N) content was determined by using a Kjehdahl method. In this analysis, sulphuric acid with a catalyst and a heating process. The organic matter of samples was then oxidized by sulfuric acid and nitrogen was changed into an ammonium sulfate form. The remaining sulfuric acid was neutralized by NaOH until the solution became basic. Ammonium sulphate was then distilled in an acid medium to obtain the quantitative amount of N. As the average protein contains 16% nitrogen, a factor 100% : 16% = 6.25 was used to obtain the value of crude protein (crude protein = N% x 6.25).
2. *Fiber.* Filtered fat-free sample was used in fiber content determination. 1.25% sulfuric acid solution was added into the sample and the mixture was heated for about 30 minutes before the residue was filtered. 1,25% NaOH solution was added into the precipitate and the mixture was heated for about 30 minutes. The mixture was then filtered and the precipitate was washed, dried, and weighed. This precipitate was burnt and the ash was weighed. The difference between the weight of precipitate before it was burnt and the weight of the ass was referred to as fiber content.
3. *Ether Extract*. Dry matter sample was extracted with diethyl ether for 5 hours. In the end of the extraction process, ether evaporated and the remaining material was referred to as fat.
4. *Ash*. The third part of dry matter sample was weighed and burnt in a crucible at 550ºC for 8 hours.

Van Soest Analysis

NDF, ADF, hemicellulose, cellulose, and lignin contents were determined by using a Van Soest method (1982).

1. Neutral Detergent Fiber (NDF). *a* gram of sample was put in a beaker glass. 50 ml NDS solution was added into the beaker before the mixture was heated for an hour. The mixture was then filtered by using a vacuum pump and a filter glass which was previously weighed (*b* gram). The mixture was then washed with hot water and acetone before it was dried in an oven and let cool in a desiccator. Finally, it was weighed as *c* gram. NDF content was calculated by using the following formula:

$$\% \text{ NDF} = \frac{c - b}{a} \times 100\%$$

2. Acid Detergent Fiber (ADF). *a* gram of sample was put in a beaker glass. 50 ml ADS solution was added into the beaker before the mixture was heated for an hour. The mixture was then filtered by using a vacuum pump and a sintered glass filter which was previously weighed (*b* gram). The mixture was then washed with hot water and acetone before it was dried in an oven and let cool in a desiccator. Finally, it was weighed as *c* gram. Cellulose content was calculated by using the following formula:

$$\% \text{ cellulose} = \frac{c - d}{a} \times 100\%$$

4. Hemicellulose. Hemicellulose content was calculated as a difference between NDF and ADF contents as follows.

$$\% \text{ Hemicellulose} = \% \text{ NDF} - \% \text{ ADF}$$

5. Lignin. Cellulose residue (*d* gram) was burnt in a furnace at 500-600ºC for 3 hours. After that, it was left to cool and weighed (*e* gram). Lignin content was calculated by using the following formula:

$$\% \text{ Lignin} = \frac{d - e}{a} \times 100\%$$

Data Analysis

The data obtained were used directly to describe the nutritional value of the swamp vegetations that could be used as a roughage source. These data were then combined with those of *in vitro* digestibility as the basis for drawing the conclusion (Syarifuddin and Wahdi, 2010).

RESULTS AND DISCUSSION

Results

Results of soil analysis showed that soil at the study site had low fertility level and was highly acidic. It also had very high organic C and total N contents, medium level of exchangeable-K and N contents, very low Ca and Mg contents, medium P content, and very high CEC level (Table 1).

Table 1. Properties of soil at the study site

	Pulau Layang		*Rambutan*	
Parameter	**Value**	**Remark**	**Value**	**Remark**
pH H_2O (1 : 1)	5.10	Low	4.41	Very low

pH KCl (1 : 1)	4.39	Very acidic	3.99	Very acidic
Organic C (g/kg)	57.66	Very high	36.14	Very high
Total N (g/kg)	3.64	Very high	2.19	Very high
Available P/Bray I (mg/kg)	11.70	Medium	2.25	Very low
Exchangeable K (cmol/kg)	0.63	Medium	0.45	Medium
Na (cmol/kg)	0.65	Medium	0.65	Medium
Ca (cmol/kg)	1.95	Very low	0.73	Very low
Mg (cmol/kg)	0.45	Very low	0.32	Very low
CEC (cmol/kg)	65.25	Very high	43.50	Very high
Exchangeable Al (cmol/kg)	1.84		2.37	
Exchangeable H (cmol/kg)	0.74		0.88	
Texture:				
Sand (%)	47.08		46.64	
Ash (%)	31.11		27.18	
Clay (%)	21.81		26.18	

Source: Laboratory of Soil Chemistry, Biology, and Fertility, Soil Department, Faculty of Agriculture, Sriwijaya University (2017).

Nutrient Contents of Lowland Swamp

Crude protein, fiber, ether extract, and ash nutrient contents of lowland swamp vegetations found in this study are listed in (Table 2).

Table 2. Crude protein, fiber, ether extract, and ash contents (%) of lowland swamp vegetations

Latin Name	Local Name	Crude Protein	Fiber	Ether Extract	Ash
Catharanthus roseus	Tapak dara	15.20	11.18	1.29	12.53
Cyperus digitatus	Kasuran	15.31	14.76	1.42	25.19
Digitaria fuscescens	Kerak Maling/Pasiran	12.00	15.64	1.24	16.26
Eichhornia crassipes	Eceng gondok	8.61	20.66	0.84	14.22
Eleocharis dulcis P	Purun tikus	8.22	25.72	0.48	15.13
Eleocharis dulcis R	Purun tikus	6.63	24.52	1.69	10.24
Hymenachne acutigluma) P	Kumpai Tembaga	6.86	30.26	2.22	7.88
Hymenachne acutigluma R	Kumpai Tembaga	10.96	23.73	1.77	10.30
Hymenachne amplexicaulis P	Kumpai Minyak	9.21	21.91	2.82	13.96
Hymenachne amplexicaulis R	Kumpai Minyak	12.00	15.64	1.24	16.26
Hymenachne sp	Kumpai Merah	8.52	21.20	1.30	12.88
Ipomoea aquatica	Kangkung merah	8.95	14.34	2.24	10.39
Leersia hexandra	Bento rayap	5.35	27.57	2.06	5.63
Ludwigia hyssopifolia	Cecengkehan	12.07	11.01	1.66	9.09
Neptunia olerancia	Kemon air	20.56	15.03	2.92	7.31
Nymphaea lotus	Telepuk Gajah	13.22	11.45	2.84	10.30
Oryza rupifogon P	Kumpai Padi	7.93	23.30	1.60	16.25
Oryza rupifogon R	Kumpai Padi	10.41	21.59	2.49	11.92
Polygonum barbatum	Are Bolong	7.53	16.60	1.57	8.40
Rhynchospora corymbosa	Berondong	5.26	22.27	1.48	14.84
Sesbania exasperata	Mutiara	18.27	11.22	1.86	19.47

Source: Laboratory of Dairy Nutrition, Department of Nutrition and Feed Technology, IPB (2017).
Notes: P : Grass in Pulau Layang Village; R : Grass in Rambutan Village.

The NDF and ADF contents of vegetations found in this study were about 40.65–79.47% and 23.66–60.33%, respectively. Lowland swamp vegetations were found to have hemicellulose and cellulose contents ranging from 7.73 to 37.14% and 5.24 to 27.08%, respectively. Lignin contents of lowland swamp vegetations ranged from 14.84 to 43.09% (Table 3).

Table 3. Composition of fiber fractions of green vegetations in lowland swamp: NDF, ADF, Hemicellulose, Cellulose, and Lignin (%).

Latin Name	NDF	ADF	Hemicellulose	Cellulose	Lignin
Catharanthus roseus	47.79	39.67	8.12	16.96	22.71
Cyperus digitatus	58.90	36.93	21.97	5.24	31.68
Digitaria fuscescens	65.43	33.56	31.87	12.11	21.45
Eichhornia crassipes	62.77	41.83	20.94	10.22	31.60
Eleocharis dulcis P	69.57	49.83	19.74	21.80	28.04
Eleocharis dulcis R	75.73	54.91	20.82	19.71	35.20
Hymenachne acutigluma P	75.89	50.60	25.29	12.25	38.34
Hymenachne acutigluma R	64.72	46.38	18.34	16.01	30.37

Hymenachne amplexicaulis	65.31	38.92	26.39	8.29	30.63
Hymenachne sp	60.14	28.40	31.74	8.64	19.76
Ipomoea aquatica	41.40	26.17	15.23	6.32	19.85
Leersia hexandra	79.47	42.33	37.14	25.88	33.92
Ludwigia hyssopifolia	40.64	32.91	7.73	8.39	24.52
Neptunia olerancia	62.31	45.44	16.87	27.08	18.36
Nymphaea lotus	46.05	23.66	22.39	8.82	14.84
Oryza rupifogon [P]	71.13	60.33	10.80	17.23	43.09
Oryza rupifogon [R]	65.49	46.19	19.30	14.96	31.24
Polygonum barbatum	61.27	48.46	12.81	20.28	28.18
Rhynchospora corymbosa	65.29	44.64	20.65	16.08	28.56

Source: Biotechnology Assessment Laboratory, Center for Biotechnology Research, Indonesian Institute of Sciences (LIPI), Cibinong, Bogor (2017).

Notes: [P] : Grass in Pulau Layang Village; [R] : Grass in Rambutan Village.

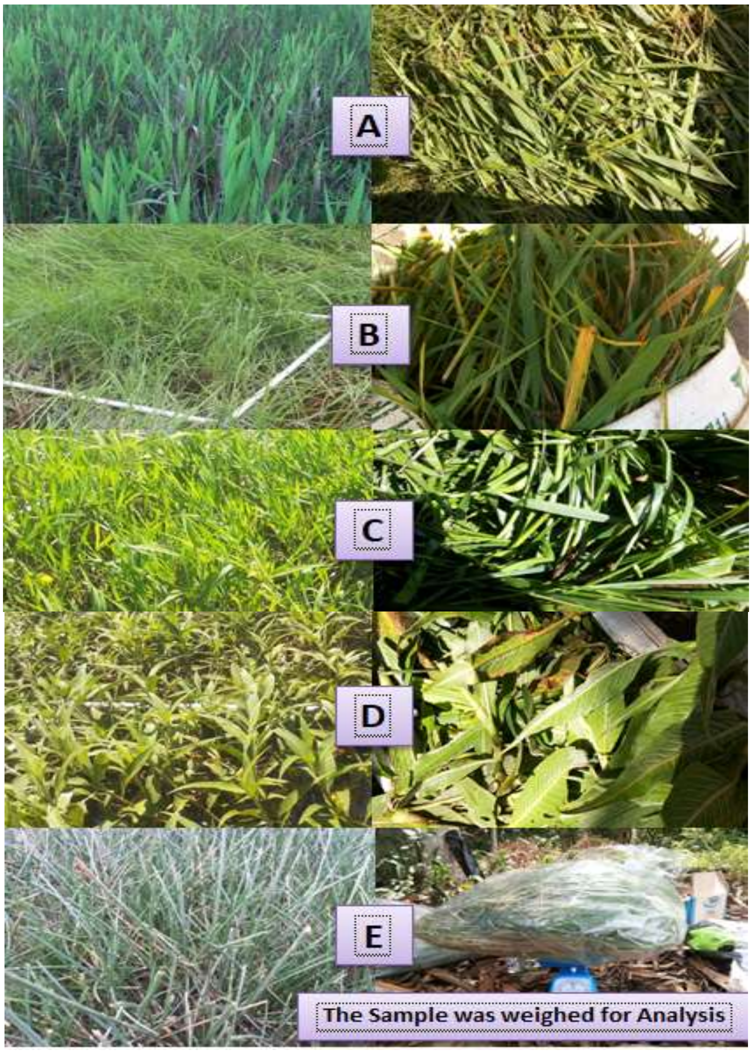


Figure 2. Dominant and palatable swamp roughages with good nutrient contents included. **A**. *Hymenachne acutigluma*, **B**. *Oryza rupifogon* **C**. *Hymenachne amplexicaulis*, **D**. *Polygonum barbatum*, and **E**. *Eleocharis dulcis*.

Discussion

Crude Protein Content

Results showed that the crude protein contents of swamp green vegetations ranged from 5.26% to 20.56% with the lowest value (5.26%) was found in Berondong grass (*R. corymbosa*) and the highest (20.56%) was found in Kemon air legume (*N. olerancia*). Kasuran grass (*C. digitatus*) had the highest crude protein content (15.31%) (Table 2). This high nutritional value of Kasuran grass was suspected as caused by the fact that most of this grass was found to grow in the area of buffalo pens where the soil was rich in organic matter. However, the growth of this grass was not dominant as it mostly occured in rainy seasons.

Kumpai minyak (*H. amplexicaulis*), Kumpai padi (*O. rupifogon*), Kumpai tembaga (*H. acutigluma*), and Purun tikus (*E. dulcis*) were found as the dominant palatable grasses containing 12.00, 10.41, 10.96, and 8.22% crude protein, respectively. Results of this study were not too different from those obtained by Rostini et al. (2014) who reported that Kumpai minyak and Pipisangan had protein contents of 10.88 and 15.92%, respectively. Crude protein (CP) contents of these swamp grasses in Pulau Layang and Rambutan Villages were closed to those of prime grasses including 9.11-12.8% CP of *elephant* grass (*P. purpureum*) (Santos et al., 2013; Dahlan and Iskandar, 2013; Rahman et al., 2014), 12.4% CP of *elephant* grass hay, 11.1% CP of *elephant* grass silage, 11.4% CP of king grass hay, and 10.2% CP of king grass silage (Santoso and Hariadi, 2008). Other vegetations even had higher CP contents including Kumpai tembaga *(H. acutigluma)* with 10.96% CP, Tapak dara (*C. roseus*) 15.20%, Telepuk gajah (*N. lotus*) 13.22%, Cecengkehan (*L. hyssopifolia*) 12.07%, Kasuran *(C. digitatus*) 15.31%, and Kumpai minyak (*H. amplexicaulis)^R* 12.0% (Table 2). CP contents of vegetations in this study were also higher than those of nature grasses found in coffee plantation areas (6.95%) and pastoral areas (6.65%) in Wulanggitang District, East Flores Regency as reported by Kleden et al. (2015). Meanwhile, CP content of grasses in lowlands was 8.41% (Rochana et al., 2016; Maswada and Elzaawely, 2013).

This high protein content was suspected to be caused by the fact that soil organic C and total N contents in the study site were also high, namely 36.14-57.66 and 2.19-3.64 g.kg^{-1}, respectively (Table 1). Soil organic C and total N contents affected protein content in plants. Four swamp grasses including Kasuran (*C. digitatus*), Tapak dara (*C. roseus*), Telepuk gajah (*N. lotus*), and Cecengkehan (*L. hyssopifolia*) and a legume, Kemon air (*N. olerancia*) were found to be the lowland swamp vegetations having the highest N contents of 15.31,15.20, 13.22, 12.07, and 20.56%, respectively.

Fiber Contents

Fiber contents of lowland swamp green vegetations ranged from 11.01 to 30.26% with the lowest content found in Cecengkehan (*L. hyssopifolia*) and the highest in Kumpai tembaga *(H. acutigluma* ^{P}*)*. Four vegetations including *Cecengkehan* (*L. hyssopifolia*), Tapak dara (*C. roseus*), Mutiara legume (*S. exasperata*), and Telepuk gajah (*N. lotus*) were found to have the lowest fiber contents of 11.01, 11.18, 11.22, and 11.45%, respectively (Table 2). These results were almost similar to those found by Ali et al. (2012) who reported that the fiber contents of roughage in a pasture ranged from 7.20 to 34.98%. These researchers found that the fiber content of Bento rayap (*Leersia hexandra*) was 27.40% which was very close to that (27.57%) of the same vegetation in this study. Meanwhile, Rostini et al. (2014) reported that the fiber contents of swamp vegetation in South Kalimantan ranged from 14.84 to 29.35% with the lowest content found in Hadangan (*Paspalum sp*) and the highest in Dadangsit (*L. adscendens*). These figures were lower than those found by Kleden et al. (2015) who revealed that nature grasses in a coffee plantation area and a pasture in Wulanggitang, East Flores contained 34.57 and 35.59% of fiber. They also found that the lowest fiber content was found in *L. peploides* and the highest in *I. rugosum*. Fiber contents reported by Kleden et al. (2015) were higher that the results reported by Ahmed *et al*. (2013) with a fiber content of 29.32% in *D. aegyptium* plants. A previous study showed that fermented *I. rugosum*, *H. amplexicaulis,* and *O. rifipogon* had fiber contents of 29.27, 29.57, and 33.07%, respectively (Muhakka et al., 2015).

The fiber content of Eceng gondok (*E. crassipes*) in this study (20.66%) was lower than those found by Hossain et al. (2015), Tham and Uder (2015), and Make et al. (2016). In addition, the fiber content of Eceng gondok (*E. crassipes*) in this study was lower than those of *Azolla*, another water plant, ranging from 13.19 to 16.54% (Kathirvelan et al., 2015; Anitha et al., 2016) and 9.25 to 13.25% (Ahmed et al., 2016). These fiber contents of *Azolla* equalled to those of Cecengkehan (*L. hyssopifolia*) (11.01%), Tapak dara (*C. roseus*) (11.18%), Mutiara legume (*S. exasperata*) (11.22%), Telepuk gajah (*N. lotus*) 11.45%, and Kangkung merah (*I. aquatica*) (14.34%) found in this study. Fiber contents of swamp green vegetations found in this study indicated that they were potential to be used as feed for Pampangan buffaloes.

Ether extract contents

Lowland swamp vegetations in this study were found to have ether extract (EE) contents of about 0.48-2.92%. The lowest EE content was found in Purun tikus (*E. dulcis*) while the highest was found in Kemon air legume *(N. olerancia*). Four vegetations of lowland swamp including Telepuk gajah (*N. lotus*) (2.84% EE), Kumpai minyak (*H. amplexicaulis*) (2.82% EE), Kumpai padi (*O. rupifogon*) (2.49% EE), and Kangkung merah (*I. aquatica* Forsk) (2.24% EE) were revealed to have the highest ether extract contents (Table 2). Results of this study were lower than those found by Rostini et al. (2014) reporting about 0.61–3.67% of EE contents in swamp vegetations in South Kalimantan with the lowest found in Pipisangan (*L. hyssopifolia*) and the highest in Padi hiang (*O. rufigopon spotanea*). EE contents of lowland swamp vegetations were 1.40–1.91% for grasses and 1.36–2.95% for legumes (Asep et al., 2012) and those of grasses in a pasture for buffaloes in Pulau Moa were 1.95–2,41% (Eoh, 2014). In other studies, grasses in a natural pasture in North *Lore*, Poso Regency had EE contents of 2.12–2.34% (Damry, 2009) and those in Sabana Timur Barat pasture in rainy season to the end of dry season had an average EE content of 1.91% (Manu, 2013). A study by Se'u et al. (2015) revealed an EE content of 1.07% in grasses in a pasture in Timor Tengah Selatan Regency. Another work by Kleden et al. (2015) showed that vegetations in a natural pasture and a coffee plantation area had EE contents of 1.23 and 1.35%, respectively.

Vegetations found in this study had EE contents equaled to those of prime grasses including *elephant* grass (*P. purpuperum*) and *king* grass (*P. purpureophoides*) preserved in the form of hay and silage. *Elephant* grass hay and silage had EE contents of 1.9 and 2.6%, respectively while those of king grass had EE contents of 1.6 and 2.4%, respectively (Santoso and Hariadi, 2008; Ukpabi et al., 2015). EE contents of some species of ruminant roughages were found to be about 1.2–4.1% (Ahmed et al., 2013). Dominant swamp roughages including Kumpai minyak (*H. amplexicaulis*) and Kumpai padi *(O. rupifogon)* had EE contents of 2.82 and 2.49%, respectively and they were palatable and potential to be used as feed for Pampangan buffaloes.

Ash Contents

Ash contents of green vegetations in lowland swamp ranged from 5.63 to 25.19%. Four types of vegetations with the highest ash contents included Kasuran (*C. digitatus*) (25.19%), Mutiara legume (*S. exasperata*) (19.47%), Kumpai minyak (*H. amplexicaulis*) (16.26%), and Kumpai padi (*O. rupifogon* ^{P}) (16.25%). Meanwhile, Bento rayap *(L. hexandra)* was found to have the lowest ash content of 5.63% (Table 2). Ash contents of vegetations found in this study were higher than those of swamp vegetations in South Kalimantan of 2.18- 3.28% during high tidal season and 3.23-9.83% during low tidal season (Rostini et al., 2014). *Elephant* grass (*P. purpureum*) was indicated to have varied ash contents of 4.4% (Dahlan and Iskandar, 2013), 0.95-1.1% (Ukpabi et al., 2015), 9.59% (Nuhuyanan, 2010), and 18% (Araica et al., 2009). Meanwhile, the ash content of grasses in lowland areas ranged from 6.32 to 8.91% (Richmond et al., 2015; Mako et al., 2016; Norman et al., 2013; Maswada et al., 2013). Alam *et al.* (2015) found that *B. mutica* had an ash content of 4.20-4.89% and rice straw had 6.63%.

Roughages were found to have average ash contents of 7.28% in a pasture for buffaloes in Pulau Moa (Eoh, 2014), 9.82–10.14% in Lore Utara, Poso Regency (Damry, 2009), 11.51% in a pasture during the rainy season until the end of dry season in Sabana Timur Barat (Manu, 2013), and 8.11 and 8.22% in a natural pasture and a coffee plantation area, respectively (Kleden et al., 2015). Differences in these ash contents were suspected to be caused by differences in plant species (internal factor) and environmental differences, particularly seasonal differences (external factor). In a dry season, pH levels in lowland swamp areas were found to be 3.9-4.8 causing a decreased supply of nutrients, especially total N and K, to the soil. This decreased supply of nutrients led to lowered nutrients contained in plants (Rostini et al., 2014). This was in line with what was stated by Gutteridge and Shelton (1994) that nutrient content in plants was affected by soil nutrient content. In addition, in acidic soil condition, activities of Fe, Al, and Mn increased which might cause in toxicity in plants (Tjondronegoro and Gunawan).

NDF and ADF Contents

Neutral Detergent Fiber (NDF) depicts plant cell walls consisting of hemicellulose, cellulose, and lignin. NDF is part of fiber which is not dissolved in neutral detergent representing the component of fiber undissolved in plant cell wall materials. NDF content of a feed affects the ability of ruminant animals to consume feed. Acid Detergent Fiber (ADF) represents parts of plant cell wall bond to cellulose and lignin. ADF content is related to energy content and higher ADF content results in lowered digestible energy content (Van Soest, 1982).

The NDF and ADF contents of vegetations found in this study were about 40.65–79.47% and 23.66–60.33%, respectively. Lowest NDF contents were found in Cecengkehan (*L. hyssopifolia*) (40.65%), Kangkung merah (*I. aquatica*) (41.40%), Telepuk gajah (*N. lotus*) (46.05%), and Tapak dara (*C. roseus*) (47.79%). In contrast, highest NDF content of 79.47% was found in Bento rayap (*L. hexandra*). Lowest ADF contents were found in Telepuk gajah (*N. lotus*) (46.05%), Kangkung merah *(I. aquatica)* (26.17%), Kumpai merah (*Hymenachne sp*) (28.40%), Cecengkehan (*L. hyssopifolia*) (32.91%). Meanwhile, the highest ADF content of 60.33% was found in Kumpai padi *(O. rupifogon* ^{P}*)* (Table 3). NDF and ADF contents of vegetations found in this study were lower than those of Asep et al. (2012) who reported that the NDF contents of swamp green vegetations in a pasture for buffaloes were about 91.73–93.45% in grasses and 68.11–90.93% in legumes and the ADF content of grasses was 51.6-86.8%. it was shown in other studies that NDF and ADF contents of roughages in a pasture during the rainy season to the end of the dry season in Sabana Timur Barat were on average 65.9 and 43.29%, respectively (Manu, 2013). Vegetations in a natural pasture and a coffee plantation area had NDF contents of 74.89 and 72.37% and ADF contents of 57.22 and 55.15%, respectively (Kleden et al., 2015). Meanwhile, swamp vegetations in South Kalimantan had average NDF and ADF contents of 55.97 and 37.87%, respectively, during high tidal season and 81.44 and 60.86% respectively, during low tidal season (Rostini et al., 2014).

NDF and ADF contents of roughages in BPTU-HPT Padang Mengatas area were found to be 75.62 and 45.96%, respectively in rain season and 69.35 and 38.66%, respectively in dry season (Muhajirin et al., 2017). NDF and ADF contents of Eceng gondok (*E. crassipes* in this study were 62.77 and 41.83%, respectively. These figures were close to those of *water hyacinth* (*E.crassipes*) plants studied by Tham (2015) with NDF and ADF contents of 63.9 and 34.68% and by Tham and Uden (2015) with NDF and ADF contents of 52.1 and 30.7%, respectively. Other studies conducted by Ahmed et al. (2016), Anitha et al. (2016), and Nampoothiri (2017) showed that *Azolla sp* had NDF and ADF contents of 53.8-54.85% and 36.57-37.0%, respectively. Meanwhile, NDF and ADF contents of *elephant* grass (*P. purpureum*) were found to be 55.8 and 46.5% (Dahlan and Iskandar, 2013) and 84.25 and 64.07% (Nuhuyanan, 2010), respectively. These figures equaled to the NDF and ADF contents of Kumpai tembaga (64.72 and 46.38%), Kumpai minyak (65.31 and 38.92), and Are bolong (61.27 and 48.46%). This indicated that, lowland swamp vegetations had fiber fraction nutritional quality which was not less than that of prime grasses including *elephant* grass and *king* grass.

In this study, NDF and ADF contents of lowland swamp vegetations were 40.65– 79.47% and 23.66%–60.33%, respectively. These figures were still within the ranges of NDF and ADF contents of prime grasses such as *elephant* grass (*P. purpureum*) which had NDF and ADF contents of 55.8 and 46.5% (Dahlan and Iskandar, 2013) and 84.25 and 64.07% (Nuhuyanan, 2010), respectively. In rumen, NDF degradation is higher than that of ADF as NDF contains hemicellulose fraction which is more soluble (Church and Pond, 1986). NDF content has a negative correlation with its degradation rate (Varga et al., 1983) and higher NDF content decreases dry matter digestibility of feed (NRC, 1988). Cellulose is an ADF component which is easy to digest while lignin is hard to digest as it contains double bonds. Higher lignin content decreases feed digestibility (Sutardi et al., 1980).

Hemicellulose and Cellulose Contents

Lowland swamp vegetations were found to have hemicellulose and cellulose contents ranging from 7.73 to 37.14% and 5.24 to 27.08%, respectively. Four green vegetations with highest hemicellulose contents were Bento rayap (*L. hexandra*) (37.14%), Kerak maling (*D. fuscescens*) (31.87%), Kumpai merah (*Hymenachne sp.*) (31.74%), and Kumpai minyak (*H. amplexicaulis*) (26.39%). In contrast, lowest hemicellulose content was found in Cecengkehan (*L. hyssopifolia*) (7.73%). Highest cellulose contents were found in Kemon air (*N. olerancia*) (27.08%), Bento rayap (*L. hexandra*) (25.88%), Purun tikus (*E. dulcis*) (21.80%), and Are bolong (*P. barbatum*) (20,28%). Meanwhile, Kasuran (*C.digitatus*) had the lowest cellulose content of 5.24% (Table 3). Results of this study were in line with those of a study conducted by Asep et al. (2012) who reported the hemicellulose and cellulose contents of lowland swamp green vegetations ranging from 7.89 to 31.55% and 30.85 to 63.35%, respectively. They also found that Kumpai padi (*O.rupifogon*) had 31.55% hemicellulose content which was higher than those of Kumpai padi (10.80- 19.30%) found in this study (Table 4). Swamp vegetations in South Kalimantan had hemicellulose contents of 0.65-25.85% in high tidal season and 5.37-40.09% in low tidal season. Cellulose contents in high and low tidal seasons were about 20.07-34.03% and 7.90- 38.31%, respectively (Rostini et al., 2014). Various water plants including Azolla, which was used as animal feed, had hemicellulose and cellulose contents of 10.20 and 12.76% (Nampoothiri, 2017), 1.15-10.20% and 12.76% (Nampoothiri, 2017), respectively. Roughages in BPTU-HPT Padang Mengatas had hemicellulose and cellulose contents of 29.79 and 33.62% in rain season and 30.69 and 31.64% in dry season, respectively (Muhajirin et al., 2017). *Elephant* grass (*P. perpureum*) was found to contain 21.18% hemicellulose and 43.32% cellulose (Nuhuyanan, 2010) and 35.3% cellulose (Dahlan and Iskandar, 2013). In a study conducted by Archimede et al. (2010), hay was found to have 37.7% hemicellulose and 35.7% cellulose. Based on the above findings, it was suggested that hemicellulose (7.73– 37.14%) and cellulose (5.24–27.08%) contents of lowland swamp vegetations in this study were within normal ranges and these vegetations were potential to be used as feed for Pampangan buffaloes.

Lignin Contents

Lignin contents of lowland swamp vegetations ranged from 14.84 to 43.09%. Four vegetations including Telepuk gajah (*N. lotus*), Kemon air (*N. olerancia*), Kumpai merah (*Hymenachne sp.*), and Kangkung merah (*I. aquatica*) were found to have the lowest lignin contents of 14.84, 18.36, 19.76, and 19.85%, respectively, while the highest lignin content of 43.09% was found in Kumpai padi (*O. rupifogon* ^{P}) (Table 3). Lignin contents in this study were higher than that obtained by Rostini et al. (2014) who reported the lignin contents of swamp vegetations in South Kalimantan were about 2.8-17.59% in high tidal season with that of Kumpai minyak as the lowest and that of *Beberasan* as the highest and 10.06-61.12% in low tidal season with that of *Beberasan* as the lowest and that of Kumpai minyak as the highest. Lignin contents of Kumpai padi (*O. rupifogon* ^{R}) (31.24%) and Kumpai padi (*O. rupifogon* ^{P}) (43.09%), Bento rayap *(L. hexandra)* (33.92%), and Eceng gondok *(E. crassipes)* (31.60%) (Table 3) found in this study were higher those of Kumpai padi (18.27%) and Bento rayap *(L. hexandra)* (17.96%) found by Asep et al. (2012) and Eceng gondok *(E. crassipes)* (8.17%) found by Tham (2015). In other studies *Azolla* was found to have lignin contents of 5.7% (Ahmed et al., 2016) and 28.24% (Nampoothiri, 2017). Meanwhile, lignin contents of *elephant* grass were found to be 15.37% (Nuhuyanan, 2010) and 11.2% (Dahlan and Iskandar, 2013).

Differences in lignin contents in green vegetations are suspected to be caused by differences in plant species, plant ages, and environmental factors including seasons (rain or dry season), tidal seasons, and fertility levels of the soil where the vegetations grow. In cell walls, cellulose is bond with hemicellulose and lignin. Lignin cannot be digested by the animals and its atomic proportion is different from other carbohydrates as it contains carbon and nitrogen of only 1-5%. Hemicellulose consists of pentose, hexose, uronic acid, and pectin substance. Pectin is a carbohydrate which is composed of aronic acid, galactose, arabinose, xylose, and methanol. Cellulose is degradable by microorganisms and functions as the source of volatile fatty acids. Young grasses (roughages) contain less than 5% lignin and 80% of their cellulose is degradable. On the contrary, in old roughages, lignin content may reach up to 10% causing a decrease in cellulose digestibility by up to 50% (Prawirokusumo, 1994).

Based on the results of the study, it was concluded that:

1. The highest protein (20.56%) and crude fat (2.92%) contents were found in Kemon air *(Neptunia olerancia)*. The highest ash content (25.19%) was found in Kasuran *(C. digitatus)* while the lowest (11.01%) was found in Cecengkehan *(L. hyssopifolia)*. The lowest NDF content (40.64%) was found in Cecengkehan *(L. hyssopifolia)* and the

highest hemicellulose content (37.14%) was found in Bento rayap. Telepuk gajah had the lowest ADF (23.66%) and lignin (14,84%) contents. Kemon air contained the highest cellulose level of 27.08%.

2. The best nutritional values were found in Kasuran *(C. digitatus)* and Cecengkehan *(L. hyssopifolia)*.
3. Dominant and palatable swamp roughages with good nutrient contents included Kumpai tembaga *(H. acutigluma)*, Kumpai minyak *(H. amplexicaulis)*, Kumpai padi *(O. rupifogon)*, Are bolong *(P. barbatum)*, and Purun tikus *(E. dulcis)*.

ACKNOWLEDGEMENTS

The author expresses his deepest gratitude to the Rector of Sriwijaya University through the Chair of the Institute for Research and Community Services funding this research in accordance with the Competitive Leading Research Contract of Sriwijaya University Number: 988 / UN9.3.1 / PP / 2017, dated 21 July 2017.

REFERENCES

Ahmed HA, Ganai A.M, Beigh YA, Sheikh GG, Reshi PA. 2016. Performance of growing sheep on *Azolla* based diets. Indian J. Anim. Res. 50 (5): 721-724.

Alam MR, Haque MM, Sumi KR, Ali MM. 2015. Proximate composition of para-grass *(Brachiaria mutica)* produced in integrated fish-fodder culture system. Bang. J. Anim. Sci. 44 (2): 113-119.

Ali AIM, Sandi S, Muhakka, Riswandi. 2012. Kualitas hijauan pakan di rawa lebak padang penggembalaan kerbau pampangan. Prosiding InSINAS 2012. 307-312.

Anitha KC, Rajeshwari YB, Prasanna SB, Shree JS. 2016. Nutritive evaluation of azolla as livestock. Journal of Experimental Biology and Agricultural Sciences. 4(6): 670-674.

AOAC (Association of Official Analytical Chemists). 1990. Official Methods of Analysis. 15th ed., Washington, DC.

Araica BM, Sporndly E, Sanchez NR, Norell L, Sporndly R. 2009. Silage quality when Moringa oleifera is ensiled in mixtures with elephant grass, sugar cane and molasses. Grass and Forage Science. 64: 364-373.

Archimede H, Gonzales-Garcia E, Despois P, Etienne T, Alexandre G. 2010. Subtitution of corn and soybean with green banana fruits and Gliricidia sepium forage in sheep fed hay-based diets: effects on intake, digestion and growth. Journal of Animal Physiology and Animal Nutrition. 94 (2010): 118-128.

Brazle FK, Kilgore GI, Fauzett MR. 2000. Effect of season on grazing native-grass pastures. The Profesional Animal Scientist. 16: 15-28.

BPS (Badan Pusat Statistik). 2010. Direktorat Jendral Tanaman Pangan. *Luas lahan rawa di Indonesia*. Departemen Pertanian. Jakarta.

BPS (Badan Pusat Statistik) Provinsi Sumatera Selatan. 2014. Sumatera Selatan dalam Angka 2014.

Church DC, Pond WG. 1986. Digestive Animal Physiologi and Nutrition. 2nd. Prentice Hell a Devision of Simon and Schuster Englewood Clief, New York.

Dahlan I, Iskandar MNZ. 2013. Use of plantain peels (Musa paradisiaca) as a fibrous feed substitute for napier grass (Pennisetum purpureum) in rusa deer (Cervus timorensis ratio under captivity. J. Anim. Sci. 3 (9): 472-480.

Damry. 2009. Produksi dan kandungan nutrisi hijauan padang penggembalaan alam di Kecamatan Lore Utara Kabupaten Poso. Jurnal Agroland. 16 (4): 296-300.

Eoh M. 2014. Kapasitas tampung dan komposisi zat-zat makanan padang penggembalaan ternak kerabau di Pulau Moa. Agrinimal. 4 (2): 77-82.

Gutteridge RC, Shelton HM. 1994. The Role of Forage Tree Legumes in Cropping and Grazing System. The Tropical Grassland Society of Australia Inc.

Hossain MdE, Sikder H, Kabir MdH, Sarma SM. 2015. Nutritive value of water hyacinth *(Eichhornia crassipes).* Online Journal of Animal and Feed Research. 5 (2): 40-44.

Kathirvelan C, Banupriya S, Purushothaman MR. 2015. Azolla-an alternate and su tainable feed for livestock. International Journal of Science Environment. 4 (4): 1153-1157.

Kleden MM, Ratu MRD, Randu MDS. 2015. Kapasitas tampung hijauan pakan dalam areal perkebunan kopi dan padang rumput alam di Kabupaten Flores Timur Nusa Tenggara Timur. Jurnal Zootek 35 (2): 340-350.

Mako AA, Akinwande VO, Anurudu NF, Ogunwole OA. 2016. Evaluation of nutritive value of water hyacinth *(Eichhornia crassipes)* and guinea grass *(Panicum maximum)* mixture as animal feed in the tropics. 2016. Bull. Anim. Hlth. Prod. Afr. (64): 463-473.

Manu AE. 2013. Produktivitas padang penggembalaan sabana Timor Barat. Jurnal Pastura. 3 (1): 25-29.

Maswada HF, Elzaawely AA. 2013. Nutritive value of Stipagrostis lanata (Forssk.) de winder as a feed for livestock. Asian Journal of Crop Sciences. 5 (2): 216-221.

Muhakka, Suwignyo RA, Budianta D dan Yakup. 2019. Vegetation analysis of no-tidal swampland in South Sumatra, Indonesia and its carrying capacity for Pampangan buffalo pasture. Journal Biodiversitas. 20 (4): 1077-1086.

Muhakka, Wijaya A, Ammar M. 2015. Nutritional dried matter, crude protein and crude fiber on lowland tidal grass fermented by probiotic microorganisms for use bali cattle feed. Journal Animal Production. 17 (1): 24-29.

Muhajirin, Despal, Khalil. 2017. Pemenuhan kebutuhan nutrien sapi potong bibit yang digembalakan di Padang Mengatas. Buletin Makanan Ternak.104 (1): 9-20.

Mulyani A, Sarwani M. 2013. Karakteristik dan potensi lahan sub optimal untuk pengembangan pertanian di Indonesia. Jurnal Sumber daya Lahan. 7 (1): 47-55.

Nampoothiri VM. 2017. Aquatic plants and marine waste as animal feed. Sch.J. Agric.Vet. Sci. 4 (6): 249-254.

Norman HC, Master DG, Barrentt-Lennard EG. 2013. Halophytes as forage in saline landscapes: Interaction between plant genotipe and environment change their feeding value to ruminants. Environmental and Experimental Botany. 92 (2013): 96-109.

NRC. 1988. Nutrition Reguirement of Beef Cattle. 6th. Rev. Ed. National.

Nuhuyanan LE. 2010. Pengaruh pemberian wafer rumput gajah dengan perekat fermented moter liquor (FML) dan tetes (molasses) terhadap konsumsi pakan, kecernaan zat-zat makanan dan kenaikan berat badan sapi bali jantan. Jurnal Ilmu Peternakan. 5 (2): 111-117.

Prawirokusumo S. 1994. Ilmu Gizi Komperatif. BPFE., Yogyakarta.

Rahman MM, Abdullah RB, Wan Khadijah WE, Nakagawa T, Akashi R. 2014. Feed intake and growth performance of goats affered napier grass *(Pennisetum purpureum)* supplemented with concentrate pellet and soya waste. Sain Malaysiana. 43 (7): 967-971.

Richmond AS, Wylie ARG, Laidlaw AS, Lively FO. 2015. Methane emissions from beef cattle grazing on semi-natural upland and improved lowland grasslands. Animal. 9 (1): 130-137.
Rostini T, Abdullah L, Wiryawan KG, Karti PDMH. (2014). Production and nutrition potency of swamp local forage in South Kalimantan as ruminant feed. Glob. J. Anim. Sci. Livestock Prod. Anim. Breed. 2 (2):107-113.
Santoso dan Hariadi BTj. 2008. Komposisi kimia, degradasi nutrien dan produksi gas metana in vitro rumput tropika yang diawetkan dengan metode silase dan hay. Media Peternakan 31(2): 128-137.
Se'u VE, Karti PDMH, Abdullah L. 2015. Botanical composition, grass production, and carrying capacity of pasture in Timor Tengah Selatan District. Journal Media Peternakan 38(3):176-182.
Statistik Peternakan Sumatera Selatan. 2014. Dinas Peternakan Provinsi Sumatera Selatan Tahun Anggaran 2015.hal:14.
Sutardi T, Pratiwi SH, Adnan A, Nuraini S. 1980. Peningkatan pemanfaatan jerami padi melalui hidrolisa basa, suplementasi urea dan belarang. Bull. Makanan Ternak. 6 Bogor.
Tham HoT. 2015. Utilisation of water hyacinth as animal feed. Nova Journal of Engineering and Applied Sciences. 4 (1): 1-6.
Tham HoT, Uden P. 2015. Effect of fresh water Hyacinth (Eichhornia crassipes) on intake and digestibility in cattle fed rice straw and molasses-urea cake. Nova Journal of Engineering and Applied Sciences. 4(1): 1-8.
Tjondronegoro AD, Gunawan A. 2000. Beberapa jenis gulma di lahan pasang surut pada tingkat kemasaman tanah yang berbeda. Prosiding Seminar Nasional. P. 247-254.
Van Soest PJ. 1982. Nutritional Ecology of the Ruminant: Ruminant Metabolism, Nutritional Stategies the Cellulolytic Fermentation and the Camisthy of Forages and Palm Fiber. Cornell University O & B Books Inc. USA.
Varga GA, Hoover WH. 1983. Rate and extent of NDF of feedstuff in-situ. J. Dairy. Sci. 66:2109.

2. Bukti konfirmasi review dan hasil review pertama (17 Desember 2019)

Notifications

[biodiv] Editor Decision

2019-12-17 11:19 PM

Muhakka Muhakka Muhakka:

We have reached a decision regarding your submission to Biodiversitas Journal of Biological Diversity, "Nutritional Values of Swamp Grasses as Feed for Pampangan Buffaloes in South Sumatra Indonesia ".

Our decision is: Revisions Required

Smujo Editors
editors@smujo.id

Reviewer A:

Line 16. **Abbreviations** (if any): All important abbreviations must be defined at their first mention there. Ensure consistency of abbreviations throughout the article.

Line 30. Is heads the common terms ?

Line 42. From which swamp ? since on the next sentence you said there are more swamp to be characterized, you should add more information for the audience and to build an argument that further study need to be conducted

Line 43. ?? species name ?

Line 43. However, many more swamp : Many more swamp area or many more swamp vegetation ? (related to the previous comment)

Line 44. Also related with the previous comment, you have to give information what differentiate this study to the previous study

Line 54. Weighed daily ? hourly ? to check the constant weight

Line 71. acidtwo ?

Line 87. All important abbreviations must be defined at their first mention

Line 95. and all the formula, Be consistent, a or *a*

Line 117. Analysis of soil in the study site didn't mention in the method part

Line 124. For the results follow the flow of the methods, first you should describe the vegetation of the study area you have sampled, how may type of vegetation, etc

Line 128. Source here is the laboratory conducting the analysis ? in that case you should have mentioned on the method part that for the analysis of ...... conducted at laboratory ....

Line 143. figure 2 and the decription of the vegetation sampled should be placed at the beginning of results

Line 167. This is where you should add the soil analysis (if you not going to put anything on the methods)

Line 321. Atomic proportion ? or molecule structure ?

Line 342. Names of journals should be abbreviated. Always use the standard abbreviation of a journal's name according to the ISSN List of Title Word Abbreviations (www.issn.org/2-22661-LTWA-online.php).

Recommendation: Revisions Required

Nutritional values of swamp grasses as feed for Pampangan Buffaloes in South Sumatra Indonesia

Abstract. This study was aimed at determining the types and quality of vegetations in the swamp area, which could be used as sources of roughage for Pampangan buffaloes in South Sumatera. In this descriptive study. Results showed that~~,~~ the highest crude protein and ether extract contents, 20.56 and 2.92%, respectively, were found in Kemon air *(N.olerancia)*. The highest ash content of 25.19% was found in Kasuran *(C.digitatus)*. The lowest fiber content (11.01%) was found in Cecengkehan *(L.hyssopifolia)*, which also had the lowest content of NDF (40.64%). Hemicellulose content was found to be highest (37.14%) in Bento rayap *(L.hexandra)*. The lowest ADF (23.66%) and lignin (14,84%) contents were found in Telepuk gajah *(N.lotus)*. Kemon air *(N.olerancia)* was found to have the lowest content (27.08%) of cellulose. It was concluded that the swamp vegetation~~s~~ found in this study consisted of 17 types of grasses (89.47%) and ~~2~~ two types of legumes (10.53%). Kasuran *(C.digitatus)* and Cecengkehan *(L.hyssopifolia)* were found to have the best nutritional values. Dominant and palatable vegetations with good nutritional values, which were potential to be used as sources of roughage for *Pampangan* buffaloes, were Kumpai tembaga *(H.acutigluma)*, Kumpai padi *(O.rupifogon)*, Kumpai minyak *(H. amplexicaulis)*, Are bolong *(P.barbatum)*, and Purun tikus *(E.dulcis)*.

Key words: Nutritional value, Swamp grass, Feed, Pampangan buffalo.

INTRODUCTION

The availability of roughage as the main feed for ruminant animals depends considerably on seasons. During the rainy season, it is abundant, and during the dry season, the availability of grasses and legumes is lacking. ~~Limited~~ The limited supply of roughage may hamper productivity including the reproductive performance of ruminant animals including buffaloes.

In South Sumatera, Pampangan buffalo is a ~~a~~ potential germplasm which needs to be preserved and developed. There were 37,405 heads of Pampangan buffaloes in 2016, and this population increased by 3.97% to 38,952 heads in 2017. In 2017, of this population, 11,150 heads (28.63%) and 2,227 heads (5.72%) were found in Ogan Komering Ilir Regency and Banyuasin Regency, respectively (Statistik Peternakan Sumsel, 2017). The population and productivity of *Pampangan* buffaloes need to be improved, and for this purpose, feed is an important factor to consider. Pampangan buffaloes feed mostly on roughage from the swamp ~~and/or~~, grassland to meet their maintenance and reproductive needs.

In Indonesia, there are 13.27 million hectares of lowland swamp areas. Only 4 million hectares of these areas ~~has~~ have been developed and cultivated by the community and private sectors (2.6 million hectares) and the government assistance (1.3 million hectares) (BPS, 2010, Mulyani and Sarwani, 2013). In Sumatera, the largest lowland swamp area of 2.98 million hectares is found in South Sumatera, but only 298,189 hectares of it ~~has~~ have been utilized (BPS Sumatera Selatan, 2014). In order to utilize the potential swamp area as a feed source for Pampangan buffaloes, a study on vegetations as sources of roughage in lowland swamp areas that include vegetation identification and nutritional quality determination needs to be conducted.

In the previous study, some swamp grasses, including Kumpai minyak grass (*H. amplexicaulis)* (Rostini et al., 2014**;** Muhakka et al., 2015), *I*, ~~*rugosum*~~ , and *L. hexandra* (Ali et al., 2012) were identified. However, many more swamp ~~vegetations~~ haves not been identified. This study was conducted to identify the types and nutritional values of vegetations that could be used as sources of roughage feed for Pampangan buffaloes in South Sumatera. This information was important to support the productivity improvement of Pampangan buffaloes as ~~a~~ germplasm in South Sumatera.

MATERIALS AND METHODS

This study was a descriptive study to assess the types and nutritional values of vegetations, which were the dominant and palatable as sources of roughage feed for Pampangan buffaloes. Vegetation samples were taken from grazing areas of

Formatted: English (United States)

Formatted: English (United States)

Formatted: English (United States)

Formatted: English (United States)

Formatted: English (United States)

Formatted: English (United States)

Formatted: English (United States)

Commented [A1]: Abbreviation

Formatted: English (United States)

Formatted: English (United States)

Formatted: English (United States)

Formatted: English (United States)

Formatted: English (United States)

Formatted: English (United States)

Commented [A2]: Is heads the common terms ?

Formatted: English (United States)

Formatted: English (United States)

Commented [A3]: ?? species name ?

Commented [A4]: From which swamp ? since on the next sentence you said there are more swamp to be characterized, you should add more information for the audience and to build an argument that further study need to be conducted

Commented [A5]: Many more swamp area or many more swamp vegetation ? (related to the previous comment)

Formatted: English (United States), Highlight

Formatted: English (United States)

Formatted: English (United States), Highlight

Formatted: English (United States)

Formatted: English (United States)

Formatted: English (United States)

Commented [A6]: Also related with the previous comment, you have to give information what differentiate this study to the previous study

Formatted: English (United States)

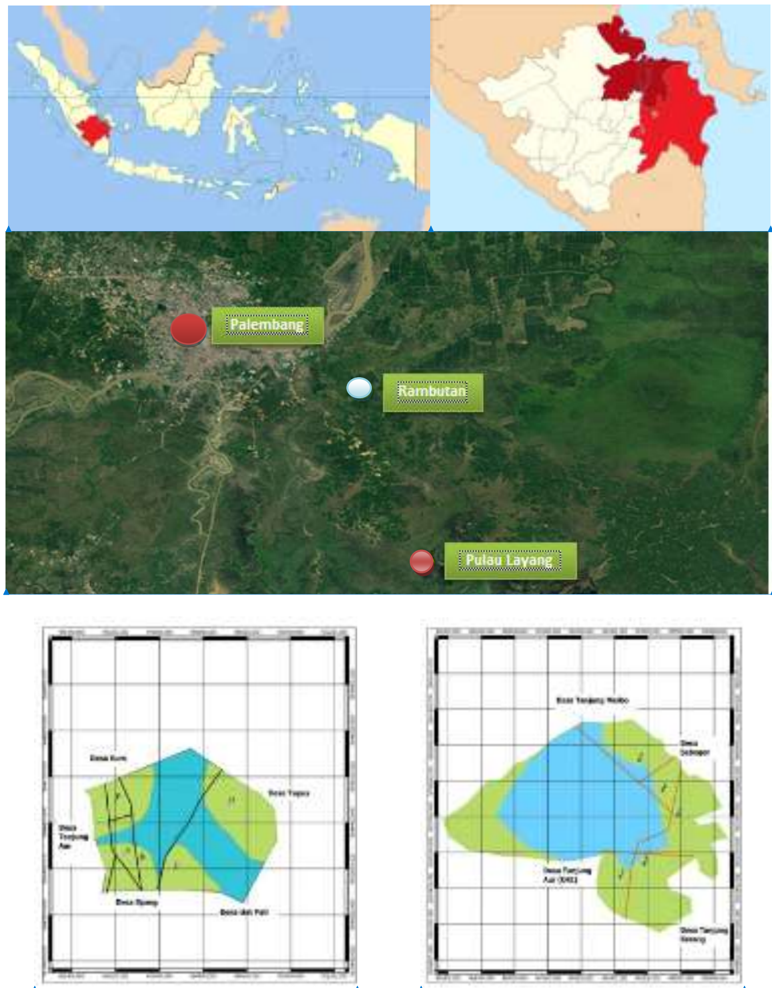
Formatted: English (United States)

Formatted: English (United States)

Formatted: English (United States)

Formatted: English (United States)

Pampangan buffaloes in Rambutan Village and Pulau Layang Village, South Sumatra, from April to Juni 2017. Vegetation samples for nutrient analysis were obtained by following these procedures: (1) vegetation collection was done based on estimated growth age (young age, medium age, and old age based on physical appearance), (2) collected samples of each vegetation was composited, and (3) samples were chopped into small sizes, homogenized. For each vegetation, 1 kg sample was taken ~~by random~~randomly, and sent to the laboratory for oven drying at 105ºC until a constant weight was obtained and dry matter content was determined. Samples were then ground for nutrient content determination by using proximate and Van Soest analyses (Syarifuddin and Wahdi, 2010).



A B

Figure 1. Research location in South Sumatera, Indonesia, **A.** Pulau Layang Village, Pampangan Sub-district, Ogan Komering Ilir District, South Sumatra, **B.** Rambutan Village, Rambutan Sub-district, Banyuasin District, South Sumatra (Muhakka et al., 2019)

Measured parameters

Proximate Analysis

Crude protein, fiber, ether extract, and ash contents were determined based on the procedures of AOAC (1990).

Formatted: English (United States)
Formatted: English (United States)
Commented [A7]: Weighed daily ? hourly ? to check the constant weight
Formatted: English (United States)
Formatted: English (United States)
Formatted: English (United States)
Formatted: English (United States)
Formatted: English (United States)
Formatted: English (United States)
Formatted: English (United States)
Formatted: English (United States)
Formatted: English (United States)
Formatted: English (United States)
Formatted: English (United States)
Formatted: English (United States)
Formatted: English (United States)
Formatted: English (United States)
Formatted: English (United States)
Formatted: English (United States)
Formatted: English (United States)

1. *Crude Protein*. Nitrogen (N) content was determined by using a ~~Kjehdahl~~ Kjeldahl method. In this analysis, sulphuric acid with a catalyst and a heating process. The organic matter of samples was then oxidized by sulfuric acidtwo, and nitrogen was changed into an ammonium sulfate form. The remaining sulfuric acid was neutralized by NaOH until the solution became basic. Ammonium ~~sulphate~~ sulfate was then distilled in an acid medium to obtain the quantitative amount of N. As the average protein contains 16% nitrogen, a factor 100~~%~~ %: 16% = 6.25 was used to obtain the value of crude protein (crude protein = N% x 6.25).
2. *Fiber*. ~~Filtered~~ The filtered fat-free sample was used in fiber content determination. 1.25% sulfuric acid solution was added into the sample, and the mixture was heated for about 30 minutes before the residue was filtered. 1,25% NaOH solution was added into the precipitate, and the mixture was heated for about 30 minutes. The mixture was then filtered, and the precipitate was washed, dried, and weighed. This precipitate was burnt, and the ash was weighed. The difference between the weight of precipitate before it was burnt and the weight of the ass was referred to as fiber content.
3. *Ether Extract*. ~~Dry~~ The dry matter sample was extracted with diethyl ether for 5 hours. ~~In~~ At the end of the extraction process, ether evaporated and the remaining material was referred to as fat.
4. *Ash*. The third part of the dry matter sample was weighed and burnt in a crucible at 550ºC for 8 hours.

Van Soest Analysis

NDF, ADF, hemicellulose, cellulose, and lignin contents were determined by using a Van Soest method (1982).

1. Neutral Detergent Fiber (NDF). *a* gram of sample was put in a beaker glass. 50 ml NDS solution was added into the beaker before the mixture was heated for an hour. The mixture was then filtered by using a vacuum pump and a filter glass which was previously weighed (*b* gram). The mixture was then washed with hot water and acetone before it was dried in an oven and let cool in a desiccator. Finally, it was weighed as *c* gram. NDF content was calculated by using the following formula:

$$\%\ NDF = \frac{c - b}{a} \times 100\%$$

2. Acid Detergent Fiber (ADF). *a* gram of sample was put in a beaker glass. 50 ml ADS solution was added into the beaker before the mixture was heated for an hour. The mixture was then filtered by using a vacuum pump and a sintered glass filter which was previously weighed (*b* gram). The mixture was then washed with hot water and acetone before it was dried in an oven and let cool in a desiccator. Finally, it was weighed as *c* gram. Cellulose content was calculated by using the following formula:

$$\%\ cellulose = \frac{c - d}{a} \times 100\%$$

4. Hemicellulose. Hemicellulose content was calculated as a difference between NDF and ADF contents as follows.

% Hemicellulose = % NDF - % ADF

5. Lignin. Cellulose residue (*d* gram) was burnt in a furnace at 500-600ºC for 3 hours. After that, it was left to cool and weighed (*e* gram). Lignin content was calculated by using the following formula:

$$\%\ Lignin = \frac{d - e}{a} \times 100\%$$

Data Analysis

The data obtained were used directly to describe the nutritional value of the swamp vegetations that could be used as a roughage source. These data were then combined with those of *in vitro* digestibility as the basis for ~~drawing the conclusion~~concluding (Syarifuddin and Wahdi, 2010).

RESULTS AND DISCUSSION

Results

Results of soil analysis showed that soil at the study site had a low fertility level and was highly acidic. It also had very high organic C and total N contents, medium level of exchangeable-K and N contents, very low Ca and Mg contents, medium P content, and very high CEC level (Table 1).

Table 1. Properties of soil at the study site

	Pulau Layang		*Rambutan*	
Parameter	**Value**	**Remark**	**Value**	**Remark**

Commented [A8]: ??

Formatted: English (United States)

Formatted: English (United States)

Commented [A9]: All important abbreviations must be defined at their first mention

Formatted: English (United States)

Formatted: English (United States)

Formatted: English (United States)

Commented [A10]: Be consistant, a or *a*

Formatted: English (United States)

Formatted: English (United States)

Formatted: English (United States)

Formatted: English (United States)

Formatted: English (United States)

Formatted: English (United States)

Formatted: English (United States)

Formatted: English (United States)

pH H_2O (1 : 1)	5.10	Low	4.41	Very low
pH KCl (1 : 1)	4.39	Very acidic	3.99	Very acidic
Organic C (g/kg)	57.66	Very high	36.14	Very high
Total N (g/kg)	3.64	Very high	2.19	Very high
Available P/Bray I (mg/kg)	11.70	Medium	2.25	Very low
Exchangeable K (cmol/kg)	0.63	Medium	0.45	Medium
Na (cmol/kg)	0.65	Medium	0.65	Medium
Ca (cmol/kg)	1.95	Very low	0.73	Very low
Mg (cmol/kg)	0.45	Very low	0.32	Very low
CEC (cmol/kg)	65.25	Very high	43.50	Very high
Exchangeable Al (cmol/kg)	1.84		2.37	
Exchangeable H (cmol/kg)	0.74		0.88	
Texture:				
Sand (%)	47.08		46.64	
Ash (%)	31.11		27.18	
Clay (%)	21.81		26.18	

Source: Laboratory of Soil Chemistry, Biology, and Fertility, Soil Department, Faculty of Agriculture, Sriwijaya University (2017).

Nutrient Contents of Lowland Swamp

Crude protein, fiber, ether extract, and ash nutrient contents of lowland swamp vegetations found in this study are listed in (Table 2).

Table 2. Crude protein, fiber, ether extract, and ash contents (%) of lowland swamp vegetations

Latin Name	Local Name	Crude Protein	Fiber	Ether Extract	Ash
Catharanthus roseus	Tapak dara	15.20	11.18	1.29	12.53
Cyperus digitatus	Kasuran	15.31	14.76	1.42	25.19
Digitaria fuscescens	Kerak Maling/Pasiran	12.00	15.64	1.24	16.26
Eichhornia crassipes	Eceng gondok	8.61	20.66	0.84	14.22
Eleocharis dulcis P	Purun tikus	8.22	25.72	0.48	15.13
Eleocharis dulcis R	Purun tikus	6.63	24.52	1.69	10.24
Hymenachne acutigluma) P	Kumpai Tembaga	6.86	30.26	2.22	7.88
Hymenachne acutigluma R	Kumpai Tembaga	10.96	23.73	1.77	10.30
Hymenachne amplexicaulis P	Kumpai Minyak	9.21	21.91	2.82	13.96
Hymenachne amplexicaulis R	Kumpai Minyak	12.00	15.64	1.24	16.26
Hymenachne sp	Kumpai Merah	8.52	21.20	1.30	12.88
Ipomoea aquatica	Kangkung merah	8.95	14.34	2.24	10.39
Leersia hexandra	Bento rayap	5.35	27.57	2.06	5.63
Ludwigia hyssopifolia	Cecengkehan	12.07	11.01	1.66	9.09
Neptunia olerancia	Kemon air	20.56	15.03	2.92	7.31
Nymphaea lotus	Telepuk Gajah	13.22	11.45	2.84	10.30
Oryza rupifogon P	Kumpai Padi	7.93	23.30	1.60	16.25
Oryza rupifogon R	Kumpai Padi	10.41	21.59	2.49	11.92
Polygonum barbatum	Are Bolong	7.53	16.60	1.57	8.40
Rhynchospora corymbosa	Berondong	5.26	22.27	1.48	14.84
Sesbania exasperata	Mutiara	18.27	11.22	1.86	19.47

Source: Laboratory of Dairy Nutrition, Department of Nutrition and Feed Technology, IPB (2017).
Notes: P : Grass in Pulau Layang Village; R : Grass in Rambutan Village.

The NDF and ADF contents of vegetations found in this study were about 40.65–79.47% and 23.66–60.33%, respectively. Lowland swamp vegetations were found to have hemicellulose and cellulose contents ranging from 7.73 to 37.14% and 5.24 to 27.08%, respectively. Lignin contents of lowland swamp vegetations ranged from 14.84 to 43.09% (Table 3).

Table 3. Composition of fiber fractions of green vegetations in lowland swamp: NDF, ADF, Hemicellulose, Cellulose, and Lignin (%).

Latin Name	NDF	ADF	Hemicellulose	Cellulose	Lignin
Catharanthus roseus	47.79	39.67	8.12	16.96	22.71
Cyperus digitatus	58.90	36.93	21.97	5.24	31.68
Digitaria fuscescens	65.43	33.56	31.87	12.11	21.45
Eichhornia crassipes	62.77	41.83	20.94	10.22	31.60
Eleocharis dulcis P	69.57	49.83	19.74	21.80	28.04
Eleocharis dulcis R	75.73	54.91	20.82	19.71	35.20
Hymenachne acutigluma P	75.89	50.60	25.29	12.25	38.34

Formatted: English (United States)

Formatted: English (United States)

Commented [A11]: Analysis of soil in the study site didn't mention in the method part

Formatted: English (United States)

Formatted: English (United States)

Commented [A12]: For the results follow the flow of the methods, first you should describe the vegetation of the study area you have sampled, how may type of vegetation, etc

Formatted: English (United States)

Formatted: English (United States)

Commented [A13]: Source here is the laboratory conducting the analysis ? in that case you should have mentioned on the method part that for the analysis of …… conducted at laboratory ……..

Formatted: English (United States)

Formatted: English (United States)

Hymenachne acutigluma R	64.72	46.38	18.34	16.01	30.37
Hymenachne amplexicaulis	65.31	38.92	26.39	8.29	30.63
Hymenachne sp	60.14	28.40	31.74	8.64	19.76
Ipomoea aquatica	41.40	26.17	15.23	6.32	19.85
Leersia hexandra	79.47	42.33	37.14	25.88	33.92
Ludwigia hyssopifolia	40.64	32.91	7.73	8.39	24.52
Neptunia olerancia	62.31	45.44	16.87	27.08	18.36
Nymphaea lotus	46.05	23.66	22.39	8.82	14.84
Oryza rupifogon P	71.13	60.33	10.80	17.23	43.09
Oryza rupifogon R	65.49	46.19	19.30	14.96	31.24
Polygonum barbatum	61.27	48.46	12.81	20.28	28.18
Rhynchospora corymbosa	65.29	44.64	20.65	16.08	28.56

Source: Biotechnology Assessment Laboratory, Center for Biotechnology Research, Indonesian Institute of Sciences (LIPI), Cibinong, Bogor (2017).

Notes: P : Grass in Pulau Layang Village; R : Grass in Rambutan Village.

Figure 2. Dominant and– palatable swamp roughages with good nutrient contents included. **A**. *Hymenachne acutigluma*, **B**. *Oryza rupifogon* **C**. *Hymenachne amplexicaulis*, **D**. *Polygonum barbatum*, and **E**. *Eleocharis dulcis*.

Discussion

Crude Protein Content

Results showed that the crude protein contents of swamp green vegetations ranged from 5.26% to 20.56% with the lowest value (5.26%) was found in Berondong grass (*R. corymbosa*) and the highest (20.56%) was found in Kemon air legume (*N. olerancia*). Kasuran grass (*C. digitatus*) had the highest crude protein content (15.31%) (Table 2). This high nutritional value of Kasuran grass was suspected as caused by the fact that most of this grass was found to grow in the area

Commented [A14]: Same as previous comment

Formatted: English (United States)

Formatted: English (United States)

Formatted: English (United States)

Formatted: English (United States)

Formatted: English (United States)

Formatted: English (United States)

Formatted: English (United States)

Formatted: English (United States)

Formatted: English (United States)

Commented [A15]: This and the decription of the vegetation sampled should be placed at the beginning of results

Formatted: English (United States)

Formatted: English (United States)

of buffalo pens where the soil was rich in organic matter. However, the growth of this grass was not dominant as it mostly occurred in rainy seasons.

Kumpai minyak (*H. amplexicaulis*), Kumpai padi (*O. rupifogon*), Kumpai tembaga (*H. acutigluma*), and Purun tikus (*E. dulcis*) were found as the dominant palatable grasses containing 12.00, 10.41, 10.96, and 8.22% crude protein, respectively. Results of this study were not too different from those obtained by Rostini et al. (2014), who reported that Kumpai minyak and Pipisangan had protein contents of 10.88 and 15.92%, respectively. Crude protein (CP) contents of these swamp grasses in Pulau Layang and Rambutan Villages were closed to those of prime grasses including 9.11-12.8% CP of *elephant* grass (*P. purpureum*) (Santos et al., 2013; Dahlan and Iskandar, 2013; Rahman et al., 2014), 12.4% CP of *elephant* grass hay, 11.1% CP of *elephant* grass silage, 11.4% CP of king grass hay, and 10.2% CP of king grass silage (Santoso and Hariadi, 2008). Other vegetations even had higher CP contents including Kumpai tembaga *(H. acutigluma)* with 10.96% CP, Tapak dara (*C. roseus*) 15.20%, Telepuk gajah (*N. lotus*) 13.22%, Cecengkehan (*L. hyssopifolia*) 12.07%, Kasuran *(C. digitatus*) 15.31%, and Kumpai minyak (*H. amplexicaulis)*[R] 12.0% (Table 2). CP contents of vegetations in this study were also higher than those of nature grasses found in coffee plantation areas (6.95%) and pastoral areas (6.65%) in Wulanggitang District, East Flores Regency as reported by Kleden et al. (2015). Meanwhile, CP content of grasses in lowlands was 8.41% (Rochana et al., 2016; Maswada and Elzaawely, 2013).

This high protein content was suspected to be caused by the fact that soil organic C and total N contents in the study site were also high, namely 36.14-57.66 and 2.19-3.64 $g.kg^{-1}$, respectively (Table 1). Soil organic C and total N contents affected protein content in plants. Four swamp grasses including Kasuran (*C. digitatus*), Tapak dara (*C. roseus*), Telepuk gajah (*N. lotus*), and Cecengkehan (*L. hyssopifolia*) and a legume, Kemon air (*N. olerancia*) were found to be the lowland swamp vegetations having the highest N contents of 15.31,15.20, 13.22, 12.07, and 20.56%, respectively.

Fiber Contents

Fiber contents of lowland swamp green vegetations ranged from 11.01 to 30.26%, with the lowest content found in Cecengkehan (*L. hyssopifolia*) and the highest in Kumpai tembaga *(H. acutigluma* [P]*)*. Four vegetations including *Cecengkehan* (*L. hyssopifolia*), Tapak dara (*C. roseus*), Mutiara legume (*S. exasperata*), and Telepuk gajah (*N. lotus*) were found to have the lowest fiber contents of 11.01, 11.18, 11.22, and 11.45%, respectively (Table 2). These results were almost similar to those found by Ali et al. (2012) who reported that the fiber contents of roughage in a pasture ranged from 7.20 to 34.98%. These researchers found that the fiber content of Bento rayap (*Leersia hexandra*) was 27.40% which was very close to that (27.57%) of the same vegetation in this study. Meanwhile, Rostini et al. (2014) reported that the fiber contents of swamp vegetation in South Kalimantan ranged from 14.84 to 29.35% with the lowest content found in Hadangan (*Paspalum sp*) and the highest in Dadangsit (*L. adscendens*). These figures were lower than those found by Kleden et al. (2015) who revealed that nature grasses in a coffee plantation area and ~~a~~ pasture in Wulanggitang, East Flores contained 34.57 and 35.59% of fiber. They also found that the lowest fiber content was found in *L. peploides* and the highest in *I. rugosum*. Fiber contents reported by Kleden et al. (2015) were higher ~~that~~ than the results reported by Ahmed *et al*. (2013) with a fiber content of 29.32% in *D. aegyptium* plants. A previous study showed that fermented *I. rugosum*, *H. amplexicaulis*, and *O. rifipogon* had fiber contents of 29.27, 29.57, and 33.07%, respectively (Muhakka et al., 2015).

The fiber content of Eceng gondok (*E. crassipes*) in this study (20.66%) was lower than those found by Hossain et al. (2015), Tham and Uder (2015), and Make et al. (2016). In addition, the fiber content of Eceng gondok (*E. crassipes*) in this study was lower than those of *Azolla*, another water plant, ranging from 13.19 to 16.54% (Kathirvelan et al., 2015; Anitha et al., 2016) and 9.25 to 13.25% (Ahmed et al., 2016). These fiber contents of *Azolla* equa~~l~~led to those of Cecengkehan (*L. hyssopifolia*) (11.01%), Tapak dara (*C. roseus*) (11.18%), Mutiara legume (*S. exasperata*) (11.22%), Telepuk gajah (*N. lotus*) 11.45%, and Kangkung merah (*I. aquatica*) (14.34%) found in this study. Fiber contents of swamp green vegetations found in this study indicated that they were potential to be used as feed for Pampangan buffaloes.

Ether extract contents

Lowland swamp vegetations in this study were found to have ether extract (EE) contents of about 0.48-2.92%. The lowest EE content was found in Purun tikus (*E. dulcis*) while the highest was found in Kemon air legume *(N. olerancia*). Four vegetations of lowland swamp including Telepuk gajah (*N. lotus*) (2.84% EE), Kumpai minyak (*H. amplexicaulis*) (2.82% EE), Kumpai padi (*O. rupifogon*) (2.49% EE), and Kangkung merah (*I. aquatica* Forsk) (2.24% EE) were revealed to have the highest ether extract contents (Table 2). Results of this study were lower than those found by Rostini et al. (2014), reporting about 0.61–3.67% of EE contents in swamp vegetations in South Kalimantan with the lowest found in Pipisangan (*L. hyssopifolia*) and the highest in Padi hiang (*O. rufigopon spotanea*). EE contents of lowland swamp vegetations were 1.40–1.91% for grasses and 1.36–2.95% for legumes (Asep et al., 2012) and those of grasses in a pasture for buffaloes in Pulau Moa were 1.95–2,41% (Eoh, 2014). In other studies, grasses in a natural pasture in North *Lore*, Poso Regency had EE contents of 2.12–2.34% (Damry, 2009) and those in Sabana Timur Barat pasture in the rainy season to the end of dry season had an average EE content of 1.91% (Manu, 2013). A study by Se'u et al. (2015) revealed an EE content of 1.07% in grasses in a pasture in Timor Tengah Selatan Regency. Another work by Kleden et al. (2015) showed that vegetations in a natural pasture and a coffee plantation area had EE contents of 1.23 and 1.35%, respectively.

Vegetations found in this study had EE contents equaled to those of prime grasses including *elephant* grass (*P. purpuperum*) and *king* grass (*P. purpureophoides*) preserved in the form of hay and silage. *Elephant* grass hay and silage

Commented [A16]: This is where you should add the soil analysis (if you not going to put anything on the methods)

Formatted: English (United States)

Formatted: English (United States)

had EE contents of 1.9 and 2.6%, respectively, while those of king grass had EE contents of 1.6 and 2.4%, respectively (Santoso and Hariadi, 2008; Ukpabi et al., 2015). EE contents of some species of ruminant roughages were found to be about 1.2–4.1% (Ahmed et al., 2013). Dominant swamp roughages including Kumpai minyak (*H.* ~~*amplexicaulis,*~~) and Kumpai padi *(O. rupifogon)* had EE contents of 2.82 and 2.49%, respectively and they were palatable and potential to be used as feed for Pampangan buffaloes.

Ash Contents

Ash contents of green vegetations in lowland swamp ranged from 5.63 to 25.19%. Four types of vegetations with the highest ash contents included Kasuran (*C. digitatus*) (25.19%), Mutiara legume (*S. exasperata*) (19.47%), Kumpai minyak (*H. amplexicaulis*) (16.26%), and Kumpai padi (*O. rupifogon* [P]) (16.25%). Meanwhile, Bento rayap *(L. hexandra)* was found to have the lowest ash content of 5.63% (Table 2). Ash contents of vegetations found in this study were higher than those of swamp vegetations in South Kalimantan of 2.18- 3.28% during the high tidal season and 3.23-9.83% during the low tidal season (Rostini et al., 2014). *Elephant* grass (*P. purpureum*) was indicated to have varied ash contents of 4.4% (Dahlan and Iskandar, 2013), 0.95-1.1% (Ukpabi et al., 2015), 9.59% (Nuhuyanan, 2010), and 18% (Araica et al., 2009). Meanwhile, the ash content of grasses in lowland areas ranged from 6.32 to 8.91% (Richmond et al., 2015; Mako et al., 2016; Norman et al., 2013; Maswada et al., 2013). Alam *et al.* (2015) found that *B. mutica* had an ash content of 4.20-4.89% and rice straw had 6.63%.

Roughages were found to have average ash contents of 7.28% in a pasture for buffaloes in Pulau Moa (Eoh, 2014), 9.82–10.14% in Lore Utara, Poso Regency (Damry, 2009), 11.51% in a pasture during the rainy season until the end of dry season in Sabana Timur Barat (Manu, 2013), and 8.11 and 8.22% in a natural pasture and a coffee plantation area, respectively (Kleden et al., 2015). Differences in these ash contents were suspected to be caused by differences in plant species (internal factor) and environmental differences, particularly seasonal differences (external factor). In a dry season, pH levels in lowland swamp areas were found to be 3.9-4.8, causing a decreased supply of nutrients, especially total N and K, to the soil. This decreased supply of nutrients led to lowered nutrients contained in plants (Rostini et al., 2014). This was in line with what was stated by Gutteridge and Shelton (1994) that nutrient content in plants was affected by soil nutrient content. In addition, in acidic soil conditions, activities of Fe, Al, and Mn increased which might cause ~~in~~ toxicity in plants (Tjondronegoro and Gunawan).

NDF and ADF Contents

Neutral Detergent Fiber (NDF) depicts plant cell walls consisting of hemicellulose, cellulose, and lignin. NDF is part of fiber which is not dissolved in neutral detergent representing the component of fiber undissolved in plant cell wall materials. NDF content of a feed affects the ability of ruminant animals to consume the feed. Acid Detergent Fiber (ADF) represents parts of the plant cell wall bond to cellulose and lignin. ADF content is related to energy content and higher ADF content results in lowered digestible energy content (Van Soest, 1982).

The NDF and ADF contents of vegetations found in this study were about 40.65–79.47% and 23.66–60.33%, respectively. Lowest NDF contents were found in Cecengkehan (*L. hyssopifolia*) (40.65%), Kangkung merah (*I. aquatica*) (41.40%), Telepuk gajah (*N. lotus*) (46.05%), and Tapak dara (*C. roseus*) (47.79%). In contrast, highest NDF content of 79.47% was found in Bento rayap (*L. hexandra*). Lowest ADF contents were found in Telepuk gajah (*N. lotus*) (46.05%), Kangkung merah *(I. aquatica)* (26.17%), Kumpai merah (*Hymenachne sp*) (28.40%), Cecengkehan (*L. hyssopifolia*) (32.91%). Meanwhile, the highest ADF content of 60.33% was found in Kumpai padi *(O. rupifogon* [P]*)* (Table 3). NDF and ADF contents of vegetations found in this study were lower than those of Asep et al. (2012) who reported that the NDF contents of swamp green vegetations in a pasture for buffaloes were about 91.73–93.45% in grasses and 68.11–90.93% in legumes and the ADF content of grasses was 51.6-86.8%. ~~i~~It was shown in other studies that NDF and ADF contents of roughages in a pasture during the rainy season to the end of the dry season in Sabana Timur Barat were on average 65.9 and 43.29%, respectively (Manu, 2013). Vegetations in a natural pasture and a coffee plantation area had NDF contents of 74.89 and 72.37% and ADF contents of 57.22 and 55.15%, respectively (Kleden et al., 2015). Meanwhile, swamp vegetations in South Kalimantan had average NDF and ADF contents of 55.97 and 37.87%, respectively, during the high tidal season and 81.44 and 60.86% respectively, during the low tidal season (Rostini et al., 2014).

NDF and ADF contents of roughages in the BPTU-HPT Padang Mengatas area were found to be 75.62 and 45.96%, respectively in the rain season and 69.35 and 38.66%, respectively in the dry season (Muhajirin et al., 2017). NDF and ADF contents of Eceng gondok (*E. crassipes* in this study were 62.77 and 41.83%, respectively. These figures were close to those of *water hyacinth* (*E.crassipes*) plants studied by Tham (2015) with NDF and ADF contents of 63.9 and 34.68% and by Tham and Uden (2015) with NDF and ADF contents of 52.1 and 30.7%, respectively. Other studies conducted by Ahmed et al. (2016), Anitha et al. (2016), and Nampoothiri (2017) showed that *Azolla sp* had NDF and ADF contents of 53.8-54.85% and 36.57-37.0%, respectively. Meanwhile, NDF and ADF contents of *elephant* grass (*P. purpureum*) were found to be 55.8 and 46.5% (Dahlan and Iskandar, 2013) and 84.25 and 64.07% (Nuhuyanan, 2010), respectively. These figures equaled to the NDF and ADF contents of Kumpai tembaga (64.72 and 46.38%), Kumpai minyak (65.31 and 38.92), and Are bolong (61.27 and 48.46%). This indicated that~~,~~ lowland swamp vegetations had fiber fraction nutritional quality which was not less than that of prime grasses including *elephant* grass and *king* grass.

In this study, NDF and ADF contents of lowland swamp vegetations were 40.65– 79.47% and 23.66%–60.33%, respectively. These figures were still within the ranges of NDF and ADF contents of prime grasses such as *elephant* grass (*P. purpureum*), which had NDF and ADF contents of 55.8 and 46.5% (Dahlan and Iskandar, 2013) and 84.25 and 64.07% (Nuhuyanan, 2010), respectively. In the rumen, NDF degradation is higher than that of ADF as NDF contains hemicellulose fraction which is more soluble (Church and Pond, 1986). NDF content has a negative correlation with its degradation rate (Varga et al., 1983) and higher NDF content decreases dry matter digestibility of feed (NRC, 1988). Cellulose is an ADF component ~~which~~ that is easy to digest while lignin is hard to digest as it contains double bonds. Higher lignin content decreases feed digestibility (Sutardi et al., 1980).

Hemicellulose and Cellulose Contents

Lowland swamp vegetations were found to have hemicellulose and cellulose contents ranging from 7.73 to 37.14% and 5.24 to 27.08%, respectively. Four green vegetations with the highest hemicellulose contents were Bento rayap (*L. hexandra*) (37.14%), Kerak maling (*D. fuscescens*) (31.87%), Kumpai merah (*Hymenachne sp.*) (31.74%), and Kumpai minyak (*H. amplexicaulis*) (26.39%). In contrast, the lowest hemicellulose content was found in Cecengkehan (*L. hyssopifolia*) (7.73%). Highest cellulose contents were found in Kemon air (*N. olerancia*) (27.08%), Bento rayap (*L. hexandra*) (25.88%), Purun tikus (*E. dulcis*) (21.80%), and Are bolong (*P. barbatum*) (20,28%). Meanwhile, Kasuran (*C.digitatus*) had the lowest cellulose content of 5.24% (Table 3). Results of this study were in line with those of a study conducted by Asep et al. (2012) who reported the hemicellulose and cellulose contents of lowland swamp green vegetations ranging from 7.89 to 31.55% and 30.85 to 63.35%, respectively. They also found that Kumpai padi (*O.rupifogon*) had 31.55% hemicellulose content which was higher than those of Kumpai padi (10.80- 19.30%) found in this study (Table 4). Swamp vegetations in South Kalimantan had hemicellulose contents of 0.65-25.85% in high tidal season and 5.37-40.09% in low tidal season. Cellulose contents in high and low tidal seasons were about 20.07-34.03% and 7.90- 38.31%, respectively (Rostini et al., 2014). Various water plants including Azolla, which was used as animal feed, had hemicellulose and cellulose contents of 10.20 and 12.76% (Nampoothiri, 2017), 1.15-10.20% and 12.76% (Nampoothiri, 2017), respectively. Roughages in BPTU-HPT Padang Mengatas had hemicellulose and cellulose contents of 29.79 and 33.62% in the rain season and 30.69 and 31.64% in the dry season, respectively (Muhajirin et al., 2017). *Elephant* grass (*P. perpureum*) was found to contain 21.18% hemicellulose and 43.32% cellulose (Nuhuyanan, 2010) and 35.3% cellulose (Dahlan and Iskandar, 2013). In a study conducted by Archimede et al. (2010), hay was found to have 37.7% hemicellulose and 35.7% cellulose. Based on the above findings, it was suggested that hemicellulose (7.73–37.14%) and cellulose (5.24–27.08%) contents of lowland swamp vegetations in this study were within normal ranges and these vegetations were potential to be used as feed for Pampangan buffaloes.

Lignin Contents

Lignin contents of lowland swamp vegetation~~s~~ ranged from 14.84 to 43.09%. Four vegetations including Telepuk gajah (*N. lotus*), Kemon air (*N. olerancia*), Kumpai merah (*Hymenachne sp.*), and Kangkung merah (*I. aquatica*) were found to have the lowest lignin contents of 14.84, 18.36, 19.76, and 19.85%, respectively, while the highest lignin content of 43.09% was found in Kumpai padi (*O. rupifogon* [P]) (Table 3). Lignin contents in this study were higher than that obtained by Rostini et al. (2014) who reported the lignin contents of swamp vegetations in South Kalimantan were about 2.8-17.59% in high tidal season with that of Kumpai minyak as the lowest and that of *Beberasan* as the highest and 10.06-61.12% in low tidal season with that of *Beberasan* as the lowest and that of Kumpai minyak as the highest. Lignin contents of Kumpai padi (*O. rupifogon* [R]) (31.24%) and Kumpai padi (*O. rupifogon* [P]) (43.09%), Bento rayap *(L. hexandra)* (33.92%), and Eceng gondok *(E. crassipes)* (31.60%) (Table 3) found in this study were higher those of Kumpai padi (18.27%) and Bento rayap *(L. hexandra)* (17.96%) found by Asep et al. (2012) and Eceng gondok *(E. crassipes)* (8.17%) found by Tham (2015). In other studies *Azolla* was found to have lignin contents of 5.7% (Ahmed et al., 2016) and 28.24% (Nampoothiri, 2017). Meanwhile, lignin contents of *elephant* grass were found to be 15.37% (Nuhuyanan, 2010) and 11.2% (Dahlan and Iskandar, 2013).

Differences in lignin contents in green vegetation~~s~~ are suspected to be caused by differences in plant species, plant ages, and environmental factors including seasons (rain or dry season), tidal seasons, and fertility levels of the soil where the vegetations grow. In cell walls, cellulose is a bond with hemicellulose and lignin. ~~Lignin cannot be digested by the animals~~The animals cannot digest lignin and its atomic proportion is different from other carbohydrates as it contains carbon and nitrogen of only 1-5%. Hemicellulose consists of pentose, hexose, uronic acid, and pectin substance. Pectin is a carbohydrate ~~which~~ that is composed of aronic acid, galactose, arabinose, xylose, and methanol. Cellulose is degradable by microorganisms and functions as the source of volatile fatty acids. Young grasses (roughages) contain less than 5% lignin and 80% of their cellulose is degradable. On the contrary, in old roughages, lignin content may reach up to 10% causing a decrease in cellulose digestibility by up to 50% (Prawirokusumo, 1994).

Based on the results of the study, it was concluded that:

1. The highest protein (20.56%) and crude fat (2.92%) contents were found in Kemon air *(Neptunia olerancia)*. The highest ash content (25.19%) was found in Kasuran *(C. digitatus)*, while the lowest (11.01%) was found in Cecengkehan *(L. hyssopifolia)*. The lowest NDF content (40.64%) was found in Cecengkehan *(L. hyssopifolia)* and the

Commented [A17]: The sentence to long

Formatted: English (United States)

Formatted: English (United States)

Commented [A18]: Atomic proportion ? or molecule structure ?

Formatted: English (United States)

Formatted: English (United States)

Commented [A19]: ????

Formatted: English (United States)

Formatted: English (United States)

highest hemicellulose content (37.14%) was found in Bento rayap. Telepuk gajah had the lowest ADF (23.66%) and lignin (14,84%) contents. Kemon air contained the highest cellulose level of 27.08%.

2. The best nutritional values were found in Kasuran *(C. digitatus)* and Cecengkehan *(L. hyssopifolia)*.
3. Dominant and palatable swamp roughages with good nutrient contents included Kumpai tembaga *(H. acutigluma)*, Kumpai minyak *(H. amplexicaulis)*, Kumpai padi *(O. rupifogon)*, Are bolong *(P. barbatum)*, and Purun tikus *(E. dulcis)*.

~~ACKNOWLEDGEMENTS~~ACKNOWLEDGMENTS

The author expresses his deepest gratitude to the Rector of Sriwijaya University through the Chair of the Institute for Research and Community Services funding this research in accordance with the Competitive Leading Research Contract of Sriwijaya University Number: 988 / UN9.3.1 / PP / 2017, dated 21 July 2017.

REFERENCES

Ahmed HA, Ganai A.M, Beigh YA, Sheikh GG, Reshi PA. 2016. Performance of growing sheep on *Azolla* based diets. Indian J. Anim. Res. 50 (5): 721-724.

Alam MR, Haque MM, Sumi KR, Ali MM. 2015. Proximate composition of para-grass *(Brachiaria mutica)* produced in integrated fish-fodder culture system. Bang. J. Anim. Sci. 44 (2): 113-119.

Ali AIM, Sandi S, Muhakka, Riswandi. 2012. Kualitas hijauan pakan di rawa lebak padang penggembalaan kerbau pampangan. Prosiding InSINAS 2012. 307-312.

Anitha KC, Rajeshwari YB, Prasanna SB, Shree JS. 2016. Nutritive evaluation of azolla as livestock. Journal of Experimental Biology and Agricultural Sciences. 4(6): 670-674.

AOAC (Association of Official Analytical Chemists). 1990. Official Methods of Analysis. 15th ed., Washington, DC.

Araica BM, Sporndly E, Sanchez NR, Norell L, Sporndly R. 2009. Silage quality when Moringa oleifera is ensiled in mixtures with elephant grass, sugar cane and molasses. Grass and Forage Science. 64: 364-373.

Archimede H, Gonzales-Garcia E, Despois P, Etienne T, Alexandre G. 2010. Subtitution of corn and soybean with green banana fruits and Gliricidia sepium forage in sheep fed hay-based diets: effects on intake, digestion and growth. Journal of Animal Physiology and Animal Nutrition. 94 (2010): 118-128.

Brazle FK, Kilgore GI, Fauzett MR. 2000. Effect of season on grazing native-grass pastures. The Profesional Animal Scientist. 16: 15-28.

BPS (Badan Pusat Statistik). 2010. Direktorat Jendral Tanaman Pangan. *Luas lahan rawa di Indonesia*. Departemen Pertanian. Jakarta.

BPS (Badan Pusat Statistik) Provinsi Sumatera Selatan. 2014. Sumatera Selatan dalam Angka 2014.

Church DC, Pond WG. 1986. Digestive Animal Physiologi and Nutrition. 2nd. Prentice Hell a Devision of Simon and Schuster Englewood Clief, New York.

Dahlan I, Iskandar MNZ. 2013. Use of plantain peels (Musa paradisiaca) as a fibrous feed substitute for napier grass (Pennisetum purpureum) in rusa deer (Cervus timorensis ratio under captivity. J. Anim. Sci. 3 (9): 472-480.

Damry. 2009. Produksi dan kandungan nutrisi hijauan padang penggembalaan alam di Kecamatan Lore Utara Kabupaten Poso. Jurnal Agroland. 16 (4): 296-300.

Eoh M. 2014. Kapasitas tampung dan komposisi zat-zat makanan padang penggembalaan ternak kerabau di Pulau Moa. Agrinimal. 4 (2): 77-82.

Gutteridge RC, Shelton HM. 1994. The Role of Forage Tree Legumes in Cropping and Grazing System. The Tropical Grassland Society of Australia Inc.

Hossain MdE, Sikder H, Kabir MdH, Sarma SM. 2015. Nutritive value of water hyacinth *(Eichhornia crassipes)*. Online Journal of Animal and Feed Research. 5 (2): 40-44.

Kathirvelan C, Banupriya S, Purushothaman MR. 2015. Azolla-an alternate and su tainable feed for livestock. International Journal of Science Environment. 4 (4): 1153-1157.

Kleden MM, Ratu MRD, Randu MDS. 2015. Kapasitas tampung hijauan pakan dalam areal perkebunan kopi dan padang rumput alam di Kabupaten Flores Timur Nusa Tenggara Timur. Jurnal Zootek 35 (2): 340-350.

Mako AA, Akinwande VO, Anurudu NF, Ogunwole OA. 2016. Evaluation of nutritive value of water hyacinth *(Eichhornia crassipes)* and guinea grass *(Panicum maximum)* mixture as animal feed in the tropics. 2016. Bull. Anim. Hith. Prod. Afr. (64): 463-473.

Manu AE. 2013. Produktivitas padang penggembalaan sabana Timor Barat. Jurnal Pastura. 3 (1): 25-29.

Maswada HF, Elzaawely AA. 2013. Nutritive value of Stipagrostis lanata (Forssk.) de winder as a feed for livestock. Asian Journal of Crop Sciences. 5 (2): 216-221.

Muhakka, Suwignyo RA, Budianta D dan Yakup. 2019. Vegetation analysis of no-tidal swampland in South Sumatra, Indonesia and its carrying capacity for Pampangan buffalo pasture. Journal Biodiversitas. 20 (4): 1077-1086.

Muhakka, Wijaya A, Ammar M. 2015. Nutritional dried matter, crude protein and crude fiber on lowland tidal grass fermented by probiotic microorganisms for use bali cattle feed. Journal Animal Production. 17 (1): 24-29.

Muhajirin, Despal, Khalil. 2017. Pemenuhan kebutuhan nutrien sapi potong bibit yang digembalakan di Padang Mengatas. Buletin Makanan Ternak.104 (1): 9-20.

Mulyani A, Sarwani M. 2013. Karakteristik dan potensi lahan sub optimal untuk pengembangan pertanian di Indonesia. Jurnal Sumber daya Lahan. 7 (1): 47-55.

Nampoothiri VM. 2017. Aquatic plants and marine waste as animal feed. Sch.J. Agric.Vet. Sci. 4 (6): 249-254.

Norman HC, Master DG, Barrentt-Lennard EG. 2013. Halophytes as forage in saline landscapes: Interaction between plant genotipe and environment change their feeding value to ruminants. Environmental and Experimental Botany. 92 (2013): 96-109.

NRC. 1988. Nutrition Reguirement of Beef Cattle. 6th. Rev. Ed. National.

Nuhuyanan LE. 2010. Pengaruh pemberian wafer rumput gajah dengan perekat fermented moter liquor (FML) dan tetes (molasses) terhadap konsumsi pakan, kecernaan zat-zat makanan dan kenaikan berat badan sapi bali jantan. Jurnal Ilmu Peternakan. 5 (2): 111-117.

Prawirokusumo S. 1994. Ilmu Gizi Komperatif. BPFE., Yogyakarta.

Rahman MM, Abdullah RB, Wan Khadijah WE, Nakagawa T, Akashi R. 2014. Feed intake and growth performance of goats affered napier grass *(Pennisetum purpureum)* supplemented with concentrate pellet and soya waste. Sain Malaysiana. 43 (7): 967-971.

Formatted: English (United States)

Formatted: English (United States)

Commented [A20]: abbrevation

Formatted: English (United States)

Formatted: English (United States)

Formatted: English (United States)

Richmond AS, Wylie ARG, Laidlaw AS, Lively FO. 2015. Methane emissions from beef cattle grazing on semi-natural upland and improved lowland grasslands. Animal. 9 (1): 130-137.
Rostini T, Abdullah L, Wiryawan KG, Karti PDMH. (2014). Production and nutrition potency of swamp local forage in South Kalimantan as ruminant feed. Glob. J. Anim. Sci. Livestock Prod. Anim. Breed. 2 (2):107-113.
Santoso dan Hariadi BTj. 2008. Komposisi kimia, degradasi nutrien dan produksi gas metana in vitro rumput tropika yang diawetkan dengan metode silase dan hay. Media Peternakan 31(2): 128-137.
Se'u VE, Karti PDMH, Abdullah L. 2015. Botanical composition, grass production, and carrying capacity of pasture in Timor Tengah Selatan District. Journal Media Peternakan 38(3):176-182.
Statistik Peternakan Sumatera Selatan. 2014. Dinas Peternakan Provinsi Sumatera Selatan Tahun Anggaran 2015.hal:14.
Sutardi T, Pratiwi SH, Adnan A, Nuraini S. 1980. Peningkatan pemanfaatan jerami padi melalui hidrolisa basa, suplementasi urea dan belarang. Bull. Makanan Ternak. 6 Bogor.
Tham HoT. 2015. Utilisation of water hyacinth as animal feed. Nova Journal of Engineering and Applied Sciences. 4 (1): 1-6.
Tham HoT, Uden P. 2015. Effect of fresh water Hyacinth (Eichhornia crassipes) on intake and digestibility in cattle fed rice straw and molasses-urea cake. Nova Journal of Engineering and Applied Sciences. 4(1): 1-8.
Tjondronegoro AD, Gunawan A. 2000. Beberapa jenis gulma di lahan pasang surut pada tingkat kemasaman tanah yang berbeda. Prosiding Seminar Nasional. P. 247-254.
Van Soest PJ. 1982. Nutritional Ecology of the Ruminant: Ruminant Metabolism, Nutritional Stategies the Cellulolytic Fermentation and the Camisthy of Forages and Palm Fiber. Cornell University O & B Books Inc. USA.
Varga GA, Hoover WH. 1983. Rate and extent of NDF of feedstuff in-situ. J. Dairy. Sci. 66:2109.

Commented [A21]: Names of journals should be abbreviated. Always use the standard abbreviation of a journal's name according to the **ISSN List of Title Word Abbreviations** (www.issn.org/2-22661-LTWA-online.php).

Formatted: English (United States)

Formatted: English (United States)

3. Bukti konfirmasi submit revisi pertama, respon kepada reviewer, dan artikel yang diresubmit (23 Desember 2019)

Nutritional values of swamp grasses as feed for Pampangan Buffaloes in South Sumatra Indonesia

Abstract. This study was aimed at determining the types and quality of vegetations in the swamp area, which could be used as sources of roughage for Pampangan buffaloes in South Sumatera. In this descriptive study. Results showed that~~,~~ the highest crude protein and ether extract contents, 20.56 and 2.92%, respectively, were found in Kemon air *(N.olerancia)*. The highest ash content of 25.19% was found in Kasuran *(C.digitatus)*. The lowest fiber content (11.01%) was found in Cecengkehan *(L.hyssopifolia)*, which also had the lowest content of Neutral Detergent Fiber (NDF) ~~NDF~~ (40.64%). Hemicellulose content was found to be highest (37.14%) in Bento rayap *(L.hexandra)*. The lowest ADF (23.66%) and lignin (14,84%) contents were found in Telepuk gajah *(N.lotus)*. Kemon air *(N.olerancia)* was found to have the lowest content (27.08%) of cellulose. It was concluded that the swamp vegetation~~s~~ found in this study consisted of 17 types of grasses (89.47%) and ~~2~~ two types of legumes (10.53%). Kasuran *(C.digitatus)* and Cecengkehan *(L.hyssopifolia)* were found to have the best nutritional values. Dominant and palatable vegetations with good nutritional values, which were potential to be used as sources of roughage for *Pampangan* buffaloes, were Kumpai tembaga *(H.acutigluma)*, Kumpai padi *(O.rupifogon)*, Kumpai minyak *(H. amplexicaulis*, Are bolong *(P.barbatum)*, and Purun tikus *(E.dulcis)*.

Key words: Nutritional value, Swamp grass, Feed, Pampangan buffalo.

INTRODUCTION

The availability of roughage as the main feed for ruminant animals depends considerably on seasons. During the rainy season, it is abundant, and during the dry season, the availability of grasses and legumes is lacking. ~~Limited~~ The limited supply of roughage may hamper productivity including the reproductive performance of ruminant animals including buffaloes.

In South Sumatera, Pampangan buffalo is a ~~a~~ potential germplasm which needs to be preserved and developed. There were 37,405 headds ~~s heads~~ of Pampangan buffaloes in 2016, and this population increased by 3.97% to 38,952 heads in 2017. In 2017, of this population, 11,150 heads (28.63%) and 2,227 heads (5.72%) were found in Ogan Komering Ilir Regency and Banyuasin Regency, respectively (Statistik Peternakan Sumsel, 2017). The population and productivity of *Pampangan* buffaloes need to be improved, and for this purpose, feed is an important factor to consider. Pampangan buffaloes feed mostly on roughage from the swamp ~~and/or~~, grassland to meet their maintenance and reproductive needs.

In Indonesia, there are 13.27 million hectares of lowland swamp areas. Only 4 million hectares of these areas ~~has~~ have been developed and cultivated by the community and private sectors (2.6 million hectares) and the government assistance (1.3 million hectares) (BPS, 2010, Mulyani and Sarwani, 2013). In Sumatera, the largest lowland swamp area of 2.98 million hectares is found in South Sumatera, but only 298,189 hectares of it ~~has~~ have been utilized (BPS Sumatera Selatan, 2014). In order to utilize the potential swamp area as a feed source for Pampangan buffaloes, a study on vegetations as sources of roughage in lowland swamp areas that include vegetation identification and nutritional quality determination needs to be conducted.

In the previous study, some swamp grasses, including Kumpai minyak grass (*H. amplexicaulis)* (Rostini et al., 2014**;** Muhakka et al., 2015), ~~*I.*~~ *I.* ~~*rugosum*~~ *,rugosum*, and *L. hexandra* (Ali et al., 2012) were identified. However, many more swamp ~~vegetations~~ ha~~ve~~s not been identified. For example, *P. barbatum,C. digitatus, R. corymbosa* . This study was conducted to identify the types and nutritional values of vegetations that could be used as sources of roughage feed for Pampangan buffaloes in South Sumatera. This information was important to support the productivity improvement of Pampangan buffaloes as ~~a~~ germplasm in South Sumatera. In this study, some new swamp found where in the previous study it's not found yet.

Formatted: English (United States)

Formatted: English (United States)

Formatted: English (United States)

Formatted: English (United States)

Formatted: English (United States)

Formatted: English (United States)

Formatted: English (United States)

Commented [A1]: Abbreviation

Formatted: English (United States)

Formatted: English (United States)

Formatted: English (United States)

Formatted: English (United States)

Formatted: English (United States)

Formatted: English (United States)

Commented [A2]: Is heads the common terms ?

Formatted: English (United States)

Formatted: English (United States)

Formatted: English (United States)

Commented [A3]: ?? species name ?

Commented [A4]: From which swamp ? since on the next sentence you said there are more swamp to be characterized, you should add more information for the audience and to build an argument that further study need to be conducted

Formatted: Font: 10 pt, English (United States)

Formatted: Font: (Default) Times New Roman, 10 pt, Not Bold, Italic

Formatted: English (United States)

Formatted: English (United States)

Formatted: English (United States)

Commented [A5]: Many more swamp area or many more swamp vegetation ? (related to the previous comment)

Formatted: English (United States)

Formatted: English (United States)

Commented [A6]: Also related with the previous comment, you have to give information what differentiate this study to the previous study

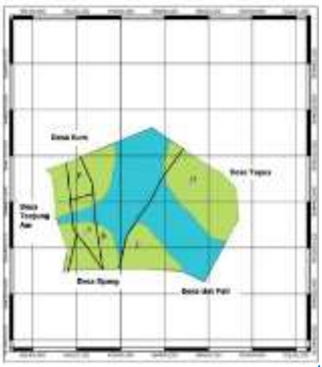
Formatted: English (United States)

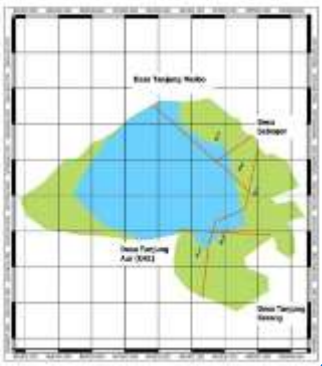
Formatted: English (United States)

Formatted: English (United States)

MATERIALS AND METHODS

This study was a descriptive study to assess the types and nutritional values of vegetations, which were the dominant and palatable as sources of roughage feed for Pampangan buffaloes. Vegetation samples were taken from grazing areas of Pampangan buffaloes in Rambutan Village and Pulau Layang Village, South Sumatra, from April to Juni 2017. Vegetation samples for nutrient analysis were obtained by following these procedures: (1) vegetation collection was done based on estimated growth age (young age, medium age, and old age based on physical appearance), (2) collected samples of each vegetation was composited, and (3) samples were chopped into small sizes, homogenized. For each vegetation, 1 kg sample was taken ~~by random~~randomly and sent to the laboratory for oven drying at 105ºC until a constant weight was obtained and dry matter content was determined. Samples were then ground for nutrient content determination by using proximate and Van Soest analyses (Syarifuddin and Wahdi, 2010). Analyses of sample conducted in Laboratory of Dairy Nutrition, Department of Nutrition and Feed Technology, Institut Pertanian Bogor (IPB). And analysis of soil conducted in Laboratory of Soil Chemistry, Biology, and Fertility, Soil Department, Faculty of Agriculture, Sriwijaya University.





A B

Formatted: English (United States)
Formatted: English (United States)
Formatted: English (United States)
Formatted: English (United States)
Commented [A7]: Weighed daily ? hourly ? to check the constant weight
Formatted: English (United States)
Formatted: English (United States)
Formatted: Indonesian
Formatted: English (United States)
Formatted: English (United States)
Formatted: English (United States)
Formatted: English (United States)
Formatted: English (United States)
Formatted: English (United States)
Formatted: English (United States)
Formatted: English (United States)
Formatted: English (United States)
Formatted: English (United States)
Formatted: English (United States)
Formatted: English (United States)
Formatted: English (United States)

Figure 1. Research location in South Sumatera, Indonesia, **A.** Pulau Layang Village, Pampangan Sub-district, Ogan Komering Ilir District, South Sumatra, **B.** Rambutan Village, Rambutan Sub-district, Banyuasin District, South Sumatra (Muhakka et al., 2019)

Measured parameters

Soil Analysis

Soil sampling is done in a composite manner at a depth of 0-20 cm. Taking the soil sample points is done by making a diagonal line in each zone and determining 5 soil sampling points to analyze chemical fertility (N, P, K) and physical fertility (texture, structure and pH).

Proximate Analysis

Crude protein, fiber, ether extract, and ash contents were determined based on the procedures of AOAC (1990).

1. *Crude Protein*. Nitrogen (N) content was determined by using a ~~Kjehdahl~~ Kjeldahl method. In this analysis, sulphuric acid with a catalyst and a heating process. The organic matter of samples was then oxidized by sulfuric acid~~two~~, and nitrogen was changed into an ammonium sulfate form. The remaining sulfuric acid was neutralized by NaOH until the solution became basic. Ammonium ~~sulphate~~ sulfate was then distilled in an acid medium to obtain the quantitative amount of N. As the average protein contains 16% nitrogen, a factor 100~~%~~ %: 16% = 6.25 was used to obtain the value of crude protein (crude protein = N% x 6.25).
2. *Fiber*. ~~Filtered~~ The filtered fat-free sample was used in fiber content determination. 1.25% sulfuric acid solution was added into the sample, and the mixture was heated for about 30 minutes before the residue was filtered. 1,25% NaOH solution was added into the precipitate, and the mixture was heated for about 30 minutes. The mixture was then filtered, and the precipitate was washed, dried, and weighed. This precipitate was burnt, and the ash was weighed. The difference between the weight of precipitate before it was burnt and the weight of the ass was referred to as fiber content.
3. *Ether Extract*. ~~Dry~~ The dry matter sample was extracted with diethyl ether for 5 hours. ~~In~~ At the end of the extraction process, ether evaporated and the remaining material was referred to as fat.
4. *Ash*. The third part of the dry matter sample was weighed and burnt in a crucible at 550ºC for 8 hours.

Van Soest Analysis

Neutral Detergent Fiber (NDF), Acid Detergent Fiber (ADF),~~NDF, ADF,~~ hemicellulose, cellulose, and lignin contents were determined by using a Van Soest method (1982).

1. Neutral Detergent Fiber (NDF). a gram of sample was put in a beaker glass. 50 ml NDS solution was added into the beaker before the mixture was heated for an hour. The mixture was then filtered by using a vacuum pump and a filter glass which was previously weighed (b gram). The mixture was then washed with hot water and acetone before it was dried in an oven and let cool in a desiccator. Finally, it was weighed as *c* gram. NDF content was calculated by using the following formula:

$$\% \text{ NDF} = \frac{c - b}{a} \times 100\%$$

2. Acid Detergent Fiber (ADF). a gram of sample was put in a beaker glass. 50 ml ADS solution was added into the beaker before the mixture was heated for an hour. The mixture was then filtered by using a vacuum pump and a sintered glass filter which was previously weighed (b gram). The mixture was then washed with hot water and acetone before it was dried in an oven and let cool in a desiccator. Finally, it was weighed as *c* gram. Cellulose content was calculated by using the following formula:

$$\% \text{ cellulose} = \frac{c - d}{a} \times 100\%$$

4. Hemicellulose. Hemicellulose content was calculated as a difference between NDF and ADF contents as follows.

$$\% \text{ Hemicellulose} = \% \text{ NDF} - \% \text{ ADF}$$

5. Lignin. Cellulose residue (*d* gram) was burnt in a furnace at 500-600ºC for 3 hours. After that, it was left to cool and weighed (*e* gram). Lignin content was calculated by using the following formula:

$$\% \text{ Lignin} = \frac{d - e}{a} \times 100\%$$

Data Analysis

The data obtained were used directly to describe the nutritional value of the swamp vegetations that could be used as a roughage source. These data were then combined with those of *in vitro* digestibility as the basis for ~~drawing the conclusion~~concluding (Syarifuddin and Wahdi, 2010).

~~Palemb~~

Formatted: Centered

Formatted: Indent: First line: 0.5 cm

Formatted: English (United States)

Commented [A8]: ??

Formatted: English (United States)

Commented [A9]: All important abbreviations must be defined at their first mention

Formatted: English (United States)

Formatted: Font: Not Italic

Formatted: Font: Not Italic

Formatted: English (United States)

Commented [A10]: Be consistant, a or *a*

Formatted: English (United States)

Formatted: English (United States)

Formatted: Font: Not Italic

Formatted: Font: Not Italic

Formatted: English (United States)

Formatted: English (United States)

Formatted: English (United States)

Formatted: English (United States)

RESULTS AND DISCUSSION

Results

Results of soil analysis showed that soil at the study site had a low fertility level and was highly acidic. It also had very high organic C and total N contents, medium level of exchangeable-K and N contents, very low Ca and Mg contents, medium P content, and very high CEC level (Table 1).

Table 1. Properties of soil at the study site

	Pulau Layang		Rambutan	
Parameter	**Value**	**Remark**	**Value**	**Remark**
pH H_2O (1 : 1)	5.10	Low	4.41	Very low
pH KCl (1 : 1)	4.39	Very acidic	3.99	Very acidic
Organic C (g/kg)	57.66	Very high	36.14	Very high
Total N (g/kg)	3.64	Very high	2.19	Very high
Available P/Bray I (mg/kg)	11.70	Medium	2.25	Very low
Exchangeable K (cmol/kg)	0.63	Medium	0.45	Medium
Na (cmol/kg)	0.65	Medium	0.65	Medium
Ca (cmol/kg)	1.95	Very low	0.73	Very low
Mg (cmol/kg)	0.45	Very low	0.32	Very low
CEC (cmol/kg)	65.25	Very high	43.50	Very high
Exchangeable Al (cmol/kg)	1.84		2.37	
Exchangeable H (cmol/kg)	0.74		0.88	
Texture:				
Sand (%)	47.08		46.64	
Ash (%)	31.11		27.18	
Clay (%)	21.81		26.18	

Source: Laboratory of Soil Chemistry, Biology, and Fertility, Soil Department, Faculty of Agriculture, Sriwijaya University (2017).

Nutrient Contents of Lowland Swamp

Crude protein, fiber, ether extract, and ash nutrient contents of lowland swamp vegetations found in this study are listed in (Table 2).

Table 2. Crude protein, fiber, ether extract, and ash contents (%) of lowland swamp vegetations

Latin Name	Local Name	Crude Protein	Fiber	Ether Extract	Ash
Catharanthus roseus	Tapak dara	15.20	11.18	1.29	12.53
Cyperus digitatus	Kasuran	15.31	14.76	1.42	25.19
Digitaria fuscescens	Kerak Maling/Pasiran	12.00	15.64	1.24	16.26
Eichhornia crassipes	Eceng gondok	8.61	20.66	0.84	14.22
Eleocharis dulcis P	Purun tikus	8.22	25.72	0.48	15.13
Eleocharis dulcis R	Purun tikus	6.63	24.52	1.69	10.24
Hymenachne acutigluma) P	Kumpai Tembaga	6.86	30.26	2.22	7.88
Hymenachne acutigluma R	Kumpai Tembaga	10.96	23.73	1.77	10.30
Hymenachne amplexicaulis P	Kumpai Minyak	9.21	21.91	2.82	13.96
Hymenachne amplexicaulis R	Kumpai Minyak	12.00	15.64	1.24	16.26
Hymenachne sp	Kumpai Merah	8.52	21.20	1.30	12.88
Ipomoea aquatica	Kangkung merah	8.95	14.34	2.24	10.39
Leersia hexandra	Bento rayap	5.35	27.57	2.06	5.63
Ludwigia hyssopifolia	Cecengkehan	12.07	11.01	1.66	9.09
Neptunia olerancia	Kemon air	20.56	15.03	2.92	7.31
Nymphaea lotus	Telepuk Gajah	13.22	11.45	2.84	10.30
Oryza rupifogon P	Kumpai Padi	7.93	23.30	1.60	16.25
Oryza rupifogon R	Kumpai Padi	10.41	21.59	2.49	11.92
Polygonum barbatum	Are Bolong	7.53	16.60	1.57	8.40
Rhynchospora corymbosa	Berondong	5.26	22.27	1.48	14.84
Sesbania exasperata	Mutiara	18.27	11.22	1.86	19.47

Source: Laboratory of Dairy Nutrition, Department of Nutrition and Feed Technology, IPB (2017).

Notes: P : Grass in Pulau Layang Village; R : Grass in Rambutan Village.

Formatted: English (United States)

Formatted: English (United States)

Formatted: English (United States)

Formatted: English (United States)

Formatted: English (United States)

Formatted: English (United States)

Commented [A11]: Analysis of soil in the study site didn't mention in the method part

Formatted: English (United States)

Formatted: English (United States)

Commented [A12]: For the results follow the flow of the methods, first you should describe the vegetation of the study area you have sampled, how may type of vegetation, etc

Formatted: English (United States)

Formatted: English (United States)

Commented [A13]: Source here is the laboratory conducting the analysis ? in that case you should have mentioned on the method part that for the analysis of …… conducted at laboratory ……..

Formatted: English (United States)

Formatted: English (United States)

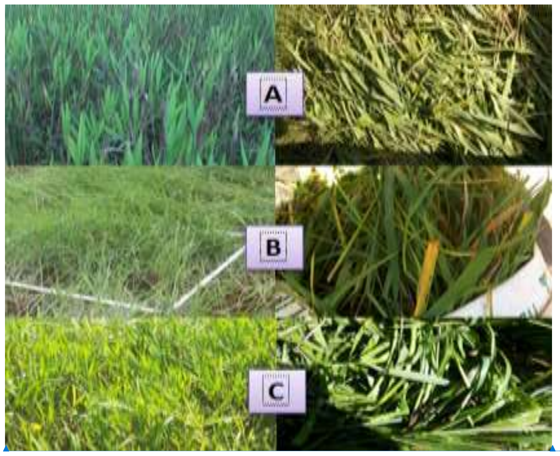
The NDF and ADF contents of vegetations found in this study were about 40.65–79.47% and 23.66–60.33%, respectively. Lowland swamp vegetations were found to have hemicellulose and cellulose contents ranging from 7.73 to 37.14% and 5.24 to 27.08%, respectively. Lignin contents of lowland swamp vegetations ranged from 14.84 to 43.09% (Table 3).

Table 3. Composition of fiber fractions of green vegetations in lowland swamp: NDF, ADF, Hemicellulose, Cellulose, and Lignin (%).

Latin Name	NDF	ADF	Hemicellulose	Cellulose	Lignin
Catharanthus roseus	47.79	39.67	8.12	16.96	22.71
Cyperus digitatus	58.90	36.93	21.97	5.24	31.68
Digitaria fuscescens	65.43	33.56	31.87	12.11	21.45
Eichhornia crassipes	62.77	41.83	20.94	10.22	31.60
Eleocharis dulcis [P]	69.57	49.83	19.74	21.80	28.04
Eleocharis dulcis [R]	75.73	54.91	20.82	19.71	35.20
Hymenachne acutigluma [P]	75.89	50.60	25.29	12.25	38.34
Hymenachne acutigluma [R]	64.72	46.38	18.34	16.01	30.37
Hymenachne amplexicaulis	65.31	38.92	26.39	8.29	30.63
Hymenachne sp	60.14	28.40	31.74	8.64	19.76
Ipomoea aquatica	41.40	26.17	15.23	6.32	19.85
Leersia hexandra	79.47	42.33	37.14	25.88	33.92
Ludwigia hyssopifolia	40.64	32.91	7.73	8.39	24.52
Neptunia olerancia	62.31	45.44	16.87	27.08	18.36
Nymphaea lotus	46.05	23.66	22.39	8.82	14.84
Oryza rupifogon [P]	71.13	60.33	10.80	17.23	43.09
Oryza rupifogon [R]	65.49	46.19	19.30	14.96	31.24
Polygonum barbatum	61.27	48.46	12.81	20.28	28.18
Rhynchospora corymbosa	65.29	44.64	20.65	16.08	28.56

Source: Biotechnology Assessment Laboratory, Center for Biotechnology Research, Indonesian Institute of Sciences (LIPI), Cibinong, Bogor (2017).

Notes: [P] : Grass in Pulau Layang Village; [R] : Grass in Rambutan Village.



Commented [A14]: Same as previous comment

Formatted: English (United States)

Formatted: English (United States)

Formatted: English (United States)

Formatted: English (United States)

Figure 2. Dominant and palatable swamp roughages with good nutrient contents included. **A**. *Hymenachne acutigluma*, **B**. *Oryza rupifogon* **C**. *Hymenachne amplexicaulis*, **D**. *Polygonum barbatum*, and **E**. *Eleocharis dulcis*.

Discussion

Crude Protein Content

Results showed that the crude protein contents of swamp green vegetations ranged from 5.26% to 20.56% with the lowest value (5.26%) was found in Berondong grass (*R. corymbosa*) and the highest (20.56%) was found in Kemon air legume (*N. olerancia*). Kasuran grass (*C. digitatus*) had the highest crude protein content (15.31%) (Table 2). This high nutritional value of Kasuran grass was suspected as caused by the fact that most of this grass was found to grow in the area of buffalo pens where the soil was rich in organic matter. However, the growth of this grass was not dominant as it mostly occurred in rainy seasons.

Kumpai minyak (*H. amplexicaulis*), Kumpai padi (*O. rupifogon*), Kumpai tembaga (*H. acutigluma*), and Purun tikus (*E. dulcis*) were found as the dominant palatable grasses containing 12.00, 10.41, 10.96, and 8.22% crude protein, respectively. Results of this study were not too different from those obtained by Rostini et al. (2014), who reported that Kumpai minyak and Pipisangan had protein contents of 10.88 and 15.92%, respectively. Crude protein (CP) contents of these swamp grasses in Pulau Layang and Rambutan Villages were closed to those of prime grasses including 9.11-12.8% CP of *elephant* grass (*P. purpureum*) (Santos et al., 2013; Dahlan and Iskandar, 2013; Rahman et al., 2014), 12.4% CP of *elephant* grass hay, 11.1% CP of *elephant* grass silage, 11.4% CP of king grass hay, and 10.2% CP of king grass silage (Santoso and Hariadi, 2008). Other vegetations even had higher CP contents including Kumpai tembaga *(H. acutigluma)* with 10.96% CP, Tapak dara (*C. roseus*) 15.20%, Telepuk gajah (*N. lotus*) 13.22%, Cecengkehan (*L. hyssopifolia*) 12.07%, Kasuran *(C. digitatus)* 15.31%, and Kumpai minyak (*H. amplexicaulis)*^{R} 12.0% (Table 2). CP contents of vegetations in this study were also higher than [illegible]f nature grasses found in coffee plantation areas (6.95%) and pastoral areas (6.65%) in Wulanggitang District, E[illegible]es Regency as reported by Kleden et al. (2015). Meanwhile, CP content of grasses in lowlands was 8.41% (Rochana et al., 2016; Maswada and Elzaawely, 2013).

This high protein content was suspected to be caused by the fact that soil organic C and total N contents in the study site were also high, namely 36.14-57.66 and 2.19-3.64 g.kg^{-1}, respectively (Table 1). Soil organic C and total N contents affected protein content in plants. Four swamp grasses including Kasuran (*C. digitatus*), Tapak dara (*C. roseus*), Telepuk gajah (*N. lotus*), and Cecengkehan (*L. hyssopifolia*) and a legume, Kemon air (*N. olerancia*) were found to be the lowland swamp vegetations having the highest N contents of 15.31,15.20, 13.22, 12.07, and 20.56%, respectively.

Fiber Contents

Fiber contents of lowland swamp green vegetations ranged from 11.01 to 30.26%, with the lowest content found in Cecengkehan (*L. hyssopifolia*) and the highest in Kumpai tembaga *(H. acutigluma* ^{P}*)*. Four vegetations including *Cecengkehan* (*L. hyssopifolia*), Tapak dara (*C. roseus*), Mutiara legume (*S. exasperata*), and Telepuk gajah (*N. lotus*) were found to have the lowest fiber contents of 11.01, 11.18, 11.22, and 11.45%, respectively (Table 2). These results were almost similar to those found by Ali et al. (2012) who reported that the fiber contents of roughage in a pasture ranged from 7.20 to 34.98%. These researchers found that the fiber content of Bento rayap (*Leersia hexandra*) was 27.40% which was very close to that (27.57%) of the same vegetation in this study. Meanwhile, Rostini et al. (2014) reported that the fiber contents of swamp vegetation in South Kalimantan ranged from 14.84 to 29.35% with the lowest content found in Hadangan (*Paspalum sp*) and the highest in Dadangsit (*L. adscendens*). These figures were lower than those found by Kleden et al. (2015) who revealed that nature grasses in a coffee plantation area and ~~a~~ pasture in Wulanggitang, East Flores contained 34.57 and 35.59% of fiber. They also found that the lowest fiber content was found in *L. peploides* and the highest in *I. rugosum*. Fiber contents reported by Kleden et al. (2015) were higher ~~that~~ than the results reported by Ahmed

Formatted: English (United States)
Formatted: English (United States)
Formatted: English (United States)
Formatted: English (United States)
Commented [A15]: This and the decription of the vegetation sampled should be placed at the beginning of results
Formatted: English (United States)
Formatted: English (United States)
Commented [A16]: This is where you should add the soil analysis (if you not going to put anything on the methods)
Formatted: English (United States)
Formatted: English (United States)

et al. (2013) with a fiber content of 29.32% in *D. aegyptium* plants. A previous study showed that fermented *I. rugosum*, *H. amplexicaulis*, and *O. rifipogon* had fiber contents of 29.27, 29.57, and 33.07%, respectively (Muhakka et al., 2015).

The fiber content of Eceng gondok (*E. crassipes*) in this study (20.66%) was lower than those found by Hossain et al. (2015), Tham and Uder (2015), and Make et al. (2016). In addition, the fiber content of Eceng gondok (*E. crassipes*) in this study was lower than those of *Azolla*, another water plant, ranging from 13.19 to 16.54% (Kathirvelan et al., 2015; Anitha et al., 2016) and 9.25 to 13.25% (Ahmed et al., 2016). These fiber contents of *Azolla* equa~~l~~led to those of Cecengkehan (*L. hyssopifolia*) (11.01%), Tapak dara (*C. roseus*) (11.18%), Mutiara legume (*S. exasperata*) (11.22%), Telepuk gajah (*N. lotus*) 11.45%, and Kangkung merah (*I. aquatica*) (14.34%) found in this study. Fiber contents of swamp green vegetations found in this study indicated that they were potential to be used as feed for Pampangan buffaloes.

Ether extract contents

Lowland swamp vegetations in this study were found to have ether extract (EE) contents of about 0.48-2.92%. The lowest EE content was found in Purun tikus (*E. dulcis*) while the highest was found in Kemon air legume *(N. olerancia*). Four vegetations of lowland swamp including Telepuk gajah (*N. lotus*) (2.84% EE), Kumpai minyak (*H. amplexicaulis*) (2.82% EE), Kumpai padi (*O. rupifogon*) (2.49% EE), and Kangkung merah (*I. aquatica* Forsk) (2.24% EE) were revealed to have the highest ether extract contents (Table 2). Results of this study were lower than those found by Rostini et al. (2014), reporting about 0.61–3.67% of EE contents in swamp vegetations in South Kalimantan with the lowest found in Pipisangan (*L. hyssopifolia*) and the highest in Padi hiang (*O. rufigopon spotanea*). EE contents of lowland swamp vegetations were 1.40–1.91% for grasses and 1.36–2.95% for legumes (Asep et al., 2012) and those of grasses in a pasture for buffaloes in Pulau Moa were 1.95–2,41% (Eoh, 2014). In other studies, grasses in a natural pasture in North *Lore*, Poso Regency had EE contents of 2.12–2.34% (Damry, 2009) and those in Sabana Timur Barat pasture in the rainy season to the end of dry season had an average EE content of 1.91% (Manu, 2013). A study by Se'u et al. (2015) revealed an EE content of 1.07% in grasses in a pasture in Timor Tengah Selatan Regency. Another work by Kleden et al. (2015) showed that vegetations in a natural pasture and a coffee plantation area had EE contents of 1.23 and 1.35%, respectively.

Vegetations found in this study had EE contents equaled to those of prime grasses including *elephant* grass (*P. purpuperum*) and *king* grass (*P. purpureophoides*) preserved in the form of hay and silage. *Elephant* grass hay and silage had EE contents of 1.9 and 2.6%, respectively, while those of king grass had EE contents of 1.6 and 2.4%, respectively (Santoso and Hariadi, 2008; Ukpabi et al., 2015). EE contents of some species of ruminant roughages were found to be about 1.2–4.1% (Ahmed et al., 2013). Dominant swamp roughages including Kumpai minyak (*H. ~~amplexicaulis,~~*,) and Kumpai padi *(O. rupifogon)* had EE contents of 2.82 and 2.49%, respectively and they were palatable and potential to be used as feed for Pampangan buffaloes.

Ash Contents

Ash contents of green vegetations in lowland swamp ranged from 5.63 to 25.19%. Four types of vegetations with the highest ash contents included Kasuran (*C. digitatus*) (25.19%), Mutiara legume (*S. exasperata*) (19.47%), Kumpai minyak (*H. amplexicaulis*) (16.26%), and Kumpai padi (*O. rupifogon* [P]) (16.25%). Meanwhile, Bento rayap *(L. hexandra)* was found to have the lowest ash content of 5.63% (Table 2). Ash contents of vegetations found in this study were higher than those of swamp vegetations in South Kalimantan of 2.18- 3.28% during the high tidal season and 3.23-9.83% during the low tidal season (Rostini et al., 2014). *Elephant* grass (*P. purpureum*) was indicated to have varied ash contents of 4.4% (Dahlan and Iskandar, 2013), 0.95-1.1% (Ukpabi et al., 2015), 9.59% (Nuhuyanan, 2010), and 18% (Araica et al., 2009). Meanwhile, the ash content of grasses in lowland areas ranged from 6.32 to 8.91% (Richmond et al., 2015; Mako et al., 2016; Norman et al., 2013; Maswada et al., 2013). Alam *et al*. (2015) found that *B. mutica* had an ash content of 4.20-4.89% and rice straw had 6.63%.

Roughages were found to have average ash contents of 7.28% in a pasture for buffaloes in Pulau Moa (Eoh, 2014), 9.82–10.14% in Lore Utara, Poso Regency (Damry, 2009), 11.51% in a pasture during the rainy season until the end of dry season in Sabana Timur Barat (Manu, 2013), and 8.11 and 8.22% in a natural pasture and a coffee plantation area, respectively (Kleden et al., 2015). Differences in these ash contents were suspected to be caused by differences in plant species (internal factor) and environmental differences, particularly seasonal differences (external factor). In a dry season, pH levels in lowland swamp areas were found to be 3.9-4.8, causing a decreased supply of nutrients, especially total N and K, to the soil. This decreased supply of nutrients led to lowered nutrients contained in plants (Rostini et al., 2014). This was in line with what was stated by Gutteridge and Shelton (1994) that nutrient content in plants was affected by soil nutrient content. In addition, in acidic soil conditions, activities of Fe, Al, and Mn increased which might cause ~~in~~ toxicity in plants (Tjondronegoro and Gunawan).

NDF and ADF Contents

Neutral Detergent Fiber (NDF) depicts plant cell walls consisting of hemicellulose, cellulose, and lignin. NDF is part of fiber which is not dissolved in neutral detergent representing the component of fiber undissolved in plant cell wall materials. NDF content of a feed affects the ability of ruminant animals to consume the feed. Acid Detergent Fiber (ADF) represents parts of the plant cell wall bond to cellulose and lignin. ADF content is related to energy content and higher ADF content results in lowered digestible energy content (Van Soest, 1982).

The NDF and ADF contents of vegetations found in this study were about 40.65–79.47% and 23.66–60.33%, respectively. Lowest NDF contents were found in Cecengkehan (*L. hyssopifolia*) (40.65%), Kangkung merah (*I. aquatica*) (41.40%), Telepuk gajah (*N. lotus*) (46.05%), and Tapak dara (*C. roseus*) (47.79%). In contrast, highest NDF content of 79.47% was found in Bento rayap (*L. hexandra*). Lowest ADF contents were found in Telepuk gajah (*N. lotus*) (46.05%), Kangkung merah *(I. aquatica)* (26.17%), Kumpai merah (*Hymenachne sp*) (28.40%), Cecengkehan (*L. hyssopifolia*) (32.91%). Meanwhile, the highest ADF content of 60.33% was found in Kumpai padi *(O. rupifogon* [P]*)* (Table 3). NDF and ADF contents of vegetations found in this study were lower than those of Asep et al. (2012) who reported that the NDF contents of swamp green vegetations in a pasture for buffaloes were about 91.73–93.45% in grasses and 68.11–90.93% in legumes and the ADF content of grasses was 51.6-86.8%. ~~i~~It was shown in other studies that NDF and ADF contents of roughages in a pasture during the rainy season to the end of the dry season in Sabana Timur Barat were on average 65.9 and 43.29%, respectively (Manu, 2013). Vegetations in a natural pasture and a coffee plantation area had NDF contents of 74.89 and 72.37% and ADF contents of 57.22 and 55.15%, respectively (Kleden et al., 2015). Meanwhile, swamp vegetations in South Kalimantan had average NDF and ADF contents of 55.97 and 37.87%, respectively, during the high tidal season and 81.44 and 60.86% respectively, during the low tidal season (Rostini et al., 2014).

NDF and ADF contents of roughages in the BPTU-HPT Padang Mengatas area were found to be 75.62 and 45.96%, respectively in the rain season and 69.35 and 38.66%, respectively in the dry season (Muhajirin et al., 2017). NDF and ADF contents of Eceng gondok (*E. crassipes* in this study were 62.77 and 41.83%, respectively. These figures were close to those of *water hyacinth* (*E.crassipes*) plants studied by Tham (2015) with NDF and ADF contents of 63.9 and 34.68% and by Tham and Uden (2015) with NDF and ADF contents of 52.1 and 30.7%, respectively. Other studies conducted by Ahmed et al. (2016), Anitha et al. (2016), and Nampoothiri (2017) showed that *Azolla sp* had NDF and ADF contents of 53.8-54.85% and 36.57-37.0%, respectively. Meanwhile, NDF and ADF contents of *elephant* grass (*P. purpureum*) were found to be 55.8 and 46.5% (Dahlan and Iskandar, 2013) and 84.25 and 64.07% (Nuhuyanan, 2010), respectively. These figures equaled to the NDF and ADF contents of Kumpai tembaga (64.72 and 46.38%), Kumpai minyak (65.31 and 38.92), and Are bolong (61.27 and 48.46%). This indicated that~~,~~ lowland swamp vegetations had fiber fraction nutritional quality which was not less than that of prime grasses including *elephant* grass and *king* grass.

In this study, NDF and ADF contents of lowland swamp vegetations were 40.65– 79.47% and 23.66%–60.33%, respectively. These figures were still within the ranges of NDF and ADF contents of prime grasses such as *elephant* grass (*P. purpureum*), which had NDF and ADF contents of 55.8 and 46.5% (Dahlan and Iskandar, 2013) and 84.25 and 64.07% (Nuhuyanan, 2010), respectively. In the rumen, NDF degradation is higher than that of ADF as NDF contains hemicellulose fraction which is more soluble (Church and Pond, 1986). NDF content has a negative correlation with its degradation rate (Varga et al., 1983) and higher NDF content decreases dry matter digestibility of feed (NRC, 1988). Cellulose is an ADF component ~~which~~ that is easy to digest while lignin is hard to digest as it contains double bonds. Higher lignin content decreases feed digestibility (Sutardi et al., 1980).

Hemicellulose and Cellulose Contents

Lowland swamp vegetations were found to have hemicellulose and cellulose contents ranging from 7.73 to 37.14% and 5.24 to 27.08%, respectively. Four green vegetations with the highest hemicellulose contents were Bento rayap (*L. hexandra*) (37.14%), Kerak maling (*D. fuscescens*) (31.87%), Kumpai merah (*Hymenachne sp.*) (31.74%), and Kumpai minyak (*H. amplexicaulis*) (26.39%). In contrast, the lowest hemicellulose content was found in Cecengkehan (*L. hyssopifolia*) (7.73%). Highest cellulose contents were found in Kemon air (*N. olerancia*) (27.08%), Bento rayap (*L. hexandra*) (25.88%), Purun tikus (*E. dulcis*) (21.80%), and Are bolong (*P. barbatum*) (20,28%). Meanwhile, Kasuran (*C.digitatus*) had the lowest cellulose content of 5.24% (Table 3). Results of this study were in line with those of a study conducted by Asep et al. (2012) who reported the hemicellulose and cellulose contents of lowland swamp green vegetations ranging from 7.89 to 31.55% and 30.85 to 63.35%, respectively. They also found that Kumpai padi (*O.rupifogon*) had 31.55% hemicellulose content which was higher than those of Kumpai padi (10.80- 19.30%) found in this study (Table 4). Swamp vegetations in South Kalimantan had hemicellulose contents of 0.65-25.85% in high tidal season and 5.37-40.09% in low tidal season. Cellulose contents in high and low tidal seasons were about 20.07-34.03% and 7.90- 38.31%, respectively (Rostini et al., 2014). Various water plants including Azolla, which was used as animal feed, had hemicellulose and cellulose contents of 10.20 and 12.76% (Nampoothiri, 2017), 1.15-10.20% and 12.76% (Nampoothiri, 2017), respectively. Roughages in BPTU-HPT Padang Mengatas had hemicellulose and cellulose contents of 29.79 and 33.62% in the rain season and 30.69 and 31.64% in the dry season, respectively (Muhajirin et al., 2017). *Elephant* grass (*P. perpureum*) was found to contain 21.18% hemicellulose and 43.32% cellulose (Nuhuyanan, 2010) and 35.3% cellulose (Dahlan and Iskandar, 2013). In a study conducted by Archimede et al. (2010), hay was found to have 37.7% hemicellulose and 35.7% cellulose. Based on the above findings, it was suggested that hemicellulose (7.73–37.14%) and cellulose (5.24–27.08%) contents of lowland swamp vegetations in this study were within normal ranges and these vegetations were potential to be used as feed for Pampangan buffaloes.

Lignin Contents

Lignin contents of lowland swamp vegetations ranged from 14.84 to 43.09%. Four vegetations including Telepuk gajah (*N. lotus*), Kemon air (*N. olerancia*), Kumpai merah (*Hymenachne sp.*), and Kangkung merah (*I. aquatica*) were found to have the lowest lignin contents of 14.84, 18.36, 19.76, and 19.85%, respectively, while the highest lignin content of 43.09% was found in Kumpai padi (*O. rupifogon* P) (Table 3). Lignin contents in this study were higher than that obtained by Rostini et al. (2014) who reported the lignin contents of swamp vegetations in South Kalimantan were about 2.8-17.59% in high tidal season with that of Kumpai minyak as the lowest and that of *Beberasan* as the highest and 10.06-61.12% in low tidal season with that of *Beberasan* as the lowest and that of Kumpai minyak as the highest. Lignin contents of Kumpai padi (*O. rupifogon* R) (31.24%) and Kumpai padi (*O. rupifogon* P) (43.09%), Bento rayap *(L. hexandra)* (33.92%), and Eceng gondok *(E. crassipes)* (31.60%) (Table 3) found in this study were higher those of Kumpai padi (18.27%) and Bento rayap *(L. hexandra)* (17.96%) found by Asep et al. (2012) and Eceng gondok *(E. crassipes)* (8.17%) found by Tham (2015). In other studies *Azolla* was found to have lignin contents of 5.7% (Ahmed et al., 2016) and 28.24% (Nampoothiri, 2017). Meanwhile, lignin contents of *elephant* grass were found to be 15.37% (Nuhuyanan, 2010) and 11.2% (Dahlan and Iskandar, 2013).

Differences in lignin contents in green vegetations are suspected to be caused by differences in plant species, plant ages, and environmental factors including seasons (rain or dry season), tidal seasons, and fertility levels of the soil where the vegetations grow. In cell walls, cellulose is a bond with hemicellulose and lignin. ~~Lignin cannot be digested by the animals~~The animals cannot digest lignin and its ~~–~~ molecule structure ~~atomic proportion~~ is different from other carbohydrates as it contains carbon and nitrogen of only 1-5%. Hemicellulose consists of pentose, hexose, uronic acid, and pectin substance. Pectin is a carbohydrate ~~which~~ that is composed of auronic acid, galactose, arabinose, xylose, and methanol. Cellulose is degradable by microorganisms and functions as the source of volatile fatty acids. Young grasses (roughages) contain less than 5% lignin and 80% of their cellulose is degradable. On the contrary, in old roughages, lignin content may reach up to 10% causing a decrease in cellulose digestibility by up to 50% (Prawirokusumo, 1994).

Based on the results of the study, it was concluded that:

1. The highest protein (20.56%) and crude fat (2.92%) contents were found in Kemon air *(Neptunia olerancia)*. The highest ash content (25.19%) was found in Kasuran *(C. digitatus)*, while the lowest (11.01%) was found in Cecengkehan *(L. hyssopifolia)*. The lowest NDF content (40.64%) was found in Cecengkehan *(L. hyssopifolia)* and the highest hemicellulose content (37.14%) was found in Bento rayap. Telepuk gajah had the lowest ADF (23.66%) and lignin (14,84%) contents. Kemon air contained the highest cellulose level of 27.08%.
2. The best nutritional values were found in Kasuran *(C. digitatus)* and Cecengkehan *(L. hyssopifolia)*.
3. Dominant and palatable swamp roughages with good nutrient contents included Kumpai tembaga *(H. acutigluma)*, Kumpai minyak *(H. amplexicaulis)*, Kumpai padi *(O. rupifogon)*, Are bolong *(P. barbatum)*, and Purun tikus *(E. dulcis)*.

~~ACKNOWLEDGEMENTS~~ACKNOWLEDGMENTS

The author expresses his deepest gratitude to the Rector of Sriwijaya University through the Chair of the Institute for Research and Community Services funding this research in accordance with the Competitive Leading Research Contract of Sriwijaya University Number: 988 / UN9.3.1 / PP / 2017, dated 21 July 2017.

REFERENCES

Ahmed HA, Ganai A.M, Beigh YA, Sheikh GG, Reshi PA. 2016. Performance of growing sheep on *Azolla* based diets. Indian J. Anim. Res. 50 (5): 721-724.

Alam MR, Haque MM, Sumi KR, Ali MM. 2015. Proximate composition of para-grass *(Brachiaria mutica)* produced in integrated fish-fodder culture system. Bang. J. Anim. Sci. 44 (2): 113-119.

Ali AIM, Sandi S, Muhakka, Riswandi. 2012. Kualitas hijauan pakan di rawa lebak padang penggembalaan kerbau pampangan. Proc.~~siding~~ InSINAS 2012. 307-312.

Anitha KC, Rajeshwari YB, Prasanna SB, Shree JS. 2016. Nutritive evaluation of azolla as livestock. J.~~ournal~~ of Experim~~ental~~. Bio~~logy~~. and Agric~~ultural~~. Sci.~~ences.~~ 4(6): 670-674.

AOAC (Association of Official Analytical Chemists). 1990. Official Methods of Analysis. 15th ed., Washington, DC.

Araica BM, Sporndly E, Sanchez NR, Norell L, Sporndly R. 2009. Silage quality when Moringa oleifera is ensiled in mixtures with elephant grass, sugar cane and molasses. Gra.~~ss~~ and For.~~age~~ Sci.~~ence.~~ 64: 364-373.

Archimede H, Gonzales-Garcia E, Despois P, Etienne T, Alexandre G. 2010. Subtitution of corn and soybean with green banana fruits and Gliricidia sepium forage in sheep fed hay-based diets: effects on intake, digestion and growth. J.~~ournal~~ of Anim.~~al~~ Physiol.~~ogy~~ and Anim.~~al~~. Nutr.~~ition.~~ 94 (2010): 118-128.

Brazle FK, Kilgore GI, Fauzett MR. 2000. Effect of season on grazing native-grass pastures. The Prof.~~esional~~ Anim.~~al~~ Sci.~~entist.~~ 16: 15-28.

BPS (Badan Pusat Statistik). 2010. Direktorat Jendral Tanaman Pangan. *Luas lahan rawa di Indonesia*. Departemen Pertanian. Jakarta.

BPS (Badan Pusat Statistik) Provinsi Sumatera Selatan. 2014. Sumatera Selatan dalam Angka 2014.

Church DC, Pond WG. 1986. Digestive Animal Physiologi and Nutrition. 2nd. Prentice Hell a Devision of Simon and Schuster Englewood Clief, New York.

Dahlan I, Iskandar MNZ. 2013. Use of plantain peels (Musa paradisiaca) as a fibrous feed substitute for napier grass (Pennisetum purpureum) in rusa deer (Cervus timorensis ratio under captivity. J. Anim. Sci. 3 (9): 472-480.

Commented [A17]: The sentence to long

Formatted: English (United States)

Formatted: English (United States)

Commented [A18]: Atomic proportion ? or molecule structure ?

Formatted: English (United States)

Commented [A19]: ????

Formatted: English (United States)

Formatted: English (United States)

Formatted: English (United States)

Formatted: English (United States)

Formatted: English (United States)

Formatted: English (United States)

Formatted: English (United States)

Commented [A20]: abbreviation

Formatted: English (United States)

Formatted: English (United States)

Formatted: English (United States)

Formatted: English (United States)

Damry. 2009. Produksi dan kandungan nutrisi hijauan padang penggembalaan alam di Kecamatan Lore Utara Kabupaten Poso. J.~~urnal~~ Agrol.~~and.~~ 16 (4): 296-300.

Eoh M. 2014. Kapasitas tampung dan komposisi zat-zat makanan padang penggembalaan ternak kerabau di Pulau Moa. Agrinimal. 4 (2): 77-82.

Gutteridge RC, Shelton HM. 1994. The Role of Forage Tree Legumes in Cropping and Grazing System. The Trop.~~ical~~ Grassl~~and~~ Soc.~~iety~~ of Aust.~~ralia~~ Inc.

Hossain MdE, Sikder H, Kabir MdH, Sarma SM. 2015. Nutritive value of water hyacinth *(Eichhornia crassipes).* Online J.~~ournal~~ of Anim.~~al~~ and Feed Resear.~~ch.~~ 5 (2): 40-44.

Kathirvelan C, Banupriya S, Purushothaman MR. 2015. Azolla-an alternate and su tainable feed for livestock. Internat.~~ional~~ J.~~ournal~~ of Sci.~~ence~~ Environ.~~ment.~~ 4 (4): 1153-1157.

Kleden MM, Ratu MRD, Randu MDS. 2015. Kapasitas tampung hijauan pakan dalam areal perkebunan kopi dan padang rumput alam di Kabupaten Flores Timur Nusa Tenggara Timur. J.~~urnal~~ Zootek 35 (2): 340-350.

Mako AA, Akinwande VO, Anurudu NF, Ogunwole OA. 2016. Evaluation of nutritive value of water hyacinth *(Eichhornia crassipes)* and guinea grass *(Panicum maximum)* mixture as animal feed in the tropics. 2016. Bull. Anim. Hith. Prod. Afr. (64): 463-473.

Manu AE. 2013. Produktivitas padang penggembalaan sabana Timor Barat. J.~~urnal~~ Pastura. 3 (1): 25-29.

Maswada HF, Elzaawely AA. 2013. Nutritive value of Stipagrostis lanata (Forssk.) de winder as a feed for livestock. Asian J.~~ournal~~ of Crop Sci.~~ences.~~ 5 (2): 216-221.

Muhakka, Suwignyo RA, Budianta D dan Yakup. 2019. Vegetation analysis of no-tidal swampland in South Sumatra, Indonesia and its carrying capacity for Pampangan buffalo pasture. J.~~ournal~~ Biodiv.~~ersitas.~~ 20 (4): 1077-1086.

Muhakka, Wijaya A, Ammar M. 2015. Nutritional dried matter, crude protein and crude fiber on lowland tidal grass fermented by probiotic microorganisms for use bali cattle feed. J.~~ournal~~ Anim.~~al~~ Prod.~~uction.~~ 17 (1): 24-29.

Muhajirin, Despal, Khalil. 2017. Pemenuhan kebutuhan nutrien sapi potong bibit yang digembalakan di Padang Mengatas. Buletin Makanan Ternak.104 (1): 9-20.

Mulyani A, Sarwani M. 2013. Karakteristik dan potensi lahan sub optimal untuk pengembangan pertanian di Indonesia. J.~~urnal~~ Sumber daya Lahan. 7 (1): 47-55.

Nampoothiri VM. 2017. Aquatic plants and marine waste as animal feed. Sch.J. Agric.Vet. Sci. 4 (6): 249-254.

Norman HC, Master DG, Barrentt-Lennard EG. 2013. Halophytes as forage in saline landscapes: Interaction between plant genotipe and environment change their feeding value to ruminants. Environ.~~mental~~ and Exp.~~erimental~~ Bot.~~any.~~ 92 (2013): 96-109.

NRC. 1988. Nutrition Reguirement of Beef Cattle. 6th. Rev. Ed. National.

Nuhuyanan LE. 2010. Pengaruh pemberian wafer rumput gajah dengan perekat fermented moter liquor (FML) dan tetes (molasses) terhadap konsumsi pakan, kecernaan zat-zat makanan dan kenaikan berat badan sapi bali jantan. J.~~urnal~~ Ilmu Peternakan. 5 (2): 111-117.

Prawirokusumo S. 1994. Ilmu Gizi Komperatif. BPFE., Yogyakarta.

Rahman MM, Abdullah RB, Wan Khadijah WE, Nakagawa T, Akashi R. 2014. Feed intake and growth performance of goats affered napier grass *(Pennisetum purpureum)* supplemented with concentrate pellet and soya waste. Sain Malaysiana. 43 (7): 967-971.

Richmond AS, Wylie ARG, Laidlaw AS, Lively FO. 2015. Methane emissions from beef cattle grazing on semi-natural upland and improved lowland grasslands. Anim.~~al.~~ 9 (1): 130-137.

Rostini T, Abdullah L, Wiryawan KG, Karti PDMH. (2014). Production and nutrition potency of swamp local forage in South Kalimantan as ruminant feed. Glob. J. Anim. Sci. Livestock Prod. Anim. Breed. 2 (2):107-113.

Santoso dan Hariadi BTj. 2008. Komposisi kimia, degradasi nutrien dan produksi gas metana in vitro rumput tropika yang diawetkan dengan metode silase dan hay. J. Media Peternakan 31(2): 128-137.

Se'u VE, Karti PDMH, Abdullah L. 2015. Botanical composition, grass production, and carrying capacity of pasture in Timor Tengah Selatan District. J.~~ournal~~ Media Peternakan 38(3):176-182.

Statistik Peternakan Sumatera Selatan. 2014. Dinas Peternakan Provinsi Sumatera Selatan Tahun Anggaran 2015.hal:14.

Sutardi T, Pratiwi SH, Adnan A, Nuraini S. 1980. Peningkatan pemanfaatan jerami padi melalui hidrolisa basa, suplementasi urea dan belarang. Bull. Makanan Ternak. 6 Bogor.

Tham HoT. 2015. Utilisation of water hyacinth as animal feed. Nova J.~~ournal~~ of Engineer.~~ing~~ and Appl.~~ied~~ Sci.~~ences.~~ 4 (1): 1-6.

Tham HoT, Uden P. 2015. Effect of fresh water Hyacinth (Eichhornia crassipes) on intake and digestibility in cattle fed rice straw and molasses-urea cake. Nova J.~~ournal~~ of Engineer.~~ing~~ and Appl.~~ied~~ Sci.~~ences.~~ 4(1): 1-8.

Tjondronegoro AD, Gunawan A. 2000. Beberapa jenis gulma di lahan pasang surut pada tingkat kemasaman tanah yang berbeda. Pros.~~iding~~ Seminar Nasional. P. 247-254.

Van Soest PJ. 1982. Nutritional Ecology of the Ruminant: Ruminant Metabolism, Nutritional Stategies the Cellulolytic Fermentation and the Camisthy of Forages and Palm Fiber. Cornell University O & B Books Inc. USA.

Varga GA, Hoover WH. 1983. Rate and extent of NDF of feedstuff in-situ. J. Dairy. Sci. 66:2109.

Formatted: English (United States)

Formatted: English (United States)

Commented [A21]: Names of journals should be abbreviated. Always use the standard abbreviation of a journal's name according to the **ISSN List of Title Word Abbreviations** (www.issn.org/2-22661-LTWA-online.php).

Formatted: English (United States)

Formatted: English (United States)

4. Bukti konfirmasi review dan hasil review kedua (7 Februari 2020)

Notifications

[biodiv] Editor Decision

2020-02-07 04:29 AM

Muhakka Muhakka Muhakka:

We have reached a decision regarding your submission to Biodiversitas Journal of Biological Diversity, "Nutritional Values of Swamp Grasses as Feed for Pampangan Buffaloes in South Sumatra Indonesia ".

Our decision is: Revisions Required

Smujo Editors
editors@smujo.id

Reviewer A:
Recommendation: Revisions Required

Biodiversitas Journal of Biological Diversity

BIODIVERSITAS
Volume 21, Number 1, January 2020
Pages: xxxx

ISSN: 1412-033X
E-ISSN: 2085-4722
DOI: 10.13057/biodiv/d2101xx

Nutritional values of swamp grasses as feed for Pampangan Buffaloes in South Sumatra, Indonesia

MUHAKKA[1,♥], RUJITO AGUS SUWIGNYO[2], DEDIK BUDIANTA[3], YAKUP[2]

[1]Department of Animal Husbandry, Faculty of Agriculture, Sriwijaya University, Jl. Palembang-Prabumulih Km, 32 Inderalaya, Ogan Ilir 30662, South Sumatra, Indonesia, Tel/Fax. +62-711-581106. ♥email: muhakka@fp.unsri.ac.id

[2]Department of Agronomy, Faculty of Agriculture, Sriwijaya University, Jl. Palembang-Prabumulih Km, 32 Inderalaya, Ogan Ilir 30662, South Sumatra, Indonesia

[3]Department of Soil Science, Faculty of Agriculture, Sriwijaya University, Jl. Palembang-Prabumulih Km, 32 Inderalaya, Ogan Ilir 30662, South Sumatra, Indonesia

Manuscript received: 17 October 2019. Revision accepted: xxx December 2019.

Abstract. *Muhakka, Suwignyo RA, Budianta D, Yakup. 2020. Nutritional values of swamp grasses as feed for Pampangan Buffaloes in South Sumatra, Indonesia. Biodiversitas 21: xxxx.* This study was aimed at determining the types and quality of vegetations in the swamp area, which could be used as sources of roughage for Pampangan buffaloes in South Sumatera. In this descriptive study. Results showed that the highest crude protein and ether extract contents, 20.56 and 2.92%, respectively, were found in Kemon air *(Neptunia olerancia)*. The highest ash content of 25.19% was found in Kasuran *(Cyperus digitatus)*. The lowest fiber content (11.01%) was found in Cecengkehan *(Ludwigia hyssopifolia)*, which also had the lowest content of Neutral Detergent Fiber (NDF) (40.64%). Hemicellulose content was found to be highest (37.14%) in Bento rayap *(Leersia hexandra)*. The lowest ADF (23.66%) and lignin (14,84%) contents were found in Telepuk gajah *(Nymphaea lotus)*. Kemon air *(N. olerancia)* was found to have the lowest content (27.08%) of cellulose. It was concluded that the swamp vegetation found in this study consisted of 17 types of grasses (89.47%) and two types of legumes (10.53%). Kasuran *(C. digitatus)* and Cecengkehan *(L. hyssopifolia)* were found to have the best nutritional values. Dominant and palatable vegetations with good nutritional values, which were potential to be used as sources of roughage for *Pampangan* buffaloes, were Kumpai tembaga *(Hymenachne acutigluma)*, Kumpai padi *(O ryza rupifogon)*, Kumpai minyak *(Hymenachne amplexicaulis*, Are bolong *(Polygonum barbatum)*, and Purun tikus *(Eleocharis dulcis)*.

Key words: Nutritional value, Swamp grass, Feed, Pampangan buffalo.

Commented [a1]: For the fist time, species name shoud be written completely with the genus name.... check all the rest

INTRODUCTION

The availability of roughage as the main feed for ruminant animals depends considerably on seasons. During the rainy season, it is abundant, and during the dry season, the availability of grasses and legumes is lacking. The limited supply of roughage may hamper productivity including the reproductive performance of ruminant animals including buffaloes.

In South Sumatera, Pampangan buffalo is a potential germplasm which needs to be preserved and developed. There were 37,405 heads of Pampangan buffaloes in 2016, and this population increased by 3.97% to 38,952 heads in 2017. In 2017, of this population, 11,150 heads (28.63%) and 2,227 heads (5.72%) were found in Ogan Komering Ilir Regency and Banyuasin Regency, respectively (Statistik Peternakan Sumsel 2017). The population and productivity of *Pampangan* buffaloes need to be improved, and for this purpose, feed is an important factor to consider. Pampangan buffaloes feed mostly on roughage from the swamp, grassland to meet their maintenance and reproductive needs.

In Indonesia, there are 13.27 million hectares of lowland swamp areas. Only 4 million hectares of these areas have been developed and cultivated by the community and private sectors (2.6 million hectares) and the government assistance (1.3 million hectares) (BPS 2010, Mulyani and Sarwani 2013). In Sumatera, the largest lowland swamp area of 2.98 million hectares is found in South Sumatera, but only 298,189 hectares of it have been utilized (BPS Sumatera Selatan 2014). In order to utilize the potential swamp area as a feed source for Pampangan buffaloes, a study on vegetations as sources of roughage in lowland swamp areas that include vegetation identification and nutritional quality determination needs to be conducted.

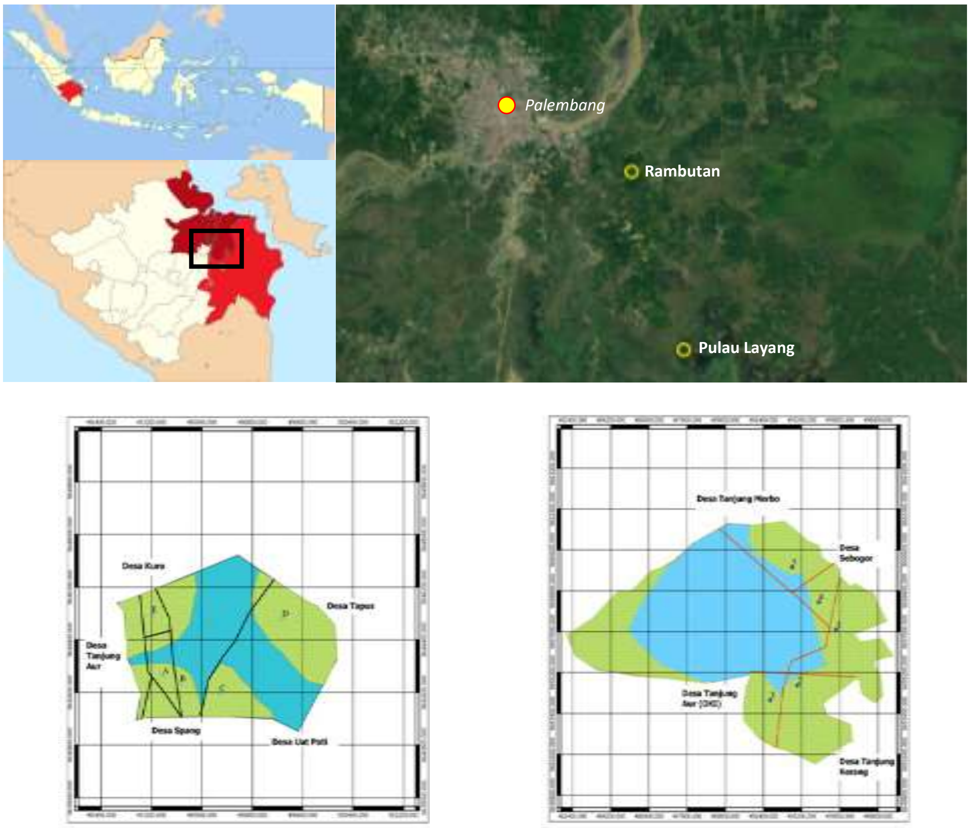
In the previous study, some swamp grasses, including Kumpai minyak grass (*H. amplexicaulis)* (Rostini et al. 2014**;** Muhakka et al. 2015), *I. rugosum* and *L. hexandra* (Ali et al. 2012) were identified. However, many more swamp has not been identified. For example, *P. barbatum,C. digitatus, R. corymbosa* This study was conducted to identify the types and nutritional values of vegetations that could be used as sources of roughage feed for Pampangan buffaloes in South Sumatera. This information was important to support the productivity improvement of Pampangan buffaloes as germplasm in South Sumatera. In this study, some new swamp found where in the previous study it's not found yet.

MATERIALS AND METHODS

Area study

This study was a descriptive study to assess the types and nutritional values of vegetations, which were the dominant and palatable as sources of roughage feed for Pampangan buffaloes. Vegetation samples were taken from grazing areas of Pampangan buffaloes in Rambutan Village and Pulau Layang Village, South Sumatra, Indonesia (Figure 1) from April to Juni 2017. Vegetation samples for nutrient analysis were obtained by following these procedures: (i) vegetation collection was done based on estimated growth age (young age, medium age, and old age based on physical appearance), (ii) collected samples of each vegetation was composited, and (iii) samples were chopped into small sizes, homogenized.

For each vegetation, 1 kg sample was taken randomly and sent to the laboratory for oven drying at 105ºC until a constant weight was obtained and dry matter content was determined. Samples were then ground for nutrient content determination by using proximate and Van Soest analyses (Syarifuddin and Wahdi 2010). Sample analyses of Crude protein, fiber, ether extract, and ash contents conducted in Laboratory of Dairy Nutrition, Department of Nutrition and Feed Technology, Institut Pertanian Bogor (IPB), Bogor, Indonesia, while analyses of NDF, ADF, hemicellulose, cellulose, and lignin conducted in Biotechnology Assessment Laboratory, Center for Biotechnology Research, Indonesian Institute of Sciences (LIPI), Cibinong, Bogor; and analysis of soil conducted in Laboratory of Soil Chemistry, Biology, and Fertility, Soil Department, Faculty of Agriculture, Sriwijaya University, Ogan Ilir, Indonesia.



A B

Figure 1. Research location in South Sumatra, Indonesia. A. Pulau Layang Village, Pampangan Sub-district, Ogan Komering Ilir District, South Sumatra. B. Rambutan Village, Rambutan Sub-district, Banyuasin District, South Sumatra, Indonesia (Muhakka et al. 2019)

Measured parameters

Soil analysis

Soil sampling is done in a composite manner at a depth of 0-20 cm. Taking the soil sample points is done by making a diagonal line in each zone and determining 5 soil sampling points to analyze chemical fertility (N, P, K) and physical fertility (texture, structure and pH).

Proximate analysis

Crude protein, fiber, ether extract, and ash contents were determined based on the procedures of AOAC (1990). *Crude protein*. Nitrogen (N) content was determined by using a Kjeldahl method. In this analysis, sulphuric acid with a catalyst and a heating process. The organic matter of samples was then oxidized by sulfuric acid, and nitrogen was changed into an ammonium sulfate form. The remaining sulfuric acid was neutralized by NaOH until the solution became basic. Ammonium sulfate was then distilled in an acid medium to obtain the quantitative amount of N. As the average protein contains 16% nitrogen, a factor 100 %: 16% = 6.25 was used to obtain the value of crude protein (crude protein = N% x 6.25). *Fiber.* The filtered fat-free sample was used in fiber content determination. 1.25% sulfuric acid solution was added into the sample, and the mixture was heated for about 30 minutes before the residue was filtered. 1,25% NaOH solution was added into the precipitate, and the mixture was heated for about 30 minutes. The mixture was then filtered, and the precipitate was washed, dried, and weighed. This precipitate was burnt, and the ash was weighed. The difference between the weight of precipitate before it was burnt and the weight of the ass was referred to as fiber content. *Ether extract*. The dry matter sample was extracted with diethyl ether for 5 hours. At the end of the extraction process, ether evaporated and the remaining material was referred to as fat. *Ash*. The third part of the dry matter sample was weighed and burnt in a crucible at 550ºC for 8 hours.

Van Soest analysis

Neutral Detergent Fiber (NDF), Acid Detergent Fiber (ADF), hemicellulose, cellulose, and lignin contents were determined by using a Van Soest method (1982).

Neutral Detergent Fiber (NDF). One gram of sample was put in a beaker glass. 50 ml NDS solution was added into the beaker before the mixture was heated for an hour. The mixture was then filtered by using a vacuum pump and a filter glass which was previously weighed (b gram). The mixture was then washed with hot water and acetone before it was dried in an oven and let cool in a desiccator. Finally, it was weighed as c gram. NDF content was calculated by using the following formula:

$$\% \text{ NDF} = \frac{c-b}{a} \times 100\%$$

Acid Detergent Fiber (ADF). One gram of sample was put in a beaker glass. 50 ml ADS solution was added into the beaker before the mixture was heated for an hour. The mixture was then filtered by using a vacuum pump and a sintered glass filter which was previously weighed (b gram). The mixture was then washed with hot water and acetone before it was dried in an oven and let cool in a desiccator. Finally, it was weighed as c gram. Cellulose content was calculated by using the following formula:

$$\% \text{ cellulose} = \frac{c-d}{a} \times 100\%$$

Hemicellulose. Hemicellulose content was calculated as a difference between NDF and ADF contents as follows.

% Hemicellulose = % NDF-% ADF

Lignin. Cellulose residue (d gram) was burnt in a furnace at 500-600ºC for 3 hours. After that, it was left to cool and weighed (e gram). Lignin content was calculated by using the following formula:

$$\% \text{ Lignin} = \frac{d-e}{a} \times 100\%$$

Data analysis

The data obtained were used directly to describe the nutritional value of the swamp vegetation that could be used as a roughage source. These data were then combined with those of *in vitro* digestibility as the basis for concluding (Syarifuddin and Wahdi 2010).

RESULTS AND DISCUSSION

Soil analysis

Results of soil analysis showed that soil at the study site had a low fertility level and was highly acidic. It also had very high organic C and total N contents, medium level of exchangeable-K and N contents, very low Ca and Mg contents, medium P content, and very high CEC level (Table 1).

Nutrient contents of lowland swamp

Crude protein, fiber, ether extract, and ash nutrient contents of lowland swamp vegetations found in this study are listed in (Table 2).

The NDF and ADF contents of vegetations found in this study were about 40.65-79.47% and 23.66-60.33%, respectively. Lowland swamp vegetations were found to have hemicellulose and cellulose contents ranging from 7.73 to 37.14% and 5.24 to 27.08%, respectively. Lignin contents of lowland swamp vegetation ranged from 14.84 to 43.09% (Table 3).

Discussion

Crude protein content

Results showed that the crude protein contents of swamp green vegetations ranged from 5.26% to 20.56% with the lowest value (5.26%) was found in Berondong grass (*R. corymbosa*) and the highest (20.56%) was found in Kemon air legume (*N. olerancia*). Kasuran grass (*C. digitatus*) had the highest crude protein content (15.31%)

(Table 2). This high nutritional value of Kasuran grass was suspected as caused by the fact that most of this grass was found to grow in the area of buffalo pens where the soil was rich in organic matter. However, the growth of this grass was not dominant as it mostly occurred in rainy seasons.

Kumpai minyak (*H. amplexicaulis*), Kumpai padi (*O. rupifogon*), Kumpai tembaga (*H. acutigluma*), and Purun tikus (*E. dulcis*) were found as the dominant palatable grasses containing 12.00, 10.41, 10.96, and 8.22% crude protein, respectively. Results of this study were not too different from those obtained by Rostini et al. (2014), who reported that Kumpai minyak and Pipisangan had protein contents of 10.88 and 15.92%, respectively. Crude protein (CP) contents of these swamp grasses in Pulau Layang and Rambutan Villages were closed to those of prime grasses including 9.11-12.8% CP of *elephant* grass (*P. purpureum*) (Santos et al. 2013; Dahlan and Iskandar 2013; Rahman et al. 2014), 12.4% CP of *elephant* grass hay, 11.1% CP of *elephant* grass silage, 11.4% CP of king grass hay, and 10.2% CP of king grass silage (Santoso and Hariadi 2008). Other vegetations even had higher CP contents including Kumpai tembaga *(H. acutigluma)* with 10.96% CP, Tapak dara (*C. roseus*) 15.20%, Telepuk gajah (*N. lotus*) 13.22%, Cecengkehan (*L. hyssopifolia*) 12.07%, Kasuran *(C. digitatus*) 15.31%, and Kumpai minyak (*H. amplexicaulis)*[R] 12.0% (Table 2). CP contents of vegetations in this study were also higher than those of nature grasses found in coffee plantation areas (6.95%) and pastoral areas (6.65%) in Wulanggitang District, East Flores Regency as reported by Kleden et al. (2015). Meanwhile, CP content of grasses in lowlands was 8.41% (Rochana et al. 2016; Maswada and Elzaawely 2013).

Table 1. Properties of soil at the study site

Parameter	*Pulau Layang*		*Rambutan*	
	Value	Remark	Value	Remark
pH H_2O (1 : 1)	5.10	Low	4.41	Very low
pH KCl (1 : 1)	4.39	Very acidic	3.99	Very acidic
Organic C (g/kg)	57.66	Very high	36.14	Very high
Total N (g/kg)	3.64	Very high	2.19	Very high
Available P/Bray I (mg/kg)	11.70	Medium	2.25	Very low
Exchangeable K (cmol/kg)	0.63	Medium	0.45	Medium
Na (cmol/kg)	0.65	Medium	0.65	Medium
Ca (cmol/kg)	1.95	Very low	0.73	Very low
Mg (cmol/kg)	0.45	Very low	0.32	Very low
CEC (cmol/kg)	65.25	Very high	43.50	Very high
Exchangeable Al (cmol/kg)	1.84		2.37	
Exchangeable H (cmol/kg)	0.74		0.88	
Texture:				
Sand (%)	47.08		46.64	
Ash (%)	31.11		27.18	
Clay (%)	21.81		26.18	

Table 2. Crude protein, fiber, ether extract, and ash contents (%) of lowland swamp vegetations

Latin name	Local name	Crude protein	Fiber	Ether extract	Ash
Catharanthus roseus	Tapak dara	15.20	11.18	1.29	12.53
Cyperus digitatus	Kasuran	15.31	14.76	1.42	25.19
Digitaria fuscescens	Kerak Maling/Pasiran	12.00	15.64	1.24	16.26
Eichhornia crassipes	Eceng gondok	8.61	20.66	0.84	14.22
Eleocharis dulcis [P]	Purun tikus	8.22	25.72	0.48	15.13
Eleocharis dulcis [R]	Purun tikus	6.63	24.52	1.69	10.24
Hymenachne acutigluma) [P]	Kumpai Tembaga	6.86	30.26	2.22	7.88
Hymenachne acutigluma [R]	Kumpai Tembaga	10.96	23.73	1.77	10.30
Hymenachne amplexicaulis [P]	Kumpai Minyak	9.21	21.91	2.82	13.96
Hymenachne amplexicaulis [R]	Kumpai Minyak	12.00	15.64	1.24	16.26
Hymenachne sp	Kumpai Merah	8.52	21.20	1.30	12.88
Ipomoea aquatica	Kangkung merah	8.95	14.34	2.24	10.39
Leersia hexandra	Bento rayap	5.35	27.57	2.06	5.63
Ludwigia hyssopifolia	Cecengkehan	12.07	11.01	1.66	9.09
Neptunia olerancia	Kemon air	20.56	15.03	2.92	7.31
Nymphaea lotus	Telepuk Gajah	13.22	11.45	2.84	10.30
Oryza rupifogon [P]	Kumpai Padi	7.93	23.30	1.60	16.25
Oryza rupifogon [R]	Kumpai Padi	10.41	21.59	2.49	11.92
Polygonum barbatum	Are Bolong	7.53	16.60	1.57	8.40
Rhynchospora corymbosa	Berondong	5.26	22.27	1.48	14.84

Sesbania exasperata	Mutiara	18.27	11.22	1.86	19.47

Notes: P : Grass in Pulau Layang Village; R : Grass in Rambutan Village.

Table 3. Composition of fiber fractions of green vegetations in lowland swamp: NDF, ADF, hemicellulose, cellulose, and lignin (%).

Latin name	**NDF**	**ADF**	**Hemi-cellulose**	**Cellulose**	**Lignin**
Catharanthus roseus	47.79	39.67	8.12	16.96	22.71
Cyperus digitatus	58.90	36.93	21.97	5.24	31.68
Digitaria fuscescens	65.43	33.56	31.87	12.11	21.45
Eichhornia crassipes	62.77	41.83	20.94	10.22	31.60
Eleocharis dulcis P	69.57	49.83	19.74	21.80	28.04
Eleocharis dulcis R	75.73	54.91	20.82	19.71	35.20
Hymenachne acutigluma P	75.89	50.60	25.29	12.25	38.34
Hymenachne acutigluma R	64.72	46.38	18.34	16.01	30.37
Hymenachne amplexicaulis	65.31	38.92	26.39	8.29	30.63
Hymenachne sp	60.14	28.40	31.74	8.64	19.76
Ipomoea aquatica	41.40	26.17	15.23	6.32	19.85
Leersia hexandra	79.47	42.33	37.14	25.88	33.92
Ludwigia hyssopifolia	40.64	32.91	7.73	8.39	24.52
Neptunia olerancia	62.31	45.44	16.87	27.08	18.36
Nymphaea lotus	46.05	23.66	22.39	8.82	14.84
Oryza rupifogon P	71.13	60.33	10.80	17.23	43.09
Oryza rupifogon R	65.49	46.19	19.30	14.96	31.24
Polygonum barbatum	61.27	48.46	12.81	20.28	28.18
Rhynchospora corymbosa	65.29	44.64	20.65	16.08	28.56

Note: P : Grass in Pulau Layang Village; R : Grass in Rambutan Village.

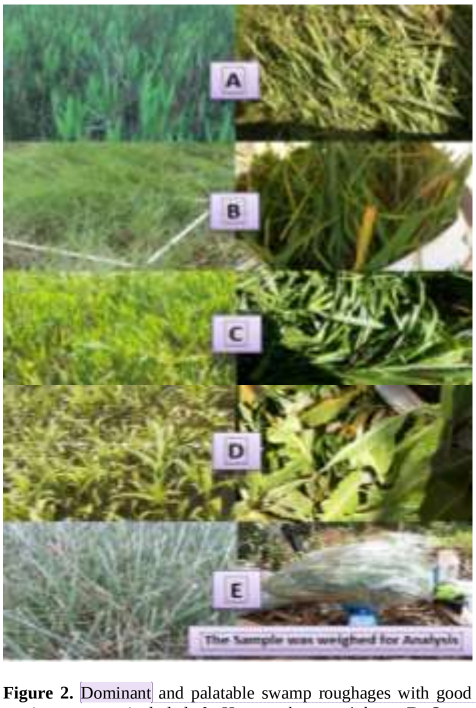


Figure 2. Dominant and palatable swamp roughages with good nutrient contents included. **A**. *Hymenachne acutigluma*, **B**. *Oryza rupifogon* **C**. *Hymenachne amplexicaulis*, **D**. *Polygonum barbatum*, and **E**. *Eleocharis dulcis*.

This high protein content was suspected to be caused by the fact that soil organic C and total N contents in the study site were also high, namely 36.14-57.66 and 2.19-3.64 $g.kg^{-1}$, respectively (Table 1). Soil organic C and total N contents affected protein content in plants. Four swamp grasses including Kasuran (*C. digitatus*), Tapak dara (*C. roseus*), Telepuk gajah (*N. lotus*), and Cecengkehan (*L. hyssopifolia*) and a legume, Kemon air (*N. olerancia*) were found to be the lowland swamp vegetations having the highest N contents of 15.31,15.20, 13.22, 12.07, and 20.56%, respectively.

Fiber contents

Fiber contents of lowland swamp green vegetations ranged from 11.01 to 30.26%, with the lowest content found in Cecengkehan (*L. hyssopifolia*) and the highest in Kumpai tembaga *(H. acutigluma* P*)*. Four vegetations including *Cecengkehan* (*L. hyssopifolia*), Tapak dara (*C. roseus*), Mutiara legume (*S. exasperata*), and Telepuk gajah (*N. lotus*) were found to have the lowest fiber contents of 11.01, 11.18, 11.22, and 11.45%, respectively (Table 2). These results were almost similar to those found by Ali et al. (2012) who reported that the fiber contents of roughage in a pasture ranged from 7.20 to 34.98%. These researchers found that the fiber content of Bento rayap (*Leersia hexandra*) was 27.40% which was very close to that (27.57%) of the same vegetation in this study. Meanwhile, Rostini et al. (2014) reported that the fiber contents of swamp vegetation in South Kalimantan ranged from 14.84 to 29.35% with the lowest content found in Hadangan (*Paspalum sp*) and the highest in Dadangsit (*L. adscendens*). These figures were lower than those found by Kleden et al. (2015) who revealed that nature grasses in a

Commented [a2]: Replace with high quality images; Do not be grouped

-Placed first in the RESULTS AND DISCUSSION, add description of vegetation diversity coffee plantation area and pasture in Wulanggitang, East Flores contained 34.57 and 35.59% of fiber. They also found that the lowest fiber content was found in *L. peploides* and the highest in *I. rugosum*. Fiber contents reported by Kleden et al. (2015) were higher than the results reported by Ahmed *et al*. (2013) with a fiber content of 29.32% in *D. aegyptium* plants. A previous study showed that fermented *I. rugosum*, *H. amplexicaulis*, and *O. rifipogon* had fiber contents of 29.27, 29.57, and 33.07%, respectively (Muhakka et al. 2015).

The fiber content of Eceng gondok (*E. crassipes*) in this study (20.66%) was lower than those found by Hossain et al. (2015), Tham and Uder (2015), and Make et al. (2016). In addition, the fiber content of Eceng gondok (*E. crassipes*) in this study was lower than those of *Azolla*, another water plant, ranging from 13.19 to 16.54% (Kathirvelan et al. 2015; Anitha et al. 2016) and 9.25 to 13.25% (Ahmed et al. 2016). These fiber contents of *Azolla* equaled to those of Cecengkehan (*L. hyssopifolia*) (11.01%), Tapak dara (*C. roseus*) (11.18%), Mutiara legume (*S. exasperata*) (11.22%), Telepuk gajah (*N. lotus*) 11.45%, and Kangkung merah (*I. aquatica*) (14.34%) found in this study. Fiber contents of swamp green vegetations found in this study indicated that they were potential to be used as feed for Pampangan buffaloes.

Ether extract contents

Lowland swamp vegetations in this study were found to have ether extract (EE) contents of about 0.48-2.92%. The lowest EE content was found in Purun tikus (*E. dulcis*) while the highest was found in Kemon air legume *(N. olerancia*). Four vegetations of lowland swamp including Telepuk gajah (*N. lotus*) (2.84% EE), Kumpai minyak (*H. amplexicaulis*) (2.82% EE), Kumpai padi (*O. rupifogon*) (2.49% EE), and Kangkung merah (*I. aquatica* Forsk) (2.24% EE) were revealed to have the highest ether extract contents (Table 2). Results of this study were lower than those found by Rostini et al. (2014), reporting about 0.61-3.67% of EE contents in swamp vegetations in South Kalimantan with the lowest found in Pipisangan (*L. hyssopifolia*) and the highest in Padi hiang (*O. rufigopon spotanea*). EE contents of lowland swamp vegetations were 1.40-1.91% for grasses and 1.36-2.95% for legumes (Asep et al. 2012) and those of grasses in a pasture for buffaloes in Pulau Moa were 1.95-2,41% (Eoh 2014). In other studies, grasses in a natural pasture in North *Lore*, Poso Regency had EE contents of 2.12-2.34% (Damry 2009) and those in Sabana Timur Barat pasture in the rainy season to the end of dry season had an average EE content of 1.91% (Manu 2013). A study by Se'u et al. (2015) revealed an EE content of 1.07% in grasses in a pasture in Timor Tengah Selatan Regency. Another work by Kleden et al. (2015) showed that vegetations in a natural pasture and a coffee plantation area had EE contents of 1.23 and 1.35%, respectively.

Vegetations found in this study had EE contents equaled to those of prime grasses including *elephant* grass (*P. purpuperum*) and *king* grass (*P. purpureophoides*) preserved in the form of hay and silage. *Elephant* grass hay and silage had EE contents of 1.9 and 2.6%, respectively, while those of king grass had EE contents of 1.6 and 2.4%, respectively (Santoso and Hariadi 2008; Ukpabi et al. 2015). EE contents of some species of ruminant roughages were found to be about 1.2-4.1% (Ahmed et al. 2013). Dominant swamp roughages including Kumpai minyak (*H. amplexicaulis* and Kumpai padi *(O. rupifogon)* had EE contents of 2.82 and 2.49%, respectively and they were palatable and potential to be used as feed for Pampangan buffaloes.

Commented [a3]: ???

Ash contents

Ash contents of green vegetations in lowland swamp ranged from 5.63 to 25.19%. Four types of vegetations with the highest ash contents included Kasuran (*C. digitatus*) (25.19%), Mutiara legume (*S. exasperata*) (19.47%), Kumpai minyak (*H. amplexicaulis*) (16.26%), and Kumpai padi (*O. rupifogon* [P]) (16.25%). Meanwhile, Bento rayap *(L. hexandra)* was found to have the lowest ash content of 5.63% (Table 2). Ash contents of vegetations found in this study were higher than those of swamp vegetations in South Kalimantan of 2.18-3.28% during the high tidal season and 3.23-9.83% during the low tidal season (Rostini et al. 2014). *Elephant* grass (*P. purpureum*) was indicated to have varied ash contents of 4.4% (Dahlan and Iskandar 2013), 0.95-1.1% (Ukpabi et al. 2015), 9.59% (Nuhuyanan 2010), and 18% (Araica et al. 2009). Meanwhile, the ash content of grasses in lowland areas ranged from 6.32 to 8.91% (Richmond et al. 2015; Mako et al. 2016; Norman et al. 2013; Maswada et al. 2013). Alam *et al.* (2015) found that *B. mutica* had an ash content of 4.20-4.89% and rice straw had 6.63%.

Roughages were found to have average ash contents of 7.28% in a pasture for buffaloes in Pulau Moa (Eoh 2014), 9.82-10.14% in Lore Utara, Poso Regency (Damry 2009), 11.51% in a pasture during the rainy season until the end of dry season in Sabana Timur Barat (Manu 2013), and 8.11 and 8.22% in a natural pasture and a coffee plantation area, respectively (Kleden et al. 2015). Differences in these ash contents were suspected to be caused by differences in plant species (internal factor) and environmental differences, particularly seasonal differences (external factor). In a dry season, pH levels in lowland swamp areas were found to be 3.9-4.8, causing a decreased supply of nutrients, especially total N and K, to the soil. This decreased supply of nutrients led to lowered nutrients contained in plants (Rostini et al. 2014). This was in line with what was stated by Gutteridge and Shelton (1994) that nutrient content in plants was affected by soil nutrient content. In addition, in acidic soil conditions, activities of Fe, Al, and Mn increased which might cause toxicity in plants (Tjondronegoro and Gunawan).

Commented [a4]: Missing in References

NDF and ADF contents

Neutral Detergent Fiber (NDF) depicts plant cell walls consisting of hemicellulose, cellulose, and lignin. NDF is part of fiber which is not dissolved in neutral detergent representing the component of fiber undissolved in plant cell wall materials. NDF content of a feed affects the ability of ruminant animals to consume the feed. Acid Detergent Fiber (ADF) represents parts of the plant cell wall bond to cellulose and lignin. ADF content is related to energy content and higher ADF content results in lowered digestible energy content (Van Soest 1982).

The NDF and ADF contents of vegetations found in this study were about 40.65-79.47% and 23.66-60.33%, respectively. Lowest NDF contents were found in Cecengkehan (*L. hyssopifolia*) (40.65%), Kangkung merah (*I. aquatica*) (41.40%), Telepuk gajah (*N. lotus*) (46.05%), and Tapak dara (*C. roseus*) (47.79%). In contrast, highest NDF content of 79.47% was found in Bento rayap (*L. hexandra*). Lowest ADF contents were found in Telepuk gajah (*N. lotus*) (46.05%), Kangkung merah *(I. aquatica)* (26.17%), Kumpai merah (*Hymenachne sp*) (28.40%), Cecengkehan (*L. hyssopifolia*) (32.91%). Meanwhile, the highest ADF content of 60.33% was found in Kumpai padi *(O. rupifogon* [P]*)* (Table 3). NDF and ADF contents of vegetations found in this study were lower than those of Asep et al. (2012) who reported that the NDF contents of swamp green vegetations in a pasture for buffaloes were about 91.73-93.45% in grasses and 68.11-90.93% in legumes and the ADF content of grasses was 51.6-86.8%. It was shown in other studies that NDF and ADF contents of roughages in a pasture during the rainy season to the end of the dry season in Sabana Timur Barat were on average 65.9 and 43.29%, respectively (Manu 2013). Vegetations in a natural pasture and a coffee plantation area had NDF contents of 74.89 and 72.37% and ADF contents of 57.22 and 55.15%, respectively (Kleden et al. 2015). Meanwhile, swamp vegetations in South Kalimantan had average NDF and ADF contents of 55.97 and 37.87%, respectively, during the high tidal season and 81.44 and 60.86% respectively, during the low tidal season (Rostini et al. 2014).

NDF and ADF contents of roughages in the BPTU-HPT Padang Mengatas area were found to be 75.62 and 45.96%, respectively in the rain season and 69.35 and 38.66%, respectively in the dry season (Muhajirin et al. 2017). NDF and ADF contents of Eceng gondok (*E. crassipes* in this study were 62.77 and 41.83%, respectively. These figures were close to those of *water hyacinth* (*E.crassipes*) plants studied by Tham (2015) with NDF and ADF contents of 63.9 and 34.68% and by Tham and Uden (2015) with NDF and ADF contents of 52.1 and 30.7%, respectively. Other studies conducted by Ahmed et al. (2016), Anitha et al. (2016), and Nampoothiri (2017) showed that *Azolla sp* had NDF and ADF contents of 53.8-54.85% and 36.57-37.0%, respectively. Meanwhile, NDF and ADF contents of *elephant* grass (*P. purpureum*) were found to be 55.8 and 46.5% (Dahlan and Iskandar 2013) and 84.25 and 64.07% (Nuhuyanan 2010), respectively. These figures equaled to the NDF and ADF contents of Kumpai tembaga (64.72 and 46.38%), Kumpai minyak (65.31 and 38.92), and Are bolong (61.27 and 48.46%). This indicated that lowland swamp vegetations had fiber fraction nutritional quality which was not less than that of prime grasses including *elephant* grass and *king* grass.

In this study, NDF and ADF contents of lowland swamp vegetations were 40.65-79.47% and 23.66%-60.33%, respectively. These figures were still within the ranges of NDF and ADF contents of prime grasses such as *elephant* grass (*P. purpureum*), which had NDF and ADF contents of 55.8 and 46.5% (Dahlan and Iskandar 2013) and 84.25 and 64.07% (Nuhuyanan 2010), respectively. In the rumen, NDF degradation is higher than that of ADF as NDF contains hemicellulose fraction which is more soluble (Church and Pond 1986). NDF content has a negative correlation with its degradation rate (Varga et al. 1983) and higher NDF content decreases dry matter digestibility of feed (NRC 1988). Cellulose is an ADF component that is easy to digest while lignin is hard to digest as it contains double bonds. Higher lignin content decreases feed digestibility (Sutardi et al. 1980).

Hemicellulose and cellulose contents

Lowland swamp vegetations were found to have hemicellulose and cellulose contents ranging from 7.73 to 37.14% and 5.24 to 27.08%, respectively. Four green vegetations with the highest hemicellulose contents were Bento rayap (*L. hexandra*) (37.14%), Kerak maling (*D. fuscescens*) (31.87%), Kumpai merah (*Hymenachne* sp.) (31.74%), and Kumpai minyak (*H. amplexicaulis*) (26.39%). In contrast, the lowest hemicellulose content was found in Cecengkehan (*L. hyssopifolia*) (7.73%). Highest cellulose contents were found in Kemon air (*N. olerancia*) (27.08%), Bento rayap (*L. hexandra*) (25.88%), Purun tikus (*E. dulcis*) (21.80%), and Are bolong (*P. barbatum*) (20.28%). Meanwhile, Kasuran (*C.digitatus*) had the lowest cellulose content of 5.24% (Table 3). Results of this study were in line with those of a study conducted by Asep et al. (2012) who reported the hemicellulose and cellulose contents of lowland swamp green vegetations ranging from 7.89 to 31.55% and 30.85 to 63.35%, respectively. They also found that Kumpai padi (*O.rupifogon*) had 31.55% hemicellulose content which was higher than those of Kumpai padi (10.80-19.30%) found in this study (Table 4). Swamp vegetations in South Kalimantan had hemicellulose contents of 0.65-25.85% in high tidal season and 5.37-40.09% in low tidal season. Cellulose contents in high and low tidal seasons were about 20.07-34.03% and 7.90-38.31%, respectively (Rostini et al. 2014). Various water plants including Azolla, which was used as animal feed, had hemicellulose and cellulose contents of 10.20 and 12.76% (Nampoothiri 2017), 1.15-10.20% and 12.76% (Nampoothiri 2017), respectively. Roughages in BPTU-HPT Padang Mengatas had hemicellulose and cellulose contents of 29.79 and 33.62% in the rain season and 30.69 and 31.64% in the dry season, respectively (Muhajirin et al. 2017). *Elephant* grass (*P. perpureum*) was found to contain 21.18% hemicellulose and 43.32% cellulose (Nuhuyanan 2010) and 35.3% cellulose (Dahlan and Iskandar 2013). In a study conducted by Archimede et al. (2010), hay was found to have 37.7% hemicellulose and 35.7% cellulose. Based on the above findings, it was suggested that hemicellulose (7.73-37.14%) and cellulose (5.24-27.08%) contents of lowland swamp vegetations in this study were within normal ranges and these vegetations were potential to be used as feed for Pampangan buffaloes.

Lignin contents

Lignin contents of lowland swamp vegetation ranged from 14.84 to 43.09%. Four vegetations including Telepuk gajah (*N. lotus*), Kemon air (*N. olerancia*), Kumpai merah (*Hymenachne* sp.), and Kangkung merah (*I. aquatica*) were found to have the lowest lignin contents of 14.84, 18.36, 19.76, and 19.85%, respectively, while the highest lignin content of 43.09% was found in Kumpai padi (*O. rupifogon* ^{P}) (Table 3). Lignin contents in this study were higher than that obtained by Rostini et al. (2014) who reported the lignin contents of swamp vegetations in South Kalimantan were about 2.8-17.59% in high tidal season with that of Kumpai minyak as the lowest and that of *Beberasan* as the highest and 10.06-61.12% in low tidal season with that of *Beberasan* as the lowest and that of Kumpai minyak as the highest. Lignin contents of Kumpai padi (*O. rupifogon* ^{R}) (31.24%) and Kumpai padi (*O. rupifogon* ^{P}) (43.09%), Bento rayap *(L. hexandra)* (33.92%), and Eceng gondok *(E. crassipes)* (31.60%) (Table 3) found in this study were higher those of Kumpai padi (18.27%) and Bento rayap *(L. hexandra)* (17.96%) found by Asep et al. (2012) and Eceng gondok *(E. crassipes)* (8.17%) found by Tham (2015). In other studies *Azolla* was found to have lignin contents of 5.7% (Ahmed et al. 2016) and 28.24% (Nampoothiri 2017). Meanwhile, lignin contents of *elephant* grass were found to be 15.37% (Nuhuyanan 2010) and 11.2% (Dahlan and Iskandar 2013).

Differences in lignin contents in green vegetation are suspected to be caused by differences in plant species, plant ages, and environmental factors including seasons (rain or dry season), tidal seasons, and fertility levels of the soil where the vegetations grow. In cell walls, cellulose is a bond with hemicellulose and lignin. The animals cannot digest lignin and its molecule structure is different from other carbohydrates as it contains carbon and nitrogen of only 1-5%. Hemicellulose consists of pentose, hexose, uronic acid, and pectin substance. Pectin is a carbohydrate that is composed of uronic acid, galactose, arabinose, xylose, and methanol. Cellulose is degradable by microorganisms and functions as the source of volatile fatty acids. Young grasses (roughages) contain less than 5% lignin and 80% of their cellulose is degradable. On the contrary, in old roughages, lignin content may reach up to 10% causing a decrease in cellulose digestibility by up to 50% (Prawirokusumo 1994).

Based on the results of the study, it was concluded that: (i) The highest protein (20.56%) and crude fat (2.92%) contents were found in Kemon air *(Neptunia olerancia)*. The highest ash content (25.19%) was found in Kasuran *(C. digitatus)*, while the lowest (11.01%) was found in Cecengkehan *(L. hyssopifolia)*. The lowest NDF content (40.64%) was found in Cecengkehan *(L. hyssopifolia)* and the highest hemicellulose content (37.14%) was found in Bento rayap. Telepuk gajah had the lowest ADF (23.66%) and lignin (14,84%) contents. Kemon air contained the highest cellulose level of 27.08%. (ii) The best nutritional values were found in Kasuran *(C. digitatus)* and Cecengkehan *(L. hyssopifolia)*. (iii) Dominant and palatable swamp roughages with good nutrient contents included Kumpai tembaga *(H. acutigluma)*, Kumpai minyak *(H. amplexicaulis)*, Kumpai padi *(O. rupifogon)*, Are bolong *(P. barbatum)*, and Purun tikus *(E. dulcis)*.

ACKNOWLEDGMENTS

The author expresses his deepest gratitude to the Rector of Sriwijaya University through the Chair of the Institute for Research and Community Services funding this research in accordance with the Competitive Leading Research Contract of Sriwijaya University Number: 988 / UN9.3.1 / PP / 2017, dated 21 July 2017.

REFERENCES

Ahmed HA, Ganai A.M, Beigh YA, Sheikh GG, Reshi PA. 2016. Performance of growing sheep on *Azolla* based diets. Indian J. Anim. Res. 50 (5): 721-724.

Alam MR, Haque MM, Sumi KR, Ali MM. 2015. Proximate composition of para-grass *(Brachiaria mutica)* produced in integrated fish-fodder culture system. Bang. J. Anim. Sci. 44 (2): 113-119.

Ali AIM, Sandi S, Muhakka, Riswandi. 2012. Kualitas hijauan pakan di rawa lebak padang penggembalaan kerbau pampangan. Proc. InSINAS 2012. 307-312.

Anitha KC, Rajeshwari YB, Prasanna SB, Shree JS. 2016. Nutritive evaluation of azolla as livestock. J. of Experim. Bio. and Agric. Sci. 4(6): 670-674.

AOAC (Association of Official Analytical Chemists). 1990. Official Methods of Analysis. 15th ed., Washington, DC.

Araica BM, Sporndly E, Sanchez NR, Norell L, Sporndly R. 2009. Silage quality when Moringa oleifera is ensiled in mixtures with elephant grass, sugar cane and molasses. Gra. and For. Sci. 64: 364-373.

Archimede H, Gonzales-Garcia E, Despois P, Etienne T, Alexandre G. 2010. Subtitution of corn and soybean with green banana fruits and Gliricidia sepium forage in sheep fed hay-based diets: effects on intake, digestion and growth. J. of Anim. Physiol. and Anim.. Nutr. 94 (2010): 118-128.

BPS (Badan Pusat Statistik) Provinsi Sumatera Selatan. 2014. Sumatera Selatan dalam Angka 2014.

BPS (Badan Pusat Statistik). 2010. Direktorat Jendral Tanaman Pangan. *Luas lahan rawa di Indonesia*. Departemen Pertanian. Jakarta.

Brazle FK, Kilgore GI, Fauzett MR. 2000. Effect of season on grazing native-grass pastures. The Prof.Anim. Sci. 16: 15-28.

Church DC, Pond WG. 1986. Digestive Animal Physiologi and Nutrition. 2nd. Prentice Hell a Devision of Simon and Schuster Englewood Clief, New York.

Dahlan I, Iskandar MNZ. 2013. Use of plantain peels (Musa paradisiaca) as a fibrous feed substitute for napier grass (Pennisetum purpureum) in rusa deer (Cervus timorensis ratio under captivity. J. Anim. Sci. 3 (9): 472-480.

Damry. 2009. Produksi dan kandungan nutrisi hijauan padang penggembalaan alam di Kecamatan Lore Utara Kabupaten Poso. J. Agrol. 16 (4): 296-300.

Eoh M. 2014. Kapasitas tampung dan komposisi zat-zat makanan padang penggembalaan ternak kerabau di Pulau Moa. Agrinimal. 4 (2): 77-82.

Gutteridge RC, Shelton HM. 1994. The Role of Forage Tree Legumes in Cropping and Grazing System. The Trop. Grassl Soc. of Aust. Inc.

Hossain MdE, Sikder H, Kabir MdH, Sarma SM. 2015. Nutritive value of water hyacinth *(Eichhornia crassipes)*. Online J. of Anim. and Feed Resear. 5 (2): 40-44.

Kathirvelan C, Banupriya S, Purushothaman MR. 2015. Azolla-an alternate and su tainable feed for livestock. Internat. J. of Sci. Environ. 4 (4): 1153-1157.

Kleden MM, Ratu MRD, Randu MDS. 2015. Kapasitas tampung hijauan pakan dalam areal perkebunan kopi dan padang rumput alam di Kabupaten Flores Timur Nusa Tenggara Timur. J. Zootek 35 (2): 340-350.

Mako AA, Akinwande VO, Anurudu NF, Ogunwole OA. 2016. Evaluation of nutritive value of water hyacinth *(Eichhornia crassipes)*

and guinea grass *(Panicum maximum)* mixture as animal feed in the tropics. 2016. Bull. Anim. Hith. Prod. Afr. (64): 463-473.
Manu AE. 2013. Produktivitas padang penggembalaan sabana Timor Barat. J. Pastura. 3 (1): 25-29.
Maswada HF, Elzaawely AA. 2013. Nutritive value of Stipagrostis lanata (Forssk.) de winder as a feed for livestock. Asian J. of Crop Sci. 5 (2): 216-221.
Muhajirin, Despal, Khalil. 2017. Pemenuhan kebutuhan nutrien sapi potong bibit yang digembalakan di Padang Mengatas. Buletin Makanan Ternak.104 (1): 9-20.
Muhakka, Suwignyo RA, Budianta D dan Yakup. 2019. Vegetation analysis of no-tidal swampland in South Sumatra, Indonesia and its carrying capacity for Pampangan buffalo pasture. J. Biodiv. 20 (4): 1077-1086.
Muhakka, Wijaya A, Ammar M. 2015. Nutritional dried matter, crude protein and crude fiber on lowland tidal grass fermented by probiotic microorganisms for use bali cattle feed. J. Anim. Prod. 17 (1): 24-29.
Mulyani A, Sarwani M. 2013. Karakteristik dan potensi lahan sub optimal untuk pengembangan pertanian di Indonesia. J. Sumber daya Lahan. 7 (1): 47-55.
Nampoothiri VM. 2017. Aquatic plants and marine waste as animal feed. Sch.J. Agric.Vet. Sci. 4 (6): 249-254.
Norman HC, Master DG, Barrentt-Lennard EG. 2013. Halophytes as forage in saline landscapes: Interaction between plant genotipe and environment change their feeding value to ruminants. Environ. and Exp. Bot. 92 (2013): 96-109.
NRC. 1988. Nutrition Reguirement of Beef Cattle. 6th. Rev. Ed. National.
Nuhuyanan LE. 2010. Pengaruh pemberian wafer rumput gajah dengan perekat fermented moter liquor (FML) dan tetes (molasses) terhadap konsumsi pakan, kecernaan zat-zat makanan dan kenaikan berat badan sapi bali jantan. J. Ilmu Peternakan. 5 (2): 111-117.
Prawirokusumo S. 1994. Ilmu Gizi Komperatif. BPFE., Yogyakarta.
Rahman MM, Abdullah RB, Wan Khadijah WE, Nakagawa T, Akashi R. 2014. Feed intake and growth performance of goats affered napier grass *(Pennisetum purpureum)* supplemented with concentrate pellet and soya waste. Sain Malaysiana. 43 (7): 967-971.
Richmond AS, Wylie ARG, Laidlaw AS, Lively FO. 2015. Methane emissions from beef cattle grazing on semi-natural upland and improved lowland grasslands. Anim. 9 (1): 130-137.
Rostini T, Abdullah L, Wiryawan KG, Karti PDMH. (2014). Production and nutrition potency of swamp local forage in South Kalimantan as ruminant feed. Glob. J. Anim. Sci. Livestock Prod. Anim. Breed. 2 (2):107-113.
Santoso dan Hariadi BTj. 2008. Komposisi kimia, degradasi nutrien dan produksi gas metana in vitro rumput tropika yang diawetkan dengan metode silase dan hay. J. Media Peternakan 31(2): 128-137.
Se’u VE, Karti PDMH, Abdullah L. 2015. Botanical composition, grass production, and carrying capacity of pasture in Timor Tengah Selatan District. J. Media Peternakan 38(3):176-182.
Statistik Peternakan Sumatera Selatan. 2014. Dinas Peternakan Provinsi Sumatera Selatan Tahun Anggaran 2015.hal:14.
Sutardi T, Pratiwi SH, Adnan A, Nuraini S. 1980. Peningkatan pemanfaatan jerami padi melalui hidrolisa basa, suplementasi urea dan belarang. Bull. Makanan Ternak. 6 Bogor.
Tham HoT, Uden P. 2015. Effect of fresh water Hyacinth (Eichhornia crassipes) on intake and digestibility in cattle fed rice straw and molasses-urea cake. Nova J. of Engineer. and Appl. Sci. 4(1): 1-8.
Tham HoT. 2015. Utilisation of water hyacinth as animal feed. Nova J. of Engineer. Appl.Sci. 4 (1): 1-6.
Tjondronegoro AD, Gunawan A. 2000. Beberapa jenis gulma di lahan pasang surut pada tingkat kemasaman tanah yang berbeda. Pros. Seminar Nasional. P. 247-254.
Van Soest PJ. 1982. Nutritional Ecology of the Ruminant: Ruminant Metabolism, Nutritional Stategies the Cellulolytic Fermentation and the Camisthy of Forages and Palm Fiber. Cornell University O & B Books Inc. USA.
Varga GA, Hoover WH. 1983. Rate and extent of NDF of feedstuff in-situ. J. Dairy. Sci. 66:2109.

5. Bukti konfirmasi submit revisi kedua, respon kepada reviewer, dan artikel yang diresubmit (8 Februari 2020)

BIODIVERSITAS ISSN: 1412-033X
Volume 21, Number 1, January 2020 E-ISSN: 2085-4722
Pages: xxxx DOI: 10.13057/biodiv/d2101xx

Nutritional values of swamp grasses as feed for Pampangan Buffaloes in South Sumatra, Indonesia

MUHAKKA[1,♥], RUJITO AGUS SUWIGNYO[2], DEDIK BUDIANTA[3], YAKUP[2]
[1]Department of Animal Husbandry, Faculty of Agriculture, Sriwijaya University, Jl. Palembang-Prabumulih Km, 32 Inderalaya, Ogan Ilir 30662, South Sumatra, Indonesia, Tel/Fax. +62-711-581106. ♥email: muhakka@fp.unsri.ac.id
[2]Department of Agronomy, Faculty of Agriculture, Sriwijaya University, Jl. Palembang-Prabumulih Km, 32 Inderalaya, Ogan Ilir 30662, South Sumatra, Indonesia
[3]Department of Soil Science, Faculty of Agriculture, Sriwijaya University, Jl. Palembang-Prabumulih Km, 32 Inderalaya, Ogan Ilir 30662, South Sumatra, Indonesia

Manuscript received: 17 October 2019. Revision accepted: xxx December 2019.

Abstract. *Muhakka, Suwignyo RA, Budianta D, Yakup. 2020. Nutritional values of swamp grasses as feed for Pampangan Buffaloes in South Sumatra, Indonesia. Biodiversitas 21: xxxx.* This study was aimed at determining the types and quality of vegetations in the swamp area, which could be used as sources of roughage for Pampangan buffaloes in South Sumatera. In this descriptive study. Results showed that the highest crude protein and ether extract contents, 20.56 and 2.92%, respectively, were found in Kemon air *(Neptunia olerancia)*. The highest ash content of 25.19% was found in Kasuran *(Cyperus digitatus)*. The lowest fiber content (11.01%) was found in Cecengkehan *(Ludwigia hyssopifolia)*, which also had the lowest content of Neutral Detergent Fiber (NDF) (40.64%). Hemicellulose content was found to be highest (37.14%) in Bento rayap *(Leersia hexandra)*. The lowest ADF (23.66%) and lignin (14,84%) contents were found in Telepuk gajah *(Nymphaea lotus)*. Kemon air *(N. olerancia)* was found to have the lowest content (27.08%) of cellulose. It was concluded that the swamp vegetation found in this study consisted of 17 types of grasses (89.47%) and two types of legumes (10.53%). Kasuran *(C. digitatus)* and Cecengkehan *(L. hyssopifolia)* were found to have the best nutritional values. Dominant and palatable vegetations with good nutritional values, which were potential to be used as sources of roughage for *Pampangan* buffaloes, were Kumpai tembaga *(Hymenachne acutigluma)*, Kumpai padi *(O ryza rupifogon)*, Kumpai minyak *(Hymenachne amplexicaulis*, Are bolong *(Polygonum barbatum)*, and Purun tikus *(Eleocharis dulcis)*.

Key words: Nutritional value, Swamp grass, Feed, Pampangan buffalo.

Commented [a1]: For the fist time, species name shoud be written completely with the genus name.... check all the rest

INTRODUCTION

The availability of roughage as the main feed for ruminant animals depends considerably on seasons. During the rainy season, it is abundant, and during the dry season, the availability of grasses and legumes is lacking. The limited supply of roughage may hamper productivity including the reproductive performance of ruminant animals including buffaloes.

In South Sumatera, Pampangan buffalo is a potential germplasm which needs to be preserved and developed. There were 37,405 heads of Pampangan buffaloes in 2016, and this population increased by 3.97% to 38,952 heads in 2017. In 2017, of this population, 11,150 heads (28.63%) and 2,227 heads (5.72%) were found in Ogan Komering Ilir Regency and Banyuasin Regency, respectively (Statistik Peternakan Sumsel 2017). The population and productivity of *Pampangan* buffaloes need to be improved, and for this purpose, feed is an important factor to consider. Pampangan buffaloes feed mostly on roughage from the swamp, grassland to meet their maintenance and reproductive needs.

In Indonesia, there are 13.27 million hectares of lowland swamp areas. Only 4 million hectares of these areas have been developed and cultivated by the community and private sectors (2.6 million hectares) and the government assistance (1.3 million hectares) (BPS 2010, Mulyani and Sarwani 2013). In Sumatera, the largest lowland swamp area of 2.98 million hectares is found in South Sumatera, but only 298,189 hectares of it have been utilized (BPS Sumatera Selatan 2014). In order to utilize the potential swamp area as a feed source for Pampangan buffaloes, a study on vegetations as sources of roughage in lowland swamp areas that include vegetation identification and nutritional quality determination needs to be conducted.

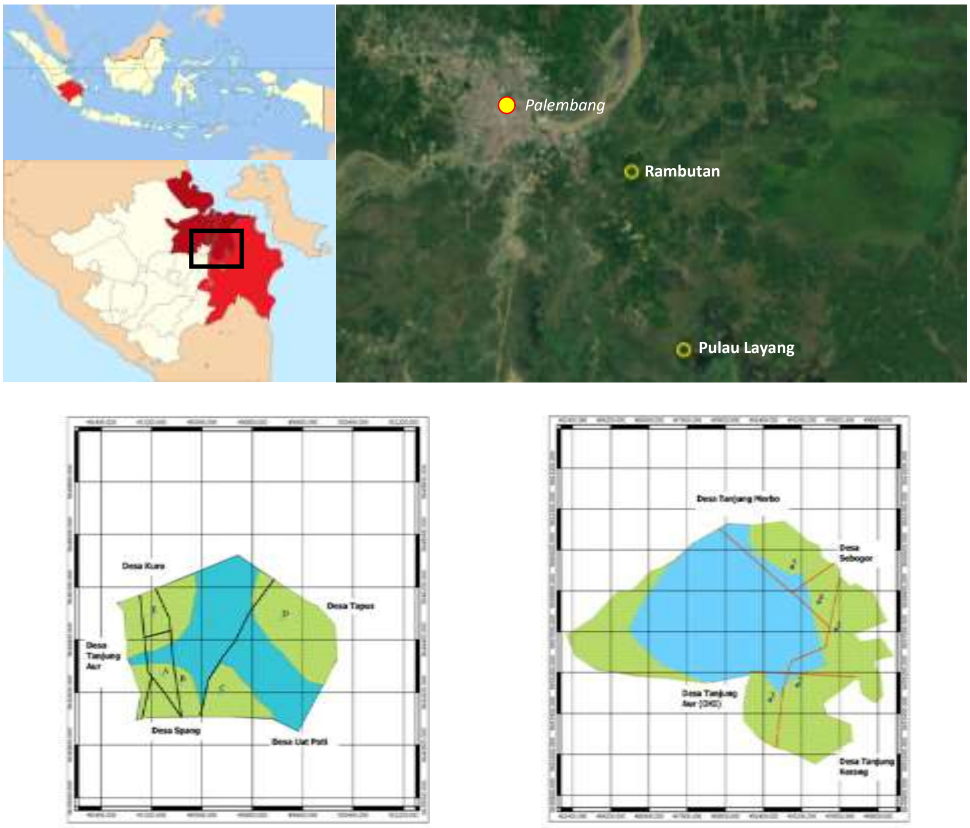
In the previous study, some swamp grasses, including Kumpai minyak grass (*H. amplexicaulis)* (Rostini et al. 2014**;** Muhakka et al. 2015), *I. rugosum* and *L. hexandra* (Ali et al. 2012) were identified. However, many more swamp has not been identified. For example, *P. barbatum,C. digitatus, R. corymbosa* This study was conducted to identify the types and nutritional values of vegetations that could be used as sources of roughage feed for Pampangan buffaloes in South Sumatera. This information was important to support the productivity improvement of Pampangan buffaloes as germplasm in South Sumatera. In this study, some new swamp found where in the previous study it's not found yet.

MATERIALS AND METHODS

Area study

This study was a descriptive study to assess the types and nutritional values of vegetations, which were the dominant and palatable as sources of roughage feed for Pampangan buffaloes. Vegetation samples were taken from grazing areas of Pampangan buffaloes in Rambutan Village and Pulau Layang Village, South Sumatra, Indonesia (Figure 1) from April to Juni 2017. Vegetation samples for nutrient analysis were obtained by following these procedures: (i) vegetation collection was done based on estimated growth age (young age, medium age, and old age based on physical appearance), (ii) collected samples of each vegetation was composited, and (iii) samples were chopped into small sizes, homogenized.

For each vegetation, 1 kg sample was taken randomly and sent to the laboratory for oven drying at 105ºC until a constant weight was obtained and dry matter content was determined. Samples were then ground for nutrient content determination by using proximate and Van Soest analyses (Syarifuddin and Wahdi 2010). Sample analyses of Crude protein, fiber, ether extract, and ash contents conducted in Laboratory of Dairy Nutrition, Department of Nutrition and Feed Technology, Institut Pertanian Bogor (IPB), Bogor, Indonesia, while analyses of NDF, ADF, hemicellulose, cellulose, and lignin conducted in Biotechnology Assessment Laboratory, Center for Biotechnology Research, Indonesian Institute of Sciences (LIPI), Cibinong, Bogor; and analysis of soil conducted in Laboratory of Soil Chemistry, Biology, and Fertility, Soil Department, Faculty of Agriculture, Sriwijaya University, Ogan Ilir, Indonesia.



A B

Figure 1. Research location in South Sumatra, Indonesia. A. Pulau Layang Village, Pampangan Sub-district, Ogan Komering Ilir District, South Sumatra. B. Rambutan Village, Rambutan Sub-district, Banyuasin District, South Sumatra, Indonesia (Muhakka et al. 2019)

Measured parameters

Soil analysis

Soil sampling is done in a composite manner at a depth of 0-20 cm. Taking the soil sample points is done by making a diagonal line in each zone and determining 5 soil sampling points to analyze chemical fertility (N, P, K) and physical fertility (texture, structure and pH).

Proximate analysis

Crude protein, fiber, ether extract, and ash contents were determined based on the procedures of AOAC (1990). *Crude protein*. Nitrogen (N) content was determined by using a Kjeldahl method. In this analysis, sulphuric acid with a catalyst and a heating process. The organic matter of samples was then oxidized by sulfuric acid, and nitrogen was changed into an ammonium sulfate form. The remaining sulfuric acid was neutralized by NaOH until the solution became basic. Ammonium sulfate was then distilled in an acid medium to obtain the quantitative amount of N. As the average protein contains 16% nitrogen, a factor 100 %: 16% = 6.25 was used to obtain the value of crude protein (crude protein = N% x 6.25). *Fiber*. The filtered fat-free sample was used in fiber content determination. 1.25% sulfuric acid solution was added into the sample, and the mixture was heated for about 30 minutes before the residue was filtered. 1,25% NaOH solution was added into the precipitate, and the mixture was heated for about 30 minutes. The mixture was then filtered, and the precipitate was washed, dried, and weighed. This precipitate was burnt, and the ash was weighed. The difference between the weight of precipitate before it was burnt and the weight of the ass was referred to as fiber content. *Ether extract*. The dry matter sample was extracted with diethyl ether for 5 hours. At the end of the extraction process, ether evaporated and the remaining material was referred to as fat. *Ash*. The third part of the dry matter sample was weighed and burnt in a crucible at 550ºC for 8 hours.

Van Soest analysis

Neutral Detergent Fiber (NDF), Acid Detergent Fiber (ADF), hemicellulose, cellulose, and lignin contents were determined by using a Van Soest method (1982).

Neutral Detergent Fiber (NDF). One gram of sample was put in a beaker glass. 50 ml NDS solution was added into the beaker before the mixture was heated for an hour. The mixture was then filtered by using a vacuum pump and a filter glass which was previously weighed (b gram). The mixture was then washed with hot water and acetone before it was dried in an oven and let cool in a desiccator. Finally, it was weighed as c gram. NDF content was calculated by using the following formula:

$$\% \text{ NDF} = \frac{c-b}{a} \times 100\%$$

Acid Detergent Fiber (ADF). One gram of sample was put in a beaker glass. 50 ml ADS solution was added into the beaker before the mixture was heated for an hour. The mixture was then filtered by using a vacuum pump and a sintered glass filter which was previously weighed (b gram). The mixture was then washed with hot water and acetone before it was dried in an oven and let cool in a desiccator. Finally, it was weighed as c gram. Cellulose content was calculated by using the following formula:

$$\% \text{ cellulose} = \frac{c-d}{a} \times 100\%$$

Hemicellulose. Hemicellulose content was calculated as a difference between NDF and ADF contents as follows.

% Hemicellulose = % NDF-% ADF

Lignin. Cellulose residue (d gram) was burnt in a furnace at 500-600ºC for 3 hours. After that, it was left to cool and weighed (e gram). Lignin content was calculated by using the following formula:

$$\% \text{ Lignin} = \frac{d-e}{a} \times 100\%$$

Data analysis

The data obtained were used directly to describe the nutritional value of the swamp vegetation that could be used as a roughage source. These data were then combined with those of *in vitro* digestibility as the basis for concluding (Syarifuddin and Wahdi 2010).

RESULTS AND DISCUSSION

Soil analysis

Results of soil analysis showed that soil at the study site had a low fertility level and was highly acidic. It also had very high organic C and total N contents, medium level of exchangeable-K and N contents, very low Ca and Mg contents, medium P content, and very high CEC level (Table 1).

Nutrient contents of lowland swamp

Crude protein, fiber, ether extract, and ash nutrient contents of lowland swamp vegetations found in this study are listed in (Table 2).

The NDF and ADF contents of vegetations found in this study were about 40.65-79.47% and 23.66-60.33%, respectively. Lowland swamp vegetations were found to have hemicellulose and cellulose contents ranging from 7.73 to 37.14% and 5.24 to 27.08%, respectively. Lignin contents of lowland swamp vegetation ranged from 14.84 to 43.09% (Table 3).

There are 19 types of forage found in Pampangan buffalo pasture that have potential that can be used as food for Pampangan buffalo, consisting of 17 types of grass (gramineae) and 2 types of legumes (legumes). Types of forage swamp forage plants, there are dominant and palatable species (Figure 2) of swamp lowland forage vegetation having potential as buffalo feed, namely Kumpai padi (*O. rupifogon)*, Kumpai tembaga *(H. acutigluma)*, and Kumpai minyak *(H. amplexicaulis)*, not dominant and palatable such as Kumpai merah *(Hymenachne sp*) and Kemon air *(N. olerancia)*; dominant and non palatable grass species (buffalo doesn't like it) namely Are bolong (*P. Barbatum*. L*)*. this grass species would be eaten by the buffaloes if there were no other species to be eaten (Muhakka et al., 2019).

Discussion

Crude protein content

Results showed that the crude protein contents of swamp green vegetations ranged from 5.26% to 20.56% with the lowest value (5.26%) was found in Berondong grass (*R. corymbosa*) and the highest (20.56%) was found in Kemon air legume (*N. olerancia*). Kasuran grass (*C. digitatus*) had the highest crude protein content (15.31%) (Table 2). This high nutritional value of Kasuran grass was suspected as caused by the fact that most of this grass was found to grow in the area of buffalo pens where the soil was rich in organic matter. However, the growth of this grass was not dominant as it mostly occurred in rainy seasons.

Kumpai minyak (*H. amplexicaulis*), Kumpai padi (*O. rupifogon*), Kumpai tembaga (*H. acutigluma*), and Purun tikus (*E. dulcis*) were found as the dominant palatable grasses containing 12.00, 10.41, 10.96, and 8.22% crude protein, respectively. Results of this study were not too different from those obtained by Rostini et al. (2014), who reported that Kumpai minyak and Pipisangan had protein contents of 10.88 and 15.92%, respectively. Crude protein (CP) contents of these swamp grasses in Pulau Layang and Rambutan Villages were closed to those of prime grasses including 9.11-12.8% CP of *elephant* grass (*P. purpureum*) (Santos et al. 2013; Dahlan and Iskandar 2013; Rahman et al. 2014), 12.4% CP of *elephant* grass hay, 11.1% CP of *elephant* grass silage, 11.4% CP of king grass hay, and 10.2% CP of king grass silage (Santoso and Hariadi 2008). Other vegetations even had higher CP contents including Kumpai tembaga *(H. acutigluma)* with 10.96% CP, Tapak dara (*C. roseus*) 15.20%, Telepuk gajah (*N. lotus*) 13.22%, Cecengkehan (*L. hyssopifolia*) 12.07%, Kasuran *(C. digitatus*) 15.31%, and Kumpai minyak (*H. amplexicaulis)*[R] 12.0% (Table 2). CP contents of vegetations in this study were also higher than those of nature grasses found in coffee plantation areas (6.95%) and pastoral areas (6.65%) in Wulanggitang District, East Flores Regency as reported by Kleden et al. (2015). Meanwhile, CP content of grasses in lowlands was 8.41% (Rochana et al. 2016; Maswada and Elzaawely 2013).

Table 1. Properties of soil at the study site

Parameter	*Pulau Layang*		*Rambutan*	
	Value	Remark	Value	Remark
pH H_2O (1 : 1)	5.10	Low	4.41	Very low
pH KCl (1 : 1)	4.39	Very acidic	3.99	Very acidic
Organic C (g/kg)	57.66	Very high	36.14	Very high
Total N (g/kg)	3.64	Very high	2.19	Very high
Available P/Bray I (mg/kg)	11.70	Medium	2.25	Very low
Exchangeable K (cmol/kg)	0.63	Medium	0.45	Medium
Na (cmol/kg)	0.65	Medium	0.65	Medium
Ca (cmol/kg)	1.95	Very low	0.73	Very low
Mg (cmol/kg)	0.45	Very low	0.32	Very low
CEC (cmol/kg)	65.25	Very high	43.50	Very high
Exchangeable Al (cmol/kg)	1.84		2.37	
Exchangeable H (cmol/kg)	0.74		0.88	
Texture:				
Sand (%)	47.08		46.64	
Ash (%)	31.11		27.18	
Clay (%)	21.81		26.18	

Table 2. Crude protein, fiber, ether extract, and ash contents (%) of lowland swamp vegetations

Latin name	Local name	Crude protein	Fiber	Ether extract	Ash
Catharanthus roseus	Tapak dara	15.20	11.18	1.29	12.53
Cyperus digitatus	Kasuran	15.31	14.76	1.42	25.19
Digitaria fuscescens	Kerak Maling/Pasiran	12.00	15.64	1.24	16.26
Eichhornia crassipes	Eceng gondok	8.61	20.66	0.84	14.22
Eleocharis dulcis [P]	Purun tikus	8.22	25.72	0.48	15.13
Eleocharis dulcis [R]	Purun tikus	6.63	24.52	1.69	10.24
Hymenachne acutigluma) [P]	Kumpai Tembaga	6.86	30.26	2.22	7.88
Hymenachne acutigluma [R]	Kumpai Tembaga	10.96	23.73	1.77	10.30
Hymenachne amplexicaulis [P]	Kumpai Minyak	9.21	21.91	2.82	13.96
Hymenachne amplexicaulis [R]	Kumpai Minyak	12.00	15.64	1.24	16.26
Hymenachne sp	Kumpai Merah	8.52	21.20	1.30	12.88

Ipomoea aquatica	Kangkung merah	8.95	14.34	2.24	10.39
Leersia hexandra	Bento rayap	5.35	27.57	2.06	5.63
Ludwigia hyssopifolia	Cecengkehan	12.07	11.01	1.66	9.09
Neptunia olerancia	Kemon air	20.56	15.03	2.92	7.31
Nymphaea lotus	Telepuk Gajah	13.22	11.45	2.84	10.30
Oryza rupifogon P	Kumpai Padi	7.93	23.30	1.60	16.25
Oryza rupifogon R	Kumpai Padi	10.41	21.59	2.49	11.92
Polygonum barbatum	Are Bolong	7.53	16.60	1.57	8.40
Rhynchospora corymbosa	Berondong	5.26	22.27	1.48	14.84
Sesbania exasperata	Mutiara	18.27	11.22	1.86	19.47

Notes: P : Grass in Pulau Layang Village; R : Grass in Rambutan Village.

Table 3. Composition of fiber fractions of green vegetations in lowland swamp: NDF, ADF, hemicellulose, cellulose, and lignin (%).

Latin name	**NDF**	**ADF**	**Hemi-cellulose**	**Cellulose**	**Lignin**
Catharanthus roseus	47.79	39.67	8.12	16.96	22.71
Cyperus digitatus	58.90	36.93	21.97	5.24	31.68
Digitaria fuscescens	65.43	33.56	31.87	12.11	21.45
Eichhornia crassipes	62.77	41.83	20.94	10.22	31.60
Eleocharis dulcis P	69.57	49.83	19.74	21.80	28.04
Eleocharis dulcis R	75.73	54.91	20.82	19.71	35.20
Hymenachne acutigluma P	75.89	50.60	25.29	12.25	38.34
Hymenachne acutigluma R	64.72	46.38	18.34	16.01	30.37
Hymenachne amplexicaulis	65.31	38.92	26.39	8.29	30.63
Hymenachne sp	60.14	28.40	31.74	8.64	19.76
Ipomoea aquatica	41.40	26.17	15.23	6.32	19.85
Leersia hexandra	79.47	42.33	37.14	25.88	33.92
Ludwigia hyssopifolia	40.64	32.91	7.73	8.39	24.52
Neptunia olerancia	62.31	45.44	16.87	27.08	18.36
Nymphaea lotus	46.05	23.66	22.39	8.82	14.84
Oryza rupifogon P	71.13	60.33	10.80	17.23	43.09
Oryza rupifogon R	65.49	46.19	19.30	14.96	31.24
Polygonum barbatum	61.27	48.46	12.81	20.28	28.18
Rhynchospora corymbosa	65.29	44.64	20.65	16.08	28.56

Note: P : Grass in Pulau Layang Village; R : Grass in Rambutan Village.

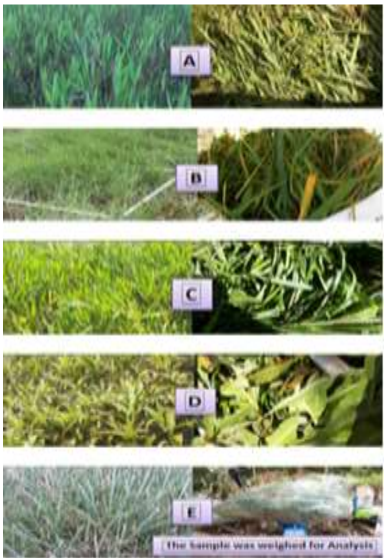


Figure 2. Dominant and palatable swamp roughages with good nutrient contents included. **A**. *Hymenachne acutigluma*, **B**. *Oryza rupifogon* **C**. *Hymenachne amplexicaulis*, **D**. *Polygonum barbatum*, and **E**. *Eleocharis dulcis*.

This high protein content was suspected to be caused by the fact that soil organic C and total N contents in the study site were also high, namely 36.14-57.66 and 2.19-3.64 $g.kg^{-1}$, respectively (Table 1). Soil organic C and total N contents affected protein content in plants. Four swamp grasses including Kasuran (*C. digitatus*), Tapak dara (*C. roseus*), Telepuk gajah (*N. lotus*), and Cecengkehan (*L. hyssopifolia*) and a legume, Kemon air (*N. olerancia*) were found to be the lowland swamp vegetations having the highest N contents of 15.31,15.20, 13.22, 12.07, and 20.56%, respectively.

Fiber contents

Fiber contents of lowland swamp green vegetations ranged from 11.01 to 30.26%, with the lowest content found in Cecengkehan (*L. hyssopifolia*) and the highest in Kumpai tembaga *(H. acutigluma* P*)*. Four vegetations including *Cecengkehan* (*L. hyssopifolia*), Tapak dara (*C. roseus*), Mutiara legume (*S. exasperata*), and Telepuk gajah (*N. lotus*) were found to have the lowest fiber contents of 11.01, 11.18, 11.22, and 11.45%, respectively (Table 2). These results were almost similar to those found by Ali et al. (2012) who reported that the fiber contents of roughage in a pasture ranged from 7.20 to 34.98%. These

Commented [a2]: Replace with high quality images; Do not be grouped

-Placed first in the RESULTS AND DISCUSSION, add description of vegetation diversity researchers found that the fiber content of Bento rayap (*Leersia hexandra*) was 27.40% which was very close to that (27.57%) of the same vegetation in this study. Meanwhile, Rostini et al. (2014) reported that the fiber contents of swamp vegetation in South Kalimantan ranged from 14.84 to 29.35% with the lowest content found in Hadangan (*Paspalum sp*) and the highest in Dadangsit (*L. adscendens*). These figures were lower than those found by Kleden et al. (2015) who revealed that nature grasses in a coffee plantation area and pasture in Wulanggitang, East Flores contained 34.57 and 35.59% of fiber. They also found that the lowest fiber content was found in *L. peploides* and the highest in *I. rugosum*. Fiber contents reported by Kleden et al. (2015) were higher than the results reported by Ahmed *et al*. (2013) with a fiber content of 29.32% in *D. aegyptium* plants. A previous study showed that fermented *I. rugosum*, *H. amplexicaulis*, and *O. rifipogon* had fiber contents of 29.27, 29.57, and 33.07%, respectively (Muhakka et al. 2015).

The fiber content of Eceng gondok (*E. crassipes*) in this study (20.66%) was lower than those found by Hossain et al. (2015), Tham and Uder (2015), and Make et al. (2016). In addition, the fiber content of Eceng gondok (*E. crassipes*) in this study was lower than those of *Azolla*, another water plant, ranging from 13.19 to 16.54% (Kathirvelan et al. 2015; Anitha et al. 2016) and 9.25 to 13.25% (Ahmed et al. 2016). These fiber contents of *Azolla* equaled to those of Cecengkehan (*L. hyssopifolia*) (11.01%), Tapak dara (*C. roseus*) (11.18%), Mutiara legume (*S. exasperata*) (11.22%), Telepuk gajah (*N. lotus*) 11.45%, and Kangkung merah (*I. aquatica*) (14.34%) found in this study. Fiber contents of swamp green vegetations found in this study indicated that they were potential to be used as feed for Pampangan buffaloes.

Ether extract contents

Lowland swamp vegetations in this study were found to have ether extract (EE) contents of about 0.48-2.92%. The lowest EE content was found in Purun tikus (*E. dulcis*) while the highest was found in Kemon air legume *(N. olerancia*). Four vegetations of lowland swamp including Telepuk gajah (*N. lotus*) (2.84% EE), Kumpai minyak (*H. amplexicaulis*) (2.82% EE), Kumpai padi (*O. rupifogon*) (2.49% EE), and Kangkung merah (*I. aquatica* Forsk) (2.24% EE) were revealed to have the highest ether extract contents (Table 2). Results of this study were lower than those found by Rostini et al. (2014), reporting about 0.61-3.67% of EE contents in swamp vegetations in South Kalimantan with the lowest found in Pipisangan (*L. hyssopifolia*) and the highest in Padi hiang (*O. rufigopon spotanea*). EE contents of lowland swamp vegetations were 1.40-1.91% for grasses and 1.36-2.95% for legumes (Asep et al. 2012) and those of grasses in a pasture for buffaloes in Pulau Moa were 1.95-2,41% (Eoh 2014). In other studies, grasses in a natural pasture in North *Lore*, Poso Regency had EE contents of 2.12-2.34% (Damry 2009) and those in Sabana Timur Barat pasture in the rainy season to the end of dry season had an average EE content of 1.91% (Manu 2013). A study by Se'u et al. (2015) revealed an EE content of 1.07% in grasses in a pasture in Timor Tengah Selatan Regency. Another work by Kleden et al. (2015) showed that vegetations in a natural pasture and a coffee plantation area had EE contents of 1.23 and 1.35%, respectively.

Vegetations found in this study had EE contents equaled to those of prime grasses including *elephant* grass (*P. purpuperum*) and *king* grass (*P. purpureophoides*) preserved in the form of hay and silage. *Elephant* grass hay and silage had EE contents of 1.9 and 2.6%, respectively, while those of king grass had EE contents of 1.6 and 2.4%, respectively (Santoso and Hariadi 2008; Ukpabi et al. 2015). EE contents of some species of ruminant roughages were found to be about 1.2-4.1% (Ahmed et al. 2013). Dominant swamp roughages including Kumpai minyak (*H. amplexicaulis* and Kumpai padi *(O. rupifogon)* had EE contents of 2.82 and 2.49%, respectively and they were palatable and potential to be used as feed for Pampangan buffaloes.

Commented [a3]: ???

Ash contents

Ash contents of green vegetations in lowland swamp ranged from 5.63 to 25.19%. Four types of vegetations with the highest ash contents included Kasuran (*C. digitatus*) (25.19%), Mutiara legume (*S. exasperata*) (19.47%), Kumpai minyak (*H. amplexicaulis*) (16.26%), and Kumpai padi (*O. rupifogon* [P]) (16.25%). Meanwhile, Bento rayap *(L. hexandra)* was found to have the lowest ash content of 5.63% (Table 2). Ash contents of vegetations found in this study were higher than those of swamp vegetations in South Kalimantan of 2.18-3.28% during the high tidal season and 3.23-9.83% during the low tidal season (Rostini et al. 2014). *Elephant* grass (*P. purpureum*) was indicated to have varied ash contents of 4.4% (Dahlan and Iskandar 2013), 0.95-1.1% (Ukpabi et al. 2015), 9.59% (Nuhuyanan 2010), and 18% (Araica et al. 2009). Meanwhile, the ash content of grasses in lowland areas ranged from 6.32 to 8.91% (Richmond et al. 2015; Mako et al. 2016; Norman et al. 2013; Maswada et al. 2013). Alam *et al.* (2015) found that *B. mutica* had an ash content of 4.20-4.89% and rice straw had 6.63%.

Roughages were found to have average ash contents of 7.28% in a pasture for buffaloes in Pulau Moa (Eoh 2014), 9.82-10.14% in Lore Utara, Poso Regency (Damry 2009), 11.51% in a pasture during the rainy season until the end of dry season in Sabana Timur Barat (Manu 2013), and 8.11 and 8.22% in a natural pasture and a coffee plantation area, respectively (Kleden et al. 2015). Differences in these ash contents were suspected to be caused by differences in plant species (internal factor) and environmental differences, particularly seasonal differences (external factor). In a dry season, pH levels in lowland swamp areas were found to be 3.9-4.8, causing a decreased supply of nutrients, especially total N and K, to the soil. This decreased supply of nutrients led to lowered nutrients contained in plants (Rostini et al. 2014). This was in line with what was stated by Gutteridge and Shelton (1994) that nutrient content in plants was affected by soil nutrient content. In addition, in acidic soil conditions, activities of Fe, Al, and Mn increased which might cause toxicity in plants (Tjondronegoro and Gunawan).

Commented [a4]: Missing in References

NDF and ADF contents

Neutral Detergent Fiber (NDF) depicts plant cell walls consisting of hemicellulose, cellulose, and lignin. NDF is part of fiber which is not dissolved in neutral detergent representing the component of fiber undissolved in plant cell wall materials. NDF content of a feed affects the ability of ruminant animals to consume the feed. Acid Detergent Fiber (ADF) represents parts of the plant cell wall bond to cellulose and lignin. ADF content is related to energy content and higher ADF content results in lowered digestible energy content (Van Soest 1982).

The NDF and ADF contents of vegetations found in this study were about 40.65-79.47% and 23.66-60.33%, respectively. Lowest NDF contents were found in Cecengkehan (*L. hyssopifolia*) (40.65%), Kangkung merah (*I. aquatica*) (41.40%), Telepuk gajah (*N. lotus*) (46.05%), and Tapak dara (*C. roseus*) (47.79%). In contrast, highest NDF content of 79.47% was found in Bento rayap (*L. hexandra*). Lowest ADF contents were found in Telepuk gajah (*N. lotus*) (46.05%), Kangkung merah *(I. aquatica)* (26.17%), Kumpai merah (*Hymenachne sp*) (28.40%), Cecengkehan (*L. hyssopifolia*) (32.91%). Meanwhile, the highest ADF content of 60.33% was found in Kumpai padi *(O. rupifogon* [p]*)* (Table 3). NDF and ADF contents of vegetations found in this study were lower than those of Asep et al. (2012) who reported that the NDF contents of swamp green vegetations in a pasture for buffaloes were about 91.73-93.45% in grasses and 68.11-90.93% in legumes and the ADF content of grasses was 51.6-86.8%. It was shown in other studies that NDF and ADF contents of roughages in a pasture during the rainy season to the end of the dry season in Sabana Timur Barat were on average 65.9 and 43.29%, respectively (Manu 2013). Vegetations in a natural pasture and a coffee plantation area had NDF contents of 74.89 and 72.37% and ADF contents of 57.22 and 55.15%, respectively (Kleden et al. 2015). Meanwhile, swamp vegetations in South Kalimantan had average NDF and ADF contents of 55.97 and 37.87%, respectively, during the high tidal season and 81.44 and 60.86% respectively, during the low tidal season (Rostini et al. 2014).

NDF and ADF contents of roughages in the BPTU-HPT Padang Mengatas area were found to be 75.62 and 45.96%, respectively in the rain season and 69.35 and 38.66%, respectively in the dry season (Muhajirin et al. 2017). NDF and ADF contents of Eceng gondok (*E. crassipes* in this study were 62.77 and 41.83%, respectively. These figures were close to those of *water hyacinth* (*E.crassipes*) plants studied by Tham (2015) with NDF and ADF contents of 63.9 and 34.68% and by Tham and Uden (2015) with NDF and ADF contents of 52.1 and 30.7%, respectively. Other studies conducted by Ahmed et al. (2016), Anitha et al. (2016), and Nampoothiri (2017) showed that *Azolla sp* had NDF and ADF contents of 53.8-54.85% and 36.57-37.0%, respectively. Meanwhile, NDF and ADF contents of *elephant* grass (*P. purpureum*) were found to be 55.8 and 46.5% (Dahlan and Iskandar 2013) and 84.25 and 64.07% (Nuhuyanan 2010), respectively. These figures equaled to the NDF and ADF contents of Kumpai tembaga (64.72 and 46.38%), Kumpai minyak (65.31 and 38.92), and Are bolong (61.27 and 48.46%). This indicated that lowland swamp vegetations had fiber fraction nutritional quality which was not less than that of prime grasses including *elephant* grass and *king* grass.

In this study, NDF and ADF contents of lowland swamp vegetations were 40.65-79.47% and 23.66%-60.33%, respectively. These figures were still within the ranges of NDF and ADF contents of prime grasses such as *elephant* grass (*P. purpureum*), which had NDF and ADF contents of 55.8 and 46.5% (Dahlan and Iskandar 2013) and 84.25 and 64.07% (Nuhuyanan 2010), respectively. In the rumen, NDF degradation is higher than that of ADF as NDF contains hemicellulose fraction which is more soluble (Church and Pond 1986). NDF content has a negative correlation with its degradation rate (Varga et al. 1983) and higher NDF content decreases dry matter digestibility of feed (NRC 1988). Cellulose is an ADF component that is easy to digest while lignin is hard to digest as it contains double bonds. Higher lignin content decreases feed digestibility (Sutardi et al. 1980).

Hemicellulose and cellulose contents

Lowland swamp vegetations were found to have hemicellulose and cellulose contents ranging from 7.73 to 37.14% and 5.24 to 27.08%, respectively. Four green vegetations with the highest hemicellulose contents were Bento rayap (*L. hexandra*) (37.14%), Kerak maling (*D. fuscescens*) (31.87%), Kumpai merah (*Hymenachne* sp.) (31.74%), and Kumpai minyak (*H. amplexicaulis*) (26.39%). In contrast, the lowest hemicellulose content was found in Cecengkehan (*L. hyssopifolia*) (7.73%). Highest cellulose contents were found in Kemon air (*N. olerancia*) (27.08%), Bento rayap (*L. hexandra*) (25.88%), Purun tikus (*E. dulcis*) (21.80%), and Are bolong (*P. barbatum*) (20.28%). Meanwhile, Kasuran (*C.digitatus*) had the lowest cellulose content of 5.24% (Table 3). Results of this study were in line with those of a study conducted by Asep et al. (2012) who reported the hemicellulose and cellulose contents of lowland swamp green vegetations ranging from 7.89 to 31.55% and 30.85 to 63.35%, respectively. They also found that Kumpai padi (*O.rupifogon*) had 31.55% hemicellulose content which was higher than those of Kumpai padi (10.80-19.30%) found in this study (Table 4). Swamp vegetations in South Kalimantan had hemicellulose contents of 0.65-25.85% in high tidal season and 5.37-40.09% in low tidal season. Cellulose contents in high and low tidal seasons were about 20.07-34.03% and 7.90-38.31%, respectively (Rostini et al. 2014). Various water plants including Azolla, which was used as animal feed, had hemicellulose and cellulose contents of 10.20 and 12.76% (Nampoothiri 2017), 1.15-10.20% and 12.76% (Nampoothiri 2017), respectively. Roughages in BPTU-HPT Padang Mengatas had hemicellulose and cellulose contents of 29.79 and 33.62% in the rain season and 30.69 and 31.64% in the dry season, respectively (Muhajirin et al. 2017). *Elephant* grass (*P. perpureum*) was found to contain 21.18% hemicellulose and 43.32% cellulose (Nuhuyanan 2010) and 35.3% cellulose (Dahlan and Iskandar 2013). In a study conducted by Archimede et al. (2010), hay was found to have 37.7% hemicellulose and 35.7% cellulose.

Based on the above findings, it was suggested that hemicellulose (7.73-37.14%) and cellulose (5.24-27.08%) contents of lowland swamp vegetations in this study were within normal ranges and these vegetations were potential to be used as feed for Pampangan buffaloes.

Lignin contents

Lignin contents of lowland swamp vegetation ranged from 14.84 to 43.09%. Four vegetations including Telepuk gajah (*N. lotus*), Kemon air (*N. olerancia*), Kumpai merah (*Hymenachne* sp.), and Kangkung merah (*I. aquatica*) were found to have the lowest lignin contents of 14.84, 18.36, 19.76, and 19.85%, respectively, while the highest lignin content of 43.09% was found in Kumpai padi (*O. rupifogon* P) (Table 3). Lignin contents in this study were higher than that obtained by Rostini et al. (2014) who reported the lignin contents of swamp vegetations in South Kalimantan were about 2.8-17.59% in high tidal season with that of Kumpai minyak as the lowest and that of *Beberasan* as the highest and 10.06-61.12% in low tidal season with that of *Beberasan* as the lowest and that of Kumpai minyak as the highest. Lignin contents of Kumpai padi (*O. rupifogon* R) (31.24%) and Kumpai padi (*O. rupifogon* P) (43.09%), Bento rayap *(L. hexandra)* (33.92%), and Eceng gondok *(E. crassipes)* (31.60%) (Table 3) found in this study were higher those of Kumpai padi (18.27%) and Bento rayap *(L. hexandra)* (17.96%) found by Asep et al. (2012) and Eceng gondok *(E. crassipes)* (8.17%) found by Tham (2015). In other studies *Azolla* was found to have lignin contents of 5.7% (Ahmed et al. 2016) and 28.24% (Nampoothiri 2017). Meanwhile, lignin contents of *elephant* grass were found to be 15.37% (Nuhuyanan 2010) and 11.2% (Dahlan and Iskandar 2013).

Differences in lignin contents in green vegetation are suspected to be caused by differences in plant species, plant ages, and environmental factors including seasons (rain or dry season), tidal seasons, and fertility levels of the soil where the vegetations grow. In cell walls, cellulose is a bond with hemicellulose and lignin. The animals cannot digest lignin and its molecule structure is different from other carbohydrates as it contains carbon and nitrogen of only 1-5%. Hemicellulose consists of pentose, hexose, uronic acid, and pectin substance. Pectin is a carbohydrate that is composed of uronic acid, galactose, arabinose, xylose, and methanol. Cellulose is degradable by microorganisms and functions as the source of volatile fatty acids. Young grasses (roughages) contain less than 5% lignin and 80% of their cellulose is degradable. On the contrary, in old roughages, lignin content may reach up to 10% causing a decrease in cellulose digestibility by up to 50% (Prawirokusumo 1994).

Based on the results of the study, it was concluded that: (i) The highest protein (20.56%) and crude fat (2.92%) contents were found in Kemon air *(Neptunia olerancia)*. The highest ash content (25.19%) was found in Kasuran *(C. digitatus)*, while the lowest (11.01%) was found in Cecengkehan *(L. hyssopifolia)*. The lowest NDF content (40.64%) was found in Cecengkehan *(L. hyssopifolia)* and the highest hemicellulose content (37.14%) was found in Bento rayap. Telepuk gajah had the lowest ADF (23.66%) and lignin (14,84%) contents. Kemon air contained the highest cellulose level of 27.08%. (ii) The best nutritional values were found in Kasuran *(C. digitatus)* and Cecengkehan *(L. hyssopifolia)*. (iii) Dominant and palatable swamp roughages with good nutrient contents included Kumpai tembaga *(H. acutigluma)*, Kumpai minyak *(H. amplexicaulis)*, Kumpai padi *(O. rupifogon)*, Are bolong *(P. barbatum)*, and Purun tikus *(E. dulcis)*.

ACKNOWLEDGMENTS

The author expresses his deepest gratitude to the Rector of Sriwijaya University through the Chair of the Institute for Research and Community Services funding this research in accordance with the Competitive Leading Research Contract of Sriwijaya University Number: 988 / UN9.3.1 / PP / 2017, dated 21 July 2017.

REFERENCES

Ahmed HA, Ganai A.M, Beigh YA, Sheikh GG, Reshi PA. 2016. Performance of growing sheep on *Azolla* based diets. Indian J. Anim. Res. 50 (5): 721-724.

Alam MR, Haque MM, Sumi KR, Ali MM. 2015. Proximate composition of para-grass *(Brachiaria mutica)* produced in integrated fish-fodder culture system. Bang. J. Anim. Sci. 44 (2): 113-119.

Ali AIM, Sandi S, Muhakka, Riswandi. 2012. Kualitas hijauan pakan di rawa lebak padang penggembalaan kerbau pampangan. Proc. InSINAS 2012. 307-312.

Anitha KC, Rajeshwari YB, Prasanna SB, Shree JS. 2016. Nutritive evaluation of azolla as livestock. J. of Experim. Bio. and Agric. Sci. 4(6): 670-674.

AOAC (Association of Official Analytical Chemists). 1990. Official Methods of Analysis. 15th ed., Washington, DC.

Araica BM, Sporndly E, Sanchez NR, Norell L, Sporndly R. 2009. Silage quality when Moringa oleifera is ensiled in mixtures with elephant grass, sugar cane and molasses. Gra. and For. Sci. 64: 364-373.

Archimede H, Gonzales-Garcia E, Despois P, Etienne T, Alexandre G. 2010. Subtitution of corn and soybean with green banana fruits and Gliricidia sepium forage in sheep fed hay-based diets: effects on intake, digestion and growth. J. of Anim. Physiol. and Anim.. Nutr. 94 (2010): 118-128.

BPS (Badan Pusat Statistik) Provinsi Sumatera Selatan. 2014. Sumatera Selatan dalam Angka 2014.

BPS (Badan Pusat Statistik). 2010. Direktorat Jendral Tanaman Pangan. *Luas lahan rawa di Indonesia*. Departemen Pertanian. Jakarta.

Brazle FK, Kilgore GI, Fauzett MR. 2000. Effect of season on grazing native-grass pastures. The Prof.Anim. Sci. 16: 15-28.

Church DC, Pond WG. 1986. Digestive Animal Physiologi and Nutrition. 2nd. Prentice Hell a Devision of Simon and Schuster Englewood Clief, New York.

Dahlan I, Iskandar MNZ. 2013. Use of plantain peels (Musa paradisiaca) as a fibrous feed substitute for napier grass (Pennisetum purpureum) in rusa deer (Cervus timorensis ratio under captivity. J. Anim. Sci. 3 (9): 472-480.

Damry. 2009. Produksi dan kandungan nutrisi hijauan padang penggembalaan alam di Kecamatan Lore Utara Kabupaten Poso. J. Agrol. 16 (4): 296-300.

Eoh M. 2014. Kapasitas tampung dan komposisi zat-zat makanan padang penggembalaan ternak kerabau di Pulau Moa. Agrinimal. 4 (2): 77-82.

Gutteridge RC, Shelton HM. 1994. The Role of Forage Tree Legumes in Cropping and Grazing System. The Trop. Grassl Soc. of Aust. Inc.

Hossain MdE, Sikder H, Kabir MdH, Sarma SM. 2015. Nutritive value of water hyacinth *(Eichhornia crassipes).* Online J. of Anim. and Feed Resear. 5 (2): 40-44.

Kathirvelan C, Banupriya S, Purushothaman MR. 2015. Azolla-an alternate and su tainable feed for livestock. Internat. J. of Sci. Environ. 4 (4): 1153-1157.
Kleden MM, Ratu MRD, Randu MDS. 2015. Kapasitas tampung hijauan pakan dalam areal perkebunan kopi dan padang rumput alam di Kabupaten Flores Timur Nusa Tenggara Timur. J. Zootek 35 (2): 340-350.
Mako AA, Akinwande VO, Anurudu NF, Ogunwole OA. 2016. Evaluation of nutritive value of water hyacinth *(Eichhornia crassipes)* and guinea grass *(Panicum maximum)* mixture as animal feed in the tropics. 2016. Bull. Anim. Hith. Prod. Afr. (64): 463-473.
Manu AE. 2013. Produktivitas padang penggembalaan sabana Timor Barat. J. Pastura. 3 (1): 25-29.
Maswada HF, Elzaawely AA. 2013. Nutritive value of Stipagrostis lanata (Forssk.) de winder as a feed for livestock. Asian J. of Crop Sci. 5 (2): 216-221.
Muhajirin, Despal, Khalil. 2017. Pemenuhan kebutuhan nutrien sapi potong bibit yang digembalakan di Padang Mengatas. Buletin Makanan Ternak.104 (1): 9-20.
Muhakka, Suwignyo RA, Budianta D dan Yakup. 2019. Vegetation analysis of no-tidal swampland in South Sumatra, Indonesia and its carrying capacity for Pampangan buffalo pasture. J. Biodiv. 20 (4): 1077-1086.
Muhakka, Wijaya A, Ammar M. 2015. Nutritional dried matter, crude protein and crude fiber on lowland tidal grass fermented by probiotic microorganisms for use bali cattle feed. J. Anim. Prod. 17 (1): 24-29.
Mulyani A, Sarwani M. 2013. Karakteristik dan potensi lahan sub optimal untuk pengembangan pertanian di Indonesia. J. Sumber daya Lahan. 7 (1): 47-55.
Nampoothiri VM. 2017. Aquatic plants and marine waste as animal feed. Sch.J. Agric.Vet. Sci. 4 (6): 249-254.
Norman HC, Master DG, Barrentt-Lennard EG. 2013. Halophytes as forage in saline landscapes: Interaction between plant genotipe and environment change their feeding value to ruminants. Environ. and Exp. Bot. 92 (2013): 96-109.
NRC. 1988. Nutrition Reguirement of Beef Cattle. 6th. Rev. Ed. National.
Nuhuyanan LE. 2010. Pengaruh pemberian wafer rumput gajah dengan perekat fermented moter liquor (FML) dan tetes (molasses) terhadap konsumsi pakan, kecernaan zat-zat makanan dan kenaikan berat badan sapi bali jantan. J. Ilmu Peternakan. 5 (2): 111-117.
Prawirokusumo S. 1994. Ilmu Gizi Komperatif. BPFE., Yogyakarta.
Rahman MM, Abdullah RB, Wan Khadijah WE, Nakagawa T, Akashi R. 2014. Feed intake and growth performance of goats affered napier grass *(Pennisetum purpureum)* supplemented with concentrate pellet and soya waste. Sain Malaysiana. 43 (7): 967-971.
Richmond AS, Wylie ARG, Laidlaw AS, Lively FO. 2015. Methane emissions from beef cattle grazing on semi-natural upland and improved lowland grasslands. Anim. 9 (1): 130-137.
Rostini T, Abdullah L, Wiryawan KG, Karti PDMH. (2014). Production and nutrition potency of swamp local forage in South Kalimantan as ruminant feed. Glob. J. Anim. Sci. Livestock Prod. Anim. Breed. 2 (2):107-113.
Santoso dan Hariadi BTj. 2008. Komposisi kimia, degradasi nutrien dan produksi gas metana in vitro rumput tropika yang diawetkan dengan metode silase dan hay. J. Media Peternakan 31(2): 128-137.
Se'u VE, Karti PDMH, Abdullah L. 2015. Botanical composition, grass production, and carrying capacity of pasture in Timor Tengah Selatan District. J. Media Peternakan 38(3):176-182.
Statistik Peternakan Sumatera Selatan. 2014. Dinas Peternakan Provinsi Sumatera Selatan Tahun Anggaran 2015.hal:14.
Sutardi T, Pratiwi SH, Adnan A, Nuraini S. 1980. Peningkatan pemanfaatan jerami padi melalui hidrolisa basa, suplementasi urea dan belarang. Bull. Makanan Ternak. 6 Bogor.
Tham HoT, Uden P. 2015. Effect of fresh water Hyacinth (Eichhornia crassipes) on intake and digestibility in cattle fed rice straw and molasses-urea cake. Nova J. of Engineer. and Appl. Sci. 4(1): 1-8.
Tham HoT. 2015. Utilisation of water hyacinth as animal feed. Nova J. of Engineer. Appl.Sci. 4 (1): 1-6.
Tjondronegoro AD, Gunawan A. 2000. Beberapa jenis gulma di lahan pasang surut pada tingkat kemasaman tanah yang berbeda. Pros. Seminar Nasional. P. 247-254.
Van Soest PJ. 1982. Nutritional Ecology of the Ruminant: Ruminant Metabolism, Nutritional Stategies the Cellulolytic Fermentation and the Camisthy of Forages and Palm Fiber. Cornell University O & B Books Inc. USA.
Varga GA, Hoover WH. 1983. Rate and extent of NDF of feedstuff in-situ. J. Dairy. Sci. 66:2109.

BIODIVERSITAS
Volume 21, Number 1, January 2020
Pages: xxxx

ISSN: 1412-033X
E-ISSN: 2085-4722
DOI: 10.13057/biodiv/d2101xx

Nutritional values of swamp grasses as feed for Pampangan Buffaloes in South Sumatra, Indonesia

> **Commented [a1]:** Maaf saya menggunakan bahasa Indonesia, karena komentar sebelumnya dalam bahasa Inggris dilewatkan oleh penulis
>
> HIDUPKAN TRACK CHANGE agar kami tahu bagian yang diubah oleh penulis
>
> Untuk revisi gunakan file ini, jangan file lainnya

MUHAKKA[1,♥], RUJITO AGUS SUWIGNYO[2], DEDIK BUDIANTA[3], YAKUP[2]
[1]Department of Animal Husbandry, Faculty of Agriculture, Sriwijaya University, Jl. Palembang-Prabumulih Km, 32 Inderalaya, Ogan Ilir 30662, South Sumatra, Indonesia, Tel/Fax. +62-711-581106. ♥email: muhakka@fp.unsri.ac.id
[2]Department of Agronomy, Faculty of Agriculture, Sriwijaya University, Jl. Palembang-Prabumulih Km, 32 Inderalaya, Ogan Ilir 30662, South Sumatra, Indonesia
[3]Department of Soil Science, Faculty of Agriculture, Sriwijaya University, Jl. Palembang-Prabumulih Km, 32 Inderalaya, Ogan Ilir 30662, South Sumatra, Indonesia

Manuscript received: 17 October 2019. Revision accepted: xxx December 2019.

Abstract. *Muhakka, Suwignyo RA, Budianta D, Yakup. 2020. Nutritional values of swamp grasses as feed for Pampangan Buffaloes in South Sumatra, Indonesia. Biodiversitas 21: xxxx.* This study was aimed at determining the types and quality of vegetations in the swamp area, which could be used as sources of roughage for Pampangan buffaloes in South Sumatra. In this descriptive study. Results showed that the highest crude protein and ether extract contents, 20.56 and 2.92%, respectively, were found in Kemon air *(Neptunia olerancia)*. The highest ash content of 25.19% was found in Kasuran *(Cyperus digitatus)*. The lowest fiber content (11.01%) was found in Cecengkehan *(Ludwigia hyssopifolia)*, which also had the lowest content of Neutral Detergent Fiber (NDF) (40.64%). Hemicellulose content was found to be highest (37.14%) in Bento rayap *(Leersia hexandra)*. The lowest ADF (23.66%) and lignin (14,84%) contents were found in Telepuk gajah *(Nymphaea lotus)*. Kemon air *(N. olerancia)* was found to have the lowest content (27.08%) of cellulose. It was concluded that the swamp vegetation found in this study consisted of 17 species ~~types~~ of grasses (89.47%) and two species ~~types~~ of legumes (10.53%). Kasuran *(C. digitatus)* and Cecengkehan *(L. hyssopifolia)* were found to have the best nutritional values. Dominant and palatable vegetations with good nutritional values, which were potential to be used as sources of roughage for *Pampangan* buffaloes, were Kumpai tembaga *(Hymenachne acutigluma)*, Kumpai padi *(O ryza rupifogon)*, Kumpai minyak *(Hymenachne amplexicaulis*, Are bolong *(Polygonum barbatum)*, and Purun tikus *(Eleocharis dulcis).*

> **Commented [a2]:** Dalam bahasa Inggris kata "jenis" diterjemahkan menjadi SPECIES, bukan TYPE(s)
> Tolong dicek kembali semua bagian sampai akhir naskah

Keywords: Nutritional value, swamp grass, feed, Pampangan buffalo

INTRODUCTION

The availability of roughage as the main feed for ruminant animals depends considerably on seasons. During the rainy season, it is abundant, and during the dry season, the availability of grasses and legumes is lacking. The limited supply of roughage may hamper productivity including the reproductive performance of ruminant animals including buffaloes.

In South Sumatra, Pampangan buffalo is a potential germplasm which needs to be preserved and developed. There were 37,405 heads of Pampangan buffaloes in 2016, and this population increased by 3.97% to 38,952 heads in 2017. In 2017, of this population, 11,150 heads (28.63%) and 2,227 heads (5.72%) were found in Ogan Komering Ilir Regency and Banyuasin Regency, respectively (Statistik Peternakan Sumsel 2017). The population and productivity of *Pampangan* buffaloes need to be improved, and for this purpose, feed is an important factor to consider. Pampangan buffaloes feed mostly on roughage from the swamp, grassland to meet their maintenance and reproductive needs.

In Indonesia, there are 13.27 million hectares of lowland swamp areas. Only 4 million hectares of these areas have been developed and cultivated by the community and private sectors (2.6 million hectares) and the government assistance (1.3 million hectares) (BPS 2010, Mulyani and Sarwani 2013). In Sumatra, the largest lowland swamp area of 2.98 million hectares is found in South Sumatra, but only 298,189 hectares of it have been utilized (BPS Sumatra Selatan 2014). In order to utilize the potential swamp area as a feed source for Pampangan buffaloes, a study on vegetations as sources of roughage in lowland swamp areas that include vegetation identification and nutritional quality determination needs to be conducted.

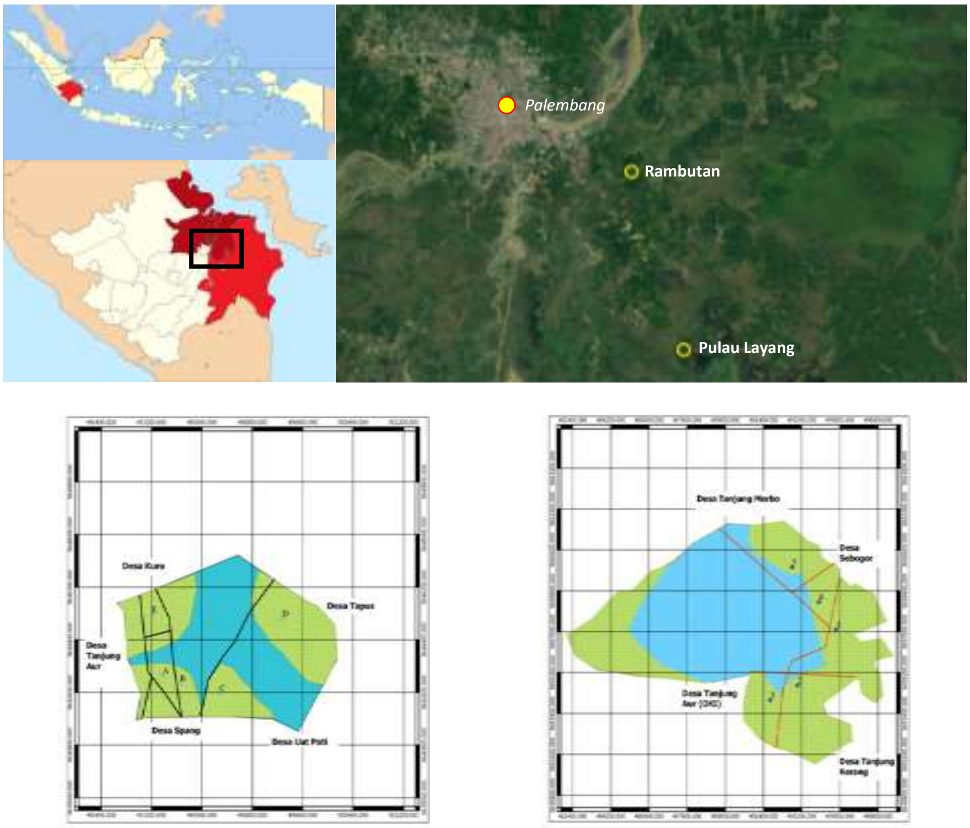
In the previous study, some swamp grasses, including Kumpai minyak grass (*H. amplexicaulis)* (Rostini et al. 2014**;** Muhakka et al. 2015), *I. rugosum* and *L. hexandra* (Ali et al. 2012) were identified. However, many more swamp has not been identified. For example, *P. barbatum,C. digitatus, R. corymbosa* This study was conducted to identify the types and nutritional values of vegetations that could be used as sources of roughage feed for Pampangan buffaloes in South Sumatra. This information was important to support the productivity improvement of Pampangan buffaloes as germplasm in South Sumatra. In this study, some new swamp found where in the previous study it's not found yet.

MATERIALS AND METHODS

Area study

This study was a descriptive study to assess the types and nutritional values of vegetations, which were the dominant and palatable as sources of roughage feed for Pampangan buffaloes. Vegetation samples were taken from grazing areas of Pampangan buffaloes in Rambutan Village and Pulau Layang Village, South Sumatra, Indonesia (Figure 1) from April to Juni 2017. Vegetation samples for nutrient analysis were obtained by following these procedures: (i) vegetation collection was done based on estimated growth age (young age, medium age, and old age based on physical appearance), (ii) collected samples of each vegetation was composited, and (iii) samples were chopped into small sizes, homogenized.

For each vegetation, 1 kg sample was taken randomly and sent to the laboratory for oven drying at 105ºC until a constant weight was obtained and dry matter content was determined. Samples were then ground for nutrient content determination by using proximate and Van Soest analyses (Syarifuddin and Wahdi 2010). Sample analyses of Crude protein, fiber, ether extract, and ash contents conducted in Laboratory of Dairy Nutrition, Department of Nutrition and Feed Technology, Institut Pertanian Bogor (IPB), Bogor, Indonesia, while analyses of NDF, ADF, hemicellulose, cellulose, and lignin conducted in Biotechnology Assessment Laboratory, Center for Biotechnology Research, Indonesian Institute of Sciences (LIPI), Cibinong, Bogor; and analysis of soil conducted in Laboratory of Soil Chemistry, Biology, and Fertility, Soil Department, Faculty of Agriculture, Sriwijaya University, Ogan Ilir, Indonesia.



A B

Figure 1. Research location in South Sumatra, Indonesia. A. Pulau Layang Village, Pampangan Sub-district, Ogan Komering Ilir District, South Sumatra. B. Rambutan Village, Rambutan Sub-district, Banyuasin District, South Sumatra, Indonesia (Muhakka et al. 2019)

Measured parameters

Soil analysis

Soil sampling is done in a composite manner at a depth of 0-20 cm. Taking the soil sample points is done by making a diagonal line in each zone and determining 5 soil sampling points to analyze chemical fertility (N, P, K) and physical fertility (texture, structure and pH).

Plant materials (1) The sampling area is divided into five zones (A, B, C, D and E) and each zone consists of 10 observation points. (2) Samples of each type of forage vegetation the dominant and palatable are collected based on the estimated age of growth, namely young age, middle age, and old age by looking at their physical appearance, (3) Samples of each type of vegetation that have been collected, put together until homogeneous and (4) Samples are finely chopped, mixed until homogeneous then randomly taken as much as 1 kg.

Proximate analysis

Crude protein, fiber, ether extract, and ash contents were determined based on the procedures of AOAC (1990). *Crude protein*. Nitrogen (N) content was determined by using a Kjeldahl method. In this analysis, sulphuric acid with a catalyst and a heating process. The organic matter of samples was then oxidized by sulfuric acid, and nitrogen was changed into an ammonium sulfate form. The remaining sulfuric acid was neutralized by NaOH until the solution became basic. Ammonium sulfate was then distilled in an acid medium to obtain the quantitative amount of N. As the average protein contains 16% nitrogen, a factor 100 %: 16% = 6.25 was used to obtain the value of crude protein (crude protein = N% x 6.25). *Fiber*. The filtered fat-free sample was used in fiber content determination. 1.25% sulfuric acid solution was added into the sample, and the mixture was heated for about 30 minutes before the residue was filtered. 1,25% NaOH solution was added into the precipitate, and the mixture was heated for about 30 minutes. The mixture was then filtered, and the precipitate was washed, dried, and weighed. This precipitate was burnt, and the ash was weighed. The difference between the weight of precipitate before it was burnt and the weight of the ass was referred to as fiber content. *Ether extract*. The dry matter sample was extracted with diethyl ether for 5 hours. At the end of the extraction process, ether evaporated and the remaining material was referred to as fat. *Ash*. The third part of the dry matter sample was weighed and burnt in a crucible at 550ºC for 8 hours.

Van Soest analysis

Neutral Detergent Fiber (NDF), Acid Detergent Fiber (ADF), hemicellulose, cellulose, and lignin contents were determined by using a Van Soest method (1982).

Neutral Detergent Fiber (NDF). One gram of sample was put in a beaker glass. 50 ml NDS solution was added into the beaker before the mixture was heated for an hour. The mixture was then filtered by using a vacuum pump and a filter glass which was previously weighed (b gram). The mixture was then washed with hot water and acetone before it was dried in an oven and let cool in a desiccator. Finally, it was weighed as c gram. NDF content was calculated by using the following formula:

$$\% \text{ NDF} = \frac{c-b}{a} \times 100\%$$

Acid Detergent Fiber (ADF). One gram of sample was put in a beaker glass. 50 ml ADS solution was added into the beaker before the mixture was heated for an hour. The mixture was then filtered by using a vacuum pump and a sintered glass filter which was previously weighed (b gram). The mixture was then washed with hot water and acetone before it was dried in an oven and let cool in a desiccator. Finally, it was weighed as c gram. Cellulose content was calculated by using the following formula:

$$\% \text{ cellulose} = \frac{c-d}{a} \times 100\%$$

Hemicellulose. Hemicellulose content was calculated as a difference between NDF and ADF contents as follows.

% Hemicellulose = % NDF-% ADF

Lignin. Cellulose residue (d gram) was burnt in a furnace at 500-600ºC for 3 hours. After that, it was left to cool and weighed (e gram). Lignin content was calculated by using the following formula:

$$\% \text{ Lignin} = \frac{d-e}{a} \times 100\%$$

Data analysis

The data obtained were used directly to describe the nutritional value of the swamp vegetation that could be used as a roughage source. These data were then combined with those of *in vitro* digestibility as the basis for concluding (Syarifuddin and Wahdi 2010).

RESULTS AND DISCUSSION

Soil analysis

Results of soil analysis showed that soil at the study site had a low fertility level and was highly acidic. It also had very high organic C and total N contents, medium level of exchangeable-K and N contents, very low Ca and Mg contents, medium P content, and very high CEC level (Table 1).

Commented [a3]: Jelaskan mengenai material tumbuhan yang digunakan dalam penelitian ini termasuk koleksi spesies yang digunakan, pemilihan bahan, bagian yang digunakan untuk pengujian, dll

Nutrient contents of lowland swamp

Crude protein, fiber, ether extract, and ash nutrient contents of lowland swamp vegetations found in this study are listed in (Table 2).

The NDF and ADF contents of vegetations found in this study were about 40.65-79.47% and 23.66-60.33%, respectively. Lowland swamp vegetations were found to have hemicellulose and cellulose contents ranging from 7.73 to 37.14% and 5.24 to 27.08%, respectively. Lignin contents of lowland swamp vegetation ranged from 14.84 to 43.09% (Table 3).

There are 19 species ~~19 types~~ of forage found in Pampangan buffalo pasture that have potential that can be used as food for Pampangan buffalo, consisting of 17 species ~~types~~ of grass (gramineae) and 2 species ~~types~~ of legumes (legumes) (Muhakka et al. 2019). Species ~~Types~~ of forage swamp forage plants, there are dominant and palatable species of swamp lowland forage vegetation having potential as buffalo feed, namely Kumpai padi (*O. rupifogon), Kumpai tembaga (H. acutigluma)*, and Kumpai minyak *(H. amplexicaulis)*, not dominant and palatable such as Kumpai merah *(Hymenachne* sp.) and Kemon air *(N. olerancia)*; dominant and non palatable grass species (buffalo does not like it) namely Are bolong (*P. barbatum*). this grass species would be eaten by the buffaloes if there were no other species to be eaten (Muhakka et al. 2019).

Commented [a4]: Tunjukkan daftar 19 spesies pakan kerbau ini beserta familia-nya

Discussion

Crude protein content

Results showed that the crude protein contents of swamp green vegetations ranged from 5.26% to 20.56% with the lowest value (5.26%) was found in Berondong grass (*R. corymbosa*) and the highest (20.56%) was found in Kemon air legume (*N. olerancia*). Kasuran grass (*C. digitatus*) had the highest crude protein content (15.31%) (Table 2). This high nutritional value of Kasuran grass was suspected as caused by the fact that most of this grass was found to grow in the area of buffalo pens where the soil was rich in organic matter. However, the growth of this grass was not dominant as it mostly occurred in rainy seasons.

Kumpai minyak (*H. amplexicaulis*), Kumpai padi (*O. rupifogon*), Kumpai tembaga (*H. acutigluma*), and Purun tikus (*E. dulcis*) were found as the dominant palatable grasses containing 12.00, 10.41, 10.96, and 8.22% crude protein, respectively. Results of this study were not too different from those obtained by Rostini et al. (2014), who reported that Kumpai minyak and Pipisangan had protein contents of 10.88 and 15.92%, respectively. Crude protein (CP) contents of these swamp grasses in Pulau Layang and Rambutan Villages were closed to those of prime grasses including 9.11-12.8% CP of *elephant* grass (*P. purpureum*) (Santos et al. 2013; Dahlan and Iskandar 2013; Rahman et al. 2014), 12.4% CP of *elephant* grass hay, 11.1% CP of *elephant* grass silage, 11.4% CP of king grass hay, and 10.2% CP of king grass silage (Santoso and Hariadi 2008). Other vegetations even had higher CP contents including Kumpai tembaga *(H. acutigluma)* with 10.96% CP, Tapak dara (*C. roseus*) 15.20%, Telepuk gajah (*N. lotus*) 13.22%, Cecengkehan (*L. hyssopifolia*) 12.07%, Kasuran *(C. digitatus*) 15.31%, and Kumpai minyak (*H. amplexicaulis)*[R] 12.0% (Table 2). CP contents of vegetations in this study were also higher than those of nature grasses found in coffee plantation areas (6.95%) and pastoral areas (6.65%) in Wulanggitang District, East Flores Regency as reported by Kleden et al. (2015). Meanwhile, CP content of grasses in lowlands was 8.41% (Maswada and Elzaawely 2013; Rochana et al. 2016).

Table 1. Properties of soil at the study site

Parameter	Pulau Layang		Rambutan	
	Value	Remark	Value	Remark
pH H_2O (1 : 1)	5.10	Low	4.41	Very low
pH KCl (1 : 1)	4.39	Very acidic	3.99	Very acidic
Organic C (g/kg)	57.66	Very high	36.14	Very high
Total N (g/kg)	3.64	Very high	2.19	Very high
Available P/Bray I (mg/kg)	11.70	Medium	2.25	Very low
Exchangeable K (cmol/kg)	0.63	Medium	0.45	Medium
Na (cmol/kg)	0.65	Medium	0.65	Medium
Ca (cmol/kg)	1.95	Very low	0.73	Very low
Mg (cmol/kg)	0.45	Very low	0.32	Very low
CEC (cmol/kg)	65.25	Very high	43.50	Very high
Exchangeable Al (cmol/kg)	1.84		2.37	
Exchangeable H (cmol/kg)	0.74		0.88	
Texture:				
Sand (%)	47.08		46.64	
Ash (%)	31.11		27.18	
Clay (%)	21.81		26.18	

Table 2. Crude protein, fiber, ether extract, and ash contents (%) of lowland swamp vegetations

	Latin name	Family	Local name	Crude protein	Fiber	Ether extract	Ash
1.	*Catharanthus roseus* P	*Apocynaceae*	Tapak dara	15.20	11.18	1.29	12.53
2.	*Cyperus digitatus* R	*Cyperaceae*	Kasuran	15.31	14.76	1.42	25.19
3.	*Digitaria fuscescens* R	*Poaceae*	Kerak Maling/Pasiran	12.00	15.64	1.24	16.26
4.	*Eichhornia crassipes* P	*Pontederiaceae*	Eceng gondok	8.61	20.66	0.84	14.22
5.	*Eleocharis dulcis* ^{P}	*Cyperaceae*	Purun tikus	8.22	25.72	0.48	15.13
6.	*Eleocharis dulcis* ^{R}	*Cyperaceae*	Purun tikus	6.63	24.52	1.69	10.24
7.	*Hymenachne acutigluma* ^{R}	*Poaceae*	Kumpai Tembaga	10.96	23.73	1.77	10.30
8.	*Hymenachne acutigluma)* ^{P}	*Poaceae*	Kumpai Tembaga	6.86	30.26	2.22	7.88
9.	*Hymenachne amplexicaulis* ^{P}	*Poaceae*	Kumpai Minyak	9.21	21.91	2.82	13.96
10.	*Hymenachne amplexicaulis* ^{R}	*Poaceae*	Kumpai Minyak	12.00	15.64	1.24	16.26
11.	*Hymenachne sp* P	*Poaceae*	Kumpai Merah	8.52	21.20	1.30	12.88
12.	*Ipomoea aquatica* P	*Convolvulaceae*	Kangkung merah	8.95	14.34	2.24	10.39
13.	*Leersia hexandra* P	*Poaceae*	Bento rayap	5.35	27.57	2.06	5.63
14.	*Ludwigia hyssopifolia* P	*Onagraceae*	Cecengkehan	12.07	11.01	1.66	9.09
15.	*Neptunia olerancia* P	*Mimoceae*	Kemon air	20.56	15.03	2.92	7.31
16.	*Nymphaea lotus* P	*Nymphaeaceae*	Telepuk Gajah	13.22	11.45	2.84	10.30
17.	*Oryza rupifogon* ^{P}	*Poaceae*	Kumpai Padi	7.93	23.30	1.60	16.25
18.	*Oryza rupifogon* ^{R}	*Poaceae*	Kumpai Padi	10.41	21.59	2.49	11.92
19.	*Polygonum barbatum* P	*Poaceae*	Are Bolong	7.53	16.60	1.57	8.40
20.	*Rhynchospora corymbosa* P	*Cyperaceae*	Berondong	5.26	22.27	1.48	14.84
21.	*Sesbania exasperata* R	*Mimoceae*	Mutiara	18.27	11.22	1.86	19.47

Notes: ^{P} : Grass in Pulau Layang Village; ^{R} : Grass in Rambutan Village.

There are some species that analysed twice, in Pulau Layang and Rambutan because they appear in both areas, and some others only analysed once because they only appear in one area. For Mutiara (*S. exasperata*) it's enough to know only its nutrient content from analysis of proximate, and the production of this grass is measly so that its potention to be buffalo's feed is measly as well, but it can be made as feed suplement. So, it's not analysed in table 3.

Table 3. Composition of fiber fractions of green vegetations in lowland swamp: NDF, ADF, hemicellulose, cellulose, and lignin (%).

	Latin name	Family	NDF	ADF	Hemi-cellulose	Cellulose	Lignin
1.	*Catharanthus roseus* P	*Apocynaceae*	47.79	39.67	8.12	16.96	22.71
2.	*Cyperus digitatus* R	*Cyperaceae*	58.90	36.93	21.97	5.24	31.68
3.	*Digitaria fuscescens* R	*Poaceae*	65.43	33.56	31.87	12.11	21.45
4.	*Eichhornia crassipes* P	*Pontederiaceae*	62.77	41.83	20.94	10.22	31.60
5.	*Eleocharis dulcis* ^{P}	*Cyperaceae*	69.57	49.83	19.74	21.80	28.04
6.	*Eleocharis dulcis* ^{R}	*Cyperaceae*	75.73	54.91	20.82	19.71	35.20
7.	*Hymenachne acutigluma* ^{P}	*Poaceae*	75.89	50.60	25.29	12.25	38.34
8.	*Hymenachne acutigluma* ^{R}	*Poaceae*	64.72	46.38	18.34	16.01	30.37
9.	*Hymenachne amplexicaulis* P	*Poaceae*	65.31	38.92	26.39	8.29	30.63
10.	*Hymenachne* sp P	*Poaceae*	60.14	28.40	31.74	8.64	19.76
11.	*Ipomoea aquatica* P	*Convolvulaceae*	41.40	26.17	15.23	6.32	19.85
12.	*Leersia hexandra* P	*Poaceae*	79.47	42.33	37.14	25.88	33.92
13.	*Ludwigia hyssopifolia* P	*Onagraceae*	40.64	32.91	7.73	8.39	24.52
14.	*Neptunia olerancia* P	*Mimoceae*	62.31	45.44	16.87	27.08	18.36
15.	*Nymphaea lotus* P	*Nymphaeaceae*	46.05	23.66	22.39	8.82	14.84
16.	*Oryza rupifogon* ^{P}	*Poaceae*	71.13	60.33	10.80	17.23	43.09
17.	*Oryza rupifogon* ^{R}	*Poaceae*	65.49	46.19	19.30	14.96	31.24
18.	*Polygonum barbatum* P	*Poaceae*	61.27	48.46	12.81	20.28	28.18
19.	*Rhynchospora corymbosa* P	*Cyperaceae*	65.29	44.64	20.65	16.08	28.56

Note: ^{P} : Grass in Pulau Layang Village; ^{R} : Grass in Rambutan Village.

Missing in table 3. It's should be number 10

Hymenachne amplexcaulis (R)	Poaceae	65.32	39.45	25.87	9.75	28.67

Figure 2. Dominant and palatable swamp roughages with good nutrient contents included. **A**. *Hymenachne acutigluma*, **B**. *Oryza*

Commented [a5]: Sebutkan Family

Commented [a6]: Mengapa ada spesies yang diuji dua kali P (

Commented [a7]: Mengapa jenis ini tidak ada/tidak diuji di

Commented [a8]: Sebutkan Family

rupifogon **C**. *Hymenachne amplexicaulis,* **D**. *Polygonum barbatum*, and **E**. *Eleocharis dulcis*.

This high protein content was suspected to be caused by the fact that soil organic C and total N contents in the study site were also high, namely 36.14-57.66 and 2.19-3.64 $g.kg^{-1}$, respectively (Table 1). Soil organic C and total N contents affected protein content in plants. Four swamp grasses including Kasuran (*C. digitatus*), Tapak dara (*C. roseus*), Telepuk gajah (*N. lotus*), and Cecengkehan (*L. hyssopifolia*) and a legume, Kemon air (*N. olerancia*) were found to be the lowland swamp vegetations having the highest N contents of 15.31,15.20, 13.22, 12.07, and 20.56%, respectively.

Fiber contents

Fiber contents of lowland swamp green vegetations ranged from 11.01 to 30.26%, with the lowest content found in Cecengkehan (*L. hyssopifolia*) and the highest in Kumpai tembaga *(H. acutigluma* [P]*)*. Four vegetations including *Cecengkehan* (*L. hyssopifolia*), Tapak dara (*C. roseus*), Mutiara legume (*S. exasperata*), and Telepuk gajah (*N. lotus*) were found to have the lowest fiber contents of 11.01, 11.18, 11.22, and 11.45%, respectively (Table 2). These results were almost similar to those found by Ali et al. (2012) who reported that the fiber contents of roughage in a pasture ranged from 7.20 to 34.98%. These researchers found that the fiber content of Bento rayap (*Leersia hexandra*) was 27.40% which was very close to that (27.57%) of the same vegetation in this study. Meanwhile, Rostini et al. (2014) reported that the fiber contents of swamp vegetation in South Kalimantan ranged from 14.84 to 29.35% with the lowest content found in Hadangan (*Paspalum sp*) and the highest in Dadangsit (*L. adscendens*). These figures were lower than those found by Kleden et al. (2015) who revealed that nature grasses in a coffee plantation area and pasture in Wulanggitang, East Flores contained 34.57 and 35.59% of fiber. They also found that the lowest fiber content was found in *L. peploides* and the highest in *I. rugosum*. Fiber contents reported by Kleden et al. (2015) were higher than the results reported by Ahmed *et al*. (2013) with a fiber content of 29.32% in *D. aegyptium* plants. A previous study showed that fermented *I. rugosum, H. amplexicaulis*, and *O. rifipogon* had fiber contents of 29.27, 29.57, and 33.07%, respectively (Muhakka et al. 2015).

The fiber content of Eceng gondok (*E. crassipes*) in this study (20.66%) was lower than those found by Hossain et al. (2015), Tham and Uder (2015), and Make et al. (2016). In addition, the fiber content of Eceng gondok (*E. crassipes*) in this study was lower than those of *Azolla*, another water plant, ranging from 13.19 to 16.54% (Kathirvelan et al. 2015; Anitha et al. 2016) and 9.25 to 13.25% (Ahmed et al. 2016). These fiber contents of *Azolla* equaled to those of Cecengkehan (*L. hyssopifolia*) (11.01%), Tapak dara (*C. roseus*) (11.18%), Mutiara legume (*S. exasperata*) (11.22%), Telepuk gajah (*N. lotus*) 11.45%, and Kangkung merah (*I. aquatica*) (14.34%) found in this study. Fiber contents of swamp green vegetations found in this study indicated that they were potential to be used as feed for Pampangan buffaloes.

Ether extract contents

Lowland swamp vegetations in this study were found to have ether extract (EE) contents of about 0.48-2.92%. The lowest EE content was found in Purun tikus (*E. dulcis*) while the highest was found in Kemon air legume *(N. olerancia*). Four vegetations of lowland swamp including Telepuk gajah (*N. lotus*) (2.84% EE), Kumpai minyak (*H. amplexicaulis*) (2.82% EE), Kumpai padi (*O. rupifogon*) (2.49% EE), and Kangkung merah (*I. aquatica* Forsk) (2.24% EE) were revealed to have the highest ether extract contents (Table 2). Results of this study were lower than those found by Rostini et al. (2014), reporting about 0.61-3.67% of EE contents in swamp vegetations in South Kalimantan with the lowest found in Pipisangan (*L. hyssopifolia*) and the highest in Padi hiang (*O. rufigopon spotanea*). EE contents of lowland swamp vegetations were 1.40-1.91% for grasses and 1.36-2.95% for legumes (Asep et al. 2012) and those of grasses in a pasture for buffaloes in Pulau Moa were 1.95-2,41% (Eoh 2014). In other studies, grasses in a natural pasture in North *Lore*, Poso Regency had EE contents of 2.12-2.34% (Damry 2009) and those in Sabana Timur Barat pasture in the rainy season to the end of dry season had an average EE content of 1.91% (Manu 2013). A study by Se'u et al. (2015) revealed an EE content of 1.07% in grasses in a pasture in Timor Tengah Selatan Regency. Another work by Kleden et al. (2015) showed that vegetations in a natural pasture and a coffee plantation area had EE contents of 1.23 and 1.35%, respectively.

Vegetations found in this study had EE contents equaled to those of prime grasses including *elephant* grass (*P. purpuperum*) and *king* grass (*P. purpureophoides*) preserved in the form of hay and silage. *Elephant* grass hay and silage had EE contents of 1.9 and 2.6%, respectively, while those of king grass had EE contents of 1.6 and 2.4%, respectively (Santoso and Hariadi 2008; Ukpabi et al. 2015). EE contents of some species of ruminant roughages were found to be about 1.2-4.1% (Ahmed et al. 2013). Dominant swamp roughages including Kumpai minyak (*H. amplexicaulis* and Kumpai padi *(O. rupifogon)* had EE contents of 2.82 and 2.49%, respectively and they were palatable and potential to be used as feed for Pampangan buffaloes.

Ash contents

Ash contents of green vegetations in lowland swamp ranged from 5.63 to 25.19%. Four types of vegetations with the highest ash contents included Kasuran (*C. digitatus*) (25.19%), Mutiara legume (*S. exasperata*) (19.47%), Kumpai minyak (*H. amplexicaulis*) (16.26%), and Kumpai padi (*O. rupifogon* [P]) (16.25%). Meanwhile, Bento rayap *(L. hexandra)* was found to have the lowest ash content of 5.63% (Table 2). Ash contents of vegetations found in this study were higher than those of swamp vegetations in South Kalimantan of 2.18-3.28% during the high tidal season and 3.23-9.83% during the low tidal season (Rostini et al. 2014). *Elephant* grass (*P. purpureum*) was indicated to have varied ash contents of 4.4% (Dahlan and Iskandar 2013), 0.95-1.1% (Ukpabi et al. 2015), 9.59% (Nuhuyanan 2010), and 18% (Araica et al. 2009). Meanwhile, the ash content of grasses in lowland areas ranged from 6.32 to 8.91% (Richmond et al. 2015; Mako et al. 2016; Norman et al. 2013; Maswada et al. 2013). Alam *et al*. (2015) found that *B. mutica* had an ash content of 4.20-4.89% and rice straw had 6.63%.

Roughages were found to have average ash contents of 7.28% in a pasture for buffaloes in Pulau Moa (Eoh 2014), 9.82-10.14% in Lore Utara, Poso Regency (Damry 2009), 11.51% in a pasture during the rainy season until the end of dry season in Sabana Timur Barat (Manu 2013), and 8.11 and 8.22% in a natural pasture and a coffee plantation area, respectively (Kleden et al. 2015). Differences in these ash contents were suspected to be caused by differences in plant species (internal factor) and environmental differences, particularly seasonal differences (external factor). In a dry season, pH levels in lowland swamp areas were found to be 3.9-4.8, causing a decreased supply of nutrients, especially total N and K, to the soil. This decreased supply of nutrients led to lowered nutrients contained in plants (Rostini et al. 2014). This was in line with what was stated by Gutteridge and Shelton (1994) that nutrient content in plants was affected by soil nutrient content. In addition, in acidic soil conditions, activities of Fe, Al, and Mn increased which might cause toxicity in plants (Tjondronegoro and Gunawan. 2000).

NDF and ADF contents

Neutral Detergent Fiber (NDF) depicts plant cell walls consisting of hemicellulose, cellulose, and lignin. NDF is part of fiber which is not dissolved in neutral detergent representing the component of fiber undissolved in plant cell wall materials. NDF content of a feed affects the ability of ruminant animals to consume the feed. Acid Detergent Fiber (ADF) represents parts of the plant cell wall bond to cellulose and lignin. ADF content is related to energy content and higher ADF content results in lowered digestible energy content (Van Soest 1982).

The NDF and ADF contents of vegetations found in this study were about 40.65-79.47% and 23.66-60.33%, respectively. Lowest NDF contents were found in Cecengkehan (*L. hyssopifolia*) (40.65%), Kangkung merah (*I. aquatica*) (41.40%), Telepuk gajah (*N. lotus*) (46.05%), and Tapak dara (*C. roseus*) (47.79%). In contrast, highest NDF content of 79.47% was found in Bento rayap (*L. hexandra*). Lowest ADF contents were found in Telepuk gajah (*N. lotus*) (46.05%), Kangkung merah *(I. aquatica)* (26.17%), Kumpai merah (*Hymenachne sp*) (28.40%), Cecengkehan (*L. hyssopifolia*) (32.91%). Meanwhile, the highest ADF content of 60.33% was found in Kumpai padi *(O. rupifogon* [P]*)* (Table 3). NDF and ADF contents of vegetations found in this study were lower than those of Asep et al. (2012) who reported that the NDF contents of swamp green vegetations in a pasture for buffaloes were about 91.73-93.45% in grasses and 68.11-90.93% in legumes and the ADF content of grasses was 51.6-86.8%. It was shown in other studies that NDF and ADF contents of roughages in a pasture during the rainy season to the end of the dry season in Sabana Timur Barat were on average 65.9 and 43.29%, respectively (Manu 2013). Vegetations in a natural pasture and a coffee plantation area had NDF contents of 74.89 and 72.37% and ADF contents of 57.22 and 55.15%, respectively (Kleden et al. 2015). Meanwhile, swamp vegetations in South Kalimantan had average NDF and ADF contents of 55.97 and 37.87%, respectively, during the high tidal season and 81.44 and 60.86% respectively, during the low tidal season (Rostini et al. 2014).

NDF and ADF contents of roughages in the BPTU-HPT Padang Mengatas area were found to be 75.62 and 45.96%, respectively in the rain season and 69.35 and 38.66%, respectively in the dry season (Muhajirin et al. 2017). NDF and ADF contents of Eceng gondok (*E. crassipes* in this study were 62.77 and 41.83%, respectively. These figures were close to those of *water hyacinth* (*E.crassipes*) plants studied by Tham (2015) with NDF and ADF contents of 63.9 and 34.68% and by Tham and Uden (2015) with NDF and ADF contents of 52.1 and 30.7%, respectively. Other studies conducted by Ahmed et al. (2016), Anitha et al. (2016), and Nampoothiri (2017) showed that *Azolla sp* had NDF and ADF contents of 53.8-54.85% and 36.57-37.0%, respectively. Meanwhile, NDF and ADF contents of *elephant* grass (*P. purpureum*) were found to be 55.8 and 46.5% (Dahlan and Iskandar 2013) and 84.25 and 64.07% (Nuhuyanan 2010), respectively. These figures equaled to the NDF and ADF contents of Kumpai tembaga (64.72 and 46.38%), Kumpai minyak (65.31 and 38.92), and Are bolong (61.27 and 48.46%). This indicated that lowland swamp vegetations had fiber fraction nutritional quality which was not less than that of prime grasses including *elephant* grass and *king* grass.

In this study, NDF and ADF contents of lowland swamp vegetations were 40.65-79.47% and 23.66%-60.33%, respectively. These figures were still within the ranges of NDF and ADF contents of prime grasses such as *elephant* grass (*P. purpureum*), which had NDF and ADF contents of 55.8 and 46.5% (Dahlan and Iskandar 2013) and 84.25 and 64.07% (Nuhuyanan 2010), respectively. In the rumen, NDF degradation is higher than that of ADF as NDF contains hemicellulose fraction which is more soluble (Church and Pond 1986). NDF content has a negative correlation with its degradation rate (Varga et al. 1983) and higher NDF content decreases dry matter digestibility of feed (NRC 1988). Cellulose is an ADF component that is easy to digest while lignin is hard to digest as it contains double bonds. Higher lignin content decreases feed digestibility (Sutardi et al. 1980).

Hemicellulose and cellulose contents

Lowland swamp vegetations were found to have hemicellulose and cellulose contents ranging from 7.73 to 37.14% and 5.24 to 27.08%, respectively. Four green vegetations with the highest hemicellulose contents were Bento rayap (*L. hexandra*) (37.14%), Kerak maling (*D. fuscescens*) (31.87%), Kumpai merah (*Hymenachne* sp.) (31.74%), and Kumpai minyak (*H. amplexicaulis*) (26.39%). In contrast, the lowest hemicellulose content was found in Cecengkehan (*L. hyssopifolia*) (7.73%). Highest cellulose contents were found in Kemon air (*N. olerancia*) (27.08%), Bento rayap (*L. hexandra*) (25.88%), Purun tikus (*E. dulcis*) (21.80%), and Are bolong (*P. barbatum*)

Commented [a11]: Missing in References

(20.28%). Meanwhile, Kasuran (*C.digitatus*) had the lowest cellulose content of 5.24% (Table 3). Results of this study were in line with those of a study conducted by Asep et al. (2012) who reported the hemicellulose and cellulose contents of lowland swamp green vegetations ranging from 7.89 to 31.55% and 30.85 to 63.35%, respectively. They also found that Kumpai padi (*O.rupifogon*) had 31.55% hemicellulose content which was higher than those of Kumpai padi (10.80-19.30%) found in this study (Table 4). Swamp vegetations in South Kalimantan had hemicellulose contents of 0.65-25.85% in high tidal season and 5.37-40.09% in low tidal season. Cellulose contents in high and low tidal seasons were about 20.07-34.03% and 7.90-38.31%, respectively (Rostini et al. 2014). Various water plants including Azolla, which was used as animal feed, had hemicellulose and cellulose contents of 10.20 and 12.76% (Nampoothiri 2017), 1.15-10.20% and 12.76% (Nampoothiri 2017), respectively. Roughages in BPTU-HPT Padang Mengatas had hemicellulose and cellulose contents of 29.79 and 33.62% in the rain season and 30.69 and 31.64% in the dry season, respectively (Muhajirin et al. 2017). *Elephant* grass (*P. perpureum*) was found to contain 21.18% hemicellulose and 43.32% cellulose (Nuhuyanan 2010) and 35.3% cellulose (Dahlan and Iskandar 2013). In a study conducted by Archimede et al. (2010), hay was found to have 37.7% hemicellulose and 35.7% cellulose. Based on the above findings, it was suggested that hemicellulose (7.73-37.14%) and cellulose (5.24-27.08%) contents of lowland swamp vegetations in this study were within normal ranges and these vegetations were potential to be used as feed for Pampangan buffaloes.

Lignin contents

Lignin contents of lowland swamp vegetation ranged from 14.84 to 43.09%. Four vegetations including Telepuk gajah (*N. lotus*), Kemon air (*N. olerancia*), Kumpai merah (*Hymenachne* sp.), and Kangkung merah (*I. aquatica*) were found to have the lowest lignin contents of 14.84, 18.36, 19.76, and 19.85%, respectively, while the highest lignin content of 43.09% was found in Kumpai padi (*O. rupifogon* ^{P}) (Table 3). Lignin contents in this study were higher than that obtained by Rostini et al. (2014) who reported the lignin contents of swamp vegetations in South Kalimantan were about 2.8-17.59% in high tidal season with that of Kumpai minyak as the lowest and that of *Beberasan* as the highest and 10.06-61.12% in low tidal season with that of *Beberasan* as the lowest and that of Kumpai minyak as the highest. Lignin contents of Kumpai padi (*O. rupifogon* ^{R}) (31.24%) and Kumpai padi (*O. rupifogon* ^{P}) (43.09%), Bento rayap *(L. hexandra)* (33.92%), and Eceng gondok *(E. crassipes)* (31.60%) (Table 3) found in this study were higher those of Kumpai padi (18.27%) and Bento rayap *(L. hexandra)* (17.96%) found by Asep et al. (2012) and Eceng gondok *(E. crassipes)* (8.17%) found by Tham (2015). In other studies *Azolla* was found to have lignin contents of 5.7% (Ahmed et al. 2016) and 28.24% (Nampoothiri 2017). Meanwhile, lignin contents of *elephant* grass were found to be 15.37% (Nuhuyanan 2010) and 11.2% (Dahlan and Iskandar 2013).

Differences in lignin contents in green vegetation are suspected to be caused by differences in plant species, plant ages, and environmental factors including seasons (rain or dry season), tidal seasons, and fertility levels of the soil where the vegetations grow. In cell walls, cellulose is a bond with hemicellulose and lignin. The animals cannot digest lignin and its molecule structure is different from other carbohydrates as it contains carbon and nitrogen of only 1-5%. Hemicellulose consists of pentose, hexose, uronic acid, and pectin substance. Pectin is a carbohydrate that is composed of uronic acid, galactose, arabinose, xylose, and methanol. Cellulose is degradable by microorganisms and functions as the source of volatile fatty acids. Young grasses (roughages) contain less than 5% lignin and 80% of their cellulose is degradable. On the contrary, in old roughages, lignin content may reach up to 10% causing a decrease in cellulose digestibility by up to 50% (Prawirokusumo 1994).

Based on the results of the study, it was concluded that: (i) The highest protein (20.56%) and crude fat (2.92%) contents were found in Kemon air *(Neptunia olerancia)*. The highest ash content (25.19%) was found in Kasuran *(C. digitatus)*, while the lowest (11.01%) was found in Cecengkehan *(L. hyssopifolia)*. The lowest NDF content (40.64%) was found in Cecengkehan *(L. hyssopifolia)* and the highest hemicellulose content (37.14%) was found in Bento rayap. Telepuk gajah had the lowest ADF (23.66%) and lignin (14,84%) contents. Kemon air contained the highest cellulose level of 27.08%. (ii) The best nutritional values were found in Kasuran *(C. digitatus)* and Cecengkehan *(L. hyssopifolia)*. (iii) Dominant and palatable swamp roughages with good nutrient contents included Kumpai tembaga *(H. acutigluma)*, Kumpai minyak *(H. amplexicaulis)*, Kumpai padi *(O. rupifogon)*, Are bolong *(P. barbatum)*, and Purun tikus *(E. dulcis)*.

ACKNOWLEDGMENTS

The author expresses his deepest gratitude to the Rector of Sriwijaya University through the Chair of the Institute for Research and Community Services funding this research in accordance with the Competitive Leading Research Contract of Sriwijaya University Number: 988 / UN9.3.1 / PP / 2017, dated 21 July 2017.

REFERENCES

Ahmed HA, Ganai A.M, Beigh YA, Sheikh GG, Reshi PA. 2016. Performance of growing sheep on *Azolla* based diets. Indian J. Anim. Res. 50 (5): 721-724.

Alam MR, Haque MM, Sumi KR, Ali MM. 2015. Proximate composition of para-grass *(Brachiaria mutica)* produced in integrated fish-fodder culture system. Bang. J. Anim. Sci. 44 (2): 113-119.

Ali AIM, Sandi S, Muhakka, Riswandi. 2012. Kualitas hijauan pakan di rawa lebak padang penggembalaan kerbau pampangan. Proc. InSINAS 2012. 307-312.

Anitha KC, Rajeshwari YB, Prasanna SB, Shree JS. 2016. Nutritive evaluation of azolla as livestock. J. of Experim. Bio. and Agric. Sci. 4(6): 670-674.

AOAC (Association of Official Analytical Chemists). 1990. Official Methods of Analysis. 15th ed., Washington, DC.

Araica BM, Sporndly E, Sanchez NR, Norell L, Sporndly R. 2009. Silage quality when Moringa oleifera is ensiled in mixtures with elephant grass, sugar cane and molasses. Gra. and For. Sci. 64: 364-373.

Archimede H, Gonzales-Garcia E, Despois P, Etienne T, Alexandre G. 2010. Subtitution of corn and soybean with green banana fruits and Gliricidia sepium forage in sheep fed hay-based diets: effects on intake, digestion and growth. J. of Anim. Physiol. and Anim.. Nutr. 94 (2010): 118-128.

BPS (Badan Pusat Statistik) Provinsi Sumatera Selatan. 2014. Sumatera Selatan dalam Angka 2014.

BPS (Badan Pusat Statistik). 2010. Direktorat Jendral Tanaman Pangan. *Luas lahan rawa di Indonesia*. Departemen Pertanian. Jakarta.

Brazle FK, Kilgore GI, Fauzett MR. 2000. Effect of season on grazing native-grass pastures. The Prof.Anim. Sci. 16: 15-28.

Church DC, Pond WG. 1986. Digestive Animal Physiologi and Nutrition. 2nd. Prentice Hell a Devision of Simon and Schuster Englewood Clief, New York.

Dahlan I, Iskandar MNZ. 2013. Use of plantain peels (Musa paradisiaca) as a fibrous feed substitute for napier grass (Pennisetum purpureum) in rusa deer (Cervus timorensis ratio under captivity. J. Anim. Sci. 3 (9): 472-480.

Damry. 2009. Produksi dan kandungan nutrisi hijauan padang penggembalaan alam di Kecamatan Lore Utara Kabupaten Poso. J. Agrol. 16 (4): 296-300.

Eoh M. 2014. Kapasitas tampung dan komposisi zat-zat makanan padang penggembalaan ternak kerabau di Pulau Moa. Agrinimal. 4 (2): 77-82.

Gutteridge RC, Shelton HM. 1994. The Role of Forage Tree Legumes in Cropping and Grazing System. The Trop. Grassl Soc. of Aust. Inc.

Hossain MdE, Sikder H, Kabir MdH, Sarma SM. 2015. Nutritive value of water hyacinth *(Eichhornia crassipes).* Online J. of Anim. and Feed Resear. 5 (2): 40-44.

Kathirvelan C, Banupriya S, Purushothaman MR. 2015. Azolla-an alternate and su tainable feed for livestock. Internat. J. of Sci. Environ. 4 (4): 1153-1157.

Kleden MM, Ratu MRD, Randu MDS. 2015. Kapasitas tampung hijauan pakan dalam areal perkebunan kopi dan padang rumput alam di Kabupaten Flores Timur Nusa Tenggara Timur. J. Zootek 35 (2): 340-350.

Mako AA, Akinwande VO, Anurudu NF, Ogunwole OA. 2016. Evaluation of nutritive value of water hyacinth *(Eichhornia crassipes)* and guinea grass *(Panicum maximum)* mixture as animal feed in the tropics. 2016. Bull. Anim. Hith. Prod. Afr. (64): 463-473.

Manu AE. 2013. Produktivitas padang penggembalaan sabana Timor Barat. J. Pastura. 3 (1): 25-29.

Maswada HF, Elzaawely AA. 2013. Nutritive value of Stipagrostis lanata (Forssk.) de winder as a feed for livestock. Asian J. of Crop Sci. 5 (2): 216-221.

Muhajirin, Despal, Khalil. 2017. Pemenuhan kebutuhan nutrien sapi potong bibit yang digembalakan di Padang Mengatas. Buletin Makanan Ternak.104 (1): 9-20.

Muhakka, Suwignyo RA, Budianta D dan Yakup. 2019. Vegetation analysis of no-tidal swampland in South Sumatra, Indonesia and its carrying capacity for Pampangan buffalo pasture. J. Biodiv. 20 (4): 1077-1086.

Muhakka, Wijaya A, Ammar M. 2015. Nutritional dried matter, crude protein and crude fiber on lowland tidal grass fermented by probiotic microorganisms for use bali cattle feed. J. Anim. Prod. 17 (1): 24-29.

Mulyani A, Sarwani M. 2013. Karakteristik dan potensi lahan sub optimal untuk pengembangan pertanian di Indonesia. J. Sumber daya Lahan. 7 (1): 47-55.

Nampoothiri VM. 2017. Aquatic plants and marine waste as animal feed. Sch.J. Agric.Vet. Sci. 4 (6): 249-254.

Norman HC, Master DG, Barrentt-Lennard EG. 2013. Halophytes as forage in saline landscapes: Interaction between plant genotipe and environment change their feeding value to ruminants. Environ. and Exp. Bot. 92 (2013): 96-109.

NRC. 1988. Nutrition Reguirement of Beef Cattle. 6th. Rev. Ed. National.

Nuhuyanan LE. 2010. Pengaruh pemberian wafer rumput gajah dengan perekat fermented moter liquor (FML) dan tetes (molasses) terhadap konsumsi pakan, kecernaan zat-zat makanan dan kenaikan berat badan sapi bali jantan. J. Ilmu Peternakan. 5 (2): 111-117.

Prawirokusumo S. 1994. Ilmu Gizi Komperatif. BPFE., Yogyakarta.

Rahman MM, Abdullah RB, Wan Khadijah WE, Nakagawa T, Akashi R. 2014. Feed intake and growth performance of goats affered napier grass *(Pennisetum purpureum)* supplemented with concentrate pellet and soya waste. Sain Malaysiana. 43 (7): 967-971.

Richmond AS, Wylie ARG, Laidlaw AS, Lively FO. 2015. Methane emissions from beef cattle grazing on semi-natural upland and improved lowland grasslands. Anim. 9 (1): 130-137.

Rostini T, Abdullah L, Wiryawan KG, Karti PDMH. (2014). Production and nutrition potency of swamp local forage in South Kalimantan as ruminant feed. Glob. J. Anim. Sci. Livestock Prod. Anim. Breed. 2 (2):107-113.

Santoso dan Hariadi BTj. 2008. Komposisi kimia, degradasi nutrien dan produksi gas metana in vitro rumput tropika yang diawetkan dengan metode silase dan hay. J. Media Peternakan 31(2): 128-137.

Se'u VE, Karti PDMH, Abdullah L. 2015. Botanical composition, grass production, and carrying capacity of pasture in Timor Tengah Selatan District. J. Media Peternakan 38(3):176-182.

Statistik Peternakan Sumatera Selatan. 2014. Dinas Peternakan Provinsi Sumatera Selatan Tahun Anggaran 2015.hal:14.

Sutardi T, Pratiwi SH, Adnan A, Nuraini S. 1980. Peningkatan pemanfaatan jerami padi melalui hidrolisa basa, suplementasi urea dan belarang. Bull. Makanan Ternak. 6 Bogor.

Tham HoT, Uden P. 2015. Effect of fresh water Hyacinth (Eichhornia crassipes) on intake and digestibility in cattle fed rice straw and molasses-urea cake. Nova J. of Engineer. and Appl. Sci. 4(1): 1-8.

Tham HoT. 2015. Utilisation of water hyacinth as animal feed. Nova J. of Engineer. Appl.Sci. 4 (1): 1-6.

Tjondronegoro AD, Gunawan A. 2000. Beberapa jenis gulma di lahan pasang surut pada tingkat kemasaman tanah yang berbeda. Pros. Seminar Nasional. P. 247-254.

Van Soest PJ. 1982. Nutritional Ecology of the Ruminant: Ruminant Metabolism, Nutritional Stategies the Cellulolytic Fermentation and the Camisthy of Forages and Palm Fiber. Cornell University O & B Books Inc. USA.

Varga GA, Hoover WH. 1983. Rate and extent of NDF of feedstuff in-situ. J. Dairy. Sci. 66:2109.

6. Bukti konfirmasi submit revisi ketiga, respon kepada reviewer, dan artikel yang diresubmit (08 Februari 2020)

BIODIVERSITAS
Volume 21, Number 1, January 2020
Pages: xxxx

ISSN: 1412-033X
E-ISSN: 2085-4722
DOI: 10.13057/biodiv/d2101xx

Nutritional values of swamp grasses as feed for Pampangan Buffaloes in South Sumatra, Indonesia

MUHAKKA[1,♥], RUJITO AGUS SUWIGNYO[2], DEDIK BUDIANTA[3], YAKUP[2]

[1]Department of Animal Husbandry, Faculty of Agriculture, Universitas Sriwijaya. Jl. Palembang-Prabumulih Km 32, Inderalaya, Ogan Ilir 30662, South Sumatra, Indonesia. Tel./fax.: +62-711-581106. ♥email: muhakka@fp.unsri.ac.id
[2]Department of Agronomy, Faculty of Agriculture, Universitas Sriwijaya. Jl. Palembang-Prabumulih Km 32, Inderalaya, Ogan Ilir 30662, South Sumatra, Indonesia
[3]Department of Soil Science, Faculty of Agriculture, Universitas Sriwijaya. Jl. Palembang-Prabumulih Km 32, Inderalaya, Ogan Ilir 30662, South Sumatra, Indonesia

Manuscript received: 17 October 2019. Revision accepted: xxx December 2019.

Abstract. *Muhakka, Suwignyo RA, Budianta D, Yakup. 2020. Nutritional values of swamp grasses as feed for Pampangan Buffaloes in South Sumatra, Indonesia. Biodiversitas 21: xxxx.* This study was aimed at determining the types and quality of ~~vegetations~~vegetation in the swamp area, which could be used as sources of roughage for Pampangan buffaloes in South Sumatra. In this descriptive study, ~~.~~ Results showed that the highest crude protein and ether extract contents, 20.56 and 2.92%, respectively, were found in Kemon air (*Neptunia oleracea*). The highest ash content of 25.19% was found in Kasuran (*Cyperus digitatus*). The lowest fiber content (11.01%) was found in Cecengkehan (*Ludwigia hyssopifolia*), which also had the lowest content of Neutral Detergent Fiber (NDF) (40.64%). Hemicellulose content was found to be highest (37.14%) in Bento rayap (*Leersia hexandra*). The lowest ADF (23.66%) and lignin (14,84%) contents were found in Telepuk gajah (*Nymphaea lotus*). Kemon air (*N. oleracea*) was found to have the lowest content (27.08%) of cellulose. It was concluded that the swamp vegetation found in this study consisted of 17 species of grasses and herbs (89.47%) and two species of legumes (10.53%). Kasuran (*C. digitatus*) and Cecengkehan (*L. hyssopifolia*) were found to have the best nutritional values. Dominant and palatable ~~vegetations~~vegetation with good nutritional values, which were potential to be used as sources of roughage for *Pampangan* buffaloes, were Kumpai tembaga (*Hymenachne acutigluma*), Kumpai padi (*Oryza rufipogon*), Kumpai minyak (*Hymenachne amplexicaulis*, Are bolong (*Polygonum barbatum*), and Purun tikus (*Eleocharis dulcis*).

Keywords: Nutritional value, swamp grass, feed, Pampangan buffalo

INTRODUCTION

The availability of roughage as the main feed for ~~ruminant animals~~ruminants depends considerably on seasons. During the rainy season, it is abundant, ~~and~~ but during the dry season, the availability of grasses/herbs and legumes is lacking. The limited supply of roughage may hamper productivity including the reproductive performance of ~~ruminant animals~~ruminants including buffaloes.

In South Sumatra, Pampangan buffalo is potential germplasm that needs to be preserved and developed. There were 37,405 ~~heads of~~ Pampangan buffaloes in 2016, and this population increased by 3.97% to 38,952 ~~heads~~ in 2017. In 2017, of this population, 11,150 ~~heads~~ (28.63%) and 2,227 ~~heads~~ (5.72%) were found in Ogan Komering Ilir District and Banyuasin District, respectively (Statistik Peternakan Sumsel 2017). The population and productivity of *Pampangan* buffaloes need to be improved, and for this purpose, feed is an important factor to consider. Pampangan buffaloes feed mostly on roughage from the swamp, grassland to meet their ~~maintenance~~ upkeeping and reproductive needs.

In Indonesia, there are 13.27 million hectares of lowland swamp areas. Only 4 million hectares of these areas have been developed and cultivated by the community and private sectors (2.6 million hectares) and the government assistance (1.3 million hectares) (BPS 2010, Mulyani and Sarwani 2013). In Sumatra, the largest lowland swamp area of 2.98 million hectares is found in South Sumatra, but only 298,189 hectares of it have been utilized (BPS Sumatra Selatan 2014). In order to utilize the potential swamp area as a feed source for Pampangan buffaloes, a study on ~~vegetations~~vegetation as sources of roughage in lowland swamp areas that include vegetation identification and nutritional quality determination needs to be conducted.

In the previous study, some swamp grasses, including Kumpai minyak grass (*H. amplexicaulis*) (Rostini et al. 2014**;** Muhakka et al. 2015), *I. rugosum* and *L. hexandra* (Ali et al. 2012) were identified. However, ~~many~~ more swamp vegetation ~~has~~have not been identified. For example, *P. barbatum*, *C. digitatus*, *R. corymbosa*. This study was conducted to identify the types and nutritional values of ~~vegetations~~vegetation that could be used as sources of roughage feed for Pampangan buffaloes in South Sumatra. This information was important to support the productivity improvement of Pampangan buffaloes as germplasm in South Sumatra. In this study, some new swamp forages were found, ~~although~~ and they were not stated in the previous study. ~~it's not found yet.~~

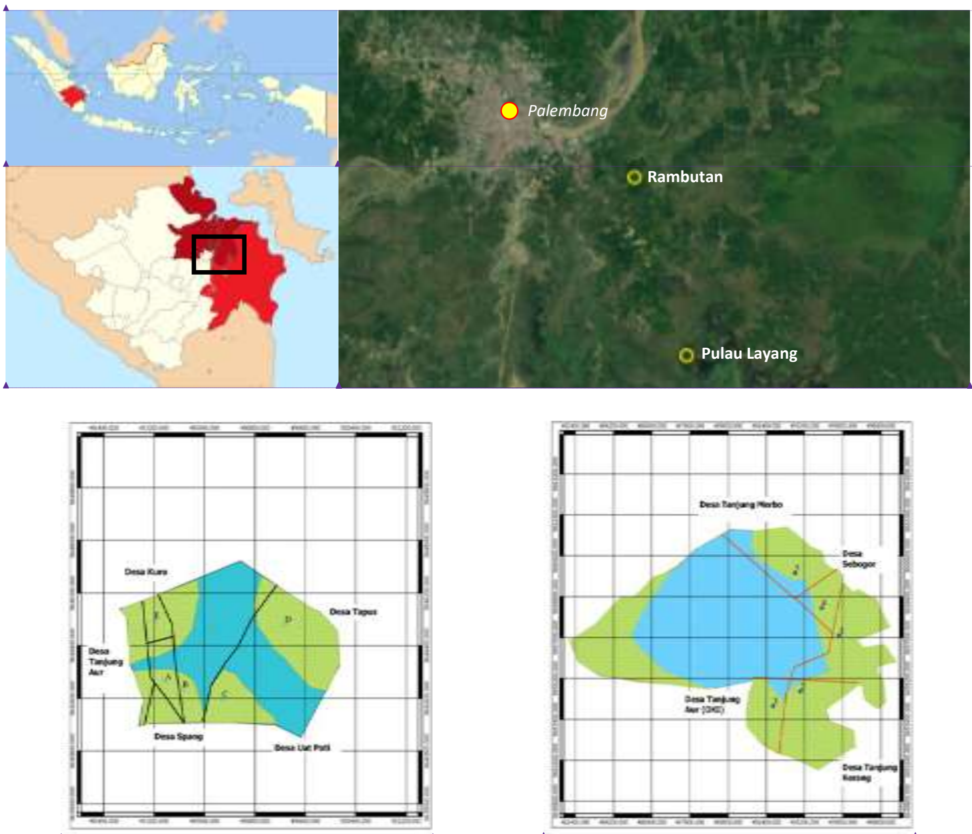
Formatted: English (United States)
Formatted ...
Formatted ...
Formatted ...
Formatted ...
Formatted ...
Formatted ...
Formatted: English (United States)
Formatted: Check spelling and grammar
Formatted ...
Formatted ...
Formatted: English (United States)

MATERIALS AND METHODS

Area study

This study was a descriptive study to assess the types and nutritional values of ~~vegetations~~vegetation, which were ~~the~~ dominant and palatable as sources of roughage feed for Pampangan buffaloes. Vegetation samples were taken from grazing areas of Pampangan buffaloes in Rambutan Village and Pulau Layang Village, South Sumatra, Indonesia (Figure 1) from April to Juni 2017. Vegetation samples for nutrient analysis were obtained by following procedures: (i) vegetation collection was done based on estimated growth age (young age, ~~medium~~ middle age, and old age based on physical appearance), (ii) collected samples of each vegetation was composited, and (iii) samples were chopped into small sizes, and then homogenized.

For each vegetation, 1 kg sample was taken randomly and sent to the laboratory for oven drying at 105ºC, until a constant weight was obtained and dry matter content was determined. Samples were then ground for nutrient content determination by using proximate and Van Soest analyses (Syarifuddin and Wahdi 2010). Sample analyses of crude protein, fiber, ether extract, and ash contents were conducted in Laboratory of Dairy Nutrition, Department of Nutrition and Feed Technology, Institut Pertanian Bogor (IPB), Bogor, Indonesia, while analyses of NDF, ADF, hemicellulose, cellulose, and lignin were conducted in Biotechnology Assessment Laboratory, Research Center for Biotechnology, Indonesian Institute of Sciences (LIPI), Cibinong, Bogor, Indonesia; and analysis of soil was conducted in Laboratory of Soil Chemistry, Biology, and Fertility, Soil Department, Faculty of Agriculture, Sriwijaya University, Ogan Ilir, Indonesia.



A B

Figure 1. Research location in South Sumatra, Indonesia. A. Pulau Layang Village, Pampangan Sub-district, Ogan Komering Ilir District, South Sumatra. B. Rambutan Village, Rambutan Sub-district, Banyuasin District, South Sumatra, Indonesia (Muhakka et al. 2019)

Formatted: English (United States)
Formatted: English (United States)
Formatted: English (United States)
Formatted: English (United States)
Formatted: English (United States)
Formatted: English (United States)
Formatted: English (United States)
Formatted: English (United States)
Formatted: English (United States)
Formatted: English (United States)
Formatted: English (United States)
Formatted: English (United States)
Formatted: English (United States)
Formatted: English (United States)
Formatted: English (United States)
Formatted: English (United States)
Formatted: English (United States)
Formatted: English (United States), Check spelling and grammar
Formatted: English (United States)
Formatted: English (United States), Check spelling and grammar
Formatted: English (United States), Check spelling and grammar
Formatted: English (United States)
Formatted: English (United States), Check spelling and grammar
Formatted: English (United States), Check spelling and grammar
Formatted: English (United States)
Formatted: Check spelling and grammar
Formatted: English (United States)
Formatted: Check spelling and grammar
Formatted: English (United States)
Formatted: English (United States)

Measured parameters

Soil analysis

Soil sampling is done in a composite manner at a depth of 0-20 cm. Taking the soil sample points is done by making a diagonal line in each zone and determining 5 soil sampling points to analyze chemical fertility (N, P, K) and physical fertility (texture, structure and pH).

Plant materials

The sampling area is divided into five zones (A, B, C, D and E) and each zone consists of 10 observation points. Samples of each type of dominant and palatable forage vegetation ~~the dominant and palatable~~ are collected based on the estimated age of growth, namely young age, middle age, and old age by looking at their physical appearance. Samples of each type of vegetation that have been collected, are put together until homogeneous. Samples are finely chopped, mixed until homogeneous then randomly taken as much as 1 kg.

There are some species that are analyzed twice,~~–~~ in Pulau Layang and Rambutan because they appear in both areas, ~~and some~~while the others are only analyzed once because they only appear in one area. For Mutiara (*Sesbania exasperata*) it is enough to know only its nutrient content from analysis of proximate, and the production of this grass is measly so that its potential to be buffalo's feed is measly as well, but it can be made as feed supplement. So, it is not analyzed for composition of fiber fractions (Table 3).

Proximate analysis

Crude protein, fiber, ether extract, and ash contents were determined based on the procedures of AOAC (1990). *Crude protein*. Nitrogen (N) content was determined by using a Kjeldahl method. In this analysis, sulphuric acid was treated with a catalyst and a heating process. The organic matter of samples was then oxidized by sulfuric acid, and nitrogen was changed into an ammonium sulfate form. The remaining sulfuric acid was neutralized by NaOH until the solution became basic. Ammonium sulfate was then distilled in an acid medium to obtain the quantitative amount of N. As the average protein contains 16% nitrogen, a factor 100%: 16% = 6.25 was used to obtain the value of crude protein (crude protein = N% x 6.25). *Fiber*. The filtered fat-free sample was used in fiber content determination. 1.25% sulfuric acid solution was added into the sample, and the mixture was heated for about 30 minutes before the residue was filtered. 1.25% NaOH solution was added into the precipitate, and the mixture was heated for about 30 minutes. The mixture was then filtered, and the precipitate was washed, dried, and weighed. This precipitate was burnt, and the ash was weighed. The difference between the weight of precipitate before it was burnt and the weight of the ~~ass~~ ash was referred to as fiber content. *Ether extract*. The dry matter sample was extracted with diethyl ether for 5 hours. At the end of the extraction process, ether evaporated and the remaining material was referred to as fat. *Ash*. The third part of the dry matter sample was weighed and burnt in a crucible at 550ºC for 8 hours.

Van Soest analysis

Neutral Detergent Fiber (NDF), Acid Detergent Fiber (ADF), hemicellulose, cellulose, and lignin contents were determined by using a Van Soest method (1982).

Neutral Detergent Fiber (*NDF*). One gram of sample was put in a beaker glass. 50 ml NDS solution was added into the beaker before the mixture was heated for an hour. The mixture was then filtered by using a vacuum pump and a filter glass which was previously weighed (b gram). The mixture was then washed with hot water and acetone before it was dried in an oven and let cool in a desiccator. Finally, it was weighed as c gram. NDF content was calculated by using the following formula:

$$\% \text{ NDF} = \frac{c-b}{a} \times 100\%$$

Acid Detergent Fiber (*ADF*). One gram of sample was put in a beaker glass. 50 ml ADS solution was added into the beaker before the mixture was heated for an hour. The mixture was then filtered by using a vacuum pump and a sintered glass filter which was previously weighed (b gram). The mixture was then washed with hot water and acetone before it was dried in an oven and let cool in a desiccator. Finally, it was weighed as c gram. Cellulose content was calculated by using the following formula:

$$\% \text{ cellulose} = \frac{c-d}{a} \times 100\%$$

Hemicellulose. Hemicellulose content was calculated as a difference between NDF and ADF contents as follows.

% Hemicellulose = % NDF-% ADF

Lignin. Cellulose residue (d gram) was burnt in a furnace at 500-600ºC for 3 hours. After that, it was left to cool and weighed (e gram). Lignin content was calculated by using the following formula:

$$\% \text{ Lignin} = \frac{d-e}{a} \times 100\%$$

Data analysis

The data obtained were used directly to describe the nutritional value of the swamp vegetation that could be used as a roughage source. These data were then combined with those of *in vitro* digestibility as the basis for concluding (Syarifuddin and Wahdi 2010).

RESULTS AND DISCUSSION

Soil analysis

Results of soil analysis showed that soil at the study site had a low fertility level and was highly acidic. It also had very high organic C and total N contents, medium level of exchangeable-K and N contents, very low Ca and Mg contents, medium P content, and very high CEC level (Table 1).

Table 1. Properties of soil at the study site

Parameter	Pulau Layang		Rambutan	
	Value	Remark	Value	Remark
pH H_2O (1 : 1)	5.10	Low	4.41	Very low
pH KCl (1 : 1)	4.39	Very acidic	3.99	Very acidic
Organic C (g/kg)	57.66	Very high	36.14	Very high
Total N (g/kg)	3.64	Very high	2.19	Very high
Available P/Bray I (mg/kg)	11.70	Medium	2.25	Very low
Exchangeable K (cmol/kg)	0.63	Medium	0.45	Medium
Na (cmol/kg)	0.65	Medium	0.65	Medium
Ca (cmol/kg)	1.95	Very low	0.73	Very low
Mg (cmol/kg)	0.45	Very low	0.32	Very low
CEC (cmol/kg)	65.25	Very high	43.50	Very high
Exchangeable Al (cmol/kg)	1.84		2.37	
Exchangeable H (cmol/kg)	0.74		0.88	
Texture:				
Sand (%)	47.08		46.64	
Ash (%)	31.11		27.18	
Clay (%)	21.81		26.18	

Nutrient contents of lowland swamp

Crude protein, fiber, ether extract, and ash nutrient contents of lowland swamp ~~vegetations~~vegetation found in this study are listed in (Table 2).

The NDF and ADF contents of ~~vegetations~~vegetation found in this study were about 40.65-79.47% and 23.66-60.33%, respectively. Lowland swamp ~~vegetations~~vegetation ~~were~~ was found to have hemicellulose and cellulose contents ranging from 7.73 to 37.14% and 5.24 to 27.08%, respectively. Lignin contents of lowland swamp vegetation ranged from 14.84 to 43.09% (Table 3).

There are 19 species of forage found in Pampangan buffalo pasture that have potential ~~that can~~ to be used as food for Pampangan buffalo, consisting of 17 species of grasses and herbs and 2 species of legumes (Muhakka et al. 2019). ~~Species of forage swamp forage plants, there~~There are dominant and palatable species of swamp lowland forage vegetation having potential as buffalo feed, namely Kumpai padi (*O. rupifogon*), Kumpai tembaga (*H. acutigluma*), and Kumpai minyak (*H. amplexicaulis*), not dominant ~~and~~ but palatable species such as Kumpai merah (*Hymenachne* sp.) and Kemon air (*N. oleracea*); dominant ~~and~~ but non-palatable grass species (buffalo does not like it) namely Are bolong (*P. barbatum*). ~~this~~ This grass species would be eaten by the buffaloes if there were no other species to be eaten (Muhakka et al. 2019).

Discussion

Crude protein content

Results showed that the crude protein contents of swamp green ~~vegetations~~vegetation ranged from 5.26% to 20.56% with the lowest value (5.26%) was found in Berondong grass (*R. corymbosa*) and the highest (20.56%) was found in Kemon air legume (*N. oleracea*). Kasuran grass (*C. digitatus*) had the highest crude protein content (15.31%) (Table 2). This high nutritional value of Kasuran grass was suspected as caused by the fact that most of this grass was found to grow in the area of buffalo pens where the soil was rich in organic matter. However, the growth of this grass was not dominant as it mostly occurred in rainy seasons.

Kumpai minyak (*H. amplexicaulis*), Kumpai padi (*O. rupifogon*), Kumpai tembaga (*H. acutigluma*), and Purun tikus (*E. dulcis*) were found as the dominant palatable grasses containing 12.00, 10.41, 10.96, and 8.22% crude protein, respectively. Results of this study were not too different from those obtained by Rostini et al. (2014), who reported that Kumpai minyak and Pipisangan had protein contents of 10.88 and 15.92%, respectively. Crude protein (CP) contents of these swamp grasses in Pulau Layang and Rambutan Villages were closed to those of prime grasses including 9.11-12.8% CP of *elephant* grass (*P. purpureum*) (Santos et al. 2013; Dahlan and Iskandar 2013; Rahman et al. 2014), 12.4% CP of *elephant* grass hay, 11.1% CP of *elephant* grass silage, 11.4% CP of king grass hay, and 10.2% CP of king grass silage (Santoso and Hariadi 2008). Other ~~vegetations~~vegetation even had higher CP contents including Kumpai tembaga (*H. acutigluma*) with 10.96% CP, Tapak dara (*C. roseus*) 15.20%, Telepuk gajah (*N. lotus*) 13.22%, Cecengkehan (*L. hyssopifolia*) 12.07%, Kasuran (*C. digitatus*) 15.31%, and Kumpai minyak (*H. amplexicaulis*)[R] 12.0% (Table 2). CP contents of ~~vegetations~~vegetation in this study were also higher than those of natural grasses found in coffee plantation areas (6.95%) and pastoral areas (6.65%) in Wulanggitang Subdistrict, East Flores District, East Nusa Tenggara, Indonesia as reported by Kleden et al. (2015). Meanwhile, CP content of grasses in lowlands was 8.41% (Maswada and Elzaawely 2013; Rochana et al. 2016).

This high protein content was suspected to be caused by the fact that soil organic C and total N contents in the study site were also high, namely 36.14-57.66 and 2.19-3.64 $g.kg^{-1}$, respectively (Table 1). Soil organic C and total N contents affected protein content in plants. Four swamp grasses/herbs including Kasuran (*C. digitatus*), Tapak dara

Formatted: English (United States)
Formatted: English (United States)
Formatted: English (United States)
Formatted: English (United States)
Formatted: English (United States)
Formatted: English (United States)
Formatted: English (United States)
Formatted: English (United States)
Formatted: English (United States)
Formatted: English (United States)
Formatted: English (United States)
Formatted: English (United States)
Formatted: English (United States)
Formatted: English (United States)

(*C. roseus*), Telepuk gajah (*N. lotus*), and Cecengkehan (*L. hyssopifolia*) and a legume, Kemon air (*N. oleracea*) were found to be the lowland swamp ~~vegetations~~vegetation having the highest N contents of 15.31,15.20, 13.22, 12.07, and 20.56%, respectively.

Table 2. Crude protein, fiber, ether extract, and ash contents (%) of lowland swamp ~~vegetations~~vegetation

Latin name	Family	Origin (Village)	Local name	Crude protein	Fiber	Ether extract	Ash
Catharanthus roseus	Apocynaceae	Pulau Layang	Tapak dara	15.20	11.18	1.29	12.53
Cyperus digitatus	Cyperaceae	Rambutan	Kasuran	15.31	14.76	1.42	25.19
Digitaria fuscescens	Poaceae	Rambutan	Kerak Maling/Pasiran	12.00	15.64	1.24	16.26
Eichhornia crassipes	Pontederiaceae	Pulau Layang	Eceng gondok	8.61	20.66	0.84	14.22
Eleocharis dulcis-P	Cyperaceae	Pulau Layang	Purun tikus	8.22	25.72	0.48	15.13
Eleocharis dulcis-R	Cyperaceae	Rambutan	Purun tikus	6.63	24.52	1.69	10.24
Hymenachne acutigluma-P	Poaceae	Rambutan	Kumpai Tembaga	10.96	23.73	1.77	10.30
Hymenachne acutigluma-R	Poaceae	Pulau Layang	Kumpai Tembaga	6.86	30.26	2.22	7.88
Hymenachne amplexicaulis-P	Poaceae	Pulau Layang	Kumpai Minyak	9.21	21.91	2.82	13.96
Hymenachne amplexicaulis-R	Poaceae	Rambutan	Kumpai Minyak	12.00	15.64	1.24	16.26
Hymenachne sp.	Poaceae	Pulau Layang	Kumpai Merah	8.52	21.20	1.30	12.88
Ipomoea aquatica	Convolvulaceae	Pulau Layang	Kangkung merah	8.95	14.34	2.24	10.39
Leersia hexandra	Poaceae	Pulau Layang	Bento rayap	5.35	27.57	2.06	5.63
Ludwigia hyssopifolia	Onagraceae	Pulau Layang	Cecengkehan	12.07	11.01	1.66	9.09
Neptunia olerancia	Fabaceae	Pulau Layang	Kemon air	20.56	15.03	2.92	7.31
Nymphaea lotus	Nymphaeaceae	Pulau Layang	Telepuk Gajah	13.22	11.45	2.84	10.30
Oryza rupifogon-P	Poaceae	Pulau Layang	Kumpai Padi	7.93	23.30	1.60	16.25
Oryza rupifogon-R	Poaceae	Rambutan	Kumpai Padi	10.41	21.59	2.49	11.92
Polygonum barbatum	Poaceae	Pulau Layang	Are Bolong	7.53	16.60	1.57	8.40
Rhynchospora corymbosa	Cyperaceae	Pulau Layang	Berondong	5.26	22.27	1.48	14.84
Sesbania exasperata	Fabaceae	Rambutan	Mutiara	18.27	11.22	1.86	19.47

Note: P: Pulau Layang Village; R: Rambutan Village

Table 3. Composition of fiber fractions of green ~~vegetations~~vegetation in lowland swamp: NDF, ADF, hemicellulose, cellulose, and lignin (%).

Latin name	Family	Origin (Village)	NDF	ADF	Hemi-cellulose	Cellulose	Lignin
Catharanthus roseus	Apocynaceae	Pulau Layang	47.79	39.67	8.12	16.96	22.71
Cyperus digitatus	Cyperaceae	Rambutan	58.90	36.93	21.97	5.24	31.68
Digitaria fuscescens	Poaceae	Rambutan	65.43	33.56	31.87	12.11	21.45
Eichhornia crassipes	Pontederiaceae	Pulau Layang	62.77	41.83	20.94	10.22	31.60
Eleocharis dulcis-P	Cyperaceae	Pulau Layang	69.57	49.83	19.74	21.80	28.04
Eleocharis dulcis-R	Cyperaceae	Rambutan	75.73	54.91	20.82	19.71	35.20
Hymenachne acutigluma-P	Poaceae	Pulau Layang	75.89	50.60	25.29	12.25	38.34
Hymenachne acutigluma-R	Poaceae	Rambutan	64.72	46.38	18.34	16.01	30.37
Hymenachne amplexicaulis-P	Poaceae	Pulau Layang	65.31	38.92	26.39	8.29	30.63
Hymenachne amplexicaulis-R	Poaceae	Rambutan	65.32	39.45	25.87	9.75	28.67
Hymenachne sp.	Poaceae	Pulau Layang	60.14	28.40	31.74	8.64	19.76
Ipomoea aquatica	Convolvulaceae	Pulau Layang	41.40	26.17	15.23	6.32	19.85
Leersia hexandra	Poaceae	Pulau Layang	79.47	42.33	37.14	25.88	33.92
Ludwigia hyssopifolia	Onagraceae	Pulau Layang	40.64	32.91	7.73	8.39	24.52
Neptunia olerancia	Fabaceae	Pulau Layang	62.31	45.44	16.87	27.08	18.36
Nymphaea lotus	Nymphaeaceae	Pulau Layang	46.05	23.66	22.39	8.82	14.84
Oryza rupifogon-P	Poaceae	Pulau Layang	71.13	60.33	10.80	17.23	43.09
Oryza rupifogon-R	Poaceae	Rambutan	65.49	46.19	19.30	14.96	31.24
Polygonum barbatum	Poaceae	Pulau Layang	61.27	48.46	12.81	20.28	28.18
Rhynchospora corymbosa	Cyperaceae	Pulau Layang	65.29	44.64	20.65	16.08	28.56

Note: P: Pulau Layang Village; R: Rambutan Village

Fiber contents

Fiber contents of lowland swamp green ~~vegetations~~vegetation ranged from 11.01 to 30.26%, with the lowest content found in Cecengkehan (*L. hyssopifolia*) and the highest in Kumpai tembaga (*H. acutigluma* P). Four ~~vegetations~~vegetation including *Cecengkehan* (*L. hyssopifolia*), Tapak dara (*C. roseus*), Mutiara legume (*S. exasperata*), and Telepuk gajah (*N. lotus*) were found to have the lowest fiber contents of 11.01, 11.18, 11.22, and 11.45%, respectively (Table 2). These results were almost similar to those found by Ali et al. (2012) who reported that the fiber contents of roughage in a pasture ranged from 7.20 to 34.98%. These researchers found that the fiber content of Bento rayap (*Leersia hexandra*) was 27.40% which was very close to that (27.57%) of the same vegetation in this study. Meanwhile, Rostini et al. (2014) reported that the fiber contents of swamp vegetation in South Kalimantan ranged from 14.84 to 29.35% with the lowest content found in Hadangan (*Paspalum* sp.) and the highest in Dadangsit (*L. adscendens*). These figures were lower than those found by Kleden et al. (2015) who revealed that nature grasses in a coffee plantation area and pasture in Wulanggitang, East Flores contained 34.57 and 35.59% of fiber. They also found that the lowest fiber content was found in *L. peploides* and the highest in *I. rugosum*. Fiber contents reported by Kleden et al. (2015) were higher than the results reported by Ahmed et al. (2013) with a fiber content of 29.32% in *D. aegyptium* plants. A previous study showed that fermented *I. rugosum*, *H. amplexicaulis*, and *O. rufipogon* had fiber contents of 29.27, 29.57, and 33.07%, respectively (Muhakka et al. 2015).

The fiber content of Eceng gondok (*E. crassipes*) in this study (20.66%) was lower than those found by Hossain et al. (2015), Tham and Uder (2015), and Make et al. (2016). In addition, the fiber content of Eceng gondok (*E. crassipes*) in this study was lower than those of *Azolla*, another water plant, ranging from 13.19 to 16.54% (Kathirvelan et al. 2015; Anitha et al. 2016) and 9.25 to 13.25% (Ahmed et al. 2016). These fiber contents of *Azolla* equaled to those of Cecengkehan (*L. hyssopifolia*) (11.01%), Tapak dara (*C. roseus*) (11.18%), Mutiara legume (*S. exasperata*) (11.22%), Telepuk gajah (*N. lotus*) 11.45%, and Kangkung merah (*I. aquatica*) (14.34%) found in this study. Fiber contents of swamp green vegetation found in this study indicated that they were potential to be used as feed for Pampangan buffaloes.

Ether extract contents

Lowland swamp ~~vegetations~~vegetation in this study ~~were~~ was found to have ether extract (EE) contents of about 0.48-2.92%. The lowest EE content was found in Purun tikus (*E. dulcis*) while the highest was found in Kemon air legume (*N. oleracea*). Four ~~vegetations~~vegetation of lowland swamp including Telepuk gajah (*N. lotus*) (2.84% EE), Kumpai minyak (*H. amplexicaulis*) (2.82% EE), Kumpai padi (*O. rufipogon*) (2.49% EE), and Kangkung merah (*I. aquatica* Forsk) (2.24% EE) were revealed to have the highest ether extract contents (Table 2). Results of this study were lower than those found by Rostini et al. (2014), reporting about 0.61-3.67% of EE contents in swamp ~~vegetations~~vegetation in South Kalimantan with the lowest found in Pipisangan (*L. hyssopifolia*) and the highest in Padi hiang (*O. rufipogon spontanea*). EE contents of lowland swamp ~~vegetations~~vegetation were 1.40-1.91% for grasses and 1.36-2.95% for legumes (Asep et al. 2012) and those of grasses in a pasture for buffaloes in Pulau Moa were 1.95-2,41% (Eoh 2014). In other studies, grasses in a natural pasture in North *Lore*, Poso District had EE contents of 2.12-2.34% (Damry 2009) and those in Sabana Timur Barat pasture in the rainy season to the end of dry season had an average EE content of 1.91% (Manu 2013). A study by Se'u et al. (2015) revealed an EE content of 1.07% in grasses in a pasture in Timor Tengah Selatan District. Another work by Kleden et al. (2015) showed that ~~vegetations~~vegetation in a natural pasture and a coffee plantation area had EE contents of 1.23 and 1.35%, respectively.

~~Vegetations~~Vegetation found in this study had EE contents equaled to those of prime grasses including *elephant* grass (*P. purpureum*) and *king* grass (*P. purpureophoides*) preserved in the form of hay and silage. *Elephant* grass hay and silage had EE contents of 1.9 and 2.6%, respectively, while those of king grass had EE contents of 1.6 and 2.4%, respectively (Santoso and Hariadi 2008; Ukpabi et al. 2015). EE contents of some species of ruminant roughages were found to be about 1.2-4.1% (Ahmed et al. 2013). Dominant swamp roughages including Kumpai minyak (*H. amplexicaulis*) and Kumpai padi (*O. rufipogon*) had EE contents of 2.82 and 2.49%, respectively and they were palatable and potential to be used as feed for Pampangan buffaloes.

Formatted: English (United States)

Ash contents

Ash contents of green ~~vegetations~~vegetation in lowland swamp ranged from 5.63 to 25.19%. Four types of ~~vegetations~~vegetation with the highest ash contents included Kasuran (*C. digitatus*) (25.19%), Mutiara legume (*S. exasperata*) (19.47%), Kumpai minyak (*H. amplexicaulis*) (16.26%), and Kumpai padi (*O. rufipogon* [P]) (16.25%). Meanwhile, Bento rayap (*L. hexandra*) was found to have the lowest ash content of 5.63% (Table 2). Ash contents of ~~vegetations~~vegetation found in this study were higher than those of swamp ~~vegetations~~vegetation in South Kalimantan of 2.18-3.28% during the high tidal season and 3.23-9.83% during the low tidal season (Rostini et al. 2014). *Elephant* grass (*P. purpureum*) was indicated to have varied ash contents of 4.4% (Dahlan and Iskandar 2013), 0.95-1.1% (Ukpabi et al. 2015), 9.59% (Nuhuyanan 2010), and 18% (Araica et al. 2009). Meanwhile, the ash content of grasses in lowland areas ranged from 6.32 to 8.91% (Richmond et al. 2015; Mako et al. 2016; Norman et al. 2013; Maswada et al. 2013). Alam et al. (2015) found that *B. mutica* had an ash content of 4.20-4.89% and rice straw had 6.63%.

Roughages were found to have average ash contents of 7.28% in a pasture for buffaloes in Pulau Moa (Eoh 2014), 9.82-10.14% in Lore Utara, Poso District (Damry 2009), 11.51% in a pasture during the rainy season until the end of dry season in Sabana Timur Barat (Manu 2013), and 8.11 and 8.22% in a natural pasture and a coffee plantation area, respectively (Kleden et al. 2015). Differences in these ash contents were suspected to be caused by differences in plant species (internal factor) and environmental differences, particularly seasonal differences (external factor). In a dry season, pH levels in lowland swamp areas were found to be 3.9-4.8, causing a decreased supply of nutrients, especially total N and K, to the soil. This decreased supply of nutrients led to lowered nutrients contained in plants (Rostini et al. 2014). This was in line with what was stated by Gutteridge and Shelton (1994) that nutrient content in plants was affected by soil nutrient content. In addition, in acidic soil conditions, activities of Fe, Al, and Mn increased which might cause toxicity in plants (Tjondronegoro and Gunawan 2000).

NDF and ADF contents

Neutral Detergent Fiber (NDF) depicts plant cell walls consisting of hemicellulose, cellulose, and lignin. NDF is part of fiber which is not dissolved in neutral detergent representing the component of fiber ~~undissolved~~ not dissolving in plant cell wall materials. NDF content of a feed affects the ability of ~~ruminant animals~~ruminants to consume the feed. Acid Detergent Fiber (ADF) represents parts of the plant cell wall bond to cellulose and lignin. ADF content is related to energy content and higher ADF content results in lowered digestible energy content (Van Soest 1982).

The NDF and ADF contents of ~~vegetations~~vegetation found in this study were about 40.65-79.47% and 23.66-60.33%, respectively. Lowest NDF contents were found in Cecengkehan (*L. hyssopifolia*) (40.65%), Kangkung merah (*I. aquatica*) (41.40%), Telepuk gajah (*N. lotus*) (46.05%), and Tapak dara (*C. roseus*) (47.79%). In contrast, highest NDF content of 79.47% was found in Bento rayap (*L. hexandra*). Lowest ADF contents were found in Telepuk gajah (*N. lotus*) (46.05%), Kangkung merah (*I. aquatica*) (26.17%), Kumpai merah (*Hymenachne* sp.) (28.40%), Cecengkehan (*L. hyssopifolia*) (32.91%). Meanwhile, the highest ADF content of 60.33% was found in Kumpai padi (*O. rufipogon* P) (Table 3). NDF and ADF contents of ~~vegetations~~vegetation found in this study were lower than those of Asep et al. (2012) who reported that the NDF contents of swamp green ~~vegetations~~vegetation in a pasture for buffaloes were about 91.73-93.45% in grasses and 68.11-90.93% in legumes and the ADF content of grasses was 51.6-86.8%. It was shown in other studies that NDF and ADF contents of roughages in a pasture during the rainy season to the end of the dry season in Sabana Timur Barat were on average 65.9 and 43.29%, respectively (Manu 2013). ~~Vegetations~~Vegetation in a natural pasture and a coffee plantation area had NDF contents of 74.89 and 72.37% and ADF contents of 57.22 and 55.15%, respectively (Kleden et al. 2015). Meanwhile, swamp ~~vegetations~~vegetation in South Kalimantan had average NDF and ADF contents of 55.97 and 37.87%, respectively, during the high tidal season and 81.44 and 60.86% respectively, during the low tidal season (Rostini et al. 2014).

NDF and ADF contents of roughages in the BPTU-HPT Padang Mengatas area were found to be 75.62 and 45.96%, respectively in the rain season and 69.35 and 38.66%, respectively in the dry season (Muhajirin et al. 2017). NDF and ADF contents of Eceng gondok (*E. crassipes* in this study were 62.77 and 41.83%, respectively. These figures were close to those of *water hyacinth* (*E.crassipes*) plants studied by Tham (2015) with NDF and ADF contents of 63.9 and 34.68% and by Tham and Uden (2015) with NDF and ADF contents of 52.1 and 30.7%, respectively. Other studies conducted by Ahmed et al. (2016), Anitha et al. (2016), and Nampoothiri (2017) showed that *Azolla* sp. had NDF and ADF contents of 53.8-54.85% and 36.57-37.0%, respectively. Meanwhile, NDF and ADF contents of *elephant* grass (*P. purpureum*) were found to be 55.8 and 46.5% (Dahlan and Iskandar 2013) and 84.25 and 64.07% (Nuhuyanan 2010), respectively. These figures equaled to the NDF and ADF contents of Kumpai tembaga (64.72 and 46.38%), Kumpai minyak (65.31 and 38.92), and Are bolong (61.27 and 48.46%). This indicated that lowland swamp ~~vegetations~~vegetation had fiber fraction nutritional quality which was not less than that of prime grasses including *elephant* grass and *king* grass.

In this study, NDF and ADF contents of lowland swamp ~~vegetations~~vegetation were 40.65-79.47% and 23.66%-60.33%, respectively. These figures were still within the ranges of NDF and ADF contents of prime grasses such as *elephant* grass (*P. purpureum*), which had NDF and ADF contents of 55.8 and 46.5% (Dahlan and Iskandar 2013) and 84.25 and 64.07% (Nuhuyanan 2010), respectively. In the rumen, NDF degradation is higher than that of ADF as NDF contains hemicellulose fraction which is more soluble (Church and Pond 1986). NDF content has a negative correlation with its degradation rate (Varga et al. 1983) and higher NDF content decreases dry matter digestibility of feed (NRC 1988). Cellulose is an ADF component that is easy to digest while lignin is hard to digest as it contains double bonds. Higher lignin content decreases feed digestibility (Sutardi et al. 1980).

Hemicellulose and cellulose contents

Lowland swamp ~~vegetations~~vegetation ~~were~~ was found to have hemicellulose and cellulose contents ranging from 7.73 to 37.14% and 5.24 to 27.08%, respectively. Four green ~~vegetations~~vegetation with the highest hemicellulose contents were Bento rayap (*L. hexandra*) (37.14%), Kerak maling (*D. fuscescens*) (31.87%), Kumpai merah (*Hymenachne* sp.) (31.74%), and Kumpai minyak (*H. amplexicaulis*) (26.39%). In contrast, the lowest hemicellulose content was found in Cecengkehan (*L. hyssopifolia*) (7.73%). Highest cellulose contents were found in Kemon air (*N. oleracea*) (27.08%), Bento rayap (*L. hexandra*) (25.88%), Purun tikus (*E. dulcis*) (21.80%), and Are bolong (*P. barbatum*) (20.28%). Meanwhile, Kasuran (*C.digitatus*) had the lowest cellulose content of 5.24% (Table 3). Results of this study were in line with those of a study conducted by Asep et al. (2012) who reported the hemicellulose and cellulose contents of lowland swamp green ~~vegetations~~vegetation ranging from 7.89 to 31.55% and 30.85 to 63.35%, respectively. They also found that Kumpai padi (*O.rufipogon*) had 31.55% hemicellulose content which was higher than those of Kumpai padi (10.80-19.30%) ~~found~~ in this study (Table 4). Swamp ~~vegetations~~vegetation in South Kalimantan had hemicellulose contents of 0.65-25.85% in high tidal season and 5.37-40.09% in low tidal season. Cellulose contents in high and low tidal seasons were about 20.07-34.03% and 7.90-38.31%, respectively (Rostini et al. 2014). Various water plants including Azolla, which was used as animal feed, had hemicellulose and cellulose contents of 10.20 and

Formatted: English (United States)

Formatted: English (United States)

12.76% (Nampoothiri 2017), 1.15-10.20% and 12.76% (Nampoothiri 2017), respectively. Roughages in BPTU-HPT Padang Mengatas had hemicellulose and cellulose contents of 29.79 and 33.62% in the rain season and 30.69 and 31.64% in the dry season, respectively (Muhajirin et al. 2017). *Elephant* grass (*P. purpureum*) was found to contain 21.18% hemicellulose and 43.32% cellulose (Nuhuyanan 2010) and 35.3% cellulose (Dahlan and Iskandar 2013). In a study conducted by Archimede et al. (2010), hay was found to have 37.7% hemicellulose and 35.7% cellulose. Based on the above findings, it was suggested that hemicellulose (7.73-37.14%) and cellulose (5.24-27.08%) contents of lowland swamp ~~vegetations~~vegetation in this study were within normal ranges and ~~these~~ this ~~vegetations~~vegetation ~~were~~ was potential to be used as feed for Pampangan buffaloes.

Lignin contents

Lignin contents of lowland swamp vegetation ranged from 14.84 to 43.09%. Four ~~vegetations~~vegetation including Telepuk gajah (*N. lotus*), Kemon air (*N. oleracea*), Kumpai merah (*Hymenachne* sp.), and Kangkung merah (*I. aquatica*) were found to have the lowest lignin contents of 14.84, 18.36, 19.76, and 19.85%, respectively, while the highest lignin content of 43.09% was found in Kumpai padi (*O. rufipogon* P) (Table 3). Lignin contents in this study were higher than that obtained by Rostini et al. (2014) who reported the lignin contents of swamp ~~vegetations~~vegetation in South Kalimantan were about 2.8-17.59% in high tidal season with that of Kumpai minyak as the lowest and that of *Beberasan* as the highest and 10.06-61.12% in low tidal season with that of *Beberasan* as the lowest and that of Kumpai minyak as the highest. Lignin contents of Kumpai padi (*O. rufipogon* R) (31.24%) and Kumpai padi (*O. rufipogon* P) (43.09%), Bento rayap (*L. hexandra*) (33.92%), and Eceng gondok (*E. crassipes*) (31.60%) (Table 3) found in this study were higher those of Kumpai padi (18.27%) and Bento rayap (*L. hexandra*) (17.96%) found by Asep et al. (2012) and Eceng gondok (*E. crassipes*) (8.17%) found by Tham (2015). In other studies, *Azolla* was found to have lignin contents of 5.7% (Ahmed et al. 2016) and 28.24% (Nampoothiri 2017). Meanwhile, lignin contents of *elephant* grass were found to be 15.37% (Nuhuyanan 2010) and 11.2% (Dahlan and Iskandar 2013).

Differences in lignin contents in green vegetation are suspected to be caused by differences in plant species, plant ages, and environmental factors including seasons (rain or dry season), tidal seasons, and fertility levels of the soil where the ~~vegetations~~vegetation grow. In cell walls, cellulose is a bond with hemicellulose and lignin. The animals cannot digest lignin and its molecular structure is different from other carbohydrates as it contains carbon and nitrogen of only 1-5%. Hemicellulose consists of pentose, hexose, uronic acid, and pectin substance. Pectin is a carbohydrate that is composed of uronic acid, galactose, arabinose, xylose, and methanol. Cellulose is degradable by microorganisms and functions as the source of volatile fatty acids. Young grasses (roughages) contain less than 5% lignin and 80% of their cellulose is degradable. On the contrary, in old roughages, lignin content may reach up to 10% causing a decrease in cellulose digestibility by up to 50% (Prawirokusumo 1994).

Based on the results of the study, it was concluded that: (i) the highest protein (20.56%) and crude fat (2.92%) contents were found in Kemon air (*Neptunia oleracea*). The highest ash content (25.19%) was found in Kasuran (*C. digitatus*), while the lowest (11.01%) was found in Cecengkehan (*L. hyssopifolia*). The lowest NDF content (40.64%) was found in Cecengkehan (*L. hyssopifolia*) and the highest hemicellulose content (37.14%) was found in Bento rayap. Telepuk gajah had the lowest ADF (23.66%) and lignin (14,84%) contents. Kemon air contained the highest cellulose level of 27.08%. (ii) The best nutritional values were found in Kasuran (*C. digitatus*) and Cecengkehan (*L. hyssopifolia*), (iii) Dominant and palatable swamp roughages with good nutrient contents included Kumpai tembaga (*H. acutigluma*), Kumpai minyak (*H. amplexicaulis*), Kumpai padi (*O. rufipogon*), Are bolong (*P. barbatum*), and Purun tikus (*E. dulcis*).

ACKNOWLEDGMENTS

The author expresses his deepest gratitude to the Rector of Sriwijaya University through the Chair of the Institute for Research and Community Services funding this research in accordance with the Competitive Leading Research Contract of Sriwijaya University Number: 988 / UN9.3.1 / PP / 2017, dated 21 July 2017.

REFERENCES

Ahmed HA, Ganai A.M, Beigh YA, Sheikh GG, Reshi PA. 2016. Performance of growing sheep on *Azolla* based diets. Indian J. Anim. Res. 50 (5): 721-724.

Alam MR, Haque MM, Sumi KR, Ali MM. 2015. Proximate composition of para-grass (*Brachiaria mutica*) produced in integrated fish-fodder culture system. Bang. J. Anim. Sci. 44 (2): 113-119.

Ali AIM, Sandi S, Muhakka, Riswandi. 2012. Kualitas hijauan pakan di rawa lebak padang penggembalaan kerbau pampangan. Proc. InSINAS 2012. 307-312.

Anitha KC, Rajeshwari YB, Prasanna SB, Shree JS. 2016. Nutritive evaluation of Azolla as livestock. J. of Experim. Bio. and Agric. Sci. 4(6): 670-674.

AOAC (Association of Official Analytical Chemists). 1990. Official Methods of Analysis. 15th ed., Washington, DC.

Araica BM, Sporndly E, Sanchez NR, Norell L, Sporndly R. 2009. Silage quality when Moringa oleifera is ensiled in mixtures with elephant grass, sugar cane and molasses. Gra. and For. Sci. 64: 364-373.

Archimede H, Gonzales-Garcia E, Despois P, Etienne T, Alexandre G. 2010. Substitution of corn and soybean with green banana fruits and Gliricidia sepium forage in sheep fed hay-based diets: effects on intake, digestion and growth. J. of Anim. Physiol. and Anim Nutr 94 (2010): 118-128.

BPS (Badan Pusat Statistik) Provinsi Sumatera Selatan. 2014. Sumatera Selatan dalam Angka 2014.

BPS (Badan Pusat Statistik). 2010. Direktorat Jendral Tanaman Pangan. *Luas lahan rawa di Indonesia*. Departemen Pertanian. Jakarta.

Brazle FK, Kilgore GI, Fauzett MR. 2000. Effect of season on grazing native-grass pastures. The Prof. Anim. Sci. 16: 15-28.

Church DC, Pond WG. 1986. Digestive Animal Physiology and Nutrition. 2nd. Prentice Hell a Division of Simon and Schuster Englewood Clief, New York.

Dahlan I, Iskandar MNZ. 2013. Use of plantain peels (Musa paradisiaca) as a fibrous feed substitute for napier grass (Pennisetum purpureum) in rusa deer (Cervus timorensis ratio under captivity. J. Anim. Sci. 3 (9): 472-480.

Damry. 2009. Produksi dan kandungan nutrisi hijauan padang penggembalaan alam di Kecamatan Lore Utara Kabupaten Poso. J. Agrol. 16 (4): 296-300.

Eoh M. 2014. Kapasitas tampung dan komposisi zat-zat makanan padang penggembalaan ternak kerabau di Pulau Moa. Agrinimal. 4 (2): 77-82.

Gutteridge RC, Shelton HM. 1994. The Role of Forage Tree Legumes in Cropping and Grazing System. The Trop. Grassl Soc. of Aust. Inc.

Hossain MdE, Sikder H, Kabir MdH, Sarma SM. 2015. Nutritive value of water hyacinth (*Eichhornia crassipes*). Online J. of Anim. and Feed Res. 5 (2): 40-44.

Kathirvelan C, Banupriya S, Purushothaman MR. 2015. Azolla-an alternate and sustainable feed for livestock. Internat. J. of Sci. Environ. 4 (4): 1153-1157.

Kleden MM, Ratu MRD, Randu MDS. 2015. Kapasitas tampung hijauan pakan dalam areal perkebunan kopi dan padang rumput alam di Kabupaten Flores Timur Nusa Tenggara Timur. J. Zootek 35 (2): 340-350.

Mako AA, Akinwande VO, Anurudu NF, Ogunwole OA. 2016. Evaluation of nutritive value of water hyacinth (*Eichhornia crassipes*) and guinea grass (*Panicum maximum*) mixture as animal feed in the tropics. 2016. Bull. Anim. Hith. Prod. Afr. (64): 463-473.

Manu AE. 2013. Produktivitas padang penggembalaan sabana Timor Barat. J. Pastura. 3 (1): 25-29.

Maswada HF, Elzaawely AA. 2013. Nutritive value of Stipagrostis lanata (Forssk.) de winder as a feed for livestock. Asian J. of Crop Sci. 5 (2): 216-221.

Muhajirin, Despal, Khalil. 2017. Pemenuhan kebutuhan nutrien sapi potong bibit yang digembalakan di Padang Mengatas. Buletin Makanan Ternak.104 (1): 9-20.

Muhakka, Suwignyo RA, Budianta D dan Yakup. 2019. Vegetation analysis of no-tidal swampland in South Sumatra, Indonesia and its carrying capacity for Pampangan buffalo pasture. J. Biodiv. 20 (4): 1077-1086.

Muhakka, Wijaya A, Ammar M. 2015. Nutritional dried matter, crude protein and crude fiber on lowland tidal grass fermented by probiotic microorganisms for use Bali cattle feed. J. Anim. Prod. 17 (1): 24-29.

Mulyani A, Sarwani M. 2013. Karakteristik dan potensi lahan sub optimal untuk pengembangan pertanian di Indonesia. J. Sumber daya Lahan. 7 (1): 47-55.

Nampoothiri VM. 2017. Aquatic plants and marine waste as animal feed. Sch.J. Agric.Vet. Sci. 4 (6): 249-254.

Norman HC, Master DG, Barrentt-Lennard EG. 2013. Halophytes as forage in saline landscapes: Interaction between plant genotype and environment change their feeding value to ruminants. Environ. and Exp. Bot. 92 (2013): 96-109.

NRC. 1988. Nutrition Requirement of Beef Cattle. 6th. Rev. Ed. National.

Nuhuyanan LE. 2010. Pengaruh pemberian wafer rumput gajah dengan perekat fermented moter liquor (FML) dan tetes (molasses) terhadap konsumsi pakan, kecernaan zat-zat makanan dan kenaikan berat badan sapi bali jantan. J. Ilmu Peternakan. 5 (2): 111-117.

Prawirokusumo S. 1994. Ilmu Gizi Komperatif. BPFE., Yogyakarta.

Rahman MM, Abdullah RB, Wan Khadijah WE, Nakagawa T, Akashi R. 2014. Feed intake and growth performance of goats offered Napier grass (*Pennisetum purpureum*) supplemented with concentrate pellet and soya waste. Sain Malaysiana. 43 (7): 967-971.

Richmond AS, Wylie ARG, Laidlaw AS, Lively FO. 2015. Methane emissions from beef cattle grazing on semi-natural upland and improved lowland grasslands. Anim. 9 (1): 130-137.

Rostini T, Abdullah L, Wiryawan KG, Karti PDMH. (2014). Production and nutrition potency of swamp local forage in South Kalimantan as ruminant feed. Glob. J. Anim. Sci. Livestock Prod. Anim. Breed. 2 (2):107-113.

Santoso dan Hariadi BTj. 2008. Komposisi kimia, degradasi nutrien dan produksi gas metana in vitro rumput tropika yang diawetkan dengan metode silase dan hay. J. Media Peternakan 31(2): 128-137.

Se'u VE, Karti PDMH, Abdullah L. 2015. Botanical composition, grass production, and carrying capacity of pasture in Timor Tengah Selatan District. J. Media Peternakan 38(3):176-182.

Statistik Peternakan Sumatera Selatan. 2014. Dinas Peternakan Provinsi Sumatera Selatan Tahun Anggaran 2015.hal:14.

Sutardi T, Pratiwi SH, Adnan A, Nuraini S. 1980. Peningkatan pemanfaatan jerami padi melalui hidrolisa basa, suplementasi urea dan belarang. Bull. Makanan Ternak. 6 Bogor.

Tham HoT, Uden P. 2015. Effect of freshwater Hyacinth (Eichhornia crassipes) on intake and digestibility in cattle fed rice straw and molasses-urea cake. Nova J. of Engineer. and Appl. Sci. 4(1): 1-8.

Tham HoT. 2015. Utilisation of water hyacinth as animal feed. Nova J. of Engineer. Appl.Sci. 4 (1): 1-6.

Tjondronegoro AD, Gunawan A. 2000. Beberapa jenis gulma di lahan pasang surut pada tingkat kemasaman tanah yang berbeda. Pros. Seminar Nasional. P. 247-254.

Van Soest PJ. 1982. Nutritional Ecology of the Ruminant: Ruminant Metabolism, Nutritional Strategies the Cellulolytic Fermentation and the Camisthy of Forages and Palm Fiber. Cornell University O & B Books Inc. USA.

Varga GA, Hoover WH. 1983. Rate and extent of NDF of feedstuff in-situ. J. Dairy. Sci. 66:2109.

7. Bukti konfirmasi artikel accepted
(8 Februari 2020)

Notifications

[biodiv] Editor Decision

2020-02-08 07:27 AM

MUHAKKA, RUJITO AGUS SUWIGNYO, DEDIK BUDIANTA, YAKUP:

We have reached a decision regarding your submission to Biodiversitas Journal of Biological Diversity, "Nutritional values of swamp grasses as feed for Pampangan Buffaloes in South Sumatra, Indonesia ".

Our decision is to: Accept Submission

Smujo Editors
editors@smujo.id

Biodiversitas Journal of Biological Diversity

BIODIVERSITAS
Volume 21, Number 3, February 2020
Pages: 953-961

ISSN: 1412-033X
E-ISSN: 2085-4722
DOI: 10.13057/biodiv/d210314

Nutritional values of swamp grasses as feed for Pampangan Buffaloes in South Sumatra, Indonesia

MUHAKKA[1,♥], RUJITO AGUS SUWIGNYO[2], DEDIK BUDIANTA[3], YAKUP[2]

[1]Department of Animal Husbandry, Faculty of Agriculture, Universitas Sriwijaya. Jl. Palembang-Prabumulih Km 32, Inderalaya, Ogan Ilir 30662, South Sumatra, Indonesia. Tel./fax.: +62-711-581106. ♥email: muhakka@fp.unsri.ac.id

[2]Department of Agronomy, Faculty of Agriculture, Universitas Sriwijaya. Jl. Palembang-Prabumulih Km 32, Inderalaya, Ogan Ilir 30662, South Sumatra, Indonesia

[3]Department of Soil Science, Faculty of Agriculture, Universitas Sriwijaya. Jl. Palembang-Prabumulih Km 32, Inderalaya, Ogan Ilir 30662, South Sumatra, Indonesia

Manuscript received: 17 October 2019. Revision accepted: 8 February 2020.

Abstract. *Muhakka, Suwignyo RA, Budianta D, Yakup. 2020. Nutritional values of swamp grasses as feed for Pampangan Buffaloes in South Sumatra, Indonesia. Biodiversitas 21: 953-961.* This study was aimed at determining the types and quality of vegetation in the swamp area, which could be used as sources of roughage for Pampangan buffaloes in South Sumatra. In this descriptive study, Results showed that the highest crude protein and ether extract contents, 20.56 and 2.92%, respectively, were found in (*Neptunia oleracea*). The highest ash content of 25.19% was found in *Cyperus digitatus*. The lowest fiber content (11.01%) was found in *Ludwigia hyssopifolia*, which also had the lowest content of Neutral Detergent Fiber (NDF) (40.64%). Hemicellulose content was found to be highest (37.14%) in *Leersia hexandra*. The lowest ADF (23.66%) and lignin (14,84%) contents were found in *Nymphaea lotus. N. oleracea* was found to have the lowest content (27.08%) of cellulose. It was concluded that the swamp vegetation found in this study consisted of 17 species of grasses and herbs (89.47%) and two species of legumes (10.53%). *C. digitatus* and *L. hyssopifolia* were found to have the best nutritional values. Dominant and palatable vegetation with good nutritional values, which were potential to be used as sources of roughage for *Pampangan* buffaloes, were *Hymenachne acutigluma*, *Oryza rufipogon*, *Hymenachne amplexicaulis*, *Polygonum barbatum*, and *Eleocharis dulcis.*

Keywords: Feed, nutritional value, Pampangan buffalo, swamp grass

INTRODUCTION

The availability of roughage as the main feed for ruminants depends considerably on seasons. During the rainy season, it is abundant, but during the dry season, the availability of grasses/herbs and legumes is lacking. The limited supply of roughage may hamper productivity including the reproductive performance of ruminants including buffaloes.

In South Sumatra, Pampangan buffalo is potential germplasm that needs to be preserved and developed. There were 37,405 Pampangan buffaloes in 2016, and this population increased by 3.97% to 38,952 in 2017. In 2017, of this population, 11,150 (28.63%) and 2,227 (5.72%) were found in Ogan Komering Ilir District and Banyuasin District, respectively (Dinas Peternakan Sumatera Selatan 2014). The population and productivity of *Pampangan* buffaloes need to be improved, and for this purpose, feed is an important factor to consider. Pampangan buffaloes feed mostly on roughage from the swamp, grassland to meet their upkeeping and reproductive needs.

In Indonesia, there are 13.27 million hectares of lowland swamp areas. Only 4 million hectares of these areas have been developed and cultivated by the community and private sectors (2.6 million hectares) and the government assistance (1.3 million hectares) (BPS 2010; Mulyani and Sarwani 2013). In Sumatra, the largest lowland swamp area of 2.98 million hectares is found in South Sumatra, but only 298,189 hectares of it have been utilized (BPS 2014). In order to utilize the potential swamp area as a feed source for Pampangan buffaloes, a study on vegetation as sources of roughage in lowland swamp areas that include vegetation identification and nutritional quality determination needs to be conducted.

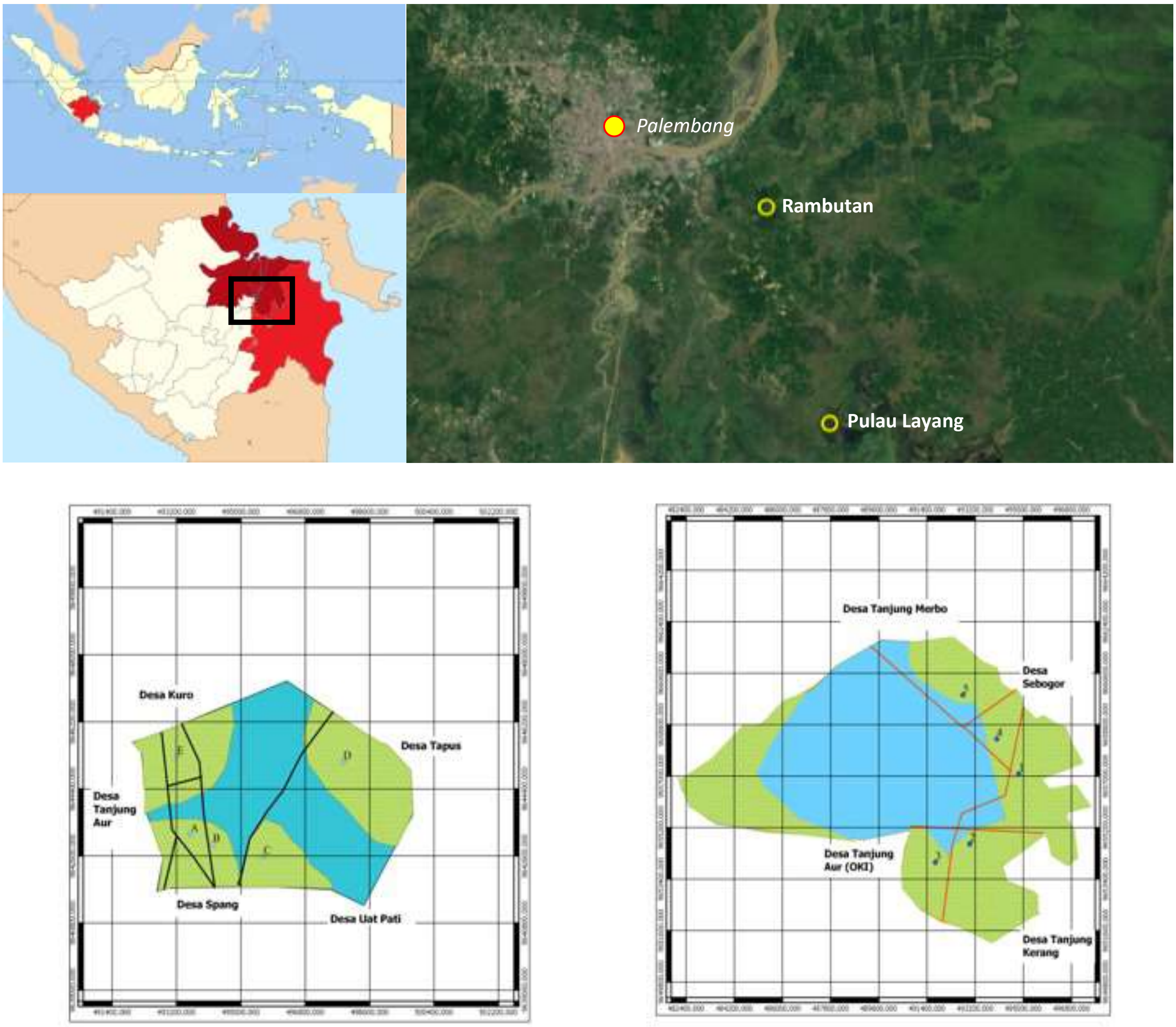
In the previous study, some swamp grasses, including *H. amplexicaulis (*Rostini et al. 2014**;** Muhakka et al. 2015), *I. rugosum* and *L. hexandra* (Ali et al. 2012) were identified. However, more swamp vegetation has not been identified. For example, *P. barbatum*, *C. digitatus*, *R. corymbosa* This study was conducted to identify the types and nutritional values of vegetation that could be used as sources of roughage feed for Pampangan buffaloes in South Sumatra. This information was important to support the productivity improvement of Pampangan buffaloes as germplasm in South Sumatra, Indonesia. In this study, some new swamp forages were found, and they were not stated in the previous study.

MATERIALS AND METHODS

Area study

This study was a descriptive study to assess the types and nutritional values of vegetation, which were dominant and palatable as sources of roughage feed for Pampangan buffaloes. Vegetation samples were taken from grazing areas of Pampangan buffaloes in Rambutan Village and Pulau Layang Village, South Sumatra, Indonesia (Figure 1) from April to Juni 2017. Vegetation samples for nutrient analysis were obtained by following procedures: (i) vegetation collection was done based on estimated growth age (young age, middle age, and old age based on physical appearance), (ii) collected samples of each vegetation was composited, and (iii) samples were chopped into small sizes, and then homogenized.

For each vegetation, 1 kg sample was taken randomly and sent to the laboratory for oven drying at 105ºC, until a constant weight was obtained and dry matter content was determined. Samples were then ground for nutrient content determination by using proximate and Van Soest analyses (Syarifuddin and Wahdi 2010). Sample analyses of crude protein, fiber, ether extract, and ash contents were conducted in Laboratory of Dairy Nutrition, Department of Nutrition and Feed Technology, Institut Pertanian Bogor (IPB), Bogor, Indonesia, while analyses of NDF, ADF, hemicellulose, cellulose, and lignin were conducted in Biotechnology Assessment Laboratory, Research Center for Biotechnology, Indonesian Institute of Sciences (LIPI), Cibinong, Bogor, Indonesia; and analysis of soil was conducted in Laboratory of Soil Chemistry, Biology, and Fertility, Department of Soil, Faculty of Agriculture, Sriwijaya University, Ogan Ilir, Indonesia.



A B

Figure 1. Research location in South Sumatra, Indonesia. A. Pulau Layang Village, Pampangan Sub-district, Ogan Komering Ilir District, South Sumatra. B. Rambutan Village, Rambutan Sub-district, Banyuasin District, South Sumatra, Indonesia (Muhakka et al. 2019)

Measured parameters

Soil analysis

Soil sampling is done in a composite manner at a depth of 0-20 cm. Taking the soil sample points is done by making a diagonal line in each zone and determining 5 soil sampling points to analyze chemical fertility (N, P, K) and physical fertility (texture, structure, and pH).

Plant materials

The sampling area is divided into five zones (A, B, C, D and E) and each zone consists of 10 observation points. Samples of each type of dominant and palatable forage vegetation are collected based on the estimated age of growth, namely young age, middle age, and old age by looking at their physical appearance. Samples of each type of vegetation that have been collected, are put together until homogeneous. Samples are finely chopped, mixed until homogeneous then randomly taken as much as 1 kg.

There are some species that are analyzed twice, in Pulau Layang and Rambutan because they appear in both areas, while the others are only analyzed once because they only appear in one area. For *Sesbania exasperata*, it is enough to know only its nutrient content from analysis of proximate, and the production of this grass is measly so that its potential to be buffalo's feed is measly as well, but it can be made as feed supplement. So, it is not analyzed for composition of fiber fractions (Table 3).

Proximate analysis

Crude protein, fiber, ether extract, and ash contents were determined based on the procedures of AOAC (1990). *Crude protein*. Nitrogen (N) content was determined by using a Kjeldahl method. In this analysis, sulphuric acid was treated with a catalyst and a heating process. The organic matter of samples was then oxidized by sulfuric acid, and nitrogen was changed into an ammonium sulfate form. The remaining sulfuric acid was neutralized by NaOH until the solution became basic. Ammonium sulfate was then distilled in an acid medium to obtain the quantitative amount of N. As the average protein contains 16% nitrogen, a factor 100%: 16% = 6.25 was used to obtain the value of crude protein (crude protein = N% x 6.25). *Fiber.* The filtered fat-free sample was used in fiber content determination. 1.25% sulfuric acid solution was added into the sample, and the mixture was heated for about 30 minutes before the residue was filtered. 1.25% NaOH solution was added into the precipitate, and the mixture was heated for about 30 minutes. The mixture was then filtered, and the precipitate was washed, dried, and weighed. This precipitate was burnt, and the ash was weighed. The difference between the weight of precipitate before it was burnt and the weight of the ash was referred to as fiber content. *Ether extract*. The dry matter sample was extracted with diethyl ether for 5 hours. At the end of the extraction process, ether evaporated and the remaining material was referred to as fat. *Ash*. The third part of the dry matter sample was weighed and burnt in a crucible at 550ºC for 8 hours.

Van Soest analysis

Neutral Detergent Fiber (NDF), Acid Detergent Fiber (ADF), hemicellulose, cellulose, and lignin contents were determined by using a Van Soest method (1982).

Neutral Detergent Fiber (NDF). One gram of sample was put in a beaker glass. 50 ml NDS solution was added into the beaker before the mixture was heated for an hour. The mixture was then filtered by using a vacuum pump and a filter glass which was previously weighed (b gram). The mixture was then washed with hot water and acetone before it was dried in an oven and let cool in a desiccator. Finally, it was weighed as c gram. NDF content was calculated by using the following formula:

$$\% \text{ NDF} = \frac{c-b}{a} \times 100\%$$

Acid Detergent Fiber (ADF). One gram of sample was put in a beaker glass. 50 ml ADS solution was added into the beaker before the mixture was heated for an hour. The mixture was then filtered by using a vacuum pump and a sintered glass filter which was previously weighed (b gram). The mixture was then washed with hot water and acetone before it was dried in an oven and let cool in a desiccator. Finally, it was weighed as c gram. Cellulose content was calculated by using the following formula:

$$\% \text{ cellulose} = \frac{c-d}{a} \times 100\%$$

Hemicellulose. Hemicellulose content was calculated as a difference between NDF and ADF contents as follows.

$$\% \text{ Hemicellulose} = \% \text{ NDF} - \% \text{ ADF}$$

Lignin. Cellulose residue (d gram) was burnt in a furnace at 500-600ºC for 3 hours. After that, it was left to cool and weighed (e gram). Lignin content was calculated by using the following formula:

$$\% \text{ Lignin} = \frac{d-e}{a} \times 100\%$$

Data analysis

The data obtained were used directly to describe the nutritional value of the swamp vegetation that could be used as a roughage source. These data were then combined with those of in vitro digestibility as the basis for concluding (Syarifuddin and Wahdi 2010).

RESULTS AND DISCUSSION

Soil analysis

Results of soil analysis showed that soil at the study site had a low fertility level and was highly acidic. It also had very high organic C and total N contents, medium level of exchangeable-K and N contents, very low Ca and Mg contents, medium P content, and very high CEC level (Table 1).

Table 1. Properties of soil at the study site

Parameter	Pulau Layang		Rambutan	
	Value	Remark	Value	Remark
pH H_2O (1 : 1)	5.10	Low	4.41	Very low
pH KCl (1 : 1)	4.39	Very acidic	3.99	Very acidic
Organic C (g/kg)	57.66	Very high	36.14	Very high
Total N (g/kg)	3.64	Very high	2.19	Very high
Available P/Bray I (mg/kg)	11.70	Medium	2.25	Very low
Exchangeable K (cmol/kg)	0.63	Medium	0.45	Medium
Na (cmol/kg)	0.65	Medium	0.65	Medium
Ca (cmol/kg)	1.95	Very low	0.73	Very low
Mg (cmol/kg)	0.45	Very low	0.32	Very low
CEC (cmol/kg)	65.25	Very high	43.50	Very high
Exchangeable Al (cmol/kg)	1.84		2.37	
Exchangeable H (cmol/kg)	0.74		0.88	
Texture:				
Sand (%)	47.08		46.64	
Ash (%)	31.11		27.18	
Clay (%)	21.81		26.18	

Nutrient contents of lowland swamp

Crude protein, fiber, ether extract, and ash nutrient contents of lowland swamp vegetation found in this study are listed in (Table 2). The NDF and ADF contents of vegetation found in this study were about 40.65-79.47% and 23.66-60.33%, respectively. Lowland swamp vegetation was found to have hemicellulose and cellulose contents ranging from 7.73 to 37.14% and 5.24 to 27.08%, respectively. Lignin contents of lowland swamp vegetation ranged from 14.84 to 43.09% (Table 3).

There are 19 species of forage found in Pampangan buffalo pasture that have potential to be used as food for Pampangan buffalo, consisting of 17 species of grasses and herbs and 2 species of legumes (Muhakka et al. 2019). There are dominant and palatable species of swamp lowland forage vegetation having potential as buffalo feed, namely *O. rupifogon, H. acutigluma*, and *H. amplexicaulis*, not dominant but palatable species such as *Hymenachne* sp. and *N. oleracea*; dominant but non-palatable grass species (buffalo does not like it) namely *P. barbatum*. This grass species would be eaten by the buffaloes if there were no other species to be eaten (Muhakka et al. 2019).

Discussion

Crude protein content

Results showed that the crude protein contents of swamp green vegetation ranged from 5.26% to 20.56% with the lowest value (5.26%) was found in *R. corymbosa* grass and the highest (20.56%) was found in *N. oleracea* legume. *C. digitatus* grass had the highest crude protein content (15.31%) (Table 2). This high nutritional value of *C. digitatus* was suspected as caused by the fact that most of this grass was found to grow in the area of buffalo pens where the soil was rich in organic matter. However, the growth of this grass was not dominant as it mostly occurred in rainy seasons.

Hymenachne amplexicaulis, *O. rupifogon*, *H. acutigluma*, and *E. dulcis* were found as the dominant palatable grasses containing 12.00, 10.41, 10.96, and 8.22% crude protein, respectively. Results of this study were not too different from those obtained by Rostini et al. (2014), who reported that *H. amplexicaulis* and *L. hyssopifolia* had protein contents of 10.88 and 15.92%, respectively. Crude protein (CP) contents of these swamp grasses in Pulau Layang and Rambutan Villages were closed to those of prime grasses including 9.11-12.8% CP of *P. purpureum* (Santos et al. 2013; Dahlan and Iskandar 2013; Rahman et al. 2014), 12.4% CP of *P. purpureum* grass hay, 11.1% CP of *P. purpureum* grass silage, 11.4% CP of *P. purpureophoides* grass hay, and 10.2% CP of *P. purpureophoides* grass silage (Santoso and Hariadi 2008). Other vegetation even had higher CP contents including *H. acutigluma* with 10.96% CP, *C. roseus* 15.20%, *N. lotus* 13.22%, *L. hyssopifolia*) 12.07%, *C. digitatus* 15.31%, and *H. amplexicaulis* ^{R} 12.0% (Table 2). CP contents of vegetation in this study were also higher than those of natural grasses found in coffee plantation areas (6.95%) and pastoral areas (6.65%) in Wulanggitang Subdistrict, East Flores District, East Nusa Tenggara Province, Indonesia as reported by Kleden et al. (2015). Meanwhile, CP content of grasses in lowlands was 8.41% (Maswada and Elzaawely 2013; Rochana et al. 2016).

This high protein content was suspected to be caused by the fact that soil organic C and total N contents in the study site were also high, namely 36.14-57.66 and 2.19-3.64 $g.kg^{-1}$, respectively (Table 1). Soil organic C and total N contents affected protein content in plants. Four swamp grasses/herbs including *C. digitatus, C. roseus, N. lotus*, and *L. hyssopifolia* and a legume, *N. oleracea* were found to be the lowland swamp vegetation having the highest N contents of 15.31,15.20, 13.22, 12.07, and 20.56%, respectively.

Table 2. Crude protein, fiber, ether extract, and ash contents (%) of lowland swamp vegetation

Latin name	Family	Origin (village)	Local name	Crude protein	Fiber	Ether extract	Ash
Catharanthus roseus	Apocynaceae	Pulau Layang	Tapak dara	15.20	11.18	1.29	12.53
Cyperus digitatus	Cyperaceae	Rambutan	Kasuran	15.31	14.76	1.42	25.19
Digitaria fuscescens	Poaceae	Rambutan	Kerak maling/pasiran	12.00	15.64	1.24	16.26
Eichhornia crassipes	Pontederiaceae	Pulau Layang	Eceng gondok	8.61	20.66	0.84	14.22
Eleocharis dulcis-P	Cyperaceae	Pulau Layang	Purun tikus	8.22	25.72	0.48	15.13
Eleocharis dulcis-R	Cyperaceae	Rambutan	Purun tikus	6.63	24.52	1.69	10.24
Hymenachne acutigluma-P	Poaceae	Rambutan	Kumpai tembaga	10.96	23.73	1.77	10.30
Hymenachne acutigluma-R	Poaceae	Pulau Layang	Kumpai tembaga	6.86	30.26	2.22	7.88
Hymenachne amplexicaulis-P	Poaceae	Pulau Layang	Kumpai minyak	9.21	21.91	2.82	13.96
Hymenachne amplexicaulis-R	Poaceae	Rambutan	Kumpai minyak	12.00	15.64	1.24	16.26
Hymenachne sp.	Poaceae	Pulau Layang	Kumpai merah	8.52	21.20	1.30	12.88
Ipomoea aquatica	Convolvulaceae	Pulau Layang	Kangkung merah	8.95	14.34	2.24	10.39
Leersia hexandra	Poaceae	Pulau Layang	Bento rayap	5.35	27.57	2.06	5.63
Ludwigia hyssopifolia	Onagraceae	Pulau Layang	Cecengkehan	12.07	11.01	1.66	9.09
Neptunia olerancia	Fabaceae	Pulau Layang	Kemon air	20.56	15.03	2.92	7.31
Nymphaea lotus	Nymphaeaceae	Pulau Layang	Telepuk gajah	13.22	11.45	2.84	10.30
Oryza rupifogon-P	Poaceae	Pulau Layang	Kumpai padi	7.93	23.30	1.60	16.25
Oryza rupifogon-R	Poaceae	Rambutan	Kumpai padi	10.41	21.59	2.49	11.92
Polygonum barbatum	Poaceae	Pulau Layang	Are bolong	7.53	16.60	1.57	8.40
Rhynchospora corymbosa	Cyperaceae	Pulau Layang	Berondong	5.26	22.27	1.48	14.84
Sesbania exasperata	Fabaceae	Rambutan	Mutiara	18.27	11.22	1.86	19.47

Note: P: Pulau Layang Village; R: Rambutan Village

Table 3. Composition of fiber fractions of green vegetation in lowland swamp: NDF, ADF, hemicellulose, cellulose, and lignin (%).

Latin name	Family	Origin (village)	NDF	ADF	Hemi-cellulose	Cellulose	Lignin
Catharanthus roseus	Apocynaceae	Pulau Layang	47.79	39.67	8.12	16.96	22.71
Cyperus digitatus	Cyperaceae	Rambutan	58.90	36.93	21.97	5.24	31.68
Digitaria fuscescens	Poaceae	Rambutan	65.43	33.56	31.87	12.11	21.45
Eichhornia crassipes	Pontederiaceae	Pulau Layang	62.77	41.83	20.94	10.22	31.60
Eleocharis dulcis-P	Cyperaceae	Pulau Layang	69.57	49.83	19.74	21.80	28.04
Eleocharis dulcis-R	Cyperaceae	Rambutan	75.73	54.91	20.82	19.71	35.20
Hymenachne acutigluma-P	Poaceae	Pulau Layang	75.89	50.60	25.29	12.25	38.34
Hymenachne acutigluma-R	Poaceae	Rambutan	64.72	46.38	18.34	16.01	30.37
Hymenachne amplexicaulis-P	Poaceae	Pulau Layang	65.31	38.92	26.39	8.29	30.63
Hymenachne amplexicaulis-R	Poaceae	Rambutan	65.32	39.45	25.87	9.75	28.67
Hymenachne sp.	Poaceae	Pulau Layang	60.14	28.40	31.74	8.64	19.76
Ipomoea aquatica	Convolvulaceae	Pulau Layang	41.40	26.17	15.23	6.32	19.85
Leersia hexandra	Poaceae	Pulau Layang	79.47	42.33	37.14	25.88	33.92
Ludwigia hyssopifolia	Onagraceae	Pulau Layang	40.64	32.91	7.73	8.39	24.52
Neptunia olerancia	Fabaceae	Pulau Layang	62.31	45.44	16.87	27.08	18.36
Nymphaea lotus	Nymphaeaceae	Pulau Layang	46.05	23.66	22.39	8.82	14.84
Oryza rupifogon-P	Poaceae	Pulau Layang	71.13	60.33	10.80	17.23	43.09
Oryza rupifogon-R	Poaceae	Rambutan	65.49	46.19	19.30	14.96	31.24
Polygonum barbatum	Poaceae	Pulau Layang	61.27	48.46	12.81	20.28	28.18
Rhynchospora corymbosa	Cyperaceae	Pulau Layang	65.29	44.64	20.65	16.08	28.56

Note: P: Pulau Layang Village; R: Rambutan Village

Fiber contents

Fiber contents of lowland swamp green vegetation ranged from 11.01 to 30.26%, with the lowest content found in *L. hyssopifolia* and the highest in *H. acutigluma* [P]. Four vegetation including *L. hyssopifolia*, *C. roseus*, *S. exasperata*, and *N. lotus* were found to have the lowest fiber contents of 11.01, 11.18, 11.22, and 11.45%, respectively (Table 2). These results were almost similar to those found by Ali et al. (2012) who reported that the fiber contents of roughage in a pasture ranged from 7.20 to 34.98%. These researchers found that the fiber content of *Leersia hexandra* was 27.40% which was very close to that (27.57%) of the same vegetation in this study. Meanwhile, Rostini et al. (2014) reported that the fiber contents of swamp vegetation in South Kalimantan ranged from 14.84 to 29.35% with the lowest content found in *Paspalum* sp. and the highest in *L. adscendens*. These figures were lower than those found by Kleden et al. (2015) who revealed that nature grasses in a coffee plantation area and pasture in Wulanggitang, East Flores contained 34.57 and 35.59% of fiber. They also found that the lowest fiber content was found in *L. peploides* and the highest in *I. rugosum*. Fiber contents reported by Kleden et al. (2015) were higher than the results reported by Ahmed et al. (2013) with a fiber content of 29.32% in *D. aegyptium* plants. A previous study showed that fermented *I. rugosum, H. amplexicaulis,* and *O. rufipogon* had fiber contents of 29.27, 29.57, and 33.07%, respectively (Muhakka et al. 2015).

The fiber content of *E. crassipes* in this study (20.66%) was lower than those found by Hossain et al. (2015), Tham and Uder (2015), and Make et al. (2016). In addition, the fiber content of *E. crassipes* in this study was lower than those of *Azolla*, another water plant, ranging from 13.19 to 16.54% (Kathirvelan et al. 2015; Anitha et al. 2016) and 9.25 to 13.25% (Ahmed et al. 2016). These fiber contents of *Azolla* equaled to those of *L. hyssopifolia* (11.01%), *C. roseus* (11.18%), *S. exasperata* (11.22%), *N. lotus* 11.45%, and *I. aquatica* (14.34%) found in this study. Fiber contents of swamp green vegetation found in this study indicated that they were potential to be used as feed for Pampangan buffaloes.

Ether extract contents

Lowland swamp vegetation in this study was found to have ether extract (EE) contents of about 0.48-2.92%. The lowest EE content was found in *E. dulcis*, while the highest was found in *N. oleracea*. Four vegetation of lowland swamp including *N. lotus* (2.84% EE), *H. amplexicaulis (*2.82% EE), *O. rufipogon* (2.49% EE), and *I. aquatica* (2.24% EE) were revealed to have the highest ether extract contents (Table 2). Results of this study were lower than those found by Rostini et al. (2014), reporting about 0.61-3.67% of EE contents in swamp vegetation in South Kalimantan with the lowest found in *L. hyssopifolia* and the highest in *O. rufipogon*. EE contents of lowland swamp vegetation were 1.40-1.91% for grasses and 1.36-2.95% for legumes (Asep et al. 2012) and those of grasses in a pasture for buffaloes in Pulau Moa were 1.95-2,41% (Eoh 2014). In other studies, grasses in a natural pasture in North *Lore*, Poso District had EE contents of 2.12-2.34% (Damry 2009) and those in Sabana Timur Barat pasture in the rainy season to the end of dry season had an average EE content of 1.91% (Manu 2013). A study by Se’u et al. (2015) revealed an EE content of 1.07% in grasses in a pasture in Timor Tengah Selatan District, Indonesia. Another work by Kleden et al. (2015) showed that vegetation in a natural pasture and a coffee plantation area had EE contents of 1.23 and 1.35%, respectively.

Vegetation found in this study had EE contents equaled to those of prime grasses including *P. purpureum* grass and *P. purpureophoides* grass preserved in the form of hay and silage. *P. purpureum* grass hay and silage had EE contents of 1.9 and 2.6%, respectively, while those of *P. purpureophoides* grass had EE contents of 1.6 and 2.4%, respectively (Santoso and Hariadi 2008; Ukpabi et al. 2015). EE contents of some species of ruminant roughages were found to be about 1.2-4.1% (Ahmed et al. 2013). Dominant swamp roughages including *H. amplexicaulis* and *O. rufipogon* had EE contents of 2.82 and 2.49%, respectively and they were palatable and potential to be used as feed for Pampangan buffaloes.

Ash contents

Ash contents of green vegetation in lowland swamp ranged from 5.63 to 25.19%. Four types of vegetation with the highest ash contents included *C. digitatus* (25.19%), *S. exasperata* (19.47%), *H. amplexicaulis* (16.26%), and *O. rufipogon* ^{P} (16.25%). Meanwhile, *L. hexandra* was found to have the lowest ash content of 5.63% (Table 2). Ash contents of vegetation found in this study were higher than those of swamp vegetation in South Kalimantan of 2.18-3.28% during the high tidal season and 3.23-9.83% during the low tidal season (Rostini et al. 2014). *P. purpureum* grass was indicated to have varied ash contents of 4.4% (Dahlan and Iskandar 2013), 0.95-1.1% (Ukpabi et al. 2015), 9.59% (Nuhuyanan 2010), and 18% (Araica et al. 2009). Meanwhile, the ash content of grasses in lowland areas ranged from 6.32 to 8.91% (Richmond et al. 2015; Mako et al. 2016; Norman et al. 2013; Maswada et al. 2013). Alam et al. (2015) found that *B. mutica* had an ash content of 4.20-4.89% and rice straw had 6.63%.

Roughages were found to have average ash contents of 7.28% in a pasture for buffaloes in Pulau Moa (Eoh 2014), 9.82-10.14% in Lore Utara, Poso District (Damry 2009), 11.51% in a pasture during the rainy season until the end of dry season in Sabana Timur Barat *(*Manu 2013), and 8.11 and 8.22% in a natural pasture and a coffee plantation area, respectively (Kleden et al. 2015). Differences in these ash contents were suspected to be caused by differences in plant species (internal factor) and environmental differences, particularly seasonal differences (external factor). In a dry season, pH levels in lowland swamp areas were found to be 3.9-4.8, causing a decreased supply of nutrients, especially total N and K, to the soil. This decreased supply of nutrients led to lowered nutrients contained in plants (Rostini et al. 2014). This was in line with what was stated by Gutteridge and Shelton (1994) that nutrient content in plants was affected by soil nutrient content. In addition, in acidic soil conditions, activities of Fe, Al, and Mn increased which might cause toxicity in plants (Tjondronegoro and Gunawan 2000).

NDF and ADF contents

Neutral Detergent Fiber (NDF) depicts plant cell walls consisting of hemicellulose, cellulose, and lignin. NDF is part of fiber that is not dissolved in neutral detergent representing the component of fiber not dissolving in plant cell wall materials. NDF content of a feed affects the ability of ruminants to consume the feed. Acid Detergent Fiber (ADF) represents parts of the plant cell wall bond to cellulose and lignin. ADF content is related to energy content and higher ADF content results in lowered digestible energy content (Van Soest 1982).

The NDF and ADF contents of vegetation found in this study were about 40.65-79.47% and 23.66-60.33%, respectively. Lowest NDF contents were found in *L. hyssopifolia* (40.65%), *I. aquatica* (41.40%), *N. lotus (*46.05%), and *C. roseus* (47.79%). In contrast, highest

NDF content of 79.47% was found in *L. hexandra*. Lowest ADF contents were found in *N. lotus (*46.05*%*), *I. aquatica* (26.17%), *Hymenachne* sp. *(*28.40%), *L. hyssopifolia* (32.91%). Meanwhile, the highest ADF content of 60.33% was found in (*O. rufipogon* P *(*Table 3). NDF and ADF contents of vegetation found in this study were lower than those of Asep et al. (2012) who reported that the NDF contents of swamp green vegetation in a pasture for buffaloes were about 91.73-93.45% in grasses and 68.11-90.93% in legumes and the ADF content of grasses was 51.6-86.8%. It was shown in other studies that NDF and ADF contents of roughages in a pasture during the rainy season to the end of the dry season in Sabana Timur Barat were on average 65.9 and 43.29%, respectively (Manu 2013). Vegetation in a natural pasture and a coffee plantation area had NDF contents of 74.89 and 72.37% and ADF contents of 57.22 and 55.15%, respectively (Kleden et al. 2015). Meanwhile, swamp vegetation in South Kalimantan had average NDF and ADF contents of 55.97 and 37.87%, respectively, during the high tidal season and 81.44 and 60.86% respectively, during the low tidal season (Rostini et al. 2014).

NDF and ADF contents of roughages in the BPTU-HPT Padang Mengatas area were found to be 75.62 and 45.96%, respectively in the rain season and 69.35 and 38.66%, respectively in the dry season (Muhajirin et al. 2017). NDF and ADF contents of *E. crassipes* in this study were 62.77 and 41.83%, respectively. These figures were close to those of *E.crassipes* plants studied by Tham (2015) with NDF and ADF contents of 63.9 and 34.68% and by Tham and Uden (2015) with NDF and ADF contents of 52.1 and 30.7%, respectively. Other studies conducted by Ahmed et al. (2016), Anitha et al. (2016), and Nampoothiri (2017) showed that *Azolla* sp. had NDF and ADF contents of 53.8-54.85% and 36.57-37.0%, respectively. Meanwhile, NDF and ADF contents of *P. purpureum* were found to be 55.8 and 46.5% (Dahlan and Iskandar 2013) and 84.25 and 64.07% (Nuhuyanan 2010), respectively. These figures equaled to the NDF and ADF contents of *H. acutigluma* (64.72 and 46.38%), *H. amplexicaulis* (65.31 and 38.92), and *P. barbatum* (61.27 and 48.46%). This indicated that lowland swamp vegetation had fiber fraction nutritional quality which was not less than that of prime grasses including *P. purpureum* and *P. purpureophoides*.

In this study, NDF and ADF contents of lowland swamp vegetation were 40.65-79.47% and 23.66%-60.33%, respectively. These figures were still within the ranges of NDF and ADF contents of prime grasses such as *P. purpureum* which had NDF and ADF contents of 55.8 and 46.5% (Dahlan and Iskandar 2013) and 84.25 and 64.07% (Nuhuyanan 2010), respectively. In the rumen, NDF degradation is higher than that of ADF as NDF contains hemicellulose fraction which is more soluble (Church and Pond 1986). NDF content has a negative correlation with its degradation rate (Varga et al. 1983) and higher NDF content decreases dry matter digestibility of feed (NRC 1988). Cellulose is an ADF component that is easy to digest while lignin is hard to digest as it contains double bonds. Higher lignin content decreases feed digestibility (Sutardi et al. 1980).

Hemicellulose and cellulose contents

Lowland swamp vegetation was found to have hemicellulose and cellulose contents ranging from 7.73 to 37.14% and 5.24 to 27.08%, respectively. Four green vegetation with the highest hemicellulose contents were *L. hexandra*) (37.14%), *D. fuscescens* (31.87%), *Hymenachne* sp. (31.74%), and *H. amplexicaulis (*26.39%). In contrast, the lowest hemicellulose content was found in *L. hyssopifolia* (7.73%). Highest cellulose contents were found in (*N. oleracea (*27.08%), *L. hexandra* (25.88%), *E. dulcis* (21.80%), and *P. barbatum (*20.28%). Meanwhile, *C.digitatus* had the lowest cellulose content of 5.24% (Table 3). Results of this study were in line with those of a study conducted by Asep et al. (2012) who reported the hemicellulose and cellulose contents of lowland swamp green vegetation ranging from 7.89 to 31.55% and 30.85 to 63.35%, respectively. They also found that *O. rufipogon* had 31.55% hemicellulose content which was higher than those of 10.80-19.30% in this study (Table 4). Swamp vegetation in South Kalimantan had hemicellulose contents of 0.65-25.85% in high tidal season and 5.37-40.09% in low tidal season. Cellulose contents in high and low tidal seasons were about 20.07-34.03% and 7.90-38.31%, respectively (Rostini et al. 2014). Various water plants including *Azolla*, which was used as animal feed, had hemicellulose and cellulose contents of 10.20 and 12.76% (Nampoothiri 2017), 1.15-10.20% and 12.76% (Nampoothiri 2017), respectively. Roughages in BPTU-HPT Padang Mengatas, Indonesia had hemicellulose and cellulose contents of 29.79 and 33.62% in the rain season and 30.69 and 31.64% in the dry season, respectively (Muhajirin et al. 2017). *P. purpureum* was found to contain 21.18% hemicellulose and 43.32% cellulose (Nuhuyanan 2010) and 35.3% cellulose (Dahlan and Iskandar 2013). In a study conducted by Archimede et al. (2010), hay was found to have 37.7% hemicellulose and 35.7% cellulose. Based on the above findings, it was suggested that hemicellulose (7.73-37.14%) and cellulose (5.24-27.08%) contents of lowland swamp vegetation in this study were within normal ranges and this vegetation was potential to be used as feed for Pampangan buffaloes.

Lignin contents

Lignin contents of lowland swamp vegetation ranged from 14.84 to 43.09%. Four vegetation including *N. lotus*, *N. oleracea*, *Hymenachne* sp., and *I. aquatica* were found to have the lowest lignin contents of 14.84, 18.36, 19.76, and 19.85%, respectively, while the highest lignin content of 43.09% was found in *O. rufipogon* P (Table 3). Lignin contents in this study were higher than that obtained by Rostini et al. (2014) who reported the lignin contents of swamp vegetation in South Kalimantan were about 2.8-17.59% in high tidal season with that of *H. amplexicaulis* as the lowest and that of *O. rufipogon* as the highest and 10.06-61.12% in low tidal season with that of *O. rufipogon* as the lowest and that of *H. amplexicaulis* as the highest. Lignin contents of *O. rufipogon*^{R} (31.24%) and *O. rufipogon*^{P} (43.09%), *L. hexandra* (33.92%), and *E. crassipes* (31.60%) (Table 3) found in this study were higher those of (18.27%) and *L. hexandra* (17.96%) found by Asep et al. (2012) and *E. crassipes* (8.17%) found by Tham (2015). In other studies, *Azolla* was found to have lignin contents of 5.7% (Ahmed et al. 2016) and 28.24% (Nampoothiri 2017). Meanwhile, lignin contents of *P. purpureum* grass were found to be 15.37% (Nuhuyanan 2010) and 11.2% (Dahlan and Iskandar 2013).

Differences in lignin contents in green vegetation are suspected to be caused by differences in plant species, plant ages, and environmental factors including seasons (rain or dry season), tidal seasons, and fertility levels of the soil where the vegetation grow. In cell walls, cellulose is a bond with hemicellulose and lignin. The animals cannot digest lignin and its molecular structure is different from other carbohydrates as it contains carbon and nitrogen of only 1-5%. Hemicellulose consists of pentose, hexose, uronic acid, and pectin substance. Pectin is a carbohydrate that is composed of uronic acid, galactose, arabinose, xylose, and methanol. Cellulose is degradable by microorganisms and functions as the source of volatile fatty acids. Young grasses (roughages) contain less than 5% lignin and 80% of their cellulose is degradable. On the contrary, in old roughages, lignin content may reach up to 10% causing a decrease in cellulose digestibility by up to 50% (Prawirokusumo 1994).

Based on the results of the study, it was concluded that: (i) the highest protein (20.56%) and crude fat (2.92%) contents were found in *N. oleracea*. The highest ash content (25.19%) was found in *C. digitatus*, while the lowest (11.01%) was found in *L. hyssopifolia*. The lowest NDF content (40.64%) was found in *L. hyssopifolia* and the highest hemicellulose content (37.14%) was found in *L. hexandra*. *N. lotus* had the lowest ADF (23.66%) and lignin (14,84%) contents. *N. olerancia* contained the highest cellulose level of 27.08%. (ii) The best nutritional values were found in *C. digitatus* and *L. hyssopifolia*. (iii) Dominant and palatable swamp roughages with good nutrient contents included *H. acutigluma*, *H. amplexicaulis*, *O. rufipogon*, *P. barbatum*, and *E. dulcis*.

ACKNOWLEDGMENTS

The author expresses his deepest gratitude to the Rector of Sriwijaya University through the Chair of the Institute for Research and Community Services funding this research in accordance with the Competitive Leading Research Contract of Sriwijaya University Number: 988/UN9.3.1/PP/2017, dated 21 July 2017.

REFERENCES

Ahmed HA, Ganai A.M, Beigh YA, Sheikh GG, Reshi PA. 2016. Performance of growing sheep on *Azolla* based diets. Indian J Anim Res 50 (5): 721-724.

Alam MR, Haque MM, Sumi KR, Ali MM. 2015. Proximate composition of para-grass (*Brachiaria mutica*) produced in integrated fish-fodder culture system. Bangladesh J Anim Sci 44 (2): 113-119.

Ali AIM, Sandi S, Muhakka, Riswandi. 2012. Kualitas hijauan pakan di rawa lebak padang penggembalaan kerbau pampangan. Proc InSINAS 2012: 307-312. [Indonesian]

Anitha KC, Rajeshwari YB, Prasanna SB, Shree JS. 2016. Nutritive evaluation of *Azolla* as livestock. J Exp Biol Agric Sci 4 (6): 670-674.

AOAC. 1990. Official Methods of Analysis. 15th ed., Association of Official Analytical Chemists, Washington, DC.

Araica BM, Sporndly E, Sanchez NR, Norell L, Sporndly R. 2009. Silage quality when Moringa oleifera is ensiled in mixtures with elephant grass, sugar cane and molasses. Grassl For Sci 64: 364-373.

Archimede H, Gonzales-Garcia E, Despois P, Etienne T, Alexandre G. 2010. Substitution of corn and soybean with green banana fruits and *Gliricidia sepium* forage in sheep fed hay-based diets: effects on intake, digestion and growth. J Anim Physiol Anim Nutr 94 (2010): 118-128.

BPS. 2010. Luas lahan rawa di Indonesia. Badan Pusat Statistik & Direktorat Jendral Tanaman Pangan, Departemen Pertanian, Jakarta. [Indonesian]

BPS. 2014. Sumatera Selatan dalam Angka 2014. Badan Pusat Statistik) Provinsi Sumatera Selatan, Palembang. [Indonesian]

Brazle FK, Kilgore GI, Fauzett MR. 2000. Effect of season on grazing native-grass pastures. Prof Anim Sci 16: 15-28.

Church DC, Pond WG. 1986. Digestive Animal Physiology and Nutrition. 2nd. Prentice Hall, Englewood Cliff, New York.

Dahlan I, Iskandar MNZ. 2013. Use of plantain peels (*Musa paradisiaca*) as a fibrous feed substitute for napier grass (*Pennisetum purpureum*) in rusa deer (*Cervus timorensis*) ratio under captivity. J Anim Sci 3 (9): 472-480.

Damry. 2009. Produksi dan kandungan nutrisi hijauan padang penggembalaan alam di Kecamatan Lore Utara Kabupaten Poso. J Agrol 16 (4): 296-300. [Indonesian]

Dinas Peternakan Sumatera Selatan. 2014. Statistik Peternakan Provinsi Sumatera Selatan Tahun Anggaran 2015. Dinas Peternakan Sumatera Selatan, Palembang. [Indonesian]

Eoh M. 2014. Kapasitas tampung dan komposisi zat-zat makanan padang penggembalaan ternak kerabau di Pulau Moa. Agrinimal 4 (2): 77-82.

Gutteridge RC, Shelton HM. 1994. The Role of Forage Tree Legumes in Cropping and Grazing System. FAO, Rome, Italy.

Hossain MdE, Sikder H, Kabir MdH, Sarma SM. 2015. Nutritive value of water hyacinth (*Eichhornia crassipes*). Online J Anim Feed Res 5 (2): 40-44.

Kathirvelan C, Banupriya S, Purushothaman MR. 2015. *Azolla*-an alternate and sustainable feed for livestock. Intl J Sci Environ 4 (4): 1153-1157.

Kleden MM, Ratu MRD, Randu MDS. 2015. Kapasitas tampung hijauan pakan dalam areal perkebunan kopi dan padang rumput alam di Kabupaten Flores Timur Nusa Tenggara Timur. J Zootek 35 (2): 340-350. [Indonesian]

Mako AA, Akinwande VO, Anurudu NF, Ogunwole OA. 2016. Evaluation of nutritive value of water hyacinth (*Eichhornia crassipes*) and guinea grass (*Panicum maximum*) mixture as animal feed in the tropics. 2016. Bull Anim Hlth Prod Afr 64: 463-473.

Manu AE. 2013. Produktivitas padang penggembalaan sabana Timor Barat. J Pastura 3 (1): 25-29. [Indonesian]

Maswada HF, Elzaawely AA. 2013. Nutritive value of *Stipagrostis lanata* (Forssk.) de Winder as a feed for livestock. Asian J Crop Sci 5 (2): 216-221.

Muhajirin, Despal, Khalil. 2017. Pemenuhan kebutuhan nutrien sapi potong bibit yang digembalakan di Padang Mengatas. Buletin Makanan Ternak 104 (1): 9-20. [Indonesian]

Muhakka, Suwignyo RA, Budianta D, Yakup. 2019. Vegetation analysis of no-tidal swampland in South Sumatra, Indonesia and its carrying capacity for Pampangan buffalo pasture. Biodiversitas 20 (4): 1077-1086.

Muhakka, Wijaya A, Ammar M. 2015. Nutritional dried matter, crude protein and crude fiber on lowland tidal grass fermented by probiotic microorganisms for use Bali cattle feed. J Anim Prod 17 (1): 24-29.

Mulyani A, Sarwani M. 2013. Karakteristik dan potensi lahan sub optimal untuk pengembangan pertanian di Indonesia. J Sumber Daya Lahan 7 (1): 47-55. [Indonesian]

Nampoothiri VM. 2017. Aquatic plants and marine waste as animal feed. Sch J Agric Vet Sci 4 (6): 249-254.

Norman HC, Master DG, Barrentt-Lennard EG. 2013. Halophytes as forage in saline landscapes: Interaction between plant genotype and environment change their feeding value to ruminants. Environ Exp Bot 92 (2013): 96-109.

NRC. 1988. Nutrition Requirement of Beef Cattle. 6th rev ed. National Research Council, Washington, DC.

Nuhuyanan LE. 2010. Pengaruh pemberian wafer rumput gajah dengan perekat fermented moter liquor (FML) dan tetes (molasses) terhadap konsumsi pakan, kecernaan zat-zat makanan dan kenaikan berat badan sapi bali jantan. J Ilmu Peternakan 5 (2): 111-117. [Indonesian]

Prawirokusumo S. 1994. Ilmu Gizi Komperatif. BPFE, Yogyakarta. [Indonesian]

Rahman MM, Abdullah RB, Wan Khadijah WE, Nakagawa T, Akashi R. 2014. Feed intake and growth performance of goats offered Napier grass (*Pennisetum purpureum*) supplemented with concentrate pellet and soya waste. Sain Malaysiana 43 (7): 967-971.

Richmond AS, Wylie ARG, Laidlaw AS, Lively FO. 2015. Methane emissions from beef cattle grazing on semi-natural upland and improved lowland grasslands. Animal 9 (1): 130-137.

Rostini T, Abdullah L, Wiryawan KG, Karti PDMH. (2014). Production and nutrition potency of swamp local forage in South Kalimantan as ruminant feed. Glob J Anim Sci Livestock Prod Anim Breed 2 (2): 107-113.

Santoso dan Hariadi BTj. 2008. Komposisi kimia, degradasi nutrien dan produksi gas metana in vitro rumput tropika yang diawetkan dengan metode silase dan hay. J Media Peternakan 31 (2): 128-137.

Se'u VE, Karti PDMH, Abdullah L. 2015. Botanical composition, grass production, and carrying capacity of pasture in Timor Tengah Selatan District. J Media Peternakan 38 (3): 176-182.

Sutardi T, Pratiwi SH, Adnan A, Nuraini S. 1980. Peningkatan pemanfaatan jerami padi melalui hidrolisa basa, suplementasi urea dan belarang. Buletin Makanan Ternak No. 6, Balai Besar Penelitian Veteriner, Bogor. [Indonesian]

Tham HoT, Uden P. 2015. Effect of freshwater Hyacinth (*Eichhornia crassipes*) on intake and digestibility in cattle fed rice straw and molasses-urea cake. Nova J Eng Appl Sci 4 (1): 1-8.

Tham HoT. 2015. Utilisation of water hyacinth as animal feed. Nova J Eng Appl Sci 4 (1): 1-6.

Tjondronegoro AD, Gunawan A. 2000. Beberapa jenis gulma di lahan pasang surut pada tingkat kemasaman tanah yang berbeda. Pros. Seminar Nasional: P. 247-254. [Indonesian]

Van Soest PJ. 1982. Nutritional Ecology of the Ruminant: Ruminant Metabolism, Nutritional Strategies the Cellulolytic Fermentation and the Camisthy of Forages and Palm Fiber. Cornell University, O & B Books Inc., USA.

Varga GA, Hoover WH. 1983. Rate and extent of NDF of feedstuff in-situ. J Dairy Sci 66: 2109.

8. Bukti konfirmasi artikel published online
(1 Maret 2020)

BIODIVERSITAS ISSN: 1412-033X
Volume 21, Number 3, February 2020 E-ISSN: 2085-4722
Pages: 953-961 DOI: 10.13057/biodiv/d210314

Nutritional values of swamp grasses as feed for Pampangan Buffaloes in South Sumatra, Indonesia

MUHAKKA[1,♥], RUJITO AGUS SUWIGNYO[2], DEDIK BUDIANTA[3], YAKUP[2]

[1]Department of Animal Husbandry, Faculty of Agriculture, Universitas Sriwijaya. Jl. Palembang-Prabumulih Km 32, Inderalaya, Ogan Ilir 30662, South Sumatra, Indonesia. Tel./fax.: +62-711-581106. ♥email: muhakka@fp.unsri.ac.id

[2]Department of Agronomy, Faculty of Agriculture, Universitas Sriwijaya. Jl. Palembang-Prabumulih Km 32, Inderalaya, Ogan Ilir 30662, South Sumatra, Indonesia

[3]Department of Soil Science, Faculty of Agriculture, Universitas Sriwijaya. Jl. Palembang-Prabumulih Km 32, Inderalaya, Ogan Ilir 30662, South Sumatra, Indonesia

Manuscript received: 17 October 2019. Revision accepted: 8 February 2020.

Abstract. *Muhakka, Suwignyo RA, Budianta D, Yakup. 2020. Nutritional values of swamp grasses as feed for Pampangan Buffaloes in South Sumatra, Indonesia. Biodiversitas 21: 953-961.* This study was aimed at determining the types and quality of vegetation in the swamp area, which could be used as sources of roughage for Pampangan buffaloes in South Sumatra. In this descriptive study, Results showed that the highest crude protein and ether extract contents, 20.56 and 2.92%, respectively, were found in (*Neptunia oleracea*). The highest ash content of 25.19% was found in *Cyperus digitatus*. The lowest fiber content (11.01%) was found in *Ludwigia hyssopifolia*, which also had the lowest content of Neutral Detergent Fiber (NDF) (40.64%). Hemicellulose content was found to be highest (37.14%) in *Leersia hexandra*. The lowest ADF (23.66%) and lignin (14,84%) contents were found in *Nymphaea lotus*. *N. oleracea* was found to have the lowest content (27.08%) of cellulose. It was concluded that the swamp vegetation found in this study consisted of 17 species of grasses and herbs (89.47%) and two species of legumes (10.53%). *C. digitatus* and *L. hyssopifolia* were found to have the best nutritional values. Dominant and palatable vegetation with good nutritional values, which were potential to be used as sources of roughage for *Pampangan* buffaloes, were *Hymenachne acutigluma*, *Oryza rufipogon*, *Hymenachne amplexicaulis*, *Polygonum barbatum*, and *Eleocharis dulcis*.

Keywords: Feed, nutritional value, Pampangan buffalo, swamp grass

INTRODUCTION

The availability of roughage as the main feed for ruminants depends considerably on seasons. During the rainy season, it is abundant, but during the dry season, the availability of grasses/herbs and legumes is lacking. The limited supply of roughage may hamper productivity including the reproductive performance of ruminants including buffaloes.

In South Sumatra, Pampangan buffalo is potential germplasm that needs to be preserved and developed. There were 37,405 Pampangan buffaloes in 2016, and this population increased by 3.97% to 38,952 in 2017. In 2017, of this population, 11,150 (28.63%) and 2,227 (5.72%) were found in Ogan Komering Ilir District and Banyuasin District, respectively (Dinas Peternakan Sumatera Selatan 2014). The population and productivity of *Pampangan* buffaloes need to be improved, and for this purpose, feed is an important factor to consider. Pampangan buffaloes feed mostly on roughage from the swamp, grassland to meet their upkeeping and reproductive needs.

In Indonesia, there are 13.27 million hectares of lowland swamp areas. Only 4 million hectares of these areas have been developed and cultivated by the community and private sectors (2.6 million hectares) and the government assistance (1.3 million hectares) (BPS 2010; Mulyani and Sarwani 2013). In Sumatra, the largest lowland swamp area of 2.98 million hectares is found in South Sumatra, but only 298,189 hectares of it have been utilized (BPS 2014). In order to utilize the potential swamp area as a feed source for Pampangan buffaloes, a study on vegetation as sources of roughage in lowland swamp areas that include vegetation identification and nutritional quality determination needs to be conducted.

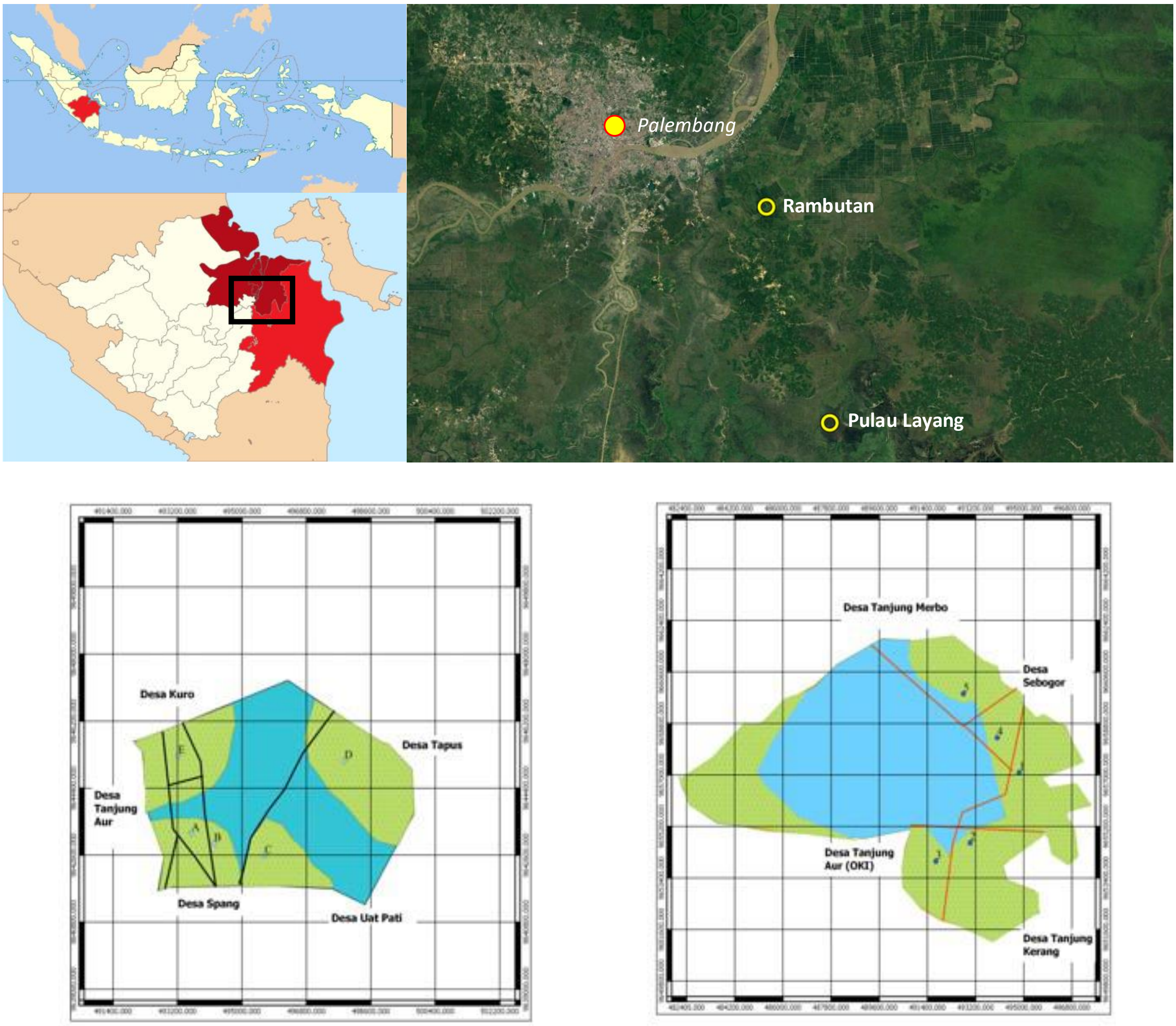
In the previous study, some swamp grasses, including *H. amplexicaulis (*Rostini et al. 2014**;** Muhakka et al. 2015), *I. rugosum* and *L. hexandra* (Ali et al. 2012) were identified. However, more swamp vegetation has not been identified. For example, *P. barbatum, C. digitatus, R. corymbosa* This study was conducted to identify the types and nutritional values of vegetation that could be used as sources of roughage feed for Pampangan buffaloes in South Sumatra. This information was important to support the productivity improvement of Pampangan buffaloes as germplasm in South Sumatra, Indonesia. In this study, some new swamp forages were found, and they were not stated in the previous study.

MATERIALS AND METHODS

Area study

This study was a descriptive study to assess the types and nutritional values of vegetation, which were dominant and palatable as sources of roughage feed for Pampangan buffaloes. Vegetation samples were taken from grazing areas of Pampangan buffaloes in Rambutan Village and Pulau Layang Village, South Sumatra, Indonesia (Figure 1) from April to Juni 2017. Vegetation samples for nutrient analysis were obtained by following procedures: (i) vegetation collection was done based on estimated growth age (young age, middle age, and old age based on physical appearance), (ii) collected samples of each vegetation was composited, and (iii) samples were chopped into small sizes, and then homogenized.

For each vegetation, 1 kg sample was taken randomly and sent to the laboratory for oven drying at 105ºC, until a constant weight was obtained and dry matter content was determined. Samples were then ground for nutrient content determination by using proximate and Van Soest analyses (Syarifuddin and Wahdi 2010). Sample analyses of crude protein, fiber, ether extract, and ash contents were conducted in Laboratory of Dairy Nutrition, Department of Nutrition and Feed Technology, Institut Pertanian Bogor (IPB), Bogor, Indonesia, while analyses of NDF, ADF, hemicellulose, cellulose, and lignin were conducted in Biotechnology Assessment Laboratory, Research Center for Biotechnology, Indonesian Institute of Sciences (LIPI), Cibinong, Bogor, Indonesia; and analysis of soil was conducted in Laboratory of Soil Chemistry, Biology, and Fertility, Department of Soil, Faculty of Agriculture, Sriwijaya University, Ogan Ilir, Indonesia.



A B

Figure 1. Research location in South Sumatra, Indonesia. A. Pulau Layang Village, Pampangan Sub-district, Ogan Komering Ilir District, South Sumatra. B. Rambutan Village, Rambutan Sub-district, Banyuasin District, South Sumatra, Indonesia (Muhakka et al. 2019)

Measured parameters

Soil analysis

Soil sampling is done in a composite manner at a depth of 0-20 cm. Taking the soil sample points is done by making a diagonal line in each zone and determining 5 soil sampling points to analyze chemical fertility (N, P, K) and physical fertility (texture, structure, and pH).

Plant materials

The sampling area is divided into five zones (A, B, C, D and E) and each zone consists of 10 observation points. Samples of each type of dominant and palatable forage vegetation are collected based on the estimated age of growth, namely young age, middle age, and old age by looking at their physical appearance. Samples of each type of vegetation that have been collected, are put together until homogeneous. Samples are finely chopped, mixed until homogeneous then randomly taken as much as 1 kg.

There are some species that are analyzed twice, in Pulau Layang and Rambutan because they appear in both areas, while the others are only analyzed once because they only appear in one area. For *Sesbania exasperata*, it is enough to know only its nutrient content from analysis of proximate, and the production of this grass is measly so that its potential to be buffalo's feed is measly as well, but it can be made as feed supplement. So, it is not analyzed for composition of fiber fractions (Table 3).

Proximate analysis

Crude protein, fiber, ether extract, and ash contents were determined based on the procedures of AOAC (1990). *Crude protein*. Nitrogen (N) content was determined by using a Kjeldahl method. In this analysis, sulphuric acid was treated with a catalyst and a heating process. The organic matter of samples was then oxidized by sulfuric acid, and nitrogen was changed into an ammonium sulfate form. The remaining sulfuric acid was neutralized by NaOH until the solution became basic. Ammonium sulfate was then distilled in an acid medium to obtain the quantitative amount of N. As the average protein contains 16% nitrogen, a factor 100%: 16% = 6.25 was used to obtain the value of crude protein (crude protein = N% x 6.25). *Fiber*. The filtered fat-free sample was used in fiber content determination. 1.25% sulfuric acid solution was added into the sample, and the mixture was heated for about 30 minutes before the residue was filtered. 1.25% NaOH solution was added into the precipitate, and the mixture was heated for about 30 minutes. The mixture was then filtered, and the precipitate was washed, dried, and weighed. This precipitate was burnt, and the ash was weighed. The difference between the weight of precipitate before it was burnt and the weight of the ash was referred to as fiber content. *Ether extract*. The dry matter sample was extracted with diethyl ether for 5 hours. At the end of the extraction process, ether evaporated and the remaining material was referred to as fat. *Ash*. The third part of the dry matter sample was weighed and burnt in a crucible at 550ºC for 8 hours.

Van Soest analysis

Neutral Detergent Fiber (NDF), Acid Detergent Fiber (ADF), hemicellulose, cellulose, and lignin contents were determined by using a Van Soest method (1982).

Neutral Detergent Fiber (NDF). One gram of sample was put in a beaker glass. 50 ml NDS solution was added into the beaker before the mixture was heated for an hour. The mixture was then filtered by using a vacuum pump and a filter glass which was previously weighed (b gram). The mixture was then washed with hot water and acetone before it was dried in an oven and let cool in a desiccator. Finally, it was weighed as c gram. NDF content was calculated by using the following formula:

$$\% \text{ NDF} = \frac{c-b}{a} \times 100\%$$

Acid Detergent Fiber (ADF). One gram of sample was put in a beaker glass. 50 ml ADS solution was added into the beaker before the mixture was heated for an hour. The mixture was then filtered by using a vacuum pump and a sintered glass filter which was previously weighed (b gram). The mixture was then washed with hot water and acetone before it was dried in an oven and let cool in a desiccator. Finally, it was weighed as c gram. Cellulose content was calculated by using the following formula:

$$\% \text{ cellulose} = \frac{c-d}{a} \times 100\%$$

Hemicellulose. Hemicellulose content was calculated as a difference between NDF and ADF contents as follows.

$$\% \text{ Hemicellulose} = \% \text{ NDF} - \% \text{ ADF}$$

Lignin. Cellulose residue (d gram) was burnt in a furnace at 500-600ºC for 3 hours. After that, it was left to cool and weighed (e gram). Lignin content was calculated by using the following formula:

$$\% \text{ Lignin} = \frac{d-e}{a} \times 100\%$$

Data analysis

The data obtained were used directly to describe the nutritional value of the swamp vegetation that could be used as a roughage source. These data were then combined with those of in vitro digestibility as the basis for concluding (Syarifuddin and Wahdi 2010).

RESULTS AND DISCUSSION

Soil analysis

Results of soil analysis showed that soil at the study site had a low fertility level and was highly acidic. It also had very high organic C and total N contents, medium level of exchangeable-K and N contents, very low Ca and Mg contents, medium P content, and very high CEC level (Table 1).

Table 1. Properties of soil at the study site

Parameter	Pulau Layang		Rambutan	
	Value	Remark	Value	Remark
pH H_2O (1 : 1)	5.10	Low	4.41	Very low
pH KCl (1 : 1)	4.39	Very acidic	3.99	Very acidic
Organic C (g/kg)	57.66	Very high	36.14	Very high
Total N (g/kg)	3.64	Very high	2.19	Very high
Available P/Bray I (mg/kg)	11.70	Medium	2.25	Very low
Exchangeable K (cmol/kg)	0.63	Medium	0.45	Medium
Na (cmol/kg)	0.65	Medium	0.65	Medium
Ca (cmol/kg)	1.95	Very low	0.73	Very low
Mg (cmol/kg)	0.45	Very low	0.32	Very low
CEC (cmol/kg)	65.25	Very high	43.50	Very high
Exchangeable Al (cmol/kg)	1.84		2.37	
Exchangeable H (cmol/kg)	0.74		0.88	
Texture:				
Sand (%)	47.08		46.64	
Ash (%)	31.11		27.18	
Clay (%)	21.81		26.18	

Nutrient contents of lowland swamp

Crude protein, fiber, ether extract, and ash nutrient contents of lowland swamp vegetation found in this study are listed in (Table 2). The NDF and ADF contents of vegetation found in this study were about 40.65-79.47% and 23.66-60.33%, respectively. Lowland swamp vegetation was found to have hemicellulose and cellulose contents ranging from 7.73 to 37.14% and 5.24 to 27.08%, respectively. Lignin contents of lowland swamp vegetation ranged from 14.84 to 43.09% (Table 3).

There are 19 species of forage found in Pampangan buffalo pasture that have potential to be used as food for Pampangan buffalo, consisting of 17 species of grasses and herbs and 2 species of legumes (Muhakka et al. 2019). There are dominant and palatable species of swamp lowland forage vegetation having potential as buffalo feed, namely *O. rupifogon*, *H. acutigluma*, and *H. amplexicaulis*, not dominant but palatable species such as *Hymenachne* sp. and *N. oleracea*; dominant but non-palatable grass species (buffalo does not like it) namely *P. barbatum*. This grass species would be eaten by the buffaloes if there were no other species to be eaten (Muhakka et al. 2019).

Discussion

Crude protein content

Results showed that the crude protein contents of swamp green vegetation ranged from 5.26% to 20.56% with the lowest value (5.26%) was found in *R. corymbosa* grass and the highest (20.56%) was found in *N. oleracea* legume. *C. digitatus* grass had the highest crude protein content (15.31%) (Table 2). This high nutritional value of *C. digitatus* was suspected as caused by the fact that most of this grass was found to grow in the area of buffalo pens where the soil was rich in organic matter. However, the growth of this grass was not dominant as it mostly occurred in rainy seasons.

Hymenachne amplexicaulis, *O. rupifogon*, *H. acutigluma*, and *E. dulcis* were found as the dominant palatable grasses containing 12.00, 10.41, 10.96, and 8.22% crude protein, respectively. Results of this study were not too different from those obtained by Rostini et al. (2014), who reported that *H. amplexicaulis* and *L. hyssopifolia* had protein contents of 10.88 and 15.92%, respectively. Crude protein (CP) contents of these swamp grasses in Pulau Layang and Rambutan Villages were closed to those of prime grasses including 9.11-12.8% CP of *P. purpureum* (Santos et al. 2013; Dahlan and Iskandar 2013; Rahman et al. 2014), 12.4% CP of *P. purpureum* grass hay, 11.1% CP of *P. purpureum* grass silage, 11.4% CP of *P. purpureophoides* grass hay, and 10.2% CP of *P. purpureophoides* grass silage (Santoso and Hariadi 2008). Other vegetation even had higher CP contents including *H. acutigluma* with 10.96% CP, *C. roseus* 15.20%, *N. lotus* 13.22%, *L. hyssopifolia*) 12.07%, *C. digitatus* 15.31%, and *H. amplexicaulis* [R] 12.0% (Table 2). CP contents of vegetation in this study were also higher than those of natural grasses found in coffee plantation areas (6.95%) and pastoral areas (6.65%) in Wulanggitang Subdistrict, East Flores District, East Nusa Tenggara Province, Indonesia as reported by Kleden et al. (2015). Meanwhile, CP content of grasses in lowlands was 8.41% (Maswada and Elzaawely 2013; Rochana et al. 2016).

This high protein content was suspected to be caused by the fact that soil organic C and total N contents in the study site were also high, namely 36.14-57.66 and 2.19-3.64 $g.kg^{-1}$, respectively (Table 1). Soil organic C and total N contents affected protein content in plants. Four swamp grasses/herbs including *C. digitatus*, *C. roseus*, *N. lotus*, and *L. hyssopifolia* and a legume, *N. oleracea* were found to be the lowland swamp vegetation having the highest N contents of 15.31,15.20, 13.22, 12.07, and 20.56%, respectively.

Table 2. Crude protein, fiber, ether extract, and ash contents (%) of lowland swamp vegetation

Latin name	Family	Origin (village)	Local name	Crude protein	Fiber	Ether extract	Ash
Catharanthus roseus	Apocynaceae	Pulau Layang	Tapak dara	15.20	11.18	1.29	12.53
Cyperus digitatus	Cyperaceae	Rambutan	Kasuran	15.31	14.76	1.42	25.19
Digitaria fuscescens	Poaceae	Rambutan	Kerak maling/pasiran	12.00	15.64	1.24	16.26
Eichhornia crassipes	Pontederiaceae	Pulau Layang	Eceng gondok	8.61	20.66	0.84	14.22
Eleocharis dulcis-P	Cyperaceae	Pulau Layang	Purun tikus	8.22	25.72	0.48	15.13
Eleocharis dulcis-R	Cyperaceae	Rambutan	Purun tikus	6.63	24.52	1.69	10.24
Hymenachne acutigluma-P	Poaceae	Rambutan	Kumpai tembaga	10.96	23.73	1.77	10.30
Hymenachne acutigluma-R	Poaceae	Pulau Layang	Kumpai tembaga	6.86	30.26	2.22	7.88
Hymenachne amplexicaulis-P	Poaceae	Pulau Layang	Kumpai minyak	9.21	21.91	2.82	13.96
Hymenachne amplexicaulis-R	Poaceae	Rambutan	Kumpai minyak	12.00	15.64	1.24	16.26
Hymenachne sp.	Poaceae	Pulau Layang	Kumpai merah	8.52	21.20	1.30	12.88
Ipomoea aquatica	Convolvulaceae	Pulau Layang	Kangkung merah	8.95	14.34	2.24	10.39
Leersia hexandra	Poaceae	Pulau Layang	Bento rayap	5.35	27.57	2.06	5.63
Ludwigia hyssopifolia	Onagraceae	Pulau Layang	Cecengkehan	12.07	11.01	1.66	9.09
Neptunia olerancia	Fabaceae	Pulau Layang	Kemon air	20.56	15.03	2.92	7.31
Nymphaea lotus	Nymphaeaceae	Pulau Layang	Telepuk gajah	13.22	11.45	2.84	10.30
Oryza rupifogon-P	Poaceae	Pulau Layang	Kumpai padi	7.93	23.30	1.60	16.25
Oryza rupifogon-R	Poaceae	Rambutan	Kumpai padi	10.41	21.59	2.49	11.92
Polygonum barbatum	Poaceae	Pulau Layang	Are bolong	7.53	16.60	1.57	8.40
Rhynchospora corymbosa	Cyperaceae	Pulau Layang	Berondong	5.26	22.27	1.48	14.84
Sesbania exasperata	Fabaceae	Rambutan	Mutiara	18.27	11.22	1.86	19.47

Note: P: Pulau Layang Village; R: Rambutan Village

Table 3. Composition of fiber fractions of green vegetation in lowland swamp: NDF, ADF, hemicellulose, cellulose, and lignin (%).

Latin name	Family	Origin (village)	NDF	ADF	Hemi-cellulose	Cellulose	Lignin
Catharanthus roseus	Apocynaceae	Pulau Layang	47.79	39.67	8.12	16.96	22.71
Cyperus digitatus	Cyperaceae	Rambutan	58.90	36.93	21.97	5.24	31.68
Digitaria fuscescens	Poaceae	Rambutan	65.43	33.56	31.87	12.11	21.45
Eichhornia crassipes	Pontederiaceae	Pulau Layang	62.77	41.83	20.94	10.22	31.60
Eleocharis dulcis-P	Cyperaceae	Pulau Layang	69.57	49.83	19.74	21.80	28.04
Eleocharis dulcis-R	Cyperaceae	Rambutan	75.73	54.91	20.82	19.71	35.20
Hymenachne acutigluma-P	Poaceae	Pulau Layang	75.89	50.60	25.29	12.25	38.34
Hymenachne acutigluma-R	Poaceae	Rambutan	64.72	46.38	18.34	16.01	30.37
Hymenachne amplexicaulis-P	Poaceae	Pulau Layang	65.31	38.92	26.39	8.29	30.63
Hymenachne amplexicaulis-R	Poaceae	Rambutan	65.32	39.45	25.87	9.75	28.67
Hymenachne sp.	Poaceae	Pulau Layang	60.14	28.40	31.74	8.64	19.76
Ipomoea aquatica	Convolvulaceae	Pulau Layang	41.40	26.17	15.23	6.32	19.85
Leersia hexandra	Poaceae	Pulau Layang	79.47	42.33	37.14	25.88	33.92
Ludwigia hyssopifolia	Onagraceae	Pulau Layang	40.64	32.91	7.73	8.39	24.52
Neptunia olerancia	Fabaceae	Pulau Layang	62.31	45.44	16.87	27.08	18.36
Nymphaea lotus	Nymphaeaceae	Pulau Layang	46.05	23.66	22.39	8.82	14.84
Oryza rupifogon-P	Poaceae	Pulau Layang	71.13	60.33	10.80	17.23	43.09
Oryza rupifogon-R	Poaceae	Rambutan	65.49	46.19	19.30	14.96	31.24
Polygonum barbatum	Poaceae	Pulau Layang	61.27	48.46	12.81	20.28	28.18
Rhynchospora corymbosa	Cyperaceae	Pulau Layang	65.29	44.64	20.65	16.08	28.56

Note: P: Pulau Layang Village; R: Rambutan Village

Fiber contents

Fiber contents of lowland swamp green vegetation ranged from 11.01 to 30.26%, with the lowest content found in *L. hyssopifolia* and the highest in *H. acutigluma* P. Four vegetation including *L. hyssopifolia*, *C. roseus*, *S. exasperata*, and *N. lotus* were found to have the lowest fiber contents of 11.01, 11.18, 11.22, and 11.45%, respectively (Table 2). These results were almost similar to those found by Ali et al. (2012) who reported that the fiber contents of roughage in a pasture ranged from 7.20 to 34.98%. These researchers found that the fiber content of *Leersia hexandra* was 27.40% which was very close to that (27.57%) of the same vegetation in this study. Meanwhile, Rostini et al. (2014) reported that the fiber contents of swamp vegetation in South Kalimantan ranged from 14.84 to 29.35% with the lowest content found in *Paspalum* sp. and the highest in *L. adscendens*. These figures were lower than those found by Kleden et al. (2015) who revealed that nature grasses in a coffee plantation area and pasture in Wulanggitang, East Flores contained 34.57 and 35.59% of fiber. They also found that the lowest fiber content was found in *L. peploides* and the highest in *I. rugosum*. Fiber contents reported by Kleden et al. (2015) were higher than the results reported by Ahmed et al. (2013) with a fiber content of 29.32% in *D. aegyptium* plants. A previous study showed that fermented *I. rugosum*, *H. amplexicaulis*, and *O. rufipogon* had fiber contents of 29.27, 29.57, and 33.07%, respectively (Muhakka et al. 2015).

The fiber content of *E. crassipes* in this study (20.66%) was lower than those found by Hossain et al. (2015), Tham and Uder (2015), and Make et al. (2016). In addition, the fiber content of *E. crassipes* in this study was lower than those of *Azolla*, another water plant, ranging from 13.19 to 16.54% (Kathirvelan et al. 2015; Anitha et al. 2016) and 9.25 to 13.25% (Ahmed et al. 2016). These fiber contents of *Azolla* equaled to those of *L. hyssopifolia* (11.01%), *C. roseus* (11.18%), *S. exasperata* (11.22%), *N. lotus* 11.45%, and *I. aquatica* (14.34%) found in this study. Fiber contents of swamp green vegetation found in this study indicated that they were potential to be used as feed for Pampangan buffaloes.

Ether extract contents

Lowland swamp vegetation in this study was found to have ether extract (EE) contents of about 0.48-2.92%. The lowest EE content was found in *E. dulcis*, while the highest was found in *N. oleracea*. Four vegetation of lowland swamp including *N. lotus* (2.84% EE), *H. amplexicaulis (*2.82% EE), *O. rufipogon* (2.49% EE), and *I. aquatica* (2.24% EE) were revealed to have the highest ether extract contents (Table 2). Results of this study were lower than those found by Rostini et al. (2014), reporting about 0.61-3.67% of EE contents in swamp vegetation in South Kalimantan with the lowest found in *L. hyssopifolia* and the highest in *O. rufipogon*. EE contents of lowland swamp vegetation were 1.40-1.91% for grasses and 1.36-2.95% for legumes (Asep et al. 2012) and those of grasses in a pasture for buffaloes in Pulau Moa were 1.95-2,41% (Eoh 2014). In other studies, grasses in a natural pasture in North *Lore*, Poso District had EE contents of 2.12-2.34% (Damry 2009) and those in Sabana Timur Barat pasture in the rainy season to the end of dry season had an average EE content of 1.91% (Manu 2013). A study by Se'u et al. (2015) revealed an EE content of 1.07% in grasses in a pasture in Timor Tengah Selatan District, Indonesia. Another work by Kleden et al. (2015) showed that vegetation in a natural pasture and a coffee plantation area had EE contents of 1.23 and 1.35%, respectively.

Vegetation found in this study had EE contents equaled to those of prime grasses including *P. purpureum* grass and *P. purpureophoides* grass preserved in the form of hay and silage. *P. purpureum* grass hay and silage had EE contents of 1.9 and 2.6%, respectively, while those of *P. purpureophoides* grass had EE contents of 1.6 and 2.4%, respectively (Santoso and Hariadi 2008; Ukpabi et al. 2015). EE contents of some species of ruminant roughages were found to be about 1.2-4.1% (Ahmed et al. 2013). Dominant swamp roughages including *H. amplexicaulis* and *O. rufipogon* had EE contents of 2.82 and 2.49%, respectively and they were palatable and potential to be used as feed for Pampangan buffaloes.

Ash contents

Ash contents of green vegetation in lowland swamp ranged from 5.63 to 25.19%. Four types of vegetation with the highest ash contents included *C. digitatus* (25.19%), *S. exasperata* (19.47%), *H. amplexicaulis* (16.26%), and *O. rufipogon* [P] (16.25%). Meanwhile, *L. hexandra* was found to have the lowest ash content of 5.63% (Table 2). Ash contents of vegetation found in this study were higher than those of swamp vegetation in South Kalimantan of 2.18-3.28% during the high tidal season and 3.23-9.83% during the low tidal season (Rostini et al. 2014). *P. purpureum* grass was indicated to have varied ash contents of 4.4% (Dahlan and Iskandar 2013), 0.95-1.1% (Ukpabi et al. 2015), 9.59% (Nuhuyanan 2010), and 18% (Araica et al. 2009). Meanwhile, the ash content of grasses in lowland areas ranged from 6.32 to 8.91% (Richmond et al. 2015; Mako et al. 2016; Norman et al. 2013; Maswada et al. 2013). Alam et al. (2015) found that *B. mutica* had an ash content of 4.20-4.89% and rice straw had 6.63%.

Roughages were found to have average ash contents of 7.28% in a pasture for buffaloes in Pulau Moa (Eoh 2014), 9.82-10.14% in Lore Utara, Poso District (Damry 2009), 11.51% in a pasture during the rainy season until the end of dry season in Sabana Timur Barat *(*Manu 2013), and 8.11 and 8.22% in a natural pasture and a coffee plantation area, respectively (Kleden et al. 2015). Differences in these ash contents were suspected to be caused by differences in plant species (internal factor) and environmental differences, particularly seasonal differences (external factor). In a dry season, pH levels in lowland swamp areas were found to be 3.9-4.8, causing a decreased supply of nutrients, especially total N and K, to the soil. This decreased supply of nutrients led to lowered nutrients contained in plants (Rostini et al. 2014). This was in line with what was stated by Gutteridge and Shelton (1994) that nutrient content in plants was affected by soil nutrient content. In addition, in acidic soil conditions, activities of Fe, Al, and Mn increased which might cause toxicity in plants (Tjondronegoro and Gunawan 2000).

NDF and ADF contents

Neutral Detergent Fiber (NDF) depicts plant cell walls consisting of hemicellulose, cellulose, and lignin. NDF is part of fiber that is not dissolved in neutral detergent representing the component of fiber not dissolving in plant cell wall materials. NDF content of a feed affects the ability of ruminants to consume the feed. Acid Detergent Fiber (ADF) represents parts of the plant cell wall bond to cellulose and lignin. ADF content is related to energy content and higher ADF content results in lowered digestible energy content (Van Soest 1982).

The NDF and ADF contents of vegetation found in this study were about 40.65-79.47% and 23.66-60.33%, respectively. Lowest NDF contents were found in *L. hyssopifolia* (40.65%), *I. aquatica* (41.40%), *N. lotus (*46.05%), and *C. roseus* (47.79%). In contrast, highest

NDF content of 79.47% was found in *L. hexandra*. Lowest ADF contents were found in *N. lotus (*46.05*%*), *I. aquatica* (26.17%), *Hymenachne* sp. *(*28.40%), *L. hyssopifolia* (32.91%). Meanwhile, the highest ADF content of 60.33% was found in (*O. rufipogon* [P] *(*Table 3). NDF and ADF contents of vegetation found in this study were lower than those of Asep et al. (2012) who reported that the NDF contents of swamp green vegetation in a pasture for buffaloes were about 91.73-93.45% in grasses and 68.11-90.93% in legumes and the ADF content of grasses was 51.6-86.8%. It was shown in other studies that NDF and ADF contents of roughages in a pasture during the rainy season to the end of the dry season in Sabana Timur Barat were on average 65.9 and 43.29%, respectively (Manu 2013). Vegetation in a natural pasture and a coffee plantation area had NDF contents of 74.89 and 72.37% and ADF contents of 57.22 and 55.15%, respectively (Kleden et al. 2015). Meanwhile, swamp vegetation in South Kalimantan had average NDF and ADF contents of 55.97 and 37.87%, respectively, during the high tidal season and 81.44 and 60.86% respectively, during the low tidal season (Rostini et al. 2014).

NDF and ADF contents of roughages in the BPTU-HPT Padang Mengatas area were found to be 75.62 and 45.96%, respectively in the rain season and 69.35 and 38.66%, respectively in the dry season (Muhajirin et al. 2017). NDF and ADF contents of *E. crassipes* in this study were 62.77 and 41.83%, respectively. These figures were close to those of *E.crassipes* plants studied by Tham (2015) with NDF and ADF contents of 63.9 and 34.68% and by Tham and Uden (2015) with NDF and ADF contents of 52.1 and 30.7%, respectively. Other studies conducted by Ahmed et al. (2016), Anitha et al. (2016), and Nampoothiri (2017) showed that *Azolla* sp. had NDF and ADF contents of 53.8-54.85% and 36.57-37.0%, respectively. Meanwhile, NDF and ADF contents of *P. purpureum* were found to be 55.8 and 46.5% (Dahlan and Iskandar 2013) and 84.25 and 64.07% (Nuhuyanan 2010), respectively. These figures equaled to the NDF and ADF contents of *H. acutigluma* (64.72 and 46.38%), *H. amplexicaulis* (65.31 and 38.92), and *P. barbatum* (61.27 and 48.46%). This indicated that lowland swamp vegetation had fiber fraction nutritional quality which was not less than that of prime grasses including *P. purpureum* and *P. purpureophoides*.

In this study, NDF and ADF contents of lowland swamp vegetation were 40.65-79.47% and 23.66%-60.33%, respectively. These figures were still within the ranges of NDF and ADF contents of prime grasses such as *P. purpureum* which had NDF and ADF contents of 55.8 and 46.5% (Dahlan and Iskandar 2013) and 84.25 and 64.07% (Nuhuyanan 2010), respectively. In the rumen, NDF degradation is higher than that of ADF as NDF contains hemicellulose fraction which is more soluble (Church and Pond 1986). NDF content has a negative correlation with its degradation rate (Varga et al. 1983) and higher NDF content decreases dry matter digestibility of feed (NRC 1988). Cellulose is an ADF component that is easy to digest while lignin is hard to digest as it contains double bonds. Higher lignin content decreases feed digestibility (Sutardi et al. 1980).

Hemicellulose and cellulose contents

Lowland swamp vegetation was found to have hemicellulose and cellulose contents ranging from 7.73 to 37.14% and 5.24 to 27.08%, respectively. Four green vegetation with the highest hemicellulose contents were *L. hexandra*) (37.14%), *D. fuscescens* (31.87%), *Hymenachne* sp. (31.74%), and *H. amplexicaulis (*26.39%). In contrast, the lowest hemicellulose content was found in *L. hyssopifolia* (7.73%). Highest cellulose contents were found in (*N. oleracea (*27.08%), *L. hexandra* (25.88%), *E. dulcis* (21.80%), and *P. barbatum (*20.28%). Meanwhile, *C.digitatus* had the lowest cellulose content of 5.24% (Table 3). Results of this study were in line with those of a study conducted by Asep et al. (2012) who reported the hemicellulose and cellulose contents of lowland swamp green vegetation ranging from 7.89 to 31.55% and 30.85 to 63.35%, respectively. They also found that *O. rufipogon* had 31.55% hemicellulose content which was higher than those of 10.80-19.30% in this study (Table 4). Swamp vegetation in South Kalimantan had hemicellulose contents of 0.65-25.85% in high tidal season and 5.37-40.09% in low tidal season. Cellulose contents in high and low tidal seasons were about 20.07-34.03% and 7.90-38.31%, respectively (Rostini et al. 2014). Various water plants including *Azolla*, which was used as animal feed, had hemicellulose and cellulose contents of 10.20 and 12.76% (Nampoothiri 2017), 1.15-10.20% and 12.76% (Nampoothiri 2017), respectively. Roughages in BPTU-HPT Padang Mengatas, Indonesia had hemicellulose and cellulose contents of 29.79 and 33.62% in the rain season and 30.69 and 31.64% in the dry season, respectively (Muhajirin et al. 2017). *P. purpureum* was found to contain 21.18% hemicellulose and 43.32% cellulose (Nuhuyanan 2010) and 35.3% cellulose (Dahlan and Iskandar 2013). In a study conducted by Archimede et al. (2010), hay was found to have 37.7% hemicellulose and 35.7% cellulose. Based on the above findings, it was suggested that hemicellulose (7.73-37.14%) and cellulose (5.24-27.08%) contents of lowland swamp vegetation in this study were within normal ranges and this vegetation was potential to be used as feed for Pampangan buffaloes.

Lignin contents

Lignin contents of lowland swamp vegetation ranged from 14.84 to 43.09%. Four vegetation including *N. lotus*, *N. oleracea*, *Hymenachne* sp., and *I. aquatica* were found to have the lowest lignin contents of 14.84, 18.36, 19.76, and 19.85%, respectively, while the highest lignin content of 43.09% was found in *O. rufipogon* [P] (Table 3). Lignin contents in this study were higher than that obtained by Rostini et al. (2014) who reported the lignin contents of swamp vegetation in South Kalimantan were about 2.8-17.59% in high tidal season with that of *H. amplexicaulis* as the lowest and that of *O. rufipogon* as the highest and 10.06-61.12% in low tidal season with that of *O. rufipogon* as the lowest and that of *H. amplexicaulis* as the highest. Lignin contents of *O. rufipogon*[R] (31.24%) and *O. rufipogon*[P] (43.09%), *L. hexandra* (33.92%), and *E. crassipes* (31.60%) (Table 3) found in this study were higher those of (18.27%) and *L. hexandra* (17.96%) found by Asep et al. (2012) and *E. crassipes* (8.17%) found by Tham (2015). In other studies, *Azolla* was found to have lignin contents of 5.7% (Ahmed et al. 2016) and 28.24% (Nampoothiri 2017). Meanwhile, lignin contents of *P. purpureum* grass were found to be 15.37% (Nuhuyanan 2010) and 11.2% (Dahlan and Iskandar 2013).

Differences in lignin contents in green vegetation are suspected to be caused by differences in plant species, plant ages, and environmental factors including seasons (rain or dry season), tidal seasons, and fertility levels of the soil where the vegetation grow. In cell walls, cellulose is a bond with hemicellulose and lignin. The animals cannot digest lignin and its molecular structure is different from other carbohydrates as it contains carbon and nitrogen of only 1-5%. Hemicellulose consists of pentose, hexose, uronic acid, and pectin substance. Pectin is a carbohydrate that is composed of uronic acid, galactose, arabinose, xylose, and methanol. Cellulose is degradable by microorganisms and functions as the source of volatile fatty acids. Young grasses (roughages) contain less than 5% lignin and 80% of their cellulose is degradable. On the contrary, in old roughages, lignin content may reach up to 10% causing a decrease in cellulose digestibility by up to 50% (Prawirokusumo 1994).

Based on the results of the study, it was concluded that: (i) the highest protein (20.56%) and crude fat (2.92%) contents were found in *N. oleracea*. The highest ash content (25.19%) was found in *C. digitatus*, while the lowest (11.01%) was found in *L. hyssopifolia*. The lowest NDF content (40.64%) was found in *L. hyssopifolia* and the highest hemicellulose content (37.14%) was found in *L. hexandra*. *N. lotus* had the lowest ADF (23.66%) and lignin (14,84%) contents. *N. olerancia* contained the highest cellulose level of 27.08%. (ii) The best nutritional values were found in *C. digitatus* and *L. hyssopifolia*. (iii) Dominant and palatable swamp roughages with good nutrient contents included *H. acutigluma*, *H. amplexicaulis*, *O. rufipogon*, *P. barbatum*, and *E. dulcis*.

ACKNOWLEDGMENTS

The author expresses his deepest gratitude to the Rector of Sriwijaya University through the Chair of the Institute for Research and Community Services funding this research in accordance with the Competitive Leading Research Contract of Sriwijaya University Number: 988/UN9.3.1/PP/2017, dated 21 July 2017.

REFERENCES

Ahmed HA, Ganai A.M, Beigh YA, Sheikh GG, Reshi PA. 2016. Performance of growing sheep on *Azolla* based diets. Indian J Anim Res 50 (5): 721-724.

Alam MR, Haque MM, Sumi KR, Ali MM. 2015. Proximate composition of para-grass (*Brachiaria mutica*) produced in integrated fish-fodder culture system. Bangladesh J Anim Sci 44 (2): 113-119.

Ali AIM, Sandi S, Muhakka, Riswandi. 2012. Kualitas hijauan pakan di rawa lebak padang penggembalaan kerbau pampangan. Proc InSINAS 2012: 307-312. [Indonesian]

Anitha KC, Rajeshwari YB, Prasanna SB, Shree JS. 2016. Nutritive evaluation of *Azolla* as livestock. J Exp Biol Agric Sci 4 (6): 670-674.

AOAC. 1990. Official Methods of Analysis. 15th ed., Association of Official Analytical Chemists, Washington, DC.

Araica BM, Sporndly E, Sanchez NR, Norell L, Sporndly R. 2009. Silage quality when Moringa oleifera is ensiled in mixtures with elephant grass, sugar cane and molasses. Grassl For Sci 64: 364-373.

Archimede H, Gonzales-Garcia E, Despois P, Etienne T, Alexandre G. 2010. Substitution of corn and soybean with green banana fruits and *Gliricidia sepium* forage in sheep fed hay-based diets: effects on intake, digestion and growth. J Anim Physiol Anim Nutr 94 (2010): 118-128.

BPS. 2010. Luas lahan rawa di Indonesia. Badan Pusat Statistik & Direktorat Jendral Tanaman Pangan, Departemen Pertanian, Jakarta. [Indonesian]

BPS. 2014. Sumatera Selatan dalam Angka 2014. Badan Pusat Statistik) Provinsi Sumatera Selatan, Palembang. [Indonesian]

Brazle FK, Kilgore GI, Fauzett MR. 2000. Effect of season on grazing native-grass pastures. Prof Anim Sci 16: 15-28.

Church DC, Pond WG. 1986. Digestive Animal Physiology and Nutrition. 2nd. Prentice Hall, Englewood Cliff, New York.

Dahlan I, Iskandar MNZ. 2013. Use of plantain peels (*Musa paradisiaca*) as a fibrous feed substitute for napier grass (*Pennisetum purpureum*) in rusa deer (*Cervus timorensis*) ratio under captivity. J Anim Sci 3 (9): 472-480.

Damry. 2009. Produksi dan kandungan nutrisi hijauan padang penggembalaan alam di Kecamatan Lore Utara Kabupaten Poso. J Agrol 16 (4): 296-300. [Indonesian]

Dinas Peternakan Sumatera Selatan. 2014. Statistik Peternakan Provinsi Sumatera Selatan Tahun Anggaran 2015. Dinas Peternakan Sumatera Selatan, Palembang. [Indonesian]

Eoh M. 2014. Kapasitas tampung dan komposisi zat-zat makanan padang penggembalaan ternak kerabau di Pulau Moa. Agrinimal 4 (2): 77-82.

Gutteridge RC, Shelton HM. 1994. The Role of Forage Tree Legumes in Cropping and Grazing System. FAO, Rome, Italy.

Hossain MdE, Sikder H, Kabir MdH, Sarma SM. 2015. Nutritive value of water hyacinth (*Eichhornia crassipes*). Online J Anim Feed Res 5 (2): 40-44.

Kathirvelan C, Banupriya S, Purushothaman MR. 2015. *Azolla*-an alternate and sustainable feed for livestock. Intl J Sci Environ 4 (4): 1153-1157.

Kleden MM, Ratu MRD, Randu MDS. 2015. Kapasitas tampung hijauan pakan dalam areal perkebunan kopi dan padang rumput alam di Kabupaten Flores Timur Nusa Tenggara Timur. J Zootek 35 (2): 340-350. [Indonesian]

Mako AA, Akinwande VO, Anurudu NF, Ogunwole OA. 2016. Evaluation of nutritive value of water hyacinth (*Eichhornia crassipes*) and guinea grass (*Panicum maximum*) mixture as animal feed in the tropics. 2016. Bull Anim Hlth Prod Afr 64: 463-473.

Manu AE. 2013. Produktivitas padang penggembalaan sabana Timor Barat. J Pastura 3 (1): 25-29. [Indonesian]

Maswada HF, Elzaawely AA. 2013. Nutritive value of *Stipagrostis lanata* (Forssk.) de Winder as a feed for livestock. Asian J Crop Sci 5 (2): 216-221.

Muhajirin, Despal, Khalil. 2017. Pemenuhan kebutuhan nutrien sapi potong bibit yang digembalakan di Padang Mengatas. Buletin Makanan Ternak 104 (1): 9-20. [Indonesian]

Muhakka, Suwignyo RA, Budianta D, Yakup. 2019. Vegetation analysis of no-tidal swampland in South Sumatra, Indonesia and its carrying capacity for Pampangan buffalo pasture. Biodiversitas 20 (4): 1077-1086.

Muhakka, Wijaya A, Ammar M. 2015. Nutritional dried matter, crude protein and crude fiber on lowland tidal grass fermented by probiotic microorganisms for use Bali cattle feed. J Anim Prod 17 (1): 24-29.

Mulyani A, Sarwani M. 2013. Karakteristik dan potensi lahan sub optimal untuk pengembangan pertanian di Indonesia. J Sumber Daya Lahan 7 (1): 47-55. [Indonesian]

Nampoothiri VM. 2017. Aquatic plants and marine waste as animal feed. Sch J Agric Vet Sci 4 (6): 249-254.

Norman HC, Master DG, Barrentt-Lennard EG. 2013. Halophytes as forage in saline landscapes: Interaction between plant genotype and environment change their feeding value to ruminants. Environ Exp Bot 92 (2013): 96-109.

NRC. 1988. Nutrition Requirement of Beef Cattle. 6th rev ed. National Research Council, Washington, DC.

Nuhuyanan LE. 2010. Pengaruh pemberian wafer rumput gajah dengan perekat fermented moter liquor (FML) dan tetes (molasses) terhadap konsumsi pakan, kecernaan zat-zat makanan dan kenaikan berat badan sapi bali jantan. J Ilmu Peternakan 5 (2): 111-117. [Indonesian]

Prawirokusumo S. 1994. Ilmu Gizi Komperatif. BPFE, Yogyakarta. [Indonesian]

Rahman MM, Abdullah RB, Wan Khadijah WE, Nakagawa T, Akashi R. 2014. Feed intake and growth performance of goats offered Napier grass (*Pennisetum purpureum*) supplemented with concentrate pellet and soya waste. Sain Malaysiana 43 (7): 967-971.

Richmond AS, Wylie ARG, Laidlaw AS, Lively FO. 2015. Methane emissions from beef cattle grazing on semi-natural upland and improved lowland grasslands. Animal 9 (1): 130-137.

Rostini T, Abdullah L, Wiryawan KG, Karti PDMH. (2014). Production and nutrition potency of swamp local forage in South Kalimantan as ruminant feed. Glob J Anim Sci Livestock Prod Anim Breed 2 (2): 107-113.

Santoso dan Hariadi BTj. 2008. Komposisi kimia, degradasi nutrien dan produksi gas metana in vitro rumput tropika yang diawetkan dengan metode silase dan hay. J Media Peternakan 31 (2): 128-137.

Se’u VE, Karti PDMH, Abdullah L. 2015. Botanical composition, grass production, and carrying capacity of pasture in Timor Tengah Selatan District. J Media Peternakan 38 (3): 176-182.

Sutardi T, Pratiwi SH, Adnan A, Nuraini S. 1980. Peningkatan pemanfaatan jerami padi melalui hidrolisa basa, suplementasi urea dan belarang. Buletin Makanan Ternak No. 6, Balai Besar Penelitian Veteriner, Bogor. [Indonesian]

Tham HoT, Uden P. 2015. Effect of freshwater Hyacinth (*Eichhornia crassipes*) on intake and digestibility in cattle fed rice straw and molasses-urea cake. Nova J Eng Appl Sci 4 (1): 1-8.

Tham HoT. 2015. Utilisation of water hyacinth as animal feed. Nova J Eng Appl Sci 4 (1): 1-6.

Tjondronegoro AD, Gunawan A. 2000. Beberapa jenis gulma di lahan pasang surut pada tingkat kemasaman tanah yang berbeda. Pros. Seminar Nasional: P. 247-254. [Indonesian]

Van Soest PJ. 1982. Nutritional Ecology of the Ruminant: Ruminant Metabolism, Nutritional Strategies the Cellulolytic Fermentation and the Camisthy of Forages and Palm Fiber. Cornell University, O & B Books Inc., USA.

Varga GA, Hoover WH. 1983. Rate and extent of NDF of feedstuff in-situ. J Dairy Sci 66: 2109.