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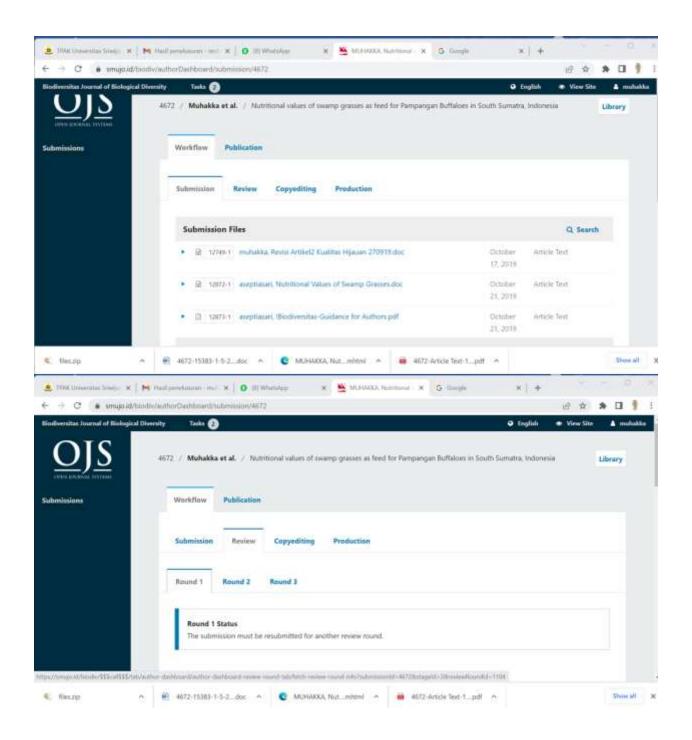
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Nutritional Values of Swamp Grasses as Feed for Pampangan Buffaloes in South Sumatera Indonesia

Author(s) name:

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Place and date:

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

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12 Abstract. This study was aimed at determining the types and quality of vegetations in swamp area which could be used as sources of 13 roughage for Pampangan buffaloes in South Sumatera. In this descriptive study. Results showed that, the highest crude protein and 14 ether extract contents, 20.56 and 2.92%, respectively were found in Kemon air (Neptunia olerancia). The highest ash content of 15 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 16 rayap(Leersia hexandra). The lowest ADF (23.66%) and lignin (14,84%) contents were found in Telepuk gajah (Nymphaea lotus). 17 18 Kemon air (Neptunia olerancia) was found to have the lowest content (27.08%) of cellulose. It was concluded that the swamp 19 vegetations found in this study consisted of 17 types of grasses (89.47%) and 2 types of legumes (10.53%). Kasuran (Cyperus 20 digitatus) and Cecengkehan (Ludwigia hyssopifolia) were found to have the best nutritional values. Dominant and palatable 21 vegetations with good nutritional values which were potential to be used as sources of roughage for Pampangan buffaloes were Kumpai 22 tembaga (Hymenachne acutigluma), Kumpai padi (Oryza rupifogon), Kumpai minyak (Hymenachne amplexicaulis, Are bolong 23 (Polygonum barbatum), and Purun tikus (Eleocharis dulcis).

24 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°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).



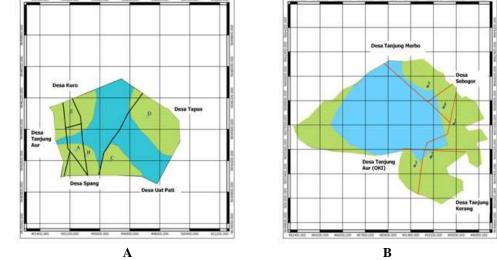


Figure 1. Research location in South Sumatera, Indonesia, **A.** Pulau Layang Village, Pampangan Sub-district, Ogan Komering Ilir District, South Sumatra, **B.** Rambutan Village, Rambutan Sub-district, Banyuasin District, South Sumatra (Muhakka et al., 2019)

67 **Measured parameters**

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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 70 a catalyst and a heating process. The organic matter of samples was then oxidized by sulfuric acid and nitrogen was 71 changed into an ammonium sulfate form. The remaining sulfuric acid was neutralized by NaOH until the solution 72 became basic. Ammonium sulphate was then distilled in an acid medium to obtain the quantitative amount of N. As 73 74 the average protein contains 16% nitrogen, a factor 100% : 16% = 6.25 was used to obtain the value of crude protein (crude protein = $N\% \times 6.25$). 75
- 76 2. Fiber. Filtered fat-free sample was used in fiber content determination. 1.25% sulfuric acid solution was added into 77 the sample and the mixture was heated for about 30 minutes before the residue was filtered. 1,25% NaOH solution was 78 added into the precipitate and the mixture was heated for about 30 minutes. The mixture was then filtered and the 79 precipitate was washed, dried, and weighed. This precipitate was burnt and the ash was weighed. The difference 80 between the weight of precipitate before it was burnt and the weight of the ass was referred to as fiber content.
- 81 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. 82
- 83 4. Ash. The third part of dry matter sample was weighed and burnt in a crucible at 550°C for 8 hours.

Van Soest Analysis

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

87 1. Neutral Detergent Fiber (NDF). a gram of sample was put in a beaker glass. 50 ml NDS solution was added into the 88 beaker before the mixture was heated for an hour. The mixture was then filtered by using a vacuum pump and a filter 89 glass which was previously weighed (b gram). The mixture was then washed with hot water and acetone before it was 90 dried in an oven and let cool in a desiccator. Finally, it was weighed as c gram. NDF content was calculated by using 91 the following formula: 92

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

95 2. Acid Detergent Fiber (ADF). a gram of sample was put in a beaker glass. 50 ml ADS solution was added into the 96 beaker before the mixture was heated for an hour. The mixture was then filtered by using a vacuum pump and a 97 sintered glass filter which was previously weighed (b gram). The mixture was then washed with hot water and acetone 98 before it was dried in an oven and let cool in a desiccator. Finally, it was weighed as c gram. Cellulose content was 99 calculated by using the following formula:

103 4. Hemicellulose. Hemicellulose content was calculated as a difference between NDF and ADF contents as follows. 104

% Hemicellulose = % NDF - % ADF

105 5. Lignin. Cellulose residue (d gram) was burnt in a furnace at 500-600°C for 3 hours. After that, it was left to cool and 106 weighed (e gram). Lignin content was calculated by using the following formula:

110 **Data Analysis**

The data obtained were used directly to describe the nutritional value of the swamp vegetations that could be used 111 112 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). 113

114

RESULTS AND DISCUSSION

Results 115

116 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, 117 medium P content, and very high CEC level (Table 1). 118

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122 Table 1. Properties of soil at the study site

		Pulau Layang		Rambutan	
Parameter	Value	Remark	Value	Remark	
pH H ₂ O (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		

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

125 Nutrient Contents of Lowland Swamp

126 Crude protein, fiber, ether extract, and ash nutrient contents of lowland swamp vegetations found in this study are 127 listed in (Table 2).

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

Latin Name	Local Name	Crude	Fiber	Ether	Ash
		Protein		Extract	
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

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

130 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 (%).

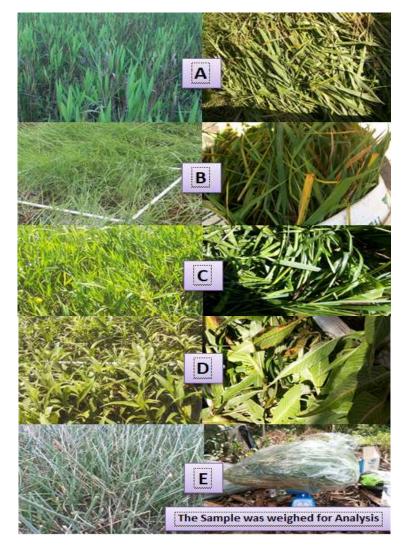
Latin Name	NDF	ADF	Hemicellulose	Cellulose	Lignin
Catharanthus roseus	47.79	39.67	8.12	16.96	22.71
Cyperus digitatus	58.90	36.93	21.97	5.24	31.68
Digitaria fuscescens	65.43	33.56	31.87	12.11	21.45
Eichhornia crassipes	62.77	41.83	20.94	10.22	31.60

¹²⁴

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, 137 Bogor (2017).

Notes: ^P: Grass in Pulau Layang Village; ^R: Grass in Rambutan Village. 140



142 143

144 Figure 2. Dominant and palatable swamp roughages with good nutrient contents included. A. Hymenachne acutigluma, 145 B. Oryza rupifogon C. Hymenachne amplexicaulis, D. Polygonum barbatum, and E. Eleocharis dulcis.

146 Discussion 147

148 **Crude Protein Content**

149 Results showed that the crude protein contents of swamp green vegetations ranged from 5.26% to 20.56% with the 150 lowest value (5.26%) was found in Berondong grass (R. corymbosa) and the highest (20.56%) was found in Kemon air

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151 legume (*N. olerancia*). Kasuran grass (*C. digitatus*) had the highest crude protein content (15.31%) (Table 2). This high 152 nutritional value of Kasuran grass was suspected as caused by the fact that most of this grass was found to grow in the area 153 of buffalo pens where the soil was rich in organic matter. However, the growth of this grass was not dominant as it mostly 154 occured in rainy seasons.

155 Kumpai minyak (H. amplexicaulis), Kumpai padi (O. rupifogon), Kumpai tembaga (H. acutigluma), and Purun tikus 156 (E. dulcis) were found as the dominant palatable grasses containing 12.00, 10.41, 10.96, and 8.22% crude protein, 157 respectively. Results of this study were not too different from those obtained by Rostini et al. (2014) who reported that 158 Kumpai minyak and Pipisangan had protein contents of 10.88 and 15.92%, respectively. Crude protein (CP) contents of 159 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 160 161 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 162 (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) 163 12.07%, Kasuran (C. digitatus) 15.31%, and Kumpai minyak (H. amplexicaulis)^R 12.0% (Table 2). CP contents of 164 vegetations in this study were also higher than those of nature grasses found in coffee plantation areas (6.95%) and 165 pastoral areas (6.65%) in Wulanggitang District, East Flores Regency as reported by Kleden et al. (2015). Meanwhile, CP 166 content of grasses in lowlands was 8.41% (Rochana et al., 2016; Maswada and Elzaawely, 2013). 167

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.

174 Fiber Contents

175 Fiber contents of lowland swamp green vegetations ranged from 11.01 to 30.26% with the lowest content found in 176 Cecengkehan (L. hyssopifolia) and the highest in Kumpai tembaga (H. acutigluma P). Four vegetations including 177 Cecengkehan (L. hyssopifolia), Tapak dara (C. roseus), Mutiara legume (S. exasperata), and Telepuk gajah (N. lotus) were 178 found to have the lowest fiber contents of 11.01, 11.18, 11.22, and 11.45%, respectively (Table 2). These results were 179 almost similar to those found by Ali et al. (2012) who reported that the fiber contents of roughage in a pasture ranged from 180 7.20 to 34.98%. These researchers found that the fiber content of Bento rayap (Leersia hexandra) was 27.40% which was 181 very close to that (27.57%) of the same vegetation in this study. Meanwhile, Rostini et al. (2014) reported that the fiber 182 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 183 184 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 185 highest in *I. rugosum*. Fiber contents reported by Kleden et al. (2015) were higher that the results reported by Ahmed et 186 al. (2013) with a fiber content of 29.32% in D. aegyptium plants. A previous study showed that fermented I. rugosum, H. 187 188 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.

197 Ether extract contents

198 Lowland swamp vegetations in this study were found to have ether extract (EE) contents of about 0.48-2.92%. The 199 lowest EE content was found in Purun tikus (E. dulcis) while the highest was found in Kemon air legume (N. olerancia). 200 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 201 202 revealed to have the highest ether extract contents (Table 2). Results of this study were lower than those found by Rostini 203 et al. (2014) reporting about 0.61-3.67% of EE contents in swamp vegetations in South Kalimantan with the lowest found 204 in Pipisangan (L. hyssopifolia) and the highest in Padi hiang (O. rufigopon spotanea). EE contents of lowland swamp 205 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, 206 Poso Regency had EE contents of 2.12–2.34% (Damry, 2009) and those in Sabana Timur Barat pasture in rainy season to 207 208 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 209 content of 1.07% in grasses in a pasture in Timor Tengah Selatan Regency. Another work by Kleden et al. (2015) showed 210 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.

219 Ash Contents

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220 Ash contents of green vegetations in lowland swamp ranged from 5.63 to 25.19%. Four types of vegetations with the 221 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 222 223 found to have the lowest ash content of 5.63% (Table 2). Ash contents of vegetations found in this study were higher than 224 those of swamp vegetations in South Kalimantan of 2.18- 3.28% during high tidal season and 3.23-9.83% during low tidal 225 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). 226 227 Meanwhile, the ash content of grasses in lowland areas ranged from 6.32 to 8.91% (Richmond et al., 2015; Mako et al., 228 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%. 229

230 Roughages were found to have average ash contents of 7.28% in a pasture for buffaloes in Pulau Moa (Eoh, 2014), 231 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 232 season in Sabana Timur Barat (Manu, 2013), and 8.11 and 8.22% in a natural pasture and a coffee plantation area, 233 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, 234 235 pH levels in lowland swamp areas were found to be 3.9-4.8 causing a decreased supply of nutrients, especially total N and 236 K, to the soil. This decreased supply of nutrients led to lowered nutrients contained in plants (Rostini et al., 2014). This 237 was in line with what was stated by Gutteridge and Shelton (1994) that nutrient content in plants was affected by soil 238 nutrient content. In addition, in acidic soil condition, activities of Fe, Al, and Mn increased which might cause in toxicity 239 in plants (Tjondronegoro and Gunawan). 240

241 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).

247 The NDF and ADF contents of vegetations found in this study were about 40.65–79.47% and 23.66–60.33%, 248 respectively. Lowest NDF contents were found in Cecengkehan (L. hyssopifolia) (40.65%), Kangkung merah (I. 249 aquatica) (41.40%), Telepuk gajah (N. lotus) (46.05%), and Tapak dara (C. roseus) (47.79%). In contrast, highest NDF 250 content of 79.47% was found in Bento rayap (L. hexandra). Lowest ADF contents were found in Telepuk gajah (N. lotus) 251 (46.05%), Kangkung merah (I. aquatica) (26.17%), Kumpai merah (Hymenachne sp) (28.40%), Cecengkehan (L. 252 hyssopifolia) (32.91%). Meanwhile, the highest ADF content of 60.33% was found in Kumpai padi (O. rupifogon P) 253 (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 254 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 255 and ADF contents of roughages in a pasture during the rainy season to the end of the dry season in Sabana Timur Barat 256 were on average 65.9 and 43.29%, respectively (Manu, 2013). Vegetations in a natural pasture and a coffee plantation 257 258 area had NDF contents of 74.89 and 72.37% and ADF contents of 57.22 and 55.15%, respectively (Kleden et al., 2015). 259 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). 260

NDF and ADF contents of roughages in BPTU-HPT Padang Mengatas area were found to be 75.62 and 45.96%, 261 262 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 263 those of water hyacinth (E.crassipes) plants studied by Tham (2015) with NDF and ADF contents of 63.9 and 34.68% and 264 265 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 266 53.8-54.85% and 36.57-37.0%, respectively. Meanwhile, NDF and ADF contents of *elephant* grass (*P. purpureum*) were 267 found to be 55.8 and 46.5% (Dahlan and Iskandar, 2013) and 84.25 and 64.07% (Nuhuyanan, 2010), respectively. These 268 269 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%, 272 respectively. These figures were still within the ranges of NDF and ADF contents of prime grasses such as *elephant* grass 273 (P. purpureum) which had NDF and ADF contents of 55.8 and 46.5% (Dahlan and Iskandar, 2013) and 84.25 and 64.07% 274 (Nuhuyanan, 2010), respectively. In rumen, NDF degradation is higher than that of ADF as NDF contains hemicellulose 275 276 fraction which is more soluble (Church and Pond, 1986). NDF content has a negative correlation with its degradation rate 277 (Varga et al., 1983) and higher NDF content decreases dry matter digestibility of feed (NRC, 1988). Cellulose is an ADF 278 component which is easy to digest while lignin is hard to digest as it contains double bonds. Higher lignin content 279 decreases feed digestibility (Sutardi et al., 1980). 280

281 Hemicellulose and Cellulose Contents

282 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. 283 284 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. 285 286 hyssopifolia) (7.73%). Highest cellulose contents were found in Kemon air (N. olerancia) (27.08%), Bento rayap (L. 287 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 288 289 conducted by Asep et al. (2012) who reported the hemicellulose and cellulose contents of lowland swamp green 290 vegetations ranging from 7.89 to 31.55% and 30.85 to 63.35%, respectively. They also found that Kumpai padi 291 (O.rupifogon) had 31.55% hemicellulose content which was higher than those of Kumpai padi (10.80-19.30%) found in 292 this study (Table 4). Swamp vegetations in South Kalimantan had hemicellulose contents of 0.65-25.85% in high tidal 293 season and 5.37-40.09% in low tidal season. Cellulose contents in high and low tidal seasons were about 20.07-34.03% 294 and 7.90- 38.31%, respectively (Rostini et al., 2014). Various water plants including Azolla, which was used as animal 295 feed, had hemicellulose and cellulose contents of 10.20 and 12.76% (Nampoothiri, 2017), 1.15-10.20% and 12.76% 296 (Nampoothiri, 2017), respectively. Roughages in BPTU-HPT Padang Mengatas had hemicellulose and cellulose contents 297 of 29.79 and 33.62% in rain season and 30.69 and 31.64% in dry season, respectively (Muhajirin et al., 2017). Elephant 298 grass (P. perpureum) was found to contain 21.18% hemicellulose and 43.32% cellulose (Nuhuyanan, 2010) and 35.3% 299 cellulose (Dahlan and Iskandar, 2013). In a study conducted by Archimede et al. (2010), hay was found to have 37.7% 300 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 301 302 vegetations were potential to be used as feed for Pampangan buffaloes.

304 Lignin Contents

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Lignin contents of lowland swamp vegetations ranged from 14.84 to 43.09%. Four vegetations including Telepuk 305 306 gajah (N. lotus), Kemon air (N. olerancia), Kumpai merah (Hymenachne sp.), and Kangkung merah (I. aquatica) were 307 found to have the lowest lignin contents of 14.84, 18.36, 19.76, and 19.85%, respectively, while the highest lignin content 308 of 43.09% was found in Kumpai padi (O. rupifogon P) (Table 3). Lignin contents in this study were higher than that 309 obtained by Rostini et al. (2014) who reported the lignin contents of swamp vegetations in South Kalimantan were about 310 2.8-17.59% in high tidal season with that of Kumpai minyak as the lowest and that of Beberasan as the highest and 10.06-311 61.12% in low tidal season with that of Beberasan as the lowest and that of Kumpai minyak as the highest. Lignin 312 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 313 (18.27%) and Bento rayap (L. hexandra) (17.96%) found by Asep et al. (2012) and Eceng gondok (E. crassipes) (8.17%) 314 found by Tham (2015). In other studies Azolla was found to have lignin contents of 5.7% (Ahmed et al., 2016) and 28.24% 315 316 (Nampoothiri, 2017). Meanwhile, lignin contents of *elephant* grass were found to be 15.37% (Nuhuyanan, 2010) and 317 11.2% (Dahlan and Iskandar, 2013).

318 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 319 320 the vegetations grow. In cell walls, cellulose is bond with hemicellulose and lignin. Lignin cannot be digested by the 321 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 322 323 of aronic acid, galactose, arabinose, xylose, and methanol. Cellulose is degradable by microorganisms and functions as the 324 source of volatile fatty acids. Young grasses (roughages) contain less than 5% lignin and 80% of their cellulose is 325 degradable. On the contrary, in old roughages, lignin content may reach up to 10% causing a decrease in cellulose 326 digestibility by up to 50% (Prawirokusumo, 1994).

327 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

- 330 Cecengkehan (L. hyssopifolia). The lowest NDF content (40.64%) was found in Cecengkehan (L. hyssopifolia) and the 331 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%. 332
- 2. The best nutritional values were found in Kasuran (C. digitatus) and Cecengkehan (L. hyssopifolia). 333
- 334 3. Dominant and palatable swamp roughages with good nutrient contents included Kumpai tembaga (H. acutigluma), 335 Kumpai minyak (H. amplexicaulis), Kumpai padi (O. rupifogon), Are bolong (P. barbatum), and Purun tikus (E. 336 dulcis).
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Nutritional Values of Swamp Grasses as Feed for Pampangan **Buffaloes in South Sumatra Indonesia**

12 Abstract. This study was aimed at determining the types and quality of vegetations in swamp area which could be used as sources of 13 roughage for Pampangan buffaloes in South Sumatera. In this descriptive study. Results showed that, the highest crude protein and 14 ether extract contents, 20.56 and 2.92%, respectively were found in Kemon air (Neptunia olerancia). The highest ash content of 15 25.19% was found in Kasuran (Cyperus digitatus). The lowest fiber content (11.01%) was found in Cecengkehan (Ludwigia 16 hyssopifolia) which also had the lowest content of NDF (40.64%). Hemicellulose content was found to be highest (37.14%) in Bento 17 rayap(Leersia hexandra). The lowest ADF (23.66%) and lignin (14,84%) contents were found in Telepuk gajah (Nymphaea lotus). 18 Kemon air (Neptunia olerancia) was found to have the lowest content (27.08%) of cellulose. It was concluded that the swamp 19 vegetations found in this study consisted of 17 types of grasses (89.47%) and 2 types of legumes (10.53%). Kasuran (Cyperus 20 digitatus) and Cecengkehan (Ludwigia hyssopifolia) were found to have the best nutritional values. Dominant and palatable 21 vegetations with good nutritional values which were potential to be used as sources of roughage for Pampangan buffaloes were Kumpai 22 tembaga (Hymenachne acutigluma), Kumpai padi (Oryza rupifogon), Kumpai minyak (Hymenachne amplexicaulis, Are bolong 23 (Polygonum barbatum), and Purun tikus (Eleocharis dulcis).

24 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 26 season, it is abundant and during dry season the availability of grasses and legumes is lacking. Limited supply of roughage 28 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 29 were 37,405 heads of Pampangan buffaloes in 2016 and this population increased by 3.97% to 38,952 heads in 2017. In 30 2017, of this population, 11,150 heads (28.63%) and 2,227 heads (5.72%) were found in Ogan Komering Ilir Regency and 31 Banyuasin Regency, respectively (Statistik Peternakan Sumsel, 2017). The population and productivity of Pampangan 32 buffaloes need to be improved and for this purpose, feed is an important factor to consider. Pampangan buffaloes feed 33 34 mostly on roughage from swamp and/or grassland to meet their maintenance and reproductive needs.

35 In Indonesia, there are 13.27 million hectares of lowland swamp areas. Only 4 million hectares of these areas has 36 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 37 38 million hectares is found in South Sumatera but only 298,189 hectares of it has been utilized (BPS Sumatera Selatan, 39 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 40 41 needs to be conducted.

42 In the previous study, some swamp grasses including Kumpai minyak grass (H. amplexicaulis) (Rostini et al., 2014; 43 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 44 45 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. 46

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MATERIALS AND METHODS

48 This study was a descriptive study to assess the types and nutritional values of vegetations which were the dominant 49 and palatable as sources of roughage feed for Pampangan buffaloes. Vegetation samples were taken from grazing areas of

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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°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).

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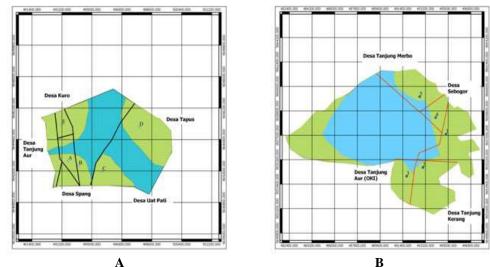


Figure 1. Research location in South Sumatera, Indonesia, **A.** Pulau Layang Village, Pampangan Sub-district, Ogan Komering Ilir District, South Sumatra, **B.** Rambutan Village, Rambutan Sub-district, Banyuasin District, South Sumatra (Muhakka et al., 2019)

Measured parameters

Proximate Analysis

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

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- 70 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 71 changed into an ammonium sulfate form. The remaining sulfuric acid was neutralized by NaOH until the solution 72 became basic. Ammonium sulphate was then distilled in an acid medium to obtain the quantitative amount of N. As 73 the average protein contains 16% nitrogen, a factor 100% : 16% = 6.25 was used to obtain the value of crude protein 74 75 (crude protein = $N\% \times 6.25$).
- 76 2. Fiber. Filtered fat-free sample was used in fiber content determination. 1.25% sulfuric acid solution was added into 77 the sample and the mixture was heated for about 30 minutes before the residue was filtered. 1.25% NaOH solution was 78 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 79 80 between the weight of precipitate before it was burnt and the weight of the ass was referred to as fiber content.
- 81 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. 82
- 4. Ash. The third part of dry matter sample was weighed and burnt in a crucible at 550°C for 8 hours. 83

Van Soest Analysis

- NDF, ADF, hemicellulose, cellulose, and lignin contents were determined by using a Van Soest method (1982).
- 87 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 88 glass which was previously weighed (b gram). The mixture was then washed with hot water and acetone before it was 89 90 dried in an oven and let cool in a desiccator. Finally, it was weighed as c gram. NDF content was calculated by using 91 the following formula: 92

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

95 2. Acid Detergent Fiber (ADF). a gram of sample was put in a beaker glass. 50 ml ADS solution was added into the 96 beaker before the mixture was heated for an hour. The mixture was then filtered by using a vacuum pump and a 97 sintered glass filter which was previously weighed (b gram). The mixture was then washed with hot water and acetone 98 before it was dried in an oven and let cool in a desiccator. Finally, it was weighed as c gram. Cellulose content was 99 calculated by using the following formula:

103 4. Hemicellulose. Hemicellulose content was calculated as a difference between NDF and ADF contents as follows. 104

105 5. Lignin. Cellulose residue (d gram) was burnt in a furnace at 500-600°C for 3 hours. After that, it was left to cool and 106 weighed (*e* gram). Lignin content was calculated by using the following formula:

110 **Data Analysis**

The data obtained were used directly to describe the nutritional value of the swamp vegetations that could be used 111 as a roughage source. These data were then combined with those of *in vitro* digestibility as the basis for drawing the 112 113 conclusion (Svarifuddin and Wahdi, 2010).

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RESULTS AND DISCUSSION

115 Results

116 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, 117 medium P content, and very high CEC level (Table 1). 118

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- 121

122 Table 1. Properties of soil at the study site

		<i>P</i>	Pulau Layang		Rambutan	
-	Parameter	Value	Remark	Value	Remark	
-	pH H ₂ O (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).

125 Nutrient Contents of Lowland Swamp

126 Crude protein, fiber, ether extract, and ash nutrient contents of lowland swamp vegetations found in this study are 127 listed in (Table 2).

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

Latin Name	Local Name	Crude	Fiber	Ether	Ash
		Protein		Extract	
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

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

130 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%

134 (Table 3).

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

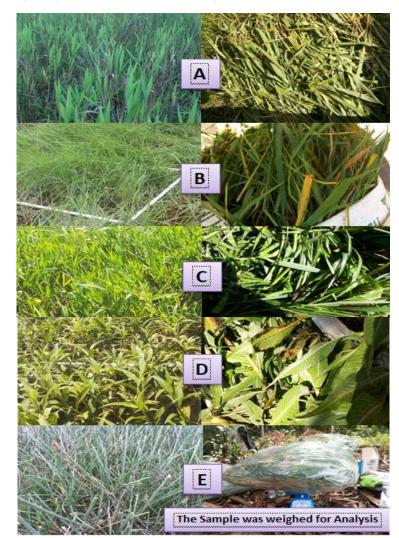
Latin Name	NDF	ADF	Hemicellulose	Cellulose	Lignin
Catharanthus roseus	47.79	39.67	8.12	16.96	22.71
Cyperus digitatus	58.90	36.93	21.97	5.24	31.68
Digitaria fuscescens	65.43	33.56	31.87	12.11	21.45
Eichhornia crassipes	62.77	41.83	20.94	10.22	31.60
Eleocharis dulcis ^P	69.57	49.83	19.74	21.80	28.04
Eleocharis 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

137 Source: Biotechnology Assessment Laboratory, Center for Biotechnology Research, Indonesian Institute of Sciences (LIPI), Cibinong, 138 Bogor (2017).

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Notes: ^P: Grass in Pulau Layang Village; ^R: Grass in Rambutan Village. 140



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144 Figure 2. Dominant and palatable swamp roughages with good nutrient contents included. A. Hymenachne acutigluma, 145 **B**. Oryza rupifogon **C**. Hymenachne amplexicaulis, **D**. Polygonum barbatum, and **E**. Eleocharis dulcis.

146 Discussion

147 148 **Crude Protein Content**

Results showed that the crude protein contents of swamp green vegetations ranged from 5.26% to 20.56% with the 149 150 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 151 152 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.

155 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, 156 respectively. Results of this study were not too different from those obtained by Rostini et al. (2014) who reported that 157 158 Kumpai minyak and Pipisangan had protein contents of 10.88 and 15.92%, respectively. Crude protein (CP) contents of 159 these swamp grasses in Pulau Layang and Rambutan Villages were closed to those of prime grasses including 9.11-12.8% 160 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 161 (Santoso and Hariadi, 2008). Other vegetations even had higher CP contents including Kumpai tembaga (H. acutigluma) 162 163 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 164 165 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 166 content of grasses in lowlands was 8.41% (Rochana et al., 2016; Maswada and Elzaawely, 2013). 167

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.

174 Fiber Contents

175 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 176 177 Cecengkehan (L. hyssopifolia), Tapak dara (C. roseus), Mutiara legume (S. exasperata), and Telepuk gajah (N. lotus) were 178 found to have the lowest fiber contents of 11.01, 11.18, 11.22, and 11.45%, respectively (Table 2). These results were 179 almost similar to those found by Ali et al. (2012) who reported that the fiber contents of roughage in a pasture ranged from 180 7.20 to 34.98%. These researchers found that the fiber content of Bento rayap (Leersia hexandra) was 27.40% which was 181 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 182 Hadangan (Paspalum sp) and the highest in Dadangsit (L. adscendens). These figures were lower than those found by 183 184 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 185 186 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. 187 amplexicaulis, and O. rifipogon had fiber contents of 29.27, 29.57, and 33.07%, respectively (Muhakka et al., 2015). 188

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.

197 Ether extract contents

198 Lowland swamp vegetations in this study were found to have ether extract (EE) contents of about 0.48-2.92%. The 199 lowest EE content was found in Purun tikus (E. dulcis) while the highest was found in Kemon air legume (N. olerancia). 200 Four vegetations of lowland swamp including Telepuk gajah (N. lotus) (2.84% EE), Kumpai minyak (H. amplexicaulis) 201 (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 202 203 et al. (2014) reporting about 0.61-3.67% of EE contents in swamp vegetations in South Kalimantan with the lowest found 204 in Pipisangan (L. hyssopifolia) and the highest in Padi hiang (O. rufigopon spotanea). EE contents of lowland swamp 205 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 206 for buffaloes in Pulau Moa were 1.95–2,41% (Eoh, 2014). In other studies, grasses in a natural pasture in North Lore, 207 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 208 209 content of 1.07% in grasses in a pasture in Timor Tengah Selatan Regency. Another work by Kleden et al. (2015) showed 210 that vegetations in a natural pasture and a coffee plantation area had EE contents of 1.23 and 1.35%, respectively.

211 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.

219 Ash Contents

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220 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 221 (H. amplexicaulis) (16.26%), and Kumpai padi (O. rupifogon P) (16.25%). Meanwhile, Bento rayap (L. hexandra) was 222 223 found to have the lowest ash content of 5.63% (Table 2). Ash contents of vegetations found in this study were higher than 224 those of swamp vegetations in South Kalimantan of 2.18- 3.28% during high tidal season and 3.23-9.83% during low tidal 225 season (Rostini et al., 2014). Elephant grass (P. purpureum) was indicated to have varied ash contents of 4.4% (Dahlan 226 and Iskandar, 2013), 0.95-1.1% (Ukpabi et al., 2015), 9.59% (Nuhuyanan, 2010), and 18% (Araica et al., 2009). 227 Meanwhile, the ash content of grasses in lowland areas ranged from 6.32 to 8.91% (Richmond et al., 2015; Mako et al., 228 2016; Norman et al., 2013; Maswada et al., 2013). Alam et al. (2015) found that B. mutica had an ash content of 4.20-229 4.89% and rice straw had 6.63%.

230 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 231 season in Sabana Timur Barat (Manu, 2013), and 8.11 and 8.22% in a natural pasture and a coffee plantation area, 232 233 respectively (Kleden et al., 2015). Differences in these ash contents were suspected to be caused by differences in plant 234 species (internal factor) and environmental differences, particularly seasonal differences (external factor). In a dry season, 235 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 236 237 was in line with what was stated by Gutteridge and Shelton (1994) that nutrient content in plants was affected by soil 238 nutrient content. In addition, in acidic soil condition, activities of Fe, Al, and Mn increased which might cause in toxicity 239 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).

247 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. 248 aquatica) (41.40%), Telepuk gajah (N. lotus) (46.05%), and Tapak dara (C. roseus) (47.79%). In contrast, highest NDF 249 250 content of 79.47% was found in Bento rayap (L. hexandra). Lowest ADF contents were found in Telepuk gajah (N. lotus) 251 (46.05%), Kangkung merah (I. aquatica) (26.17%), Kumpai merah (Hymenachne sp) (28.40%), Cecengkehan (L. 252 hyssopifolia) (32.91%). Meanwhile, the highest ADF content of 60.33% was found in Kumpai padi (O. rupifogon P) 253 (Table 3). NDF and ADF contents of vegetations found in this study were lower than those of Asep et al. (2012) who 254 reported that the NDF contents of swamp green vegetations in a pasture for buffaloes were about 91.73–93.45% in grasses 255 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 256 were on average 65.9 and 43.29%, respectively (Manu, 2013). Vegetations in a natural pasture and a coffee plantation 257 area had NDF contents of 74.89 and 72.37% and ADF contents of 57.22 and 55.15%, respectively (Kleden et al., 2015). 258 Meanwhile, swamp vegetations in South Kalimantan had average NDF and ADF contents of 55.97 and 37.87%, 259 260 respectively, during high tidal season and 81.44 and 60.86% respectively, during low tidal season (Rostini et al., 2014).

261 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 262 contents of Eceng gondok (E. crassipes in this study were 62.77 and 41.83%, respectively. These figures were close to 263 264 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 265 266 Ahmed et al. (2016), Anitha et al. (2016), and Nampoothiri (2017) showed that Azolla sp had NDF and ADF contents of 267 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 268 figures equaled to the NDF and ADF contents of Kumpai tembaga (64.72 and 46.38%), Kumpai minyak (65.31 and 269 38.92), and Are bolong (61.27 and 48.46%). This indicated that, lowland swamp vegetations had fiber fraction nutritional 270 271 quality which was not less than that of prime grasses including *elephant* grass and *king* grass.

272 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 273 (P. purpureum) which had NDF and ADF contents of 55.8 and 46.5% (Dahlan and Iskandar, 2013) and 84.25 and 64.07% 274 (Nuhuyanan, 2010), respectively. In rumen, NDF degradation is higher than that of ADF as NDF contains hemicellulose 275 fraction which is more soluble (Church and Pond, 1986). NDF content has a negative correlation with its degradation rate 276 277 (Varga et al., 1983) and higher NDF content decreases dry matter digestibility of feed (NRC, 1988). Cellulose is an ADF 278 component which is easy to digest while lignin is hard to digest as it contains double bonds. Higher lignin content 279 decreases feed digestibility (Sutardi et al., 1980).

281 Hemicellulose and Cellulose Contents

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282 Lowland swamp vegetations were found to have hemicellulose and cellulose contents ranging from 7.73 to 37.14% 283 and 5.24 to 27.08%, respectively. Four green vegetations with highest hemicellulose contents were Bento rayap (L. 284 hexandra) (37.14%), Kerak maling (D. fuscescens) (31.87%), Kumpai merah (Hymenachne sp.) (31.74%), and Kumpai 285 minyak (H. amplexicaulis) (26.39%). In contrast, lowest hemicellulose content was found in Cecengkehan (L. 286 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 287 288 (*C.digitatus*) had the lowest cellulose content of 5.24% (Table 3). Results of this study were in line with those of a study 289 conducted by Asep et al. (2012) who reported the hemicellulose and cellulose contents of lowland swamp green 290 vegetations ranging from 7.89 to 31.55% and 30.85 to 63.35%, respectively. They also found that Kumpai padi 291 (O.rupifogon) had 31.55% hemicellulose content which was higher than those of Kumpai padi (10.80-19.30%) found in 292 this study (Table 4). Swamp vegetations in South Kalimantan had hemicellulose contents of 0.65-25.85% in high tidal 293 season and 5.37-40.09% in low tidal season. Cellulose contents in high and low tidal seasons were about 20.07-34.03% 294 and 7.90- 38.31%, respectively (Rostini et al., 2014). Various water plants including Azolla, which was used as animal 295 feed, had hemicellulose and cellulose contents of 10.20 and 12.76% (Nampoothiri, 2017), 1.15-10.20% and 12.76% 296 (Nampoothiri, 2017), respectively. Roughages in BPTU-HPT Padang Mengatas had hemicellulose and cellulose contents 297 of 29.79 and 33.62% in rain season and 30.69 and 31.64% in dry season, respectively (Muhajirin et al., 2017). Elephant 298 grass (P. perpureum) was found to contain 21.18% hemicellulose and 43.32% cellulose (Nuhuyanan, 2010) and 35.3% 299 cellulose (Dahlan and Iskandar, 2013). In a study conducted by Archimede et al. (2010), hay was found to have 37.7% 300 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 301 302 vegetations were potential to be used as feed for Pampangan buffaloes. 303

304 Lignin Contents

305 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 306 found to have the lowest lignin contents of 14.84, 18.36, 19.76, and 19.85%, respectively, while the highest lignin content 307 of 43.09% was found in Kumpai padi (O. rupifogon P) (Table 3). Lignin contents in this study were higher than that 308 309 obtained by Rostini et al. (2014) who reported the lignin contents of swamp vegetations in South Kalimantan were about 310 2.8-17.59% in high tidal season with that of Kumpai minyak as the lowest and that of Beberasan as the highest and 10.06-311 61.12% in low tidal season with that of Beberasan as the lowest and that of Kumpai minyak as the highest. Lignin 312 contents of Kumpai padi (O. rupifogon^R) (31.24%) and Kumpai padi (O. rupifogon^P) (43.09%), Bento rayap (L. hexandra) 313 (33.92%), and Eceng gondok (E. crassipes) (31.60%) (Table 3) found in this study were higher those of Kumpai padi 314 (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% 315 (Nampoothiri, 2017). Meanwhile, lignin contents of *elephant* grass were found to be 15.37% (Nuhuyanan, 2010) and 316 11.2% (Dahlan and Iskandar, 2013). 317

318 Differences in lignin contents in green vegetations are suspected to be caused by differences in plant species, plant 319 ages, and environmental factors including seasons (rain or dry season), tidal seasons, and fertility levels of the soil where 320 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%. 321 322 Hemicellulose consists of pentose, hexose, uronic acid, and pectin substance. Pectin is a carbohydrate which is composed 323 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 324 325 degradable. On the contrary, in old roughages, lignin content may reach up to 10% causing a decrease in cellulose 326 digestibility by up to 50% (Prawirokusumo, 1994).

327 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 331 332 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). 333
- 3. Dominant and palatable swamp roughages with good nutrient contents included Kumpai tembaga (H. acutigluma), 334
- 335 Kumpai minyak (H. amplexicaulis), Kumpai padi (O. rupifogon), Are bolong (P. barbatum), and Purun tikus (E. 336 dulcis).
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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

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Biodiversitas Journal of Biological Diversity

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

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12 Abstract. This study was aimed at determining the types and quality of vegetations in the swamp area, which could be used as sources 13 of roughage for Pampangan buffaloes in South Sumatera. In this descriptive study. Results showed that, the highest crude protein and 14 ether extract contents, 20.56 and 2.92%, respectively, were found in Kemon air (N. olerancia). The highest ash content of 25.19% was 15 found in Kasuran (C.digitatus). The lowest fiber content (11.01%) was found in Cecengkehan (Lhyssopifolia), which also had the 16 lowest content of NDF 40.64%). Hemicellulose content was found to be highest (37.14%) in Bento rayap (L.hexandra). The lowest 17 ADF (23.66%) and lignin (14,84%) contents were found in Telepuk gajah (N.lotus). Kemon air (N.olerancia) was found to have the 18 lowest content (27.08%) of cellulose. It was concluded that the swamp vegetations found in this study consisted of 17 types of grasses 19 (89.47%) and 2-two types of legumes (10.53%). Kasuran (C. digitatus) and Cecengkehan (L. hyssopifolia) were found to have the 20 best nutritional values. Dominant and palatable vegetations with good nutritional values, which were potential to be used as sources of 21 roughage for Pampangan buffaloes, were Kumpai tembaga (H.acutigluma), Kumpai padi (O.rupifogon), Kumpai minyak (H. 22 amplexicaulis, Are bolong (P.barbatum), and Purun tikus (E.dulcis).

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

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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), *Integrational and L. hexandra* (Ali et al., 2012) were identified. However, many more swamp Advectations 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

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50 51 52 53	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	
54	kg sample was taken by randomrandomly and sent to the laboratory for oven drying at 105°C until a constant weight was	Formatted: English (United States)
55 56	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).	Formatted: English (United States)
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63 64	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)	Formatted: English (United States)
65	, , , , , , , , , , , , , , , , , , ,	Formatted: English (United States)
66 67	Measured parameters	Formatted: English (United States)
68	Proximate Analysis	Formatted: English (United States)
69	Crude protein, fiber, ether extract, and ash contents were determined based on the procedures of AOAC (1990).	

70		
70 71	 Crude Protein. Nitrogen (N) content was determined by using a <u>Kjehdahl Kjeldahl</u> method. In this analysis, sulphuric acid with a catalyst and a heating process. The organic matter of samples was then oxidized by sulfuric acid<u>two</u>, and 	Commented [A8]: ??
72	nitrogen was changed into an ammonium sulfate form. The remaining sulfuric acid was neutralized by NaOH until the	Formatted: English (United States)
73 74	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	Formatted. English (onited States)
75	value of crude protein (crude protein = N% x 6.25).	
76	 Fiber. Filtered The filtered fat-free sample was used in fiber content determination. 1.25% sulfuric acid solution was 	
77	added into the sample, and the mixture was heated for about 30 minutes before the residue was filtered. 1,25% NaOH	
78	solution was added into the precipitate, and the mixture was heated for about 30 minutes. The mixture was then	
79	filtered, and the precipitate was washed, dried, and weighed. This precipitate was burnt, and the ash was weighed. The	
80 81	difference between the weight of precipitate before it was burnt and the weight of the ass was referred to as fiber content.	
82	3. <i>Ether Extract.</i> Dry-The dry matter sample was extracted with diethyl ether for 5 hours. In At the end of the extraction	
83	process, ether evaporated and the remaining material was referred to as fat.	
84	4. Ash. The third part of the dry matter sample was weighed and burnt in a crucible at 550°C for 8 hours.	Formatted: English (United States)
85		
86 87	Van Soest Analysis NDF, ADF, hemicellulose, cellulose, and lignin contents were determined by using a Van Soest method (1982).	
88	 Neutral Detergent Fiber (NDF). a gram of sample was put in a beaker glass. 50 ml NDS solution was added into the 	Commented [A9]: All important abbreviations must be defined at their first mention
89	beaker before the mixture was heated for an hour. The mixture was then filtered by using a vacuum pump and a filter	
90	glass which was previously weighed (b gram). The mixture was then washed with hot water and acetone before it was	Formatted: English (United States)
91 92	dried in an oven and let cool in a desiccator. Finally, it was weighed as <i>c</i> gram. NDF content was calculated by using the following formula:	Formatted: English (United States)
92 93		Formatted: English (United States)
94	% NDF = x 100%	Formatted. English (Onited States)
95	% NDF = $\frac{e - b}{\frac{1}{2}}$ x 100%	Commented [A10]: Be consistant, a or <i>a</i>
96 97	2. Acid Detergent Fiber (ADF). <i>a</i> 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	Formatted: English (United States)
98	sintered glass filter which was previously weighed (<i>b</i> gram). The mixture was then washed with hot water and acetone	Formatted: English (United States)
99	before it was dried in an oven and let cool in a desiccator. Finally, it was weighed as c gram. Cellulose content was	
100	calculated by using the following formula:	
101 102	<u>c - d</u> % cellulose = x 100%	Formatted: English (United States)
102	a a	Formatted: English (United States)
104	4. Hemicellulose. Hemicellulose content was calculated as a difference between NDF and ADF contents as follows.	
105	% Hemicellulose = % NDF - % ADF	
106 107	5. Lignin. Cellulose residue (<i>d</i> gram) was burnt in a furnace at 500-600°C for 3 hours. After that, it was left to cool and weighed (<i>e</i> gram). Lignin content was calculated by using the following formula:	
107	d - e	
109	% Lignin = x 100%	
110	a	
111	Data Analysis	
112	The data obtained were used directly to describe the nutritional value of the swamp vegetations that could be used	
113 114	as a roughage source. These data were then combined with those of <i>in vitro</i> digestibility as the basis for drawing the <u>conclusionconcluding</u> (Syarifuddin and Wahdi, 2010).	
114	concrusion <u>concruding</u> (oya nuduli and wardi, 2010).	
115	RESULTS AND DISCUSSION	
116	Results	Formatted: English (United States)
117	Results of soil analysis showed that soil at the study site had a low fertility level and was highly acidic. It also had	
118	very high organic C and total N contents, medium level of exchangeable-K and N contents, very low Ca and Mg contents,	Formatted: English (United States)
119 120	medium P content, and very high CEC level (Table 1).	Formatted: English (United States)
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102	Table 1 m and the state of the	
123	Table 1. Properties of soil at the study site Pulau Layang Rambutan	Formatted: English (United States)
	Parameter Value Remark Value Remark	

1	24
1	25

126 Nutrient Contents of Lowland Swamp

pH H₂O (1 : 1) pH KCl (1 : 1)

Na (cmol/kg)

Ca (cmol/kg) Mg (cmol/kg)

CEC (cmol/kg)

Texture:

Organic C (g/kg)

Total N (g/kg) Available P/Bray I (mg/kg) Exchangeable K (cmol/kg)

Exchangeable Al (cmol/kg) Exchangeable H (cmol/kg)

Sand (%)

Ash (%) Clay (%)

Crude protein, fiber, ether extract, and ash nutrient contents of lowland swamp vegetations found in this study are 127 128 listed in (Table 2). 129

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

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

5.10

4.39

57.66

3.64

11.70

0.63

0.65

1 95

0.45

65.25

1.84 0.74

47.08

31.11

21.81

Low

Very acidic

Very high

Very high

Medium

Medium

Medium

Very low

Verv low

Very high

4.41

3.99

36.14

2.19 2.25

0.45

0.65

0.73

0.32

43.50

2.370.88

46.64

27.18

26.18

Very low Very acidic Very high

Very high

Very low

Medium

Medium

Very low

Verv low

Very high

Latin Name	Local Name	Crude	Fiber	Ether	Ash
		Protein		Extract	
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

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

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

132 The NDF and ADF contents of vegetations found in this study were about 40.65-79.47% and 23.66-60.33%, 133 respectively. Lowland swamp vegetations were found to have hemicellulose and cellulose contents ranging from 7.73 to 134 37.14% and 5.24 to 27.08%, respectively. Lignin contents of lowland swamp vegetations ranged from 14.84 to 43.09% 135 (Table 3).

136 137 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

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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)

138 139 140 141 Notes: P : Grass in Pulau Layang Village; R : Grass in Rambutan Village.

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Discussion

Crude Protein Content



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151 lowest value (5.26%) was found in Berondong grass (R. corymbosa) and the highest (20.56%) was found in Kemon air 152 153 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

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

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

Results showed that the crude protein contents of swamp green vegetations ranged from 5.26% to 20.56% with the

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.

156 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, 157 158 respectively. Results of this study were not too different from those obtained by Rostini et al. (2014) who reported that 159 Kumpai minyak and Pipisangan had protein contents of 10.88 and 15.92%, respectively. Crude protein (CP) contents of 160 these swamp grasses in Pulau Layang and Rambutan Villages were closed to those of prime grasses including 9.11-12.8% 161 CP of elephant grass (P. purpureum) (Santos et al., 2013; Dahlan and Iskandar, 2013; Rahman et al., 2014), 12.4% CP of 162 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 163 (Santoso and Hariadi, 2008). Other vegetations even had higher CP contents including Kumpai tembaga (H. acutigluma) 164 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 165 166 vegetations in this study were also higher than those of nature grasses found in coffee plantation areas (6.95%) and 167 pastoral areas (6.65%) in Wulanggitang District, East Flores Regency as reported by Kleden et al. (2015). Meanwhile, CP 168 content of grasses in lowlands was 8.41% (Rochana et al., 2016; Maswada and Elzaawely, 2013).

169 [This high protein content was suspected to be caused by the fact that soil organic C and total N contents in the study 170 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 171 affected protein content in plants. Four swamp grasses including Kasuran (*C. digitatus*), Tapak dara (*C. roseus*), Telepuk 172 gajah (*N. lotus*), and Cecengkehan (*L. hyssopifolia*) and a legume, Kemon air (*N. olerancia*) were found to be the lowland 173 swamp vegetations having the highest N contents of 15.31,15.20, 13.22, 12.07, and 20.56%, respectively.

175 Fiber Contents

176 Fiber contents of lowland swamp green vegetations ranged from 11.01 to 30.26%. with the lowest content found in 177 Cecengkehan (L. hyssopifolia) and the highest in Kumpai tembaga (H. acutigluma P). Four vegetations including 178 Cecengkehan (L. hyssopifolia), Tapak dara (C. roseus), Mutiara legume (S. exasperata), and Telepuk gajah (N. lotus) were 179 found to have the lowest fiber contents of 11.01, 11.18, 11.22, and 11.45%, respectively (Table 2). These results were 180 almost similar to those found by Ali et al. (2012) who reported that the fiber contents of roughage in a pasture ranged from 181 7.20 to 34.98%. These researchers found that the fiber content of Bento rayap (Leersia hexandra) was 27.40% which was 182 very close to that (27.57%) of the same vegetation in this study. Meanwhile, Rostini et al. (2014) reported that the fiber 183 contents of swamp vegetation in South Kalimantan ranged from 14.84 to 29.35% with the lowest content found in 184 Hadangan (Paspalum sp) and the highest in Dadangsit (L. adscendens). These figures were lower than those found by 185 Kleden et al. (2015) who revealed that nature grasses in a coffee plantation area and a-pasture in Wulanggitang, East Flores 186 contained 34.57 and 35.59% of fiber. They also found that the lowest fiber content was found in L. peploides and the 187 highest in I. rugosum. Fiber contents reported by Kleden et al. (2015) were higher that than the results reported by Ahmed 188 et al. (2013) with a fiber content of 29.32% in D. aegyptium plants. A previous study showed that fermented I. rugosum, 189 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.

198 Ether extract contents

199 Lowland swamp vegetations in this study were found to have ether extract (EE) contents of about 0.48-2.92%. The 200 lowest EE content was found in Purun tikus (E. dulcis) while the highest was found in Kemon air legume (N. olerancia). 201 Four vegetations of lowland swamp including Telepuk gajah (N. lotus) (2.84% EE), Kumpai minyak (H. amplexicaulis) 202 (2.82% EE), Kumpai padi (O. rupifogon) (2.49% EE), and Kangkung merah (I. aquatica Forsk) (2.24% EE) were 203 revealed to have the highest ether extract contents (Table 2). Results of this study were lower than those found by Rostini 204 et al. (2014), reporting about 0.61-3.67% of EE contents in swamp vegetations in South Kalimantan with the lowest found 205 in Pipisangan (L. hyssopifolia) and the highest in Padi hiang (O. rufigopon spotanea). EE contents of lowland swamp 206 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 207 for buffaloes in Pulau Moa were 1.95-2,41% (Eoh, 2014). In other studies, grasses in a natural pasture in North Lore, 208 Poso Regency had EE contents of 2.12-2.34% (Damry, 2009) and those in Sabana Timur Barat pasture in the rainy season 209 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 210 211 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)

214 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 215 216 217 218 219 220 221 (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 222 223 224 225 226 227 228 229 230 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%

231 Roughages were found to have average ash contents of 7.28% in a pasture for buffaloes in Pulau Moa (Eoh, 2014), 232 233 234 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 235 species (internal factor) and environmental differences, particularly seasonal differences (external factor). In a dry season, 236 pH levels in lowland swamp areas were found to be 3.9-4.8 causing a decreased supply of nutrients, especially total N and 237 238 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 239 nutrient content. In addition, in acidic soil conditions, activities of Fe, Al, and Mn increased which might cause in toxicity 240 in plants (Tjondronegoro and Gunawan).

NDF and ADF Contents

241

242 243 Neutral Detergent Fiber (NDF) depicts plant cell walls consisting of hemicellulose, cellulose, and lignin. NDF is part 244 of fiber which is not dissolved in neutral detergent representing the component of fiber undissolved in plant cell wall 245 materials. NDF content of a feed affects the ability of ruminant animals to consume the feed. Acid Detergent Fiber (ADF) 246 represents parts of the plant cell wall bond to cellulose and lignin. ADF content is related to energy content and higher 247 ADF content results in lowered digestible energy content (Van Soest, 1982).

248 The NDF and ADF contents of vegetations found in this study were about 40.65-79.47% and 23.66-60.33%, 249 respectively. Lowest NDF contents were found in Cecengkehan (L. hyssopifolia) (40.65%), Kangkung merah (I. 250 aquatica) (41.40%), Telepuk gajah (N. lotus) (46.05%), and Tapak dara (C. roseus) (47.79%). In contrast, highest NDF 251 content of 79.47% was found in Bento rayap (L. hexandra). Lowest ADF contents were found in Telepuk gajah (N. lotus) 252 (46.05%), Kangkung merah (I. aquatica) (26.17%), Kumpai merah (Hymenachne sp) (28.40%), Cecengkehan (L. 253 hyssopifolia) (32.91%). Meanwhile, the highest ADF content of 60.33% was found in Kumpai padi (O. rupifogon^P) 254 (Table 3). NDF and ADF contents of vegetations found in this study were lower than those of Asep et al. (2012) who 255 reported that the NDF contents of swamp green vegetations in a pasture for buffaloes were about 91.73-93.45% in grasses 256 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 257 and ADF contents of roughages in a pasture during the rainy season to the end of the dry season in Sabana Timur Barat 258 were on average 65.9 and 43.29%, respectively (Manu, 2013). Vegetations in a natural pasture and a coffee plantation 259 area had NDF contents of 74.89 and 72.37% and ADF contents of 57.22 and 55.15%, respectively (Kleden et al., 2015). 260 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., 261 262 2014).

263 NDF and ADF contents of roughages in the BPTU-HPT Padang Mengatas area were found to be 75.62 and 45.96%, 264 respectively in the rain season and 69.35 and 38.66%, respectively in the dry season (Muhajirin et al., 2017). NDF and 265 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% 266 267 and by Tham and Uden (2015) with NDF and ADF contents of 52.1 and 30.7%, respectively. Other studies conducted by 268 Ahmed et al. (2016), Anitha et al. (2016), and Nampoothiri (2017) showed that Azolla sp had NDF and ADF contents of 269 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 270 271 figures equaled to the NDF and ADF contents of Kumpai tembaga (64.72 and 46.38%), Kumpai minyak (65.31 and 272 273 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*)₂ 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).

282283 Hemicellulose and Cellulose Contents

284 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. 285 286 hexandra) (37.14%), Kerak maling (D. fuscescens) (31.87%), Kumpai merah (Hymenachne sp.) (31.74%), and Kumpai 287 minyak (H. amplexicaulis) (26.39%). In contrast, the lowest hemicellulose content was found in Cecengkehan (L. 288 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 289 290 (C.digitatus) had the lowest cellulose content of 5.24% (Table 3). Results of this study were in line with those of a study 291 conducted by Asep et al. (2012) who reported the hemicellulose and cellulose contents of lowland swamp green 292 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 293 294 this study (Table 4). Swamp vegetations in South Kalimantan had hemicellulose contents of 0.65-25.85% in high tidal 295 season and 5.37-40.09% in low tidal season. Cellulose contents in high and low tidal seasons were about 20.07-34.03% 296 and 7.90- 38.31%, respectively (Rostini et al., 2014). Various water plants including Azolla, which was used as animal 297 feed, had hemicellulose and cellulose contents of 10.20 and 12.76% (Nampoothiri, 2017), 1.15-10.20% and 12.76% 298 (Nampoothiri, 2017), respectively. Roughages in BPTU-HPT Padang Mengatas had hemicellulose and cellulose contents 299 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). 300 Elephant grass (P. perpureum) was found to contain 21.18% hemicellulose and 43.32% cellulose (Nuhuyanan, 2010) and 301 35.3% cellulose (Dahlan and Iskandar, 2013). In a study conducted by Archimede et al. (2010), hay was found to have 302 37.7% hemicellulose and 35.7% cellulose. Based on the above findings, it was suggested that hemicellulose (7.73-303 37.14%) and cellulose (5.24-27.08%) contents of lowland swamp vegetations in this study were within normal ranges and 304 these vegetations were potential to be used as feed for Pampangan buffaloes. 305

306 Lignin Contents

307 Lignin contents of lowland swamp vegetations ranged from 14.84 to 43.09%. Four vegetations including Telepuk 308 gajah (N. lotus), Kemon air (N. olerancia), Kumpai merah (Hymenachne sp.), and Kangkung merah (I. aquatica) were 309 found to have the lowest lignin contents of 14.84, 18.36, 19.76, and 19.85%, respectively, while the highest lignin content 310 of 43.09% was found in Kumpai padi (O. rupifogon P) (Table 3). Lignin contents in this study were higher than that 311 obtained by Rostini et al. (2014) who reported the lignin contents of swamp vegetations in South Kalimantan were about 312 2.8-17.59% in high tidal season with that of Kumpai minyak as the lowest and that of Beberasan as the highest and 10.06-313 61.12% in low tidal season with that of Beberasan as the lowest and that of Kumpai minyak as the highest. Lignin 314 contents of Kumpai padi (O. rupifogon R) (31.24%) and Kumpai padi (O. rupifogon P) (43.09%), Bento rayap (L. hexandra) 315 (33.92%), and Eceng gondok (E. crassipes) (31.60%) (Table 3) found in this study were higher those of Kumpai padi 316 (18.27%) and Bento rayap (L. hexandra) (17.96%) found by Asep et al. (2012) and Eceng gondok (E. crassipes) (8.17%) 317 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 318 319 11.2% (Dahlan and Iskandar, 2013).

320 Differences in lignin contents in green vegetations are suspected to be caused by differences in plant species, plant 321 ages, and environmental factors including seasons (rain or dry season), tidal seasons, and fertility levels of the soil where 322 the vegetations grow. In cell walls, cellulose is a bond with hemicellulose and lignin. Lignin cannot be digested by the 323 animals The animals cannot digest lignin and its atomic proportion is different from other carbohydrates as it contains 324 carbon and nitrogen of only 1-5%. Hemicellulose consists of pentose, hexose, uronic acid, and pectin substance. Pectin is 325 a carbohydrate which that is composed of aronic acid, galactose, arabinose, xylose, and methanol. Cellulose is degradable 326 by microorganisms and functions as the source of volatile fatty acids. Young grasses (roughages) contain less than 5% 327 lignin and 80% of their cellulose is degradable. On the contrary, in old roughages, lignin content may reach up to 10% 328 causing a decrease in cellulose digestibility by up to 50% (Prawirokusumo, 1994).

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

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

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338 dulcis). 339 ACKNOWLEDGEMENTSACKNOWLEDGMENTS 340 The author expresses his deepest gratitude to the Rector of Sriwijaya University through the Chair of the Institute for 341 Research and Community Services funding this research in accordance with the Competitive Leading Research Contract 342 of Sriwijaya University Number: 988 / UN9.3.1 / PP / 2017, dated 21 July 2017. 343 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-Alam MR, Haque MM, Sumi KR, Ali MM. 2015. Proximate composition of para-grass (Brachiaria mutica) produced in integrated fish-fodder culture Saysten, Bang, J. Anim, Sci. 44 (2): 113-119.
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highest hemicellulose content (37.14%) was found in Bento rayap. Telepuk gajah had the lowest ADF (23.66%) and

Kumpai minyak (H. amplexicaulis), Kumpai padi (O. rupifogon), Are bolong (P. barbatum), and Purun tikus (E.

3. Dominant and palatable swamp roughages with good nutrient contents included Kumpai tembaga (H. acutigluma),

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).

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

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12 Abstract. This study was aimed at determining the types and quality of vegetations in the swamp area, which could be used as sources 13 of roughage for Pampangan buffaloes in South Sumatera. In this descriptive study. Results showed that, the highest crude protein and 14 ether extract contents, 20.56 and 2.92%, respectively, were found in Kemon air (N. olerancia). The highest ash content of 25.19% was 15 found in Kasuran (C.digitatus). The lowest fiber content (11.01%) was found in Cecengkehan (Lhyssopifolia), which also had the 16 lowest content of Neutral Detergent Fiber (NDF) NDF (40.64%). Hemicellulose content was found to be highest (37.14%) in Bento 17 rayap (L.hexandra). The lowest ADF (23.66%) and lignin (14,84%) contents were found in Telepuk gajah (N.lotus). Kemon air 18 (N.olerancia) was found to have the lowest content (27.08%) of cellulose. It was concluded that the swamp vegetations found in this 19 study consisted of 17 types of grasses (89.47%) and 2-two types of legumes (10.53%). Kasuran (C. digitatus) and Cecengkehan 20 (Lhyssopifolia) were found to have the best nutritional values. Dominant and palatable vegetations with good nutritional values, 21 which were potential to be used as sources of roughage for Pampangan buffaloes, were Kumpai tembaga (H.acutigluma), Kumpai 22 padi (O.rupifogon), Kumpai minyak (H. amplexicaulis, Are bolong (P. barbatum), and Purun tikus (E. dulcis).

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

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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 <u>a</u> <u>a</u>-potential germplasm which needs to be preserved and developed. There were <u>37,405 heads <u>s</u>-heads <u>of</u> 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 <u>the</u>_swamp_<u>and/or</u> grassland to meet their maintenance and reproductive needs.</u>

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), <u>L. rugosum_grugosum_</u> and *L. hexandra* (Ali et al., 2012) were identified. However, many more swamp <u>vegetations</u> haves 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.

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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 randomrandomly and sent to the laboratory for oven drying at [105°C 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.



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70 71	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)	
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73	Maria da serie da se	
74 75	Measured parameters Soil Analysis	Formatted: Centered
76	Soil sampling is done in a composite manner at a depth of 0-20 cm. Taking the soil sample points is done by	
77	making a diagonal line in each zone and determining 5 soil sampling points to analyze chemical fertility (N, P, K)	Formatted: Indent: First line: 0.5 cm
78 79	and physical fertility (texture, structure and pH).	
80	Proximate Analysis	Formatted: English (United States)
81	Crude protein, fiber, ether extract, and ash contents were determined based on the procedures of AOAC (1990).	(· · · · · · · · · · · · · · · · · · ·
82 83	1. Crude Protein. Nitrogen (N) content was determined by using a <u>Kjehdahl-Kjeldahl</u> 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	
83 84	nitrogen was changed into an ammonium sulfate form. The remaining sulfuric acid was neutralized by NaOH until the	Commented [A8]: ??
85	solution became basic. Ammonium sulphate sulfate was then distilled in an acid medium to obtain the quantitative	
86	amount of N. As the average protein contains 16% nitrogen, a factor 100% . $16\% = 6.25$ was used to obtain the	
87	value of crude protein (crude protein = $N\% x 6.25$). 2. <i>Fiber</i> . Filtered -The filtered fat-free sample was used in fiber content determination. 1.25% sulfuric acid solution was	
88 89	2. <i>Fiber</i> . <u>Hittered in Entered lat-free sample was used in fiber content determination</u> . 1.25% suffuric acid solution was added into the sample, and the mixture was heated for about 30 minutes before the residue was filtered. 1,25% NaOH	
90	solution was added into the precipitate, and the mixture was heated for about 30 minutes. The mixture was then	
91	filtered, and the precipitate was washed, dried, and weighed. This precipitate was burnt, and the ash was weighed. The	
92 93	difference between the weight of precipitate before it was burnt and the weight of the ass was referred to as fiber content.	
93 94	3. <i>Ether Extract.</i> Dry-The dry matter sample was extracted with diethyl ether for 5 hours. In <u>At</u> the end of the extraction	
95	process, ether evaporated and the remaining material was referred to as fat.	
96	4. Ash. The third part of the dry matter sample was weighed and burnt in a crucible at 550°C for 8 hours.	Formatted: English (United States)
97 98	Van Soest Analysis	
99	Neutral Detergent Fiber (NDF), Acid Detergent Fiber (ADF), NDF, ADF, hemicellulose, cellulose, and lignin	Commented [A9]: All important abbreviations must be
100	contents were determined by using a Van Soest method (1982).	defined at their first mention
101	1. Neutral Detergent Fiber (NDF). a gram of sample was put in a beaker glass. 50 ml NDS solution was added into the	Formatted: English (United States)
102 103	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	Formatted: Font: Not Italic
104	dried in an oven and let cool in a desiccator. Finally, it was weighed as c gram. NDF content was calculated by using	
105	the following formula:	Formatted: Font: Not Italic
106 107	$\frac{a^{c}-b}{m} =x + 100\%$	Formatted: English (United States)
108	% NDF = $\frac{c - b}{$	Commented [A10]: Be consistant, a or <i>a</i>
109	2. Acid Detergent Fiber (ADF). a gram of sample was put in a beaker glass. 50 ml ADS solution was added into the	Formatted: English (United States)
110 111	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	Formatted: English (United States)
112	before it was dried in an oven and let cool in a desiccator. Finally, it was weighed as c gram. Cellulose content was	
113	calculated by using the following formula:	Formatted: Font: Not Italic
114 115	calculated by using the following formula: c - d % cellulose = x 100% a	Formatted: Font: Not Italic
116	a	Formatted: English (United States)
117	4. Hemicellulose. Hemicellulose content was calculated as a difference between NDF and ADF contents as follows.	Formatted: English (United States)
118 119	% Hemicellulose = % NDF - % ADF 5. Lignin. Cellulose residue (<i>d</i> gram) was burnt in a furnace at 500-600°C for 3 hours. After that, it was left to cool and	
120	weighed (<i>e</i> gram). Lignin content was calculated by using the following formula:	
121	d-e	
122	% Lignin = $x \ 100\%$	
123 124	a Data Analysis	
125	The data obtained were used directly to describe the nutritional value of the swamp vegetations that could be used	Formatted: English (United States)
126	as a roughage source. These data were then combined with those of <i>in vitro</i> digestibility as the basis for drawing the	
127	eonelusionconcluding (Syarifuddin and Wahdi, 2010).	Formatted: English (United States)
	Palemb	

RESULTS AND DISCUSSION

Results						Formatted: English (United States)
very high organic C and total N	owed that soil at the study si contents, medium level of e					Formatted: English (United States)
medium P content, and very hig						Formatted: English (United States)
Table 1. Properties of soil at the st						Formatted: English (United States)
D. (Pulau La			Rambutan		
Parameter	Value Rem	ark	Value	Remark		
pH H ₂ O (1 : 1)	5.10 Low		4.41	Very low		
pH KCl (1 : 1)		acidic	3.99	Very acidic		
Organic C (g/kg)	57.66 Very		36.14	Very high		
Total N (g/kg)	3.64 Very		2.19	Very high		
Available P/Bray I (mg/kg)	11.70 Medi		2.25	Very low		
Exchangeable K (cmol/kg)	0.63 Medi		0.45	Medium		Formatted: English (United States)
Na (cmol/kg)	0.65 Medi		0.65	Medium		
Ca (cmol/kg)	1.95 Very		0.73	Very low		
Mg (cmol/kg)	0.45 Very		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) Texture:	0.74		0.88			
Sand (%)	47.08		46.64			
Ash (%)	31.11		27.18			
Clay (%)	21.81		26.18			Formatted: English (United States)
Source: Laboratory of Soil Chemi	Commented [A11]: Analysis of soil in the study					
						mention in the method part
Nutrient Contents of Lowland	1 Swamp					Formatted: English (United States)
	r extract, and ash nutrient co	ntents of lowland swamp	vegetatior	is found in this	study are	Formatted: English (United States)
listed in (Table 2). Table 2. Crude protein, fiber, ether	extract, and ash contents (%) of	lowland swamp vegetations				Commented [A12]: For the results follow the flor
Latin Name	Local Name	e Crude	Fiber	Ether	Ash	methods, first you should describe the vegetation of
		Protein		Extract		area you have sampled, how may type of vegetation
Catharanthus roseus	Tapak dara	15.20	11.18	1.29	12.53	
Cyperus digitatus	Kasuran	15.31	14.76	1.42	25.19	Formatted: English (United States)
Digitaria fuscescens	Kerak Maling/Pasiran	12.00	15.64	1.24	16.26	Formatted: English (United States)
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	Telenuk Gaiah	13.22	11/15	2.84	10.30	

16.60 22.27 11.22

8.40

14.84 19.47

1.86

Nymphaea lotus Telepuk Gajah 13.22 11.45 2.84 10.30 Oryza rupifogon ^P Oryza rupifogon ^R Polygonum barbatum 7.93 10.41 7.53 5.26 1.60 2.49 1.57 1.48 Kumpai Padi Kumpai Padi 23.30 21.59 16.25 11.92

Rhynchospora corymbosa

 Sesbania exasperata
 Mutiara
 18.27

 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.

Are Bolong Berondong

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¹⁴³ 144

145 146 147 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% 148 (Table 3).

149 150 Table 3. Composition of fiber fractions of green vegetations in lowland swamp: NDF, ADF, Hemicellulose, Cellulose, and Lignin (%).

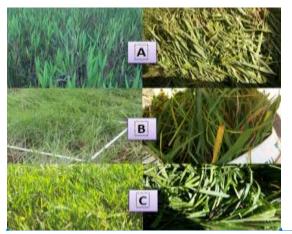
Latin Name	NDF	ADF	Hemicellulose	Cellulose	Li
Catharanthus roseus	47.79	39.67	8.12	16.96	2
Cyperus digitatus	58.90	36.93	21.97	5.24	3
Digitaria fuscescens	65.43	33.56	31.87	12.11	2
Eichhornia crassipes	62.77	41.83	20.94	10.22	3
Eleocharis dulcis ^P	69.57	49.83	19.74	21.80	2
Eleocharis dulcis ^R	75.73	54.91	20.82	19.71	3
Hymenachne acutigluma ^P	75.89	50.60	25.29	12.25	3
Hymenachne acutigluma ^R	64.72	46.38	18.34	16.01	3
Hymenachne amplexicaulis	65.31	38.92	26.39	8.29	3
Hymenachne sp	60.14	28.40	31.74	8.64	1
Ipomoea aquatica	41.40	26.17	15.23	6.32	1
Leersia hexandra	79.47	42.33	37.14	25.88	3
Ludwigia hyssopifolia	40.64	32.91	7.73	8.39	2
Neptunia olerancia	62.31	45.44	16.87	27.08	1
Nymphaea lotus	46.05	23.66	22.39	8.82	1
Oryza rupifogon ^P	71.13	60.33	10.80	17.23	2
Oryza rupifogon ^R	65.49	46.19	19.30	14.96	3
Polygonum barbatum	61.27	48.46	12.81	20.28	2
Rhynchospora corymbosa	65.29	44.64	20.65	16.08	2

Bogor (2017) ^P: Grass in Pulau Layang Village; ^R: Grass in Rambutan Village.

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Notes:



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156 157

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

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

160 Discussion161

162 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 169 170 (E. dulcis) were found as the dominant palatable grasses containing 12.00, 10.41, 10.96, and 8.22% crude protein, 171 respectively. Results of this study were not too different from those obtained by Rostini et al. (2014) who reported that 172 Kumpai minyak and Pipisangan had protein contents of 10.88 and 15.92%, respectively. Crude protein (CP) contents of 173 these swamp grasses in Pulau Layang and Rambutan Villages were closed to those of prime grasses including 9.11-12.8% 174 CP of elephant grass (P. purpureum) (Santos et al., 2013; Dahlan and Iskandar, 2013; Rahman et al., 2014), 12.4% CP of 175 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 176 (Santoso and Hariadi, 2008). Other vegetations even had higher CP contents including Kumpai tembaga (H. acutigluma) 177 with 10.96% CP, Tapak dara (C. roseus) 15.20%, Telepuk gajah (N. lotus) 13.22%, Cecengkehan (L. hyssopifolia) 178 12.07%, Kasuran (C. digitatus) 15.31%, and Kumpai minyak (H. amplexicaulis)^R 12.0% (Table 2). CP contents of 179 f nature grasses found in coffee plantation areas (6.95%) and vegetations in this study were also higher than Les Regency as reported by Kleden et al. (2015). Meanwhile, CP 180 pastoral areas (6.65%) in Wulanggitang District, E content of grasses in lowlands was 8.41% (Rochana et al., 2016; Maswada and Elzaawely, 2013). 181

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.

188 Fiber Contents

189 Fiber contents of lowland swamp green vegetations ranged from 11.01 to 30.26% with the lowest content found in 190 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 191 192 found to have the lowest fiber contents of 11.01, 11.18, 11.22, and 11.45%, respectively (Table 2). These results were 193 almost similar to those found by Ali et al. (2012) who reported that the fiber contents of roughage in a pasture ranged from 194 7.20 to 34.98%. These researchers found that the fiber content of Bento rayap (Leersia hexandra) was 27.40% which was 195 very close to that (27.57%) of the same vegetation in this study. Meanwhile, Rostini et al. (2014) reported that the fiber 196 contents of swamp vegetation in South Kalimantan ranged from 14.84 to 29.35% with the lowest content found in 197 Hadangan (Paspalum sp) and the highest in Dadangsit (L. adscendens). These figures were lower than those found by 198 Kleden et al. (2015) who revealed that nature grasses in a coffee plantation area and a pasture in Wulanggitang, East Flores 199 contained 34.57 and 35.59% of fiber. They also found that the lowest fiber content was found in L. peploides and the 200 highest in I. rugosum. Fiber contents reported by Kleden et al. (2015) were higher that than the results reported by Ahmed

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201 et al. (2013) with a fiber content of 29.32% in D. aegyptium plants. A previous study showed that fermented I. rugosum, 202 H. amplexicaulis, and O. rifipogon had fiber contents of 29.27, 29.57, and 33.07%, respectively (Muhakka et al., 2015).

203 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 204 205 this study was lower than those of Azolla, another water plant, ranging from 13.19 to 16.54% (Kathirvelan et al., 2015; 206 Anitha et al., 2016) and 9.25 to 13.25% (Ahmed et al., 2016). These fiber contents of Azolla equalled to those of 207 Cecengkehan (L. hyssopifolia) (11.01%), Tapak dara (C. roseus) (11.18%), Mutiara legume (S. exasperata) (11.22%), 208 Telepuk gajah (N. lotus) 11.45%, and Kangkung merah (I. aquatica) (14.34%) found in this study. Fiber contents of 209 swamp green vegetations found in this study indicated that they were potential to be used as feed for Pampangan buffaloes.

210 211 212 Ether extract contents

Lowland swamp vegetations in this study were found to have ether extract (EE) contents of about 0.48-2.92%. The 213 lowest EE content was found in Purun tikus (E. dulcis) while the highest was found in Kemon air legume (N. olerancia). 214 Four vegetations of lowland swamp including Telepuk gajah (N. lotus) (2.84% EE), Kumpai minyak (H. amplexicaulis) 215 216 (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 217 218 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 219 220 221 222 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 223 224 225 226 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 227 228 229 230 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 231 used as feed for Pampangan buffaloes. 232

Ash Contents

233 234 Ash contents of green vegetations in lowland swamp ranged from 5.63 to 25.19%. Four types of vegetations with the 235 highest ash contents included Kasuran (C. digitatus) (25.19%), Mutiara legume (S. exasperata) (19.47%), Kumpai minyak 236 (H. amplexicaulis) (16.26%), and Kumpai padi (O. rupifogon P) (16.25%). Meanwhile, Bento rayap (L. hexandra) was 237 found to have the lowest ash content of 5.63% (Table 2). Ash contents of vegetations found in this study were higher than 238 those of swamp vegetations in South Kalimantan of 2.18- 3.28% during the high tidal season and 3.23-9.83% during the 239 low tidal season (Rostini et al., 2014). Elephant grass (P. purpureum) was indicated to have varied ash contents of 4.4% 240 (Dahlan and Iskandar, 2013), 0.95-1.1% (Ukpabi et al., 2015), 9.59% (Nuhuyanan, 2010), and 18% (Araica et al., 2009). 241 Meanwhile, the ash content of grasses in lowland areas ranged from 6.32 to 8.91% (Richmond et al., 2015; Mako et al., 242 2016; Norman et al., 2013; Maswada et al., 2013). Alam et al. (2015) found that B. mutica had an ash content of 4.20-243 4.89% and rice straw had 6.63%

244 Roughages were found to have average ash contents of 7.28% in a pasture for buffaloes in Pulau Moa (Eoh, 2014), 245 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 246 season in Sabana Timur Barat (Manu, 2013), and 8.11 and 8.22% in a natural pasture and a coffee plantation area, 247 respectively (Kleden et al., 2015). Differences in these ash contents were suspected to be caused by differences in plant 248 species (internal factor) and environmental differences, particularly seasonal differences (external factor). In a dry season, 249 pH levels in lowland swamp areas were found to be 3.9-4.8, causing a decreased supply of nutrients, especially total N and 250 K, to the soil. This decreased supply of nutrients led to lowered nutrients contained in plants (Rostini et al., 2014). This 251 was in line with what was stated by Gutteridge and Shelton (1994) that nutrient content in plants was affected by soil 252 nutrient content. In addition, in acidic soil conditions, activities of Fe, Al, and Mn increased which might cause in-toxicity 253 in plants (Tjondronegoro and Gunawan).

255 NDF and ADF Contents

254

256 Neutral Detergent Fiber (NDF) depicts plant cell walls consisting of hemicellulose, cellulose, and lignin. NDF is part 257 of fiber which is not dissolved in neutral detergent representing the component of fiber undissolved in plant cell wall 258 materials. NDF content of a feed affects the ability of ruminant animals to consume the feed. Acid Detergent Fiber (ADF) 259 represents parts of the plant cell wall bond to cellulose and lignin. ADF content is related to energy content and higher 260 ADF content results in lowered digestible energy content (Van Soest, 1982).

261 The NDF and ADF contents of vegetations found in this study were about 40.65-79.47% and 23.66-60.33%, 262respectively. Lowest NDF contents were found in Cecengkehan (L. hyssopifolia) (40.65%), Kangkung merah (I. 263 aquatica) (41.40%), Telepuk gajah (N. lotus) (46.05%), and Tapak dara (C. roseus) (47.79%). In contrast, highest NDF 264 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%. +1 twas 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). 272 273 274 275 276 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%, 277 respectively in the rain season and 69.35 and 38.66%, respectively in the dry season (Muhajirin et al., 2017). NDF and 278 ADF contents of Eceng gondok (E. crassipes in this study were 62.77 and 41.83%, respectively. These figures were close 279 to those of water hyacinth (E.crassipes) plants studied by Tham (2015) with NDF and ADF contents of 63.9 and 34.68% 280and by Tham and Uden (2015) with NDF and ADF contents of 52.1 and 30.7%, respectively. Other studies conducted by 281 Ahmed et al. (2016), Anitha et al. (2016), and Nampoothiri (2017) showed that Azolla sp had NDF and ADF contents of 282 53.8-54.85% and 36.57-37.0%, respectively. Meanwhile, NDF and ADF contents of *elephant* grass (P. purpureum) were 283 found to be 55.8 and 46.5% (Dahlan and Iskandar, 2013) and 84.25 and 64.07% (Nuhuyanan, 2010), respectively. These 284 figures equaled to the NDF and ADF contents of Kumpai tembaga (64.72 and 46.38%), Kumpai minyak (65.31 and 285 38.92), and Are bolong (61.27 and 48.46%). This indicated that, lowland swamp vegetations had fiber fraction nutritional 286 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%, 287 288 respectively. These figures were still within the ranges of NDF and ADF contents of prime grasses such as elephant grass 289 (P. purpureum), which had NDF and ADF contents of 55.8 and 46.5% (Dahlan and Iskandar, 2013) and 84.25 and 64.07% 290 (Nuhuyanan, 2010), respectively. In the rumen, NDF degradation is higher than that of ADF as NDF contains 291 hemicellulose fraction which is more soluble (Church and Pond, 1986). NDF content has a negative correlation with its 292 degradation rate (Varga et al., 1983) and higher NDF content decreases dry matter digestibility of feed (NRC, 1988). 293 Cellulose is an ADF component which that is easy to digest while lignin is hard to digest as it contains double bonds. 294 Higher lignin content decreases feed digestibility (Sutardi et al., 1980). 295

296 Hemicellulose and Cellulose Contents

Lowland swamp vegetations were found to have hemicellulose and cellulose contents ranging from 7.73 to 37.14% 297 298 and 5.24 to 27.08%, respectively. Four green vegetations with the highest hemicellulose contents were Bento rayap (L. 299 hexandra) (37.14%), Kerak maling (D. fuscescens) (31.87%), Kumpai merah (Hymenachne sp.) (31.74%), and Kumpai 300 minyak (H. amplexicaulis) (26.39%). In contrast, the lowest hemicellulose content was found in Cecengkehan (L. 301 hyssopifolia) (7.73%). Highest cellulose contents were found in Kemon air (N. olerancia) (27.08%), Bento rayap (L. 302 hexandra) (25.88%), Purun tikus (E. dulcis) (21.80%), and Are bolong (P. barbatum) (20,28%). Meanwhile, Kasuran 303 (C.digitatus) had the lowest cellulose content of 5.24% (Table 3). Results of this study were in line with those of a study 304 conducted by Asep et al. (2012) who reported the hemicellulose and cellulose contents of lowland swamp green 305 vegetations ranging from 7.89 to 31.55% and 30.85 to 63.35%, respectively. They also found that Kumpai padi 306 (O.rupifogon) had 31.55% hemicellulose content which was higher than those of Kumpai padi (10.80-19.30%) found in 307 this study (Table 4). Swamp vegetations in South Kalimantan had hemicellulose contents of 0.65-25.85% in high tidal 308 season and 5.37-40.09% in low tidal season. Cellulose contents in high and low tidal seasons were about 20.07-34.03% 309 and 7.90- 38.31%, respectively (Rostini et al., 2014). Various water plants including Azolla, which was used as animal 310 feed, had hemicellulose and cellulose contents of 10.20 and 12.76% (Nampoothiri, 2017), 1.15-10.20% and 12.76% 311 (Nampoothiri, 2017), respectively. Roughages in BPTU-HPT Padang Mengatas had hemicellulose and cellulose contents 312 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 313 314 35.3% cellulose (Dahlan and Iskandar, 2013). In a study conducted by Archimede et al. (2010), hay was found to have 315 37.7% hemicellulose and 35.7% cellulose. Based on the above findings, it was suggested that hemicellulose (7.73-316 37.14%) and cellulose (5.24-27.08%) contents of lowland swamp vegetations in this study were within normal ranges and 317 these vegetations were potential to be used as feed for Pampangan buffaloes.

318 319 **Lignin Contents**

320 Lignin contents of lowland swamp vegetations ranged from 14.84 to 43.09%. Four vegetations including Telepuk 321 gajah (N. lotus), Kemon air (N. olerancia), Kumpai merah (Hymenachne sp.), and Kangkung merah (I. aquatica) were 322 323 324 325 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 10.06-326 327 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) 328 (33.92%), and Eceng gondok (E. crassipes) (31.60%) (Table 3) found in this study were higher those of Kumpai padi 329 (18.27%) and Bento rayap (L. hexandra) (17.96%) found by Asep et al. (2012) and Eceng gondok (E. crassipes) (8.17%) 330 found by Tham (2015). In other studies Azolla was found to have lignin contents of 5.7% (Ahmed et al., 2016) and 28.24% 331 (Nampoothiri, 2017). Meanwhile, lignin contents of elephant grass were found to be 15.37% (Nuhuyanan, 2010) and 332 11.2% (Dahlan and Iskandar, 2013).

333 Differences in lignin contents in green vegetations are suspected to be caused by differences in plant species, plant 334 ages, and environmental factors including seasons (rain or dry season), tidal seasons, and fertility levels of the soil where 335 the vegetations grow. In cell walls, cellulose is a bond with hemicellulose and lignin. Lignin cannot be digested by the 336 animals<u>The animals cannot digest lignin</u> and its<u>molecule structure</u> atomic propor rtion is different from other 337 carbohydrates as it contains carbon and nitrogen of only 1-5%. Hemicellulose consists of pentose, hexose, uronic acid, 338 and pectin substance. Pectin is a carbohydrate which that is composed of auronic acid, galactose, arabinose, xylose, and 339 methanol. Cellulose is degradable by microorganisms and functions as the source of volatile fatty acids. Young grasses 340 (roughages) contain less than 5% lignin and 80% of their cellulose is degradable. On the contrary, in old roughages, lignin 341 content may reach up to 10% causing a decrease in cellulose digestibility by up to 50% (Prawirokusumo, 1994).

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

352

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- 343 1. The highest protein (20.56%) and crude fat (2.92%) contents were found in Kemon air (Neptunia olerancia). The 344 highest ash content (25.19%) was found in Kasuran (C. digitatus), while the lowest (11.01%) was found in 345 Cecengkehan (L. hyssopifolia). The lowest NDF content (40.64%) was found in Cecengkehan (L. hyssopifolia) and the 346 highest hemicellulose content (37.14%) was found in Bento rayap. Telepuk gajah had the lowest ADF (23.66%) and 347 lignin (14,84%) contents. Kemon air contained the highest cellulose level of 27.08%.
- 348 2. The best nutritional values were found in Kasuran (C. digitatus) and Cecengkehan (L. hyssopifolia).
- 349 3. Dominant and palatable swamp roughages with good nutrient contents included Kumpai tembaga (H. acutigluma), 350 Kumpai minyak (H. amplexicaulis), Kumpai padi (O. rupifogon), Are bolong (P. barbatum), and Purun tikus (E. 351 dulcis).

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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

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

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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 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.

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.

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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 105 $^{\rm o}{\rm C}$ 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.

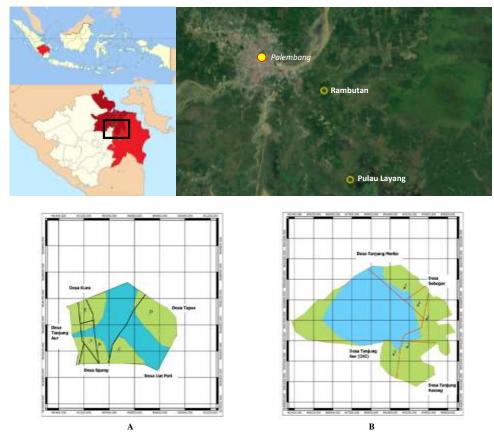


Figure 1. Research location in South Sumatra, Indonesia. A. Pulau Layang Village, Pampangan Sub-district, Ogan Komering Ilir District, South Sumatra. B. Rambutan Village, Rambutan Sub-district, Banyuasin District, South Sumatra, Indonesia (Muhakka et al. 2019)

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 = $N\% \times 6.25$). 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 550°C 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:

$$NDF = ----x 100\%$$

%

а

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:

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 500-600°C for 3 hours. After that, it was left to cool and weighed (e gram). Lignin content was calculated by using the following formula:

d-e

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 ₂ O (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

10.07

11.00

1.04

Sesbania exasperata N	/Iutiara		18.27 11.22	2 1.86	19.47		
Notes: P : Grass in Pulau Layang Village;	R : Grass in Rambutan V	illage.					
Table 3. Composition of fiber fractions of	f green vegetations in lov	and swamp	NDF, ADF, hemicel	lulose, cellulose, an	d 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.

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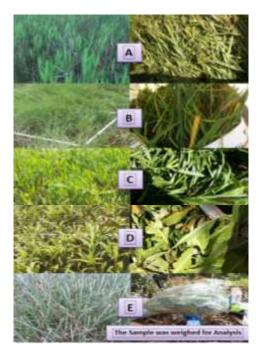


Figure 2. Dominant and palatable swamp roughages with good nutrient contents included. A. Hymenachne acutigluma, B. Oryza rupifogon C. Hymenachne amplexicaulis, D. Polygonum barbatum, and E. Eleocharis dulcis.

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. that (2/.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

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10.47

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. Fiber contents of swamp green

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).

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 Commented [a3]: ???

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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).

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

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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 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.

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.

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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 105°C 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.

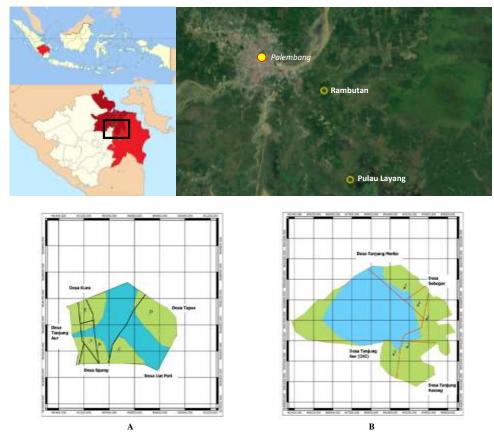


Figure 1. Research location in South Sumatra, Indonesia. A. Pulau Layang Village, Pampangan Sub-district, Ogan Komering Ilir District, South Sumatra. B. Rambutan Village, Rambutan Sub-district, Banyuasin District, South Sumatra, Indonesia (Muhakka et al. 2019)

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 = $N\% \times 6.25$). 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 550°C 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:

а

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:

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 500-600°C for 3 hours. After that, it was left to cool and weighed (e gram). Lignin content was calculated by using the following formula:

d-e

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 ₂ O (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, fibe	r, ether extract	, and ash contents	(%) of lowland swamp vegetations
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Latin name	Local name	Local name Crude protein		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	

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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.

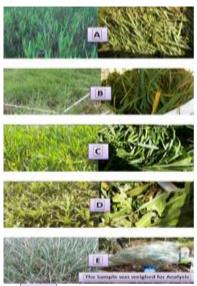


Figure 2. Dominant and palatable swamp roughages with good nutrient contents included. A. Hymenachne acutigluma, B. Oryza

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

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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. Fiber contents of swamp green

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).

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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).

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

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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 Pampangam buffaloes, were Kumpai tembaga (Hymenachne acutigluma), Kumpai padi (O ryza rupifogon), 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 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 vet.

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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 105 $^{\rm o}{\rm C}$ 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.

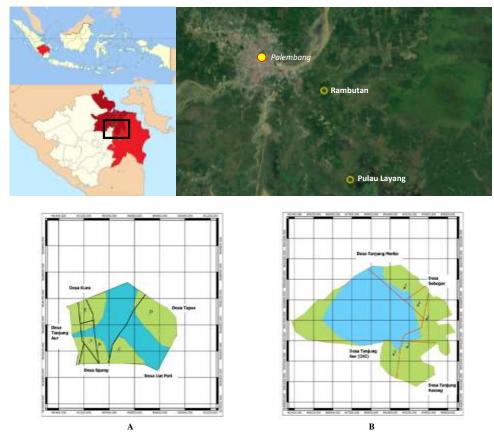


Figure 1. Research location in South Sumatra, Indonesia. A. Pulau Layang Village, Pampangan Sub-district, Ogan Komering Ilir District, South Sumatra. B. Rambutan Village, Rambutan Sub-district, Banyuasin District, South Sumatra, Indonesia (Muhakka et al. 2019)

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 550°C 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 aceton 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:

$$6 \text{ NDF} = -----x 1009$$

Acid Detergent Fiber (ADF). One gram of sample wa put in a beaker glass. 50 ml ADS solution was added int the beaker before the mixture was heated for an hour. Th mixture was then filtered by using a vacuum pump and a sintered glass filter which was previously weighed (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: a d

$$c-u$$
 cellulose = -----x 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 500-600°C for 3 hours. After that, it was left to cool and weighed (e gram). Lignin content was calculated by using the following formula:

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).

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Nutrient contents of lowland swamp

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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 <u>19 species</u> <u>19 types</u> of forage found in Pampangan buffalo pasture that have potential that can be used as food for Pampangan buffalo, consisting of 17 <u>species types</u> of grass (gramineae) and 2 <u>species types</u> of legumes (legumes) <u>(Muhakka et al. 2019)</u>. 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 no 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).

Discussion

Crude protein content

Table 1. Properties of soil at the study site

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).

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Parameter	Pulau Layang			Rambutan
	Value	Remark	Value	Remark
pH H ₂ O (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	

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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 <u>R</u>	Cyperaceae	Kasuran	15.31	14.76	1.42	25.19
3.	Digitaria fuscescens <u>R</u>	Poaceae	Kerak Maling/Pasiran	12.00	15.64	1.24	16.26
4.	Eichhornia crassipes <u>P</u>	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 <u>P</u>	Poaceae,	Kumpai Merah	8.52	21.20	1.30	12.88
12.	Ipomoea aquatica <u>P</u>	Convolvulaceae	Kangkung merah	8.95	14.34	2.24	10.39
13.	Leersia hexandra <u>P</u>	Poaceae	Bento rayap	5.35	27.57	2.06	5.63
14.	Ludwigia hyssopifolia <u>P</u>	<u>Onagraceae</u>	Cecengkehan	12.07	11.01	1.66	9.09
15.	Neptunia olerancia <u>P</u>	Mimoceae,	Kemon air	20.56	15.03	2.92	7.31
16.	Nymphaea lotus <u>P</u>	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 <u>P</u>	Poaceae	Are Bolong	7.53	16.60	1.57	8.40
20.	Rhynchospora corymbosa <u>P</u>	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 na	me	Family	NDF	ADF	Hemi-	Cellulose	Lignin	
					cellulose			
1.	Catharanthus roseus P	Apocynaceae	47.79	39.67	8.12	16.96	22.71	•
2.	Cyperus digitatus <u>R</u>	Cyperaceae.	58.90	36.93	21.97	5.24	31.68	•
3.	Digitaria fuscescens <u>R</u>	Poaceae,	65.43	33.56	31.87	12.11	21.45	-
4.	Eichhornia crassipes <u>P</u>	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	Poaceae,	65.31	38.92	26.39	8.29	30.63	-
10.	Hymenachne sp <u>P</u>	Poaceae,	60.14	28.40	31.74	8.64	19.76	-
11.	Ipomoea aquatica <u>P</u>	Convolvulaceae,	41.40	26.17	15.23	6.32	19.85	
12.	Leersia hexandra <u>P</u>	Poaceae	79.47	42.33	37.14	25.88	33.92	
13.	Ludwigia hyssopifolia <u>P</u>	<u>Onagraceae</u> ,	40.64	32.91	7.73	8.39	24.52	-
14.	Neptunia olerancia <u>P</u>	Mimoceae,	62.31	45.44	16.87	27.08	18.36	-
15.	Nymphaea lotus <u>P</u>	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 <u>P</u>	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	-

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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

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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 ravap (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

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(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).

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

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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 (*Leresia, hexandra*). The lowest ADF (23.66%) and lignin (14,84%) contents were found in Telepuk gajah (Nymphaea, lotus). Kemon air (N_a 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 herts (89.47%) and two species of legumes (10.53%). Kasuran (C_a digitatus) and Cecengkehan (L_a, hyssopifolia) were found to have the best nutritional values. Dominant and palatable vegetations were Kumpai tembaga (Hymenachne, acutigluma), Kumpai padi (Oryaa, 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 animalsruminants 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 animalsruminants 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) (BP\$ 2010, Mulyani and Sarwani 2013). In Sumatra, the largest lowland swamp area of 2.98 million hectares is found ih 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 vegetationsyegetation 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), *J. rugosum* and *L. hexandra* (Ali et al. 2012) were identified. However, many—more swamp <u>vegetation hashave</u> not been identified, Fdr example, *P_a parbatum_a*_C. digitatus, *R. corymbosa*, Thik study was conducted to identify the types and nutritional values of vegetationsvegetation 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 net stated in the previous study_it's not found yet.

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MATERIALS AND METHODS

Area study

This study was a descriptive study to assess the types and nutritional values of vegetationsvegetation, 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, <u>Indonesia</u> (Figure 1) from April to Juni 2017. Vegetation samples for nutrient analysis were obtained by following procedures: (j) vegetation collection was done based on estimated growth age (young age, <u>medium_middle</u> age, and old age based on physical appearance), (<u>ji</u>) collected samples of each vegetation was composited, and (<u>jii</u>) samples were chopped into small sizes, <u>and then homogenized</u>.

For each vegetation, 1 kg sample was taken randomly and sent to the laboratory for oven drying at 105°C, 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.

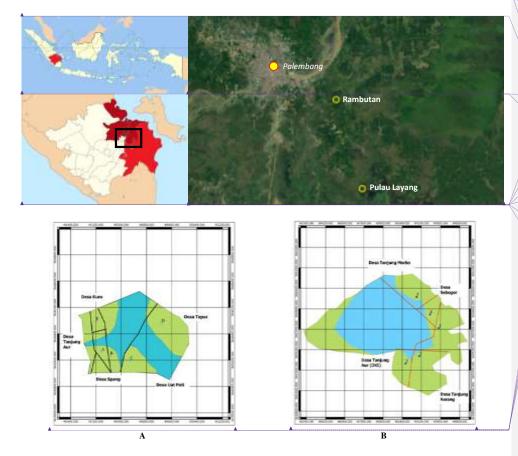


Figure 1. Research location in South Sumatra, Indonesia. A. Pulau Layang Village, Pampangan Sub-district, Ogan Komering Ilir District, South Sumatra. B. Rambutan Village, Rambutan Sub-district, Banyuasin District, South Sumatra, Indonesia (Muhakka et al. 2019)

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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 somewhile 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 550°C for 8 hours.

Van Soest analysis

Neutral Detergent Fiber (NDF), Acid Detergent Fiber (ADF), hemicellulose, cellulose, and lignin contents wer 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 adde into the beaker before the mixture was heated for an hou The mixture was then filtered by using a vacuum pump an a filter glass which was previously weighed (b gram). Th mixture was then washed with hot water and aceton 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: c-b

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

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 500-600°C for 3 hours. After that, it was left t cool and weighed (e gram). Lignin content was calculate by using the following formula:

d-	e	
% Lignin =	x 100%	

Data analysis

The data obtained were used directly to describe th nutritional value of the swamp vegetation that could b 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 sit had a low fertility level and was highly acidic. It also ha very high organic C and total N contents, medium level of exchangeable-K and N contents, very low Ca and M contents, medium P content, and very high CEC leve (Table 1).

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Table 1. Properties of soil at the study site

Parameter	Pu	lau Layang		Rambutan	
	Value	Remark	Value	Remark	
pH H ₂ O (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	 Formatted: English (United States)
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		 Formatted: English (United States)
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 <u>vegetationsvegetation</u> found in this study are listed in (Table 2).

The NDF and ADF contents of <u>vegetationsvegetation</u> found in this study were about 40.65-79.47% and 23.66-60.33%, respectively. Lowland swamp <u>vegetationsvegetation</u> 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, thereThere 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 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 vegetationsvegetation 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 vegetationsvegetation 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

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

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

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 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 vegetationsvegetation 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

vegetationsvegetation including Cecengkehan (1. 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

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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 vere 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 vegetationsvegetation 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 vegetationsvegetation 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 vegetationsvegetation 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_x 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 vegetations vegetation in lowland swamp ranged from 5.63 to 25.19%. Four types of vegetationsvegetation 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 vegetationsvegetation found in this study were higher than those of swamp vegetationsvegetation 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 <u>undissolved_not</u> <u>dissolving_in</u> plant cell wall materials. NDF content of a feed affects the ability of <u>ruminant_animalsruminants</u> 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 vegetationsvegetation 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 vegetationsvegetation found in this study were lower than those of Asep et al. (2012) who reported that the NDF contents of swamp green vegetationsvegetation 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 vegetationsvegetation 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<u>vegetation</u> 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 vegetationsvegetation 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 vegetationsvegetation 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)

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 the vegetationsvegetation 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 vegetationsvegetation 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 vegetationsvegetation 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 vegetationsvegetation 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).

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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

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

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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 105°C, 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.

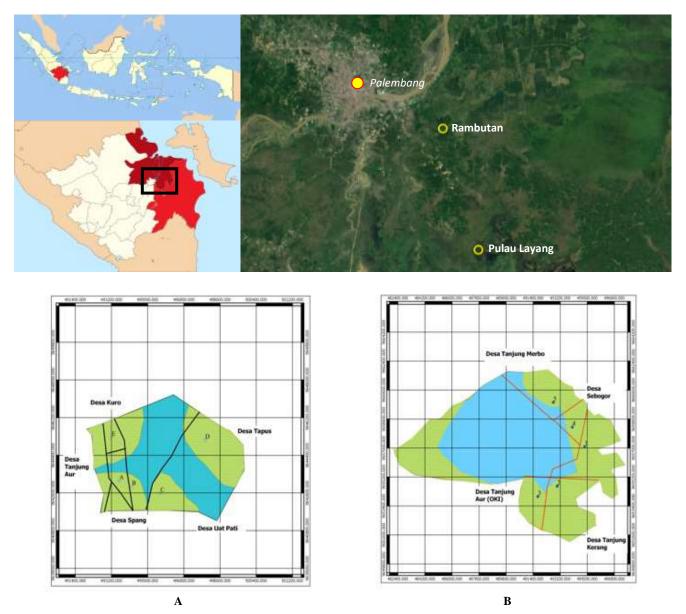


Figure 1. Research location in South Sumatra, Indonesia. A. Pulau Layang Village, Pampangan Sub-district, Ogan Komering Ilir District, South Sumatra. B. Rambutan Village, Rambutan Sub-district, Banyuasin District, South Sumatra, Indonesia (Muhakka et al. 2019)

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 550°C 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:

% NDF =
$$\frac{c-b}{2}$$

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:

% cellulose =
$$---x$$
 100%

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

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

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	l. Prop	erties	of	soil	at	the	study	site

Parameter	Pula	u Layang	Ra	mbutan
	Value	Remark	Value	Remark
pH H ₂ O (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.

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

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

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

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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% 12.76% and (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*.

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

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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 105°C, 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.

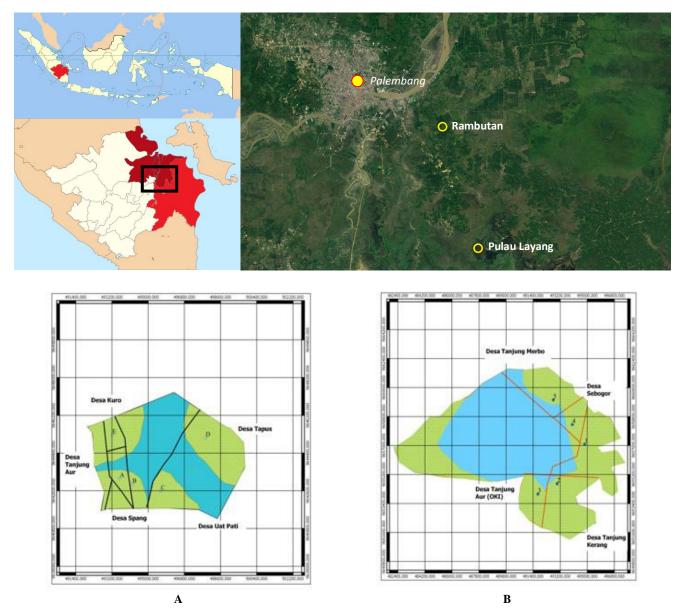


Figure 1. Research location in South Sumatra, Indonesia. A. Pulau Layang Village, Pampangan Sub-district, Ogan Komering Ilir District, South Sumatra. B. Rambutan Village, Rambutan Sub-district, Banyuasin District, South Sumatra, Indonesia (Muhakka et al. 2019)

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 550°C 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:

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:

% cellulose =
$$---x = 100\%$$

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

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

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	. Pro	perties	of	soil	at	the	study	site
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Parameter	Pula	u Layang	Rambutan		
	Value	Remark	Value	Remark	
pH H ₂ O (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, Н. 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.

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% 2017), 1.15-10.20% 12.76% (Nampoothiri and (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*.

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