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Seasonal influence on mineral concentration of forages on flooded pastures in South Sumatra of Indonesia

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Abstract

This study was conducted to evaluate macro and micro mineral concentration of forages on flooded pastures in non tidal swamp of South Sumatra of Indonesia. Five species of Poaceae, four species of Mimoceae, three species of Cyperaceae and one species of Onagraceae were collected during flooded and dry seasons. The results showed that mineral concentrations of forages greatly varied between seasons. Higher concentration of Ca and Fe in flooded season and higher concentration of Mg in dry season were found in most forages. All forages had deficient P but most forages had sufficient Mg concentration and just Mimoceae and *L. peploides* had sufficient Ca for grazing buffalo requirement. Sulphur sufficiency occured in some of Mimoceae and Cyperaceae species. Most forages had Cu, Fe, Zn, and Mn concentrations which more than critical level for buffalo grazing even though all deficiencies were found in flooded season. Copper deficiency occurred in *Brachiaria muticum*, *Mimosa gigantica*, *Scirpus grossus* and *Scleria pterora*; Zn deficiency occured in *Oryza Rupifogon*; Mn deficiency occured in *Eleocharis dulcis* in flooded season. Copper toxicity occured in *Neptunia oleraceae* in dry season, *Aeschynomene sensitive* and *Ludwigia peploides* during all seasons. Iron toxicity occured in *Leersia hexandra* in flooded season, *Eleocharis dulcis* and *Ludwigia peploides* in all seasons and Mn toxicity occured in *Neptunia oleraceae* in dry season.

Keywords**:** buffalo, deficiency, toxicity

Introduction

Natural pasture species in non-tidal swamp have been the main source of feed for swamp buffalo in South Sumatra. Forage nutritive values fluctuate with seasons and the dry season is the most limiting in terms of nutrient supply to grazing buffaloes. Most grazing livestock in tropical countries including Indonesia fulfill their mineral requirements usually only from the forages. Forages represent important source of minerals for grazing ruminants, and play essential roles in preventing diseases and inhibiting or stimulating ruminal microbial activity (Spears 1994).

The concentration of individual minerals in forages varies greatly depending on interaction of number of factors including soil, plant species and stage of maturity, yield, management factor, and climate. Mineral profiles of tropical forages in flooded pasture have been received little attention, and in some situation they are deficient in one or more elements, thus supplementation is required for optimal animal performance and health (Camarao et al. 2002; Camarao et al. 2004).

Data on variation of the mineral concentrations in forage species and their variability between seasons are essential for proper or cost effective feed formulation and swamp buffalo nutrition. Thus, objectives of this study were to estimate and compare seasonal dynamics of Ca, P, Mg, S, Cu, Fe Zn, and Mn of native flooded pasture species in non-tidal swamp of South Sumatra, Indonesia.

Materials and methods

Site description

Research was conducted on February until September 2014 located in non-tidal swamp administrated in Rambutan subdistrict, Banyuasin district and Pampangan subdistrict, OKI

(Ogan Komering Ilir) district of South Sumatra Province and geographycally covered on 3^{o}05’27.2” – 3^{o}11’24.9” South Latitude and 104 ^{o}55’23.9” – 104 ^{o}58’57.9” East Longitude.

The dry season begins from April to September while the rainy season relatively occurs from October to March with the average of rainfall being 2,100 - 3,264 mm per year. The research location has lowest temperatures ranged from 22 to 25^{o}C (at 05.00 - 08.00 a.m.) and highest temperatures ranged from 30 to 34^{o}C (11.00 a.m.- 02.00 p.m.).

Forage sampling

Native vegetation species consumed by buffaloes include Poaceae (*Brachiaria muticum, Leersia hexandra, Hymenachne acutigluma, Ischaemum rugosum, Oryza rupifogon*), Mimoceae (*Mimosa gigantica, Sesbania exasperata, Neptunia oleracea, Aeschynomene sensitive*), Cyperaceae (*Scirpus grossus L, Scleria pterora Presl, Eleocharis dulcis*), and Onagraceae (*Ludwigia peploides*) were collected from different part of flooded pasture.

Observation of forage was conducted by observing the species of vegetation which consumed by grazing buffaloes. This observation was played on 08.00-11.00 a.m. and 02.00-05.00 p.m (Hirata et al. 2008; Setianah et al. 2004) in our previous study (Ali et al. 2013). The forages were collected by hand picking during flood in wet season (March 2014) and dry season (August and September 2014) from at least nine different sites. Samples were chopped, dried at 50 ^{o}C, pooled, and then coarsely milled to pass 1 mm screen for mineral analysis.

Mineral analysis

For each season and each forage species, representative samples (duplicate) were digested stepwise with nitric acid (HNO_3). Concentrations of minerals of the forage samples were analyzed by using inductively coupled plasma emission spectrometer (SPS7700, Seiko

Instruments Inc., Chiba, Japan) in Laboratory of Feed Technology and Dairy Nutrition, Faculty of Animal Husbandry, Bogor Agricultural University.

Statistical analysis

Data were analyzed using StatView SAS (1999). The differences of means between seasons were determined using unpaired t-test. The difference was assumed statistically significant ($P<0.05$).

Result

There was difference ($P<0.05$) in Ca. P, Mg, and S concentration within seasons (Table 1). Calcium concentration in most forages was higher in flooded than in dry season except in *B. muticum*, *N. oleracea*, *S. pterora Presl*, *E. dulcis*, and *L. peploides*. With an exception of *B. muticum*, Ca concentrations in Poaceae and Cyperaceae lower than Ca concentrations in Mimoceae. Similar to Ca, the concentration of P in forages varied ($P<0.05$) between seasons on most forages except in *O. rupifogon*, *A. sensitive*, *S. pterora Presl* and *E. dulcis*. On the contrary to Ca concentration, Mg concentration in most forages was higher in dry than in flooded season except in *S. grossus L*, *I. rugosum*, *N. oleracea*, *A. sensitive*, and *H. acutigluma* which was higher in flooded than in dry season.

There was difference ($P<0.05$) in micro minerals concentration within seasons (Table 1). In most Poaceae species, Cu concentrations not significantly different between seasons except in *B. muticum* while Fe, Zn and Mn concentrations fluctuated between seasons. Higher Fe concentrations in flooded season were found in most forages while other micro minerals fluctuated between seasons in most forage.

Table 1. Concentrations and seasonal variation of macro and micro minerals in forages

Species	Season	Macro mineral (% DM)				Micro mineral (ppm DM)			
		Ca	**P**	**Mg**	**S**	**Cu**	**Fe**	**Zn**	**Mn**
Poaceae									
B. muticum	dry	0.62^{b}	0.10^{b}	1.59^{b}	0.50^{b}	11.6^{b}	105.0^{a}	41.8^{a}	366.2^{b}
	flooded	0.11^{a}	0.01^{a}	0.86^{a}	0.04^{a}	9.6^{a}	107.0^{a}	60.2^{a}	128.0^{a}
L. hexandra	dry	0.08^{a}	0.16^{b}	1.01^{b}	0.13^{a}	15.3^{a}	193.2^{a}	128.0^{b}	274.0^{a}
	flooded	0.12^{b}	0.09^{a}	0.84^{a}	0.14^{a}	12.3^{a}	806.0^{b}	97.8^{a}	283.0^{a}
H. acutigluma	dry	0.07^{a}	0.11^{b}	1.02^{a}	0.17^{a}	15.5^{a}	139.0^{a}	40.9^{a}	225.0^{a}
	flooded	0.19^{b}	0.08^{a}	1.09^{b}	0.09^{a}	17.5^{a}	208.0^{b}	56.8^{b}	252.0^{a}
I. rugosum	dry	0.08^{a}	0.04^{a}	1.03^{a}	0.06^{a}	13.2^{a}	184.0^{b}	57.0^{a}	125.0^{a}
	flooded	0.14^{b}	0.07^{b}	1.11^{b}	0.38^{b}	12.2^{a}	121.0^{a}	78.1^{a}	297.0^{b}
O. rupifogon	dry	0.12^{a}	0.05^{a}	1.19^{b}	0.03^{a}	16.8^{a}	499.0^{b}	45.8^{b}	906.0^{a}
	flooded	0.16^{b}	0.08^{a}	0.95^{a}	0.03^{a}	13.6^{a}	188.0^{a}	26.1^{a}	1044.0^{b}
Mimoceae									
M. gigantica	dry	0.32^{a}	0.14^{b}	1.68^{b}	0.30^{b}	22.1^{b}	206.0^{a}	76.9^{b}	252.2^{a}
	flooded	0.39^{b}	0.10^{a}	1.54^{a}	0.14^{a}	8.6^{a}	317.0^{a}	33.7^{a}	342.1^{a}
S. exasperata	dry	0.42^{a}	0.17^{b}	1.41^{b}	0.30^{b}	23.4^{a}	100.0^{a}	76.4^{a}	153.0^{a}
	flooded	0.64^{b}	0.15^{a}	1.17^{a}	0.23^{a}	21.3^{a}	181.0^{b}	64.3^{a}	128.0^{a}
N. oleracea	dry	0.66^{b}	0.07^{a}	1.80^{a}	0.05^{a}	43.3^{b}	202.0^{a}	176.0^{b}	1076.0^{b}
	flooded	0.43^{a}	0.14^{b}	2.01^{b}	0.18^{b}	21.7^{a}	358.0^{b}	43.2^{a}	402.0^{a}
A. sensitive	dry	0.46^{a}	0.12^{a}	1.98^{a}	0.43^{a}	29.2^{a}	129.0^{a}	86.7^{a}	407.0^{b}
	flooded	0.48^{b}	0.13^{a}	2.35^{b}	0.40^{a}	42.1^{b}	145.0^{a}	94.4^{a}	286.0^{a}
Cyperaceae									
S. grossus L	dry	0.08^{a}	0.21^{b}	0.65^{a}	0.31^{a}	14.3^{b}	89.4^{a}	49.6^{b}	291.0^{a}
	flooded	0.20^{b}	0.11^{a}	1.32^{b}	0.33^{a}	9.9^{a}	318.0^{b}	43.3^{a}	568.0^{b}
S. pterora Presl	dry	0.25^{b}	0.06^{a}	0.89^{b}	0.05^{a}	14.7^{b}	69.0^{a}	48.1^{a}	487.0^{b}
	flooded	0.10^{a}	0.08^{a}	0.74^{a}	0.08^{b}	9.6^{a}	151.0^{b}	62.3^{a}	210.0^{a}
E. dulcis	dry	0.08^{b}	0.14^{a}	1.01^{b}	0.29^{a}	20.1^{a}	936.0^{a}	55.1^{b}	231.0^{b}
	flooded	0.03^{a}	0.20^{a}	0.17^{a}	0.49^{b}	19.1^{a}	1629.0^{b}	28.0^{a}	$34 .4^{a}$
Onagraceae									
L. peploides	dry	0.56^{b}	0.16^{a}	2.62^{b}	0.16^{a}	31.2^{a}	728.0^{a}	198.0^{a}	969.0^{b}
	flooded	0.33^{a}	0.21^{b}	2.06^{a}	0.15^{a}	244.0^{b}	926.0^{b}	207.0^{a}	691.0^{a}
Critical level*		0.30	0.25	0.20	0.26	11	50	33	40
Toxic level *						25	500	750	1000

^{a,b}Means with different superscripts within a species between season are significantly different ($P<0.05$).

* in accordance with McDowell et al. (1997).

Discussion

Macro minerals

In most forages, the concentration of minerals declined with advancing maturity and could probabably be explained by their genetic variations, climate or mineral level in soils (Minson 1990; Underwood and Suttle 1999). It was observed that Ca concentrations of Mimoceae (legume) and most Poaceae (grass) were higher in flooded season than in dry season. This was agreed with a study in dry land of South Sumatra, Indonesia (Evitayani et al. 2006) which showed that Ca concentration in two species of grasses and four species of legumes in rainy season was relatively higher than in dry season and varied from 0.57 (*Pennisetum purpuphoides*) to 2.61% (*Leucaena leucocephala*) in rainy and from 0.51 (*P. purpuphoides*) to 2.44% (*L. leucocephala*) in dry season. Oppositely, Warly et al. (2006a) in dry land of West Sumatra concluded that Ca concentration of seven species of grasses and 13 species of legumes in rainy season were lower than in dry season and ranged from 0.39 (*Euchlaena mexicana*) to 1.69% (*Gliricidia maculata*) while Nasrullah et al. (2004) in dry land of South Sulawesi showed that the concentration ranged from 0.3 (*Cenchrus ciliaris*) to 4.0% (*Desmanthus virgatus*). Results of the current study showed that range of Ca concentration was lower than previous studies (Nasrullah et al. 2004; Evitayani et al. 2006; Mtui et al. 2006; Warly et al. 2006a). Calcium concentration in Mimoceae and Onagraceae was more than 0.30% which meet the ruminant's requirement (Mc Dowell et al. 1997), in agreement with the previous studies that Ca concentration was normally higher in legumes than in grasses. This indicated that Mimoceae is good Calcium source for grazing buffalo in all seasons on flooded pasture.

Phosphor concentration in all forages in present result was lower than ruminant's requirement (0.25%) and fluctuated in both seasons. Nasrullah et al. (2004) reported that P concentration ranged from 0.20 (*E. mexicana*) to 1.80% (*Centrocema plumieri*) and was not significantly affected by seasons. Warly et al. (2006a) concluded that P concentration was higher in dry season than in rainy season and range from 0.21 (*E.mexicana*) to 0.47% (*Setaria sphacelata*). Study by Evitayani et al. (2006), which sampled same species but different location, showed that P concentration ranged from 0.29 (*Centrocema pubescens*) to 0.68% (*P. purpuphoides*) and was higher in rainy season than in dry season and all the forages had P concentration more than 0.25% in rainy season. The low concentration of Ca and P in current results related to acid soil condition in study location with low availability of Ca and P for plants (Ali et al. 2013). Study of Jumba et al. (1995) showed the significant correlation between soil P and herbage P while Kano et al. (2006) showed that soil pH not only related to grass growth and P uptake but also mycorrhizal dependency.

Underwood and Suttle (1999) recomended that diets of livestock should have Ca: P ratio about 1:1 to 2:1 and more important than the absolute concentration for utilizattion by ruminants. This present results showed that the Ca:P ratio range from 0.16 (*E. dulcis*) to 10.0 (*B. muticum*) and implicated that high Ca concentration increase the demand of P in buffalo diets. Study by Jones (1990) and Miller et al. (1990), which described some low cost strategies in dry land, was recommended for overcoming P deficiency in the flooded pasture.

With an exception of *E. dulcis* in flooded season, all forages had sufficient Mg concentration for ruminant’s requirement (Mc Dowell et al. 1997) which indicated that buffalo consuming varieties of forages in the area are unlikely to had Mg sufficiency. This agreed with Minson (1990) that grass tetany, which caused by Mg deficiency, in the ruminant grazing on tropical forage have not been reported. The sufficiency of Mg concentration in most forages also reported by previous studies (Nasrullah et al. 2004; Evitayani et al. 2006; Warly et al. 2006a). Unlike Ca and P concentrations, range of Mg concentrations was higher than previous studies in dry land.

Sulphur provides microbial protein synthesis in rumen and its concentration depends on the availability of soil sulphur, nitrogen and phosphor, and the maturity of the forage. The concentration of S varied ($P < 0.05$) between seasons in seven of thirteen forage species. Sulphur deficiency occured in most Poaceae species except on *B. Muticum*, and *I. Rugosum* and most Mimoceae and Cyperaceae species had sufficient S concentrations for ruminant's requirement. Sulphur deficiency in dry season was reported by Evitayani et al. (2006). Warly et al. (2006a) reported that percentage of forage species with S deficiency was higher in dry season than in rainy season. The present results indicated that high level of Mimoceae and Cyperaceae in buffalo diet lead sufficient consumption of Ca, Mg, and S in the flooded pasture, which dominated by Poaceae and Cyperaceae spesies (Ali et al. 2013).

Micro minerals

Based on mineral requirement (Mc Dowell et al. 1997) most forages in flooded pasture had Cu, Fe, Zn, and Mn concentration more than critical level of requirement for grazing ruminants in tropical region and had range of concentrations higher than in dry land. Copper deficiency was found in *B. muticum*, *M. gigantica*, *S. grossus*, and *S. pterora* in flooded season while Cu toxicity was found in *N. oleraceae* in dry season, in *A. sensitive* and *L. peploides* in all seasons. The range of Cu concentration in Poaceae and Mimoceae in present results was higher than range reported by Fariani (2008) from 5.6 to 10.1 ppm and 3.8 to 16.6 ppm in three species of grasses and four species of legumes in dry land of South Sumatra. Warly et al. (2006b) reported that Cu concentration of thirteen species of grasses varied from 2.3 to 14.4 ppm.

In present results, Cu concentration of most Poaceae species not significantly varied between seasons except *B. muticum*. Warly et al. (2006b) also reported similar result but Cu deficiency was higher in dry season than in rainy season while Fariani (2008) reported that Cu concentration of *Axonopus compressus* and *Panicum maximum* was higher in dry season than in rainy season. Copper concentrations of Mimoceae in current results varied between seasons. Other studies also reported similar result (Mtui et al. 2006), or higher in rainy than dry season (Khan et al. 2006 and Evitayani and Warly 2010). Khan et al. (2006) reported range from 10.91 to 25.69 ppm while Evitayani and Warly (2010) reported range from 3.8 to 16.6 ppm in West Sumatra.

All forages had Fe concentration more than critical level for ruminant's requirement while toxicity was found in *L. hexandra* in flooded season, *E. dulcis*, and *L. peploides* in all seasons. Present results showed that Fe concentration in most Mimoceae, Cyperaceae, and Onagraceae species was higher in flooded season than in dry season and could be explained probably due to natural dilution process and translocation of minerals to the root. Similar result was reported by Mtui et al. (2006) with range from 66.76 to 618.9 ppm, and Warly et al (2006b) with range from 96.3 to 569.2 ppm. Khan et al. (2006) also reported that all forages had Fe sufficient and higher concentration in winter than in summer and ranged from 92.53 to 201.73 ppm. Differently Fariani (2008) reported that the higher Fe concentration was just found in grasses with range 116.40 to 511.40 ppm. The excessive Fe concentration was also reported by Rubanza et al. (2006) and Warly et al. (2006b).

It was observed that Zn concentration in all forages was less than toxic level while Zn deficiency was just found in *O. rupifogon* and *E. dulcis* in flooded season. Mn deficiency was found in *E. dulcis* in flooded season while toxicity in *N. oleraceae* in dry season. The low Zn and Mn concentration was also reported by Fariani (2008), Mtui et al. (2006), Rubanza et al. (2006), and Warly et al. (2006b). Khan et al. (2006) found that Zn and Mn concentration in all forages was above critical level and Zn concentration was higher in winter than in summer. Similar to Cu and Fe concentration, range of Zn and Mn concentration in current results was higher than studies in dry land (Fariani 2008, Khan et al. 2006, Kakengi et al. 2007, Mtui et al. 2006, Rubanza et al. 2006, and Warly et al. 2006b).

This finding could probably be explained by mineral level in soils (Minson 1990; Underwood and Suttle 1999). Soil condition in study location characterized with low pH, low availability of Ca, P, and excessive micro mineral solubility for plants (Ali et al. 2013 and Waluyo et al. 2012). Beside that high micro mineral concentration in aquatic plants could be associated with the ability to accumulate the minerals in their tissue (Abdul-Wahab et al. 2014a, 2014b, Asikin and Thamrin 2012, and Veschasit 2012) and excessive micro minerals in water, which probably caused by poor management of wastewater in study area and intensive agricultural practices as significant sources of metal pollution in soils and water. Research by Jan et al. (2011) showed that there was higher concentration of Cu, Zn, Cr, Ni, Pb, and Mn in meat and milk in contaminated area than in control area and concluded that consumption of the foods had significantly increased the minerals concentration in human blood. Similar results was also reported by Miranda et al. (2009) Skalická et al. (2005) and Blanco-Penedo et al. (2006) or reviewed by Rajaganapathy et al. (2011)**.** Therefore, high concentration of Cu, Fe, and Mn in *N. oleraceae*, *A. sensitiva*, *E. dulcis*, and *O. rupifogon* in current study might not only raise toxicity for buffaloes, when especially consumed in large amounts, but also contaminate to meat and milk of buffalo as food for human consumption. Hence, there is a need to further investigate the status of trace and toxic minerals in blood, liver, kidney, meat, and milk of buffalo in the region.

Conclusion

It could be concluded that mineral concentration of forages greatly varied between seasons on flooded pastures in South Sumatra. All of forages had deficient P but most forages had sufficient Mg concentration for grazing buffalo except *E. Dulcis* during flooded season and just Mimoceae and *L. peploides* had sufficient Ca for grazing buffalo in all seasons. Sulphur sufficiency was just found in some of Mimoceae and Cyperaceae species.

Most forages had Cu, Fe, Zn, and Mn concentration which more than critical level for buffalo grazing even though all deficiencies were found in flooded season. Copper deficiency was found in *B. muticum*, *M. gigantica*, *S. grossus* and *S. pterora*. Zinc deficiency found in *O. Rupifogon* and Mn deficiency in *E. dulcis* in flooded season. Copper toxicity was found in *N. oleraceae* in dry season, *A. sensitive* and *L. peploides* during all seasons. Iron toxicity was found in *L. hexandra* in flooded season, *E. dulcis* and *L. peploides* in all seasons and Mn toxicity was found in *N. oleraceae* in dry season.

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References

Abdul-Wahab AS; Syed-Ismail SN; Emilia ZA; Sarva MP. 2014a. *Neptunia oleracea* (water mimosa) as phyto remediation plant and the risk to human health: A review. Advances in Environmental Biology 8:187-194. http://goo.gl/R0lzU3.

Abdul-Wahab AS; Syed-Ismail SN; Emilia ZA; Sarva MP. 2014b. Heavy metals uptake of water mimosa (*Neptunia oleraceae*) and its safety for human consumption. Iranian Journal Public Health 43:103-111. http://goo.gl/vdZc5N

Ali AIM; Sandi S; Muhakka; Riswandi; Budianta D. 2013. The grazing of pampangan buffaloes at non tidal swamp in south sumatra of Indonesia. Proceedings International Conference on Asia Agriculture and Animal (ICAAA2013), Russia.http://dx.doi.org/10.1016/j.apcbee.2014.03.006

Asikin S; Thamrin M. 2012. The benefits of Chinese water chestnut (*Eleocharis dulcis*) in swamp land rice field ecosystem. Jurnal Litbang Pertanian 31: 35-42. http://goo.gl/1Q8GTF

Blanco-Penedo I; Cruz JM; López-Alonso M; Miranda M; Castillo C; Hernandez J; Benedito J.L. 2006. Influence of copper status on the accumulation of toxic and essential metals in cattle. Environment International 32:901–906.

Camarao AP; Lourenco J; Dutra S. 2002. Flooded pasture production for grazing buffalo in the Brazilian Amazon, 56–70. Proceedings Buffalo Symposium of the Americas, Bele´m, Para´, Brazil.

Camarao AP; Lourenço JB; Dutra S; Hornick JL; Bastos Da Silva M. 2004. Grazing buffalo on flooded pastures in the Brazilian Amazon region. Tropical Grasslands 38:193–203. http://goo.gl/4zNOyG.

Evitayani; Warly L; Fariani A; Ichinohe T; Hayashida M; Abdul Razak SA; Fujihara T. 2006. Macro mineral distribution of forages in South Sumatra during rainy and dry seasons. Journal of Food, Agriculture & Environment 4: 155-160. http://goo.gl/XEVSsL

Fariani A. 2008. Concentration of micro minerals in fiber fraction of forages in South Sumatra, Indonesia. Journal Indonesia Tropical Animal and Agriculture 33:79-83. http://eprints.undip.ac.id/18921/

Hirata M; Hasegawa N; Takahashi T; Chowdappa R; Ogura S; Nogami K; Sonoda T. 2008. Grazing behaviour, diet selection and feed intake of cattle in a young tree plantation in Southern Kyushu, Japan. Tropical Grasslands 42:170–180. http://goo.gl/4zNOyG

Jan FA; Ishaq M; Khan S; Shakirullah M; Asim SM; Ahmad I; Mabood F. 2011. Bioaccumulation of metals in human blood in industrially contaminated area. Journal of Environmental Sciences 23:2069-2077 https://goo.gl/xIvzgM

Jumba IO; Suttle NF; E.A Hunter; Wandiga SOW.1995. Effects of soil origin and mineral composition of herbage species on the mineral composition of forages in the Mount Elgon region of Kenya I. Calcium, Phosphorus, Magnesium and Sulphur. Tropical Grasslands 29: 40-46. http://goo.gl/gkLSba.

Jones RJ. 1990. Phosphorus and beef production in northern Australia. 1 Phosphorus and pasture productivity. A review. Tropical Grasslands 24: 131-139. http://goo.gl/EmHm0m

Kanno T; Saito M; Ando Y; Macedo MCM; Nakamura T; Miranda CHB. 2006. Importance of indigenous arbuscular mycorrhiza for growth and phosphorus uptake in tropical forage grasses growing on an acid, infertile soil from the Brazilian savannas. Tropical Grasslands 40: 94–101.http://goo.gl/uACGSK

Khan ZI; Hussain A; Ashraf M; McDowell LR. 2006. Mineral status of soils and forages in Southwestern Punjab-Pakistan: Micro minerals. Asian Australian. Journal of Animal Science. 8: 1139 - 1147 http://goo.gl/DUWFF5

Mc Dowell LR; Conrad JH; Glen Hembry F. 1997. Minerals for Grazing Ruminants in Tropical Regions. Report from US Agency for International Development and Caribbean Basin Advisory Group (CBAG). Animal Science Department, Center for Tropical Agriculture, University of Florida

Minson DJ. 1990. Forage in Ruminant Nutrition. Academic Press, Inc. San Diego

Miller CP; Winter WH; Coates DB; Kerridge PC. 1990. Phosphorus and beef production in northern Australia.10. Strategies for phosphorus use. Tropical Grasslands 24: 139-149. http://goo.gl/kNaETz

Miranda M; Benedito JL; Blanco-Penedo I; López-Lamas C; Merino A; López-Alonso M. 2009. Metal accumulation in cattle raised in a serpentine-soil area: relationship between metal concentrations in soil, forage and animal tissues. Journal of Trace Element & Medical Biology 23:231-238.

Mtui DJ; Lekule FP; Shem MN; Rubanza CDK; Ichinohe T; Hayashida M; Fujihara T. 2006. Seasonal influence on mineral content of forages used by smallholder dairy farmers in lowlands of Mvomero District, Morogoro, Tanzania. Journal of Food, Agriculture & Environment 4: 216-221. http://goo.gl/LnvXhc

Nasrullah; Niimi M; Akashi R; Kawamura O. 2004. Nutritive evaluation of forage plants in South Sulawesi, Indonesia II. Mineral composition. Asian-Australian Journal of Animal Science 17: 63-67. http://goo.gl/zPkgD7

Rajaganapathy V; Xavier F; Sreekumar D; Mandal PK. 2011. Heavy metal contamination in soil, water and fodder and their presence in livestock and products. A Review. Journal of

Environmental Science and Technology 4: 234-249. http://www.scialert.net/fulltext/?doi=jest.2011.234.249

Rubanza CDK; Shem MN; Ichinohe T; Fujihara T. 2006. Polyphenolics and minerals composition of selected browse tree species leaves native to north-western Tanzania traditional fodder banks. Journal of Food, Agriculture & Environment 4: 328-332. http://goo.gl/3M5pmh

SAS. 1999. Statistical Analysis System User's guide. Statistical analysis Institute, Inc. Carry, NC. USA

Setianah R; Jayadi S; Herman R. 2004. Eating behavior of local goat cross pasturing in peatland: a case study in Kalampangan, Palangkaraya, Central Kalimantan. Media Peternakan., 27:111-122. http://goo.gl/MNXicL

Skalická M; Koréneková B; Nad P. 2005. Copper in livestock from polluted area**.** Bulletin of Environmental Contamination and Toxicology 74:740–744. http://goo.gl/kgYBK9

Spears JW. 1994. Minerals in forages. Proceedings. The National Conference on Forage Quality, Evaluation and Utilization. University of Nebraska.

Underwood EJ; Suttle NF. 1999. The Mineral Nutrition of Livestock. 3rd ed., CABI Publishing, Oxon, UK

Veschasit O; Meksumpun S; Meksumpun. 2012. Heavy metals contamination in water and aquatic plants in the Tha Chin River, Thailand. Kasetsart Journal: Natural Science 46: 931-943. http://goo.gl/8naMGb

Waluyo; Alkasuma; Susilawati; Suparwoto. 2012. Spatial inventory of potential competitiveness swamp land for agricultural development in south Sumatra. Jurnal Lahan Suboptimal 1: 64-71. http://goo.gl/Z7zmBy

Warly L; Fariani A; Evitayani; Hayashida M; Fujihara T. 2006a. Mineral status of forages and grazing goats in West Sumatra, Indonesia: 1. Macro minerals. Journal: Food, Agriculture and Environment 4: 234-236. http://goo.gl/6PKBKW

Warly L; Fariani A; Evitayani; Hayashida M; Fujihara T. 2006b. Mineral status of forages and grazing goats in West Sumatra, Indonesia: 2. Micro minerals. Journal: Food, Agriculture and Environment 4: 204-207. http://goo.gl/DfGVI3

Gmail

asep ali <asepali76@gmail.com>

VERY URGENT: RE: Your manuscript 301 for publication in Tropical Grasslands-Forrajes Tropicales

Schultze-Kraft, Rainer (CIAT) <R.SchultzeKraft@cgiar.org> Mon, Nov 25, 2019 at 7:35 PM
To: "Ali, Asep (ILRI)" <asepali76@gmail.com>

Dear Dr. Ali

I need your immediate reply.

Regards

Rainer Schultze-Kraft

From: Schultze-Kraft, Rainer (CIAT)
Sent: Wednesday, November 20, 2019 10:46 AM
To: asep ali <indranutrisi@yahoo.co.id>
Subject: VERY URGENT: RE: Your manuscript 301 for publication in Tropical Grasslands-Forrajes Tropicales
Importance: High

Dear Dr. Ali,

It is now very urgent that you reply to my email of 14 November and provide the citation substitutes.

Thank you for your cooperation.

Regards

Rainer Schultze-Kraft

From: Schultze-Kraft, Rainer (CIAT)
Sent: Thursday, November 14, 2019 8:03 PM

To: 'asep ali' <indranutrisi@yahoo.co.id>
Subject: RE: Your manuscript 301 for publication in Tropical Grasslands-Forrajes Tropicales

Dear Dr. Ali,

During the process of checking and verifying the references cited in your manuscript, we found that the following five correspond to articles published in journals that are considered to be potentially predatory:

Evitayani; Warly L; Fariani A; Ichinohe T; Hayashida M; Abdul Razak SA; Fujihara T. 2006. Macro mineral distribution of forages in South Sumatra during rainy and dry seasons. Journal of Food, Agriculture and Environment 4(2):155–160. http://bit.ly/370gPTe

Mtui DJ; Lekule FP; Shem MN; Rubanza CDK; Ichinohe T; Hayashida M; Fujihara T. 2006. Seasonal influence on mineral content of forages used by smallholder dairy

farmers in lowlands of Mvomero District, Morogoro, Tanzania. Journal of Food, Agriculture and Environment 4(2):216–221. http://bit.ly/350x2Wv

Rajaganapathy V; Xavier F; Sreekumar D; Mandal PK. 2011. Heavy metal contamination in soil, water and fodder and their presence in livestock and products. A review. Journal of Environmental Science and Technology 4:234–249. doi: http://dx.doi.org/10.3923/jest.2011.234.249

Rubanza CDK; Shem MN; Ichinohe T; Fujihara T. 2006. Polyphenolics and minerals composition of selected browse tree species leaves native to north-western Tanzania traditional fodder banks. Journal of Food, Agriculture and Environment 4(2):328–332. http://bit.ly/2KisFOL

Warly L; Fariani A; Evitayani; Hayashida M; Fujihara T. 2006a. Mineral status of forages and grazing goats in West Sumatra, Indonesia: 1. Macro minerals. Journal of Food, Agriculture and Environment 4(2):234–236. http://bit.ly/2rx0Hbt

Since Tropical Grasslands-Forrajes Tropicales does not encourage citing articles from such journals, I would appreciate it if you could identify substitutes for these citations. Just let me know any new substitute citations – we will adjust the text accordingly.

In order to send you the proofs of your paper soon, kindly reply at your earliest convenience.

Best regards

Rainer Schultze-Kraft

From: asep ali <indranutrisi@yahoo.co.id>

Sent: Thursday, October 31, 2019 11:49 PM

To: asep_ali@fp.uncri.ac.id; Schultze-Kraft, Rainer (CIAT) <R.SchultzeKraft@CGIAR.ORG>

Subject: Re: Your manuscript 301 for publication in Tropical Grasslands-Forrajes Tropicales

Dear Dr. Schultze-Kraft

All your comments and questions have been followed and so I just deleted your comments in the document. Kindly I also attached a file about your comments and my further explanations and the line number which might you need.

Thank you so much

Asep Ali

Pada Rabu, 30 Oktober 2019 23.08.48 WIB, Schultze-Kraft, Rainer (CIAT) <mailto:r.schultzekraft@cgiar.org> menulis:

Dear Dr. Ali,

I would greatly appreciate hearing from you whether I can expect an amended version of manuscript 301 from you for publication in the next issue of Tropical Grasslands-Forrajes Tropicales.

There is one more issue that I would like to ask you to clarify, for the benefit of better understanding of the reader: What does ´flooded´ resp. ´dry´ season mean regarding water in the pasture? Is there standing water only in the wet (= ´flooded´) season and the soil surface is dry in the other season.

Looking forward to hearing from you.

Kind regards

Rainer Schultze-Kraft

From: Schultze-Kraft, Rainer (CIAT)

Sent: Monday, October 28, 2019 1:53 PM

To: mailto:indranutrisi@yahoo.co.id; mailto:asep_ali@fp.uncri.ac.id

Subject: Your manuscript 301 for publication in Tropical Grasslands-Forrajes Tropicales

Dear Dr. Ali:

A few weeks ago I received from my editor colleague, Lyle Winks, a version of your manuscript, Seasonal influence on mineral concentration of forages on flooded pastures in South Sumatra, Indonesia, modified and edited on the basis of the Journal´s peer review. I read the manuscript thoroughly and after consultation with my colleague we are prepared to publish it as a Short Communication in the next issue of Tropical Grasslands-Forrajes Tropicales.

However, there are still a few minor queries that we have. Please refer to the attached document where the queries are expressed in the form of comments. Kindly address them and return the manuscript to me. It is imperative that any modification of yours (deletion, correction, addition) to the manuscript is done using the “track changes” mode. I would furthermore appreciate it if in each “Comment” you could very briefly annotate how you reacted to the respective query, e.g. by using the “Reply to Comment” mode.

For your information, I have replaced ‘Mimosaceae’ with ‘Leguminosae’ in the attached text because Sesbania and Aeschynomene are not mimosoids. In the Journal we prefer that the GRIN plant taxonomy be used; therefore I have modified several of the species names and their authorities.

Kindly acknowledge receipt of this email and let me know if you are in the position to send me the amended manuscript within the next few days. This would enable us to include your paper in the next Journal issue which is scheduled for 30 November.

Looking forward to hearing from you.

Kind regards,

Rainer Schultze-Kraft

Professor Rainer Schultze-Kraft

Co-Editor, Tropical Grasslands-Forrajes Tropicales

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Email: http://cn.mc151.mail.yahoo.com/mc/compose?to=R.Schultzekraft@cgiar.org

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asep ali <asepali76@gmail.com>

VERY URGENT: RE: Your manuscript 301 for publication in Tropical Grasslands-Forrajes Tropicales

asep ali <asepali76@gmail.com> Mon, Nov 25, 2019 at 8:20 PM
To: "Schultze-Kraft, Rainer (CIAT)" <R.SchultzeKraft@cgiar.org>

I searching other citatations now. Thank you so much for your effort to find my current email.

Asep Ali
[Quoted text hidden]

Gmail

asep ali <asepali76@gmail.com>

VERY URGENT: RE: Your manuscript 301 for publication in Tropical Grasslands-Forrajes Tropicales

Schultze-Kraft, Rainer (CIAT) <R.SchultzeKraft@cgiar.org> Mon, Nov 25, 2019 at 9:02 PM
To: "Ali, Asep (ILRI)" <asepali76@gmail.com>

Dear Dr. Ali,

Good to know that you received my communication.

I consider that the citations Rubanza et al. (2006) could be deleted, also Mtui et al. (2006) and Rajaganapathy et al. (2011). For the other three, hopefully you find a substitute.

Regards

[Quoted text hidden]

DOI: 10.17138/TGFT(7)524-530

Short Communication

Seasonal influence on mineral concentration of forages on flooded pastures in South Sumatra, Indonesia

Concentración de minerales en forrajes nativos en pastizales estacionalmente inundados en South Sumatra, Indonesia

ASEP INDRA MUNAWAR ALI, SOFIA SANDI, RISWANDI AND MUHAKKA

Department of Animal Science, Faculty of Agriculture, University of Sriwijaya, Palembang, South Sumatra, Indonesia.
unsri.ac.id

Abstract

This study was conducted to evaluate macro- and micro-mineral concentrations in forages growing on seasonally flooded native pastures in non-tidal swamps of South Sumatra, Indonesia and grazed by buffalo. The upper part of native forage plants from 5 species of Poaceae, 4 species of Leguminosae, 3 species of Cyperaceae and 1 species of Onagraceae were sampled by hand-plucking during flooded and dry seasons. The results showed that mineral concentrations of forages varied greatly between seasons. In general concentrations of most minerals were adequate to supply the dietary needs of grazing ruminants in both wet and dry seasons. Phosphorus (P) concentrations were low in all species in both wet and dry seasons but growing animals should select a diet adequate in P, while lactating females could benefit from P supplementation. In cut-and-carry situations, animals would probably respond to additional P in the diet. These hypotheses need testing in the field.

Keywords: Buffalo, mineral deficiency, mineral toxicity.

Resumen

En South Sumatra, Indonesia se realizó un estudio para evaluar las concentraciones de macro- y micro-minerales en plantas forrajeras nativas comunes en pastizales estacionalmente inundados y utilizadas con búfalos. Para el estudio see muestrearon por el método ´hand-plucking´ plantas de 5 especies de Poaceae, 4 especies de Leguminosae, 3 especies de Cyperaceae y 1 especie de Onagraceae durante las estaciones inundada y seca. Los resultados mostraron que las concentraciones minerales variaron considerablemente entre estaciones. No obstante, las concentraciones de la mayoría de los minerales fueron adecuadas para satisfacer los requerimientos nutricionales de rumiantes en pastoreo en ambas estaciones. Las concentraciones de fósforo (P) fueron bajas en todas las especies en ambas estaciones, pero se considera que bajo condiciones de pastoreo los animales en crecimiento seleccionan una dieta adecuada en P, mientras que hembras lactantes podrían beneficiarse de P suplementado. En situaciones de corte y acarreo, los animales probablemente responderían a P adicional en la dieta. Estas hipótesis necesitan ser probadas en el campo.

Palabras clave: Búfalos, deficiencia mineral, toxicidad mineral.

Introduction

The concentrations of individual minerals in forages vary greatly depending on the interactions of a range of factors including soil, plant species, stage of maturity, yield, management factors and climate. Forages represent an important source of minerals for grazing ruminants and play essential roles in preventing diseases and inhibiting or stimulating ruminal microbial activity (Spears 1994). Natural pasture species in non-tidal swamps have been traditionally the main source of feed for swamp buffalo in e.g. Brazil (Camarão et al. 2004) and South Sumatra (Ali

Correspondence: A.I.M. Ali, Department of Animal Science, Faculty of Agriculture, University of Sriwijaya, Palembang 30662, South Sumatra, Indonesia. Email: asep_ali@fp.uncri.ac.id

et al. 2014). Forage nutritive values fluctuate with seasons and the dry season is the most limiting in terms of nutrient supply to grazing buffalo. As most grazing livestock in tropical countries including Indonesia are usually un-supplemented, they must fulfill their mineral requirements from forage. Camarão et al. (2004) failed to find evidence of mineral deficiencies in grazing buffalo. Data on mineral concentrations in forage species and their variability between seasons are essential for correct and cost-effective ration formulation and swamp buffalo nutrition.

However, mineral profiles of tropical forages in flooded pasture have received little attention and limited studies showed that forages can be deficient in one or more elements. In this study we aimed to estimate and compare the concentrations of mineral elements including calcium (Ca), phosphorus (P), magnesium (Mg), sulphur (S), copper (Cu), iron (Fe), zinc (Zn) and manganese (Mn) in native flooded pasture species in non-tidal swamps of South Sumatra, Indonesia during the flooded and dry seasons.

Materials and Methods

Site description

Research was conducted during February–September 2014 on communal pastures in non-tidal swamps in Rambutan subdistrict, Banyuasin district and Pampangan subdistrict, OKI (Ogan Komering Ilir) district of South Sumatra Province (between 3°05' and 3°11' S, and 104°55' and 104°58' E). The study area was selected as representative of non-tidal swamps used for grazing buffalo where the highest population of swamp buffalo were found. The study area (± 567 ha) is part of the Batang hari river watershed and is surrounded by settlements and plantations of oil palm and rubber. The soils are poorly drained, acid fluvisols with low availability of Ca, P and Mg and high solubility of Fe and Zn (Ali et al. 2014).

The dry season extends from April to September while the rainy season normally occurs from October to March with annual rainfall of 2,100–3,264 mm. The study area is regularly inundated for 3–8 months during rainy seasons. Minimum temperatures range from 22 to 25 °C (at 05.00–08.00 h) and maximum temperatures range from 30 to 34 °C (at 11.00–14.00 h). Farmers also use the communal pastures for paddy fields and vegetable production (± 304 ha) when the water level is low.

Forage sampling

In the representative areas forage plants were never fertilized, nor had any management intervention. Observations of forage consumed by grazing buffalo during 08.00–11.00 h and 14.00–17.00 h (Setianah et al. 2004; Hirata et al. 2008) and in our previous study (Ali et al. 2014) revealed that native vegetation species consumed by buffalo included: Poaceae [*Urochloa mutica* (Forssk.) T.Q. Nguyen (syn. *Brachiaria mutica* (Forssk.) Stapf), *Leersia hexandra* Sw., *Hymenachne amplexicaulis* (Rudge) Nees, *Ischaemum rugosum* Salisb., *Oryza rufipogon* Griff.]; Leguminosae [*Mimosa pigra* L., *Sesbania exasperata* Kunth, *Neptunia oleracea* Lour., *Aeschynomene sensitiva* Sw.]; Cyperaceae [*Actinoscirpus grossus* (L.f.) Goetgh. & D.A. Simpson, *Scleria gaertneri* Raddi, *Eleocharis dulcis* (Burm.f.) Trin. ex Hensch.]; and Onagraceae [*Ludwigia peploides* (Kunth) P.H. Raven].

The study area on both left and right sides of the river was divided into 2 subareas based on land use. Samples of the forages eaten by buffalo were randomly collected by hand-plucking during flooding in the wet season (March 2014) and in the dry season (August and September 2014) from at least 2 different sites within each subarea. A mix of leaf and stem (± 250 g) was hand-plucked from the upper parts of herbaceous plants in the pre-flowering stage and from younger twigs of the shrubs, *M. pigra* and *S. exasperata*. Samples for each species were washed with distilled water, chopped and dried at 50 °C. The oven-dried samples were pooled within the subarea and then coarsely milled to pass 1 mm screen for mineral analyses.

Mineral analyses

Representative samples (in duplicate) were digested stepwise with nitric acid (HNO_3). Concentrations of minerals in the forage samples were analyzed by using inductively coupled plasma emission spectrophotometer (SPS7700, Seiko Instruments Inc., Chiba, Japan) in the Laboratory of Feed Technology and Dairy Nutrition, Faculty of Animal Husbandry, Bogor Agricultural University.

Statistical analyses

Data were analyzed using StatView SAS (1999). The differences in means between seasons were determined using an unpaired t-test and were considered significant if P<0.05.

Results

While season had a significant effect (P<0.05) on concentrations of Ca, P, Mg and S, the effects were

Table 1. Concentrations of macro- and micro-minerals in forages in swamps in South Sumatra during flooded and dry seasons.

Species	Season	Macro-mineral (% DM)				Micro-mineral (ppm DM)			
		Ca	P	Mg	S	Cu	Fe	Zn	Mn
Poaceae									
Urochloa mutica	dry	0.62b[1]	0.10b	1.59b	0.50b	11.6b	105a	41.8a	366b
	flooded	0.11a	0.01a	0.86a	0.04a	9.6a	107a	60.2a	128a
Leersia hexandra	dry	0.08a	0.16b	1.01b	0.13a	15.3a	193a	128.0b	274a
	flooded	0.12b	0.09a	0.84a	0.14a	12.3a	806b	97.8a	283a
Hymenachne amplexicaulis	dry	0.07a	0.11b	1.02a	0.17a	15.5a	139a	40.9a	225a
	flooded	0.19b	0.08a	1.09b	0.09a	17.5a	208b	56.8b	252a
Ischaemum rugosum	dry	0.08a	0.04a	1.03a	0.06a	13.2a	184b	57.0a	125a
	flooded	0.14b	0.07b	1.11b	0.38b	12.2a	121a	78.1a	297b
Oryza rufipogon	dry	0.12a	0.05a	1.19b	0.03a	16.8a	499b	45.8b	906a
	flooded	0.16b	0.08a	0.95a	0.03a	13.6a	188a	26.1a	1,044b
Leguminosae									
Mimosa pigra	dry	0.32a	0.14b	1.68b	0.30b	22.1b	206a	76.9b	252a
	flooded	0.39b	0.10a	1.54a	0.14a	8.6a	317a	33.7a	342a
Sesbania exasperata	dry	0.42a	0.17b	1.41b	0.30b	23.4a	100a	76.4a	153a
	flooded	0.64b	0.15a	1.17a	0.23a	21.3a	181b	64.3a	128a
Neptunia oleracea	dry	0.66b	0.07a	1.80a	0.05a	43.3b	202a	176.0b	1,076b
	flooded	0.43a	0.14b	2.01b	0.18b	21.7a	358b	43.2a	402a
Aeschynomene sensitiva	dry	0.46a	0.12a	1.98a	0.43a	29.2a	129a	86.7a	407b
	flooded	0.48b	0.13a	2.35b	0.40a	42.1b	145a	94.4a	286a
Cyperaceae									
Actinoscirpus grossus	dry	0.08a	0.21b	0.65a	0.31a	14.3b	89a	49.6b	291a
	flooded	0.20b	0.11a	1.32b	0.33a	9.9a	318b	43.3a	568b
Scleria gaertneri	dry	0.25b	0.06a	0.89b	0.05a	14.7b	69a	48.1a	487b
	flooded	0.10a	0.08a	0.74a	0.08b	9.6a	151b	62.3a	210a
Eleocharis dulcis	dry	0.08b	0.14a	1.01b	0.29a	20.1a	936a	55.1b	231b
	flooded	0.03a	0.20a	0.17a	0.49b	19.1a	1,629b	28.0a	34a
Onagraceae									
Ludwigia peploides	dry	0.56b	0.16a	2.62b	0.16a	31.2a	728a	198.0a	969b
	flooded	0.33a	0.21b	2.06a	0.15a	244.0b	926b	207.0a	691a
Critical level[2]		0.30	0.25	0.20	0.26	11	50	33	40
Toxic level[3]						25	500	750	1,000

[1]Means followed by different letters within a species between seasons are significantly different (P<0.05).
[2]Levels for growth and production of ruminant animals (McDowell et al. 1997).
[3]Levels suggested to produce toxic symptoms in ruminant animals (McDowell et al. 1997).

inconsistent across species (Table 1). Calcium concentrations in most forages were higher in the flooded season than in the dry season except for *U. mutica*, *N. oleracea*, *S. gaertneri*, *E. dulcis* and *L. peploides*. With the exception of *U. mutica*, Ca concentrations in Poaceae and Cyperaceae were lower than those in Leguminosae. Concentrations of P in most forages also varied (P<0.05) between seasons with the exception of *O. rufipogon*, *A. sensitiva*, *S. gaertneri* and *E. dulcis*. Some species had higher P concentrations in the dry while others had higher concentrations during flooding. As opposed to Ca concentrations, Mg concentrations in most forages were higher during the dry than in the flooded season.

Concentrations of micro-minerals also varied (P<0.05) between seasons and among species (Table 1). In most Poaceae species, Cu concentrations did not differ significantly between seasons, while Fe concentrations were usually higher during flooding periods and Zn and Mn concentrations were usually higher in the dry season.

Discussion

Macro-minerals

The variation between species in occurrence of peak concentrations of nutrients could be due to a combination of main growth periods, time of maturity and genetic variation (Minson 1990; Underwood and Suttle 1999).

The higher Ca concentrations in Leguminosae and most Poaceae during the flooded season than in the dry season agree with a study in dry land of South Sumatra, Indonesia by Evitayani et al. (2006) who showed that Ca concentration in 2 species of grasses and 4 species of legumes was higher in the rainy season than in the dry season and varied from 0.57 in Napier grass [*Cenchrus purpureus* (Schumach.) Morrone syn. *Pennisetum purpureum* Schumach.] to 2.61% in leucaena [*Leucaena leucocephala* (Lam.) de Wit] in rainy and from 0.51 (Napier) to 2.44% (leucaena) in dry seasons. On the contrary, Warly et al. (2006a) in dry land of West Sumatra concluded that Ca concentrations of 7 species of grasses and 13 species of legumes were lower in the rainy season than in the dry season. The higher concentrations in legumes than in grasses agree with the findings of Warly et al. (2006a) of 0.39 [*Zea mays* L. subsp. *mexicana* (Schrad.) H.H. Iltis, syn. *Euchlaena mexicana* (Schrad.) Kuntze)] to 1.69% [*Gliricidia maculata* (Kunth) Kunth.] and Nasrullah et al. (2004) in dry land of South Sulawesi of 0.3 (*Cenchrus ciliaris* L.) to 4.0% [*Desmanthus virgatus* (L.) Willd.]. Results of the current study showed that the range of Ca concentrations was lower than in previous studies (Nasrullah et al. 2004; Evitayani et al. 2006; Mtui et al. 2006; Warly et al. 2006a). Calcium concentration in the Leguminosae and Onagraceae species exceeded the 0.30% which meets the requirements of ruminants (McDowell et al. 1997).

Phosphorus concentrations in all forages in this study were lower than the critical level for ruminants (0.25%; McDowell et al. 1997) and fluctuated in both seasons. At the early heading stage, Nasrullah et al. (2004) reported that P concentration ranged from 0.20 (*Z. mays* subsp. *mexicana*, syn. *E. mexicana*) to 1.80% [*Centrosema plumieri* (Turpin ex Pers.) Benth.] and was not significantly affected by season, while Warly et al. (2006a) found that P concentration was higher in the dry season than in the rainy season and ranged from 0.21 (*Z. mays* subsp. *mexicana*, syn. *E. mexicana*) to 0.47% [*Setaria sphacelata* (Schumach.) Stapf & C.E. Hubb.]. In a further study, which sampled the same species but at a different location, Evitayani et al. (2006) showed that P concentration ranged from 0.29 (*Centrosema molle* Mart. ex Benth., syn. *C. pubescens* auct.pl.) to 0.68% (*Cenchrus purpureus* syn. *Pennisetum purpureum*) being higher in the rainy season than in the dry season and that all forages had P concentration >0.25% in the rainy season.

The low concentrations of Ca and P in forage in our study would be a function of acid soil conditions at this location with low availability of Ca and P for plants (Ali et al. 2014). Jumba et al. (1995) showed a significant positive correlation between soil P and herbage P, while Kanno et al. (2006) showed that soil pH related to not only grass growth and P uptake but also mycorrhizal dependency. Underwood and Suttle (1999) recommended that diets of livestock should have a Ca:P ratio in the range 1:1 to 2:1, and claimed this was more important than the absolute concentration for utilization by ruminants. In our study the Ca:P ratio for individual species ranged from 0.16 (*E. dulcis*) to 10.0 (*U. mutica*); thus grazing livestock would have a wide range from which to select an acceptable diet. Depending on the ability to select from available pasture, grazing buffalo, especially lactating females, could suffer from a P deficiency in the diet and would benefit from P supplementation. Studies by Jones (1990) and Miller et al. (1990) described some low-cost strategies on dryland pastures for overcoming P deficiency in grazing livestock. Direct P supplementation through the use of non-protein supplementation in urea-mineral blocks may serve as a more valuable alternative.

With the exception of *E. dulcis* in the flooded season, all forages had sufficient Mg concentration for requirements of ruminants (McDowell et al. 1997); thus buffalo consuming forages in the area are unlikely to suffer Mg deficiency. The adequacy of Mg concentration in most forages has been reported in previous studies (Nasrullah et al. 2004; Evitayani et al. 2006; Warly et al. 2006a).

Sulphur is essential for microbial protein synthesis in the rumen and its concentration in ruminant diets is important. There was wide variation between seasons and species in S concentrations in the forages examined and some species contained sufficient S to satisfy ruminant requirements for effective rumen functioning. Availability of the various species and the opportunity to select by animals would determine the need for supplementation with sulphur. Sulphur deficiency in the dry season has been reported by Evitayani et al. (2006). Warly et al. (2006a) found that the percentage of forage species with S deficiency was higher in the dry season than in the rainy season.

Micro-minerals

Based on mineral requirements (McDowell et al. 1997) concentrations of Cu, Fe, Zn and Mn in most forages in flooded pasture exceeded the critical levels for grazing ruminants in tropical regions. Very high levels of Cu were found in *N. oleracea* in the dry season and in *A. sensitiva* and *L. peploides* throughout the year. If these species formed a significant portion of the diet, Cu toxicity could possibly occur in grazing animals. The range in Cu concentration in Poaceae and Leguminosae was higher than that reported by Fariani (2008) of 5.6–10.1 ppm and 3.8–16.6 ppm in 3 species of grasses and 4 species of legumes, respectively, in dry land of South

Sumatra. Warly et al. (2006b) reported that Cu concentration in 13 species of grasses varied from 2.3 to 14.4 ppm, while Khan et al. (2006) reported a range from 10.9 to 25.7 ppm in Pakistan and Evitayani and Warly (2010) a range from 3.8 to 16.6 ppm in West Sumatra.

The generally higher Fe concentration in most Leguminosae, Cyperaceae and Onagraceae species during the flooded season than in the dry season was probably a function of a natural dilution process and translocation of minerals to the roots as plants mature. Similar results were reported by Mtui et al. (2006) with a range from 619 to 678 ppm, and Warly et al. (2006b) with a range from 96 to 569 ppm. Khan et al. (2006) also reported that all forages had higher Fe concentrations in winter than in summer with a range from 93 to 202 ppm. As in our study, Khan et al. (2006) found that Zn and Mn concentrations in all forages were above critical levels and overall concentrations were higher in winter than in summer. Similar to Cu and Fe concentrations, ranges of Zn and Mn concentrations in our study were higher than studies in dry land (Khan et al. 2006; Mtui et al. 2006; Rubanza et al. 2006; Warly et al. 2006b; Fariani 2008).

Our findings could probably be explained by mineral level in soils (Minson 1990; Underwood and Suttle 1999). Soil condition in the study location was characterized by low pH, low availability of Ca and P, and excessive micro-mineral solubility for plants (Waluyo et al. 2012; Ali et al. 2014). High micro-mineral concentrations in aquatic plants could be associated with the ability to accumulate these minerals in their tissues (Asikin and Thamrin 2012; Veschasit et al. 2012) and with excessive micro-mineral concentrations in soils and water, possibly caused by intensive agricultural practices. Research by Jan et al. (2011) showed that there were higher concentrations of Cu, Zn, Cr, Ni, Pb and Mn in meat and milk in contaminated areas than in control areas and concluded that consumption of the foods had significantly increased the mineral concentrations in human blood. Similar results have been reported by Skalická et al. (2005), Blanco-Penedo et al. (2006) and Miranda et al. (2009) or reviewed by Rajaganapathy et al. (2011). Therefore, high concentrations of Cu, Fe and Mn in *N. oleracea*, *A. sensitiva*, *E. dulcis* and *O. rufipogon* might not only raise toxicity risks for grazing buffalo, when consumed in large amounts, but also contaminate meat and milk of buffalo when milked or slaughtered for human consumption. Hence, there is a need to further investigate the status of trace and toxic minerals in blood, liver, kidney, meat and milk of buffalo in the region.

Conclusion

Mineral concentrations of forages varied greatly between seasons on flooded pastures in South Sumatra. Concentrations of most minerals appeared adequate for the dietary needs of grazing buffalo given that the samples we collected were not whole plant samples but attempted to be similar to forage that buffalo would select. However, all forages had low P concentrations and grazing animals, especially lactating females, might suffer P deficiency in the diet, while stalled animals fed on a cut-and-carry basis would certainly suffer a deficiency. Feeding studies would be warranted to test benefits from supplementing animals with P.

Acknowledgment

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References

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Ali AIM; Sandi S; Muhakka; Riswandi; Budianta D. 2014. The grazing of pampangan buffaloes at non tidal swamp in South Sumatra of Indonesia. APCBEE Procedia 8:87–92. doi: 10.1016/j.apcbee.2014.03.006

Asikin S; Thamrin M. 2012. The benefits of Chinese water chestnut (*Eleocharis dulcis*) in swamp rice ecosystems. Jurnal Litbang Pertanian 31:35–42. (In Indonesian). bit.ly/2rC1mbH

Blanco-Penedo I; Cruz JM; López-Alonso M; Miranda M; Castillo C; Hernandez J; Benedito JL. 2006. Influence of copper status on the accumulation of toxic and essential metals in cattle. Environment International 32:901–906. doi: 10.1016/j.envint.2006.05.012

Camarão AP; Lourenço JB; Dutra S; Hornick JL; Silva MB da. 2004. Grazing buffalo on flooded pastures in the Brazilian Amazon region. Tropical Grasslands 38:193–203. bit.ly/2QfP8j9

Evitayani; Warly L; Fariani A; Ichinohe T; Hayashida M; Abdul Razak SA; Fujihara T. 2006. Macro mineral distribution of forages in South Sumatra during rainy and dry seasons. Journal of Food, Agriculture and Environment 4(2):155–160. bit.ly/370gPTe

Evitayani; Warly L. 2010. The concentration of Zn, Fe, Mn, Cu and Se in fiber fractions of legumes in Indonesia. Animal Production 12:105–110. bit.ly/2Kjxpns

Fariani A. 2008. Micro mineral distribution on fiber fraction of forages in South Sumatra, Indonesia. Journal of the

Indonesian Tropical Animal Agriculture 33:79–86. eprints.undip.ac.id/18921

Hirata M; Hasegawa N; Takahashi T; Chowdappa R; Ogura S; Nogami K; Sonoda T. 2008. Grazing behaviour, diet selection and feed intake of cattle in a young tree plantation in Southern Kyushu, Japan. Tropical Grasslands 42:170–180. bit.ly/2NH5rUJ

Jan FA; Ishaq M; Khan S; Shakirullah M; Asim SM; Ahmad I; Mabood F. 2011. Bioaccumulation of metals in human blood in industrially contaminated area. Journal of Environmental Sciences 23:2069–2077. doi: 10.1016/S1001-0742(10)60616-X

Jones RJ. 1990. Phosphorus and beef production in northern Australia. 1. Phosphorus and pasture productivity - a review. Tropical Grasslands 24:131–139. goo.gl/EmHm0m

Jumba IO; Suttle NF; Hunter EA; Wandiga SOW.1995. Effects of soil origin and mineral composition of herbage species on the mineral composition of forages in the Mount Elgon region of Kenya. 1. Calcium, phosphorus, magnesium and sulphur. Tropical Grasslands 29:40–46. bit.ly/34UYLYQ

Kanno T; Saito M; Ando Y; Macedo MCM; Nakamura T; Miranda CHB. 2006. Importance of indigenous arbuscular mycorrhiza for growth and phosphorus uptake in tropical forage grasses growing on an acid, infertile soil from the Brazilian savannas. Tropical Grasslands 40: 94–101. bit.ly/2NJEwrj

Khan ZI; Hussain A; Ashraf M; McDowell LR. 2006. Mineral status of soils and forages in Southwestern Punjab-Pakistan: Micro-minerals. Asian-Australasian Journal of Animal Sciences 19:1139–1147. doi: 10.5713/ajas.2006.1139

McDowell LR. 1997. Minerals for grazing ruminants in tropical regions. 3rd Edn. University of Florida Press, Gainesville, FL, USA.

Minson DJ. 1990. Forage in ruminant nutrition. Academic Press Inc., San Diego, CA, USA. doi: 10.1016/B978-0-12-498310-6.X5001-9

Miller CP; Winter WH; Coates DB; Kerridge PC. 1990. Phosphorus and beef production in northern Australia. 10. Strategies for phosphorus use. Tropical Grasslands 24:239–249. bit.ly/32HEfJR

Miranda M; Benedito JL; Blanco-Penedo I; López-Lamas C; Merino A; López-Alonso M. 2009. Metal accumulation in cattle raised in a serpentine-soil area: Relationship between metal concentrations in soil, forage and animal tissues. Journal of Trace Elements in Medicine and Biology 23:231–238. doi: 10.1016/j.jtemb.2009.03.004

Mtui DJ; Lekule FP; Shem MN; Rubanza CDK; Ichinohe T; Hayashida M; Fujihara T. 2006. Seasonal influence on mineral content of forages used by smallholder dairy farmers in lowlands of Mvomero District, Morogoro, Tanzania. Journal of Food, Agriculture and Environment 4(2):216–221. bit.ly/350x2Wv

Nasrullah; Niimi M; Akashi R; Kawamura O. 2004. Nutritive evaluation of forage plants grown in South Sulawesi, Indonesia II. Mineral composition. Asian-Australasian Journal of Animal Sciences 17:63–67. doi: 10.5713/ajas.2004.63

Rajaganapathy V; Xavier F; Sreekumar D; Mandal PK. 2011. Heavy metal contamination in soil, water and fodder and their presence in livestock and products. A review. Journal of Environmental Science and Technology 4:234–249. doi: 10.3923/jest.2011.234.249

Rubanza CDK; Shem MN; Ichinohe T; Fujihara T. 2006. Polyphenolics and minerals composition of selected browse tree species leaves native to north-western Tanzania traditional fodder banks. Journal of Food, Agriculture and Environment 4(1):328–332. bit.ly/2KisFOL

SAS. 1999. SAS/STAT users guide. SAS Institute Inc., Cary, NC, USA.

Setianah R; Jayadi S; Herman R. 2004. Eating behavior of crossed local goat pasturing in peatland: A case study in Kalampangan, Palangkaraya, Central Kalimantan. Media Peternakan 27:111–122. (In Indonesian). bit.ly/32DVH1D

Skalická M; Koréneková B; Nad P. 2005. Copper in livestock from polluted area. Bulletin of Environmental Contamination and Toxicology 74:740–744. doi: 10.1007/s00128-005-0644-9

Spears JW. 1994. Minerals in forages. In: Collins M; Mertens DR; Moser LE, eds. Proceedings of the National Conference on Forage Quality, Evaluation and Utilization. Lincoln, NB, USA, 13–15 April 1994. bit.ly/2Q9r8hT

Underwood EJ; Suttle NF. 1999. The mineral nutrition of livestock. 3rd Edn. CABI Publishing, Wallingford, UK.

Veschasit O; Meksumpun S; Meksumpun C. 2012. Heavy metals contamination in water and aquatic plants in the Tha Chin River, Thailand. Agriculture and Natural Resources 46:931–943. goo.gl/8naMGb

Waluyo; Alkasuma; Susilawati; Suparwoto. 2012. Spatial inventory of potential competitiveness swamp land for agricultural development in South Sumatra. Jurnal Lahan Suboptimal 1:64–71. (In Indonesian). bit.ly/2qMBA47

Warly L; Fariani A; Evitayani; Hayashida M; Fujihara T. 2006a. Mineral status of forages and grazing goats in West Sumatra, Indonesia: 1. Macro minerals. Journal of Food, Agriculture and Environment 4(2):234–236. bit.ly/2rx0Hbt

Warly L; Fariani A; Evitayani; Hayashida M; Fujihara T. 2006b. Mineral status of forages and grazing goats in West Sumatra, Indonesia: 2. Micro minerals. Journal of Food, Agriculture and Environment 4(2):204–207. bit.ly/2X70asH

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VERY URGENT: RE: Your manuscript 301 for publication in Tropical Grasslands-Forrajes Tropicales

asep ali <asepali76@gmail.com> Tue, Nov 26, 2019 at 4:36 PM
To: "Schultze-Kraft, Rainer (CIAT)" <R.SchultzeKraft@cgiar.org>

Dear Dr. Schultze-Kraft
The attached file is the revised manuscript after deleting/substitution the predatory citations/references.
I couldn't find a study with the identic result as Evitayani et al. (2006) and Warly et al. (2006a, 2006b) so the change in sentences was accordingly made as inserted new references (Espinoza et al. 1991; Pastrana et al. 1991; Lundu et al. 2012; Uemura et al. 2014) in the revised manuscript.
Thank you so much
Asep
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VERY URGENT: RE: Your manuscript 301 for publication in Tropical Grasslands-Forrajes Tropicales

Schultze-Kraft, Rainer (CIAT) <R.SchultzeKraft@cgiar.org> Tue, Nov 26, 2019 at 5:08 AM
To: "Ali, Asep (ILRI)" <asepali76@gmail.com>

Dear Dr. Ali,

Attached please find the latest version of your ms 301, in Word format.

Please perform the requested literature citation changes (and corresponding text adjustments) **using the track changes mode** and return the ms to me. It is important that I receive your feedback tomorrow, 26 November.

Kind regards

Rainer Schultze-Kraft

From: Schultze-Kraft, Rainer (CIAT)
Sent: Monday, November 25, 2019 9:02 AM
To: 'asep ali' <asepali76@gmail.com>
Subject: RE: VERY URGENT: RE: Your manuscript 301 for publication in Tropical Grasslands-Forrajes Tropicales

Dear Dr. Ali,

Good to know that you received my communication.

I consider that the citations Rubanza et al. (2006) could be deleted, also Mtui et al. (2006) and Rajaganapathy et al. (2011). For the other three, hopefully you find a substitute.

Regards

Rainer Schultze-Kraft

From: asep ali <asepali76@gmail.com>
Sent: Monday, November 25, 2019 8:20 AM

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Short Communication

Seasonal influence on mineral concentration of forages on flooded pastures in South Sumatra, Indonesia

Concentración de minerales en forrajes nativos en pastizales estacionalmente inundados en South Sumatra, Indonesia

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Abstract

This study was conducted to evaluate macro- and micro-mineral concentrations in forages growing on seasonally flooded native pastures in non-tidal swamps of South Sumatra, Indonesia and grazed by buffalo. The upper part of native forage plants from 5 species of Poaceae, 4 species of Leguminosae, 3 species of Cyperaceae and 1 species of Onagraceae were sampled by hand-plucking during flooded and dry seasons. The results showed that mineral concentrations of forages varied greatly between seasons. In general concentrations of most minerals were adequate to supply the dietary needs of grazing ruminants in both wet and dry seasons. Phosphorus (P) concentrations were low in all species in both wet and dry seasons but growing animals should select a diet adequate in P, while lactating females could benefit from P supplementation. In cut-and-carry situations, animals would probably respond to additional P in the diet. These hypotheses need testing in the field.

Keywords: Buffalo, mineral deficiency, mineral toxicity.

Resumen

En South Sumatra, Indonesia se realizó un estudio para evaluar las concentraciones de macro- y micro-minerales en plantas forrajeras nativas comunes en pastizales estacionalmente inundados y utilizadas con búfalos. Para el estudio see muestrearon por el método ´hand-plucking´ plantas de 5 especies de Poaceae, 4 especies de Leguminosae, 3 especies de Cyperaceae y 1 especie de Onagraceae durante las estaciones inundada y seca. Los resultados mostraron que las concentraciones minerales variaron considerablemente entre estaciones. No obstante, las concentraciones de la mayoría de los minerales fueron adecuadas para satisfacer los requerimientos nutricionales de rumiantes en pastoreo en ambas estaciones. Las concentraciones de fósforo (P) fueron bajas en todas las especies en ambas estaciones, pero se considera que bajo condiciones de pastoreo los animales en crecimiento seleccionan una dieta adecuada en P, mientras que hembras lactantes podrían beneficiarse de P suplementado. En situaciones de corte y acarreo, los animales probablemente responderían a P adicional en la dieta. Estas hipótesis necesitan ser probadas en el campo.

Palabras clave: Búfalos, deficiencia mineral, toxicidad mineral.

Introduction

The concentrations of individual minerals in forages vary greatly depending on the interactions of a range of factors including soil, plant species, stage of maturity, yield, management factors and climate. Forages represent an important source of minerals for grazing ruminants and play essential roles in preventing diseases and inhibiting or stimulating ruminal microbial activity (Spears 1994). Natural pasture species in non-tidal swamps have been traditionally the main source of feed for swamp buffalo in e.g. Brazil (Camarão et al. 2004) and South Sumatra (Ali

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et al. 2014). Forage nutritive values fluctuate with seasons and the dry season is the most limiting in terms of nutrient supply to grazing buffalo. As most grazing livestock in tropical countries including Indonesia are usually un-supplemented, they must fulfill their mineral requirements from forage. Camarão et al. (2004) failed to find evidence of mineral deficiencies in grazing buffalo. Data on mineral concentrations in forage species and their variability between seasons are essential for correct and cost-effective ration formulation and swamp buffalo nutrition.

However, mineral profiles of tropical forages in flooded pasture have received little attention and limited studies showed that forages can be deficient in one or more elements. In this study we aimed to estimate and compare the concentrations of mineral elements including calcium (Ca), phosphorus (P), magnesium (Mg), sulphur (S), copper (Cu), iron (Fe), zinc (Zn) and manganese (Mn) in native flooded pasture species in non-tidal swamps of South Sumatra, Indonesia during the flooded and dry seasons.

Materials and Methods

Site description

Research was conducted during February–September 2014 on communal pastures in non-tidal swamps in Rambutan subdistrict, Banyuasin district and Pampangan subdistrict, OKI (Ogan Komering Ilir) district of South Sumatra Province (between 3°05' and 3°11' S, and 104°55' and 104°58' E). The study area was selected as representative of non-tidal swamps used for grazing buffalo where the highest population of swamp buffalo were found. The study area (± 567 ha) is part of the Batang hari river watershed and is surrounded by settlements and plantations of oil palm and rubber. The soils are poorly drained, acid fluvisols with low availability of Ca, P and Mg and high solubility of Fe and Zn (Ali et al. 2014).

The dry season extends from April to September while the rainy season normally occurs from October to March with annual rainfall of 2,100–3,264 mm. The study area is regularly inundated for 3–8 months during rainy seasons. Minimum temperatures range from 22 to 25 °C (at 05.00–08.00 h) and maximum temperatures range from 30 to 34 °C (at 11.00–14.00 h). Farmers also use the communal pastures for paddy fields and vegetable production (± 304 ha) when the water level is low.

Forage sampling

In the representative areas forage plants were never fertilized, nor had any management intervention. Observations of forage consumed by grazing buffalo during 08.00–11.00 h and 14.00–17.00 h (Setianah et al. 2004; Hirata et al. 2008) and in our previous study (Ali et al. 2014) revealed that native vegetation species consumed by buffalo included: Poaceae [*Urochloa mutica* (Forssk.) T.Q. Nguyen (syn. *Brachiaria mutica* (Forssk.) Stapf), *Leersia hexandra* Sw., *Hymenachne amplexicaulis* (Rudge) Nees, *Ischaemum rugosum* Salisb., *Oryza rufipogon* Griff.]; Leguminosae [*Mimosa pigra* L., *Sesbania exasperata* Kunth, *Neptunia oleracea* Lour., *Aeschynomene sensitiva* Sw.]; Cyperaceae [*Actinoscirpus grossus* (L.f.) Goetgh. & D.A. Simpson, *Scleria gaertneri* Raddi, *Eleocharis dulcis* (Burm.f.) Trin. ex Hensch.]; and Onagraceae [*Ludwigia peploides* (Kunth) P.H. Raven].

The study area on both left and right sides of the river was divided into 2 subareas based on land use. Samples of the forages eaten by buffalo were randomly collected by hand-plucking during flooding in the wet season (March 2014) and in the dry season (August and September 2014) from at least 2 different sites within each subarea. A mix of leaf and stem (± 250 g) was hand-plucked from the upper parts of herbaceous plants in the pre-flowering stage and from younger twigs of the shrubs, *M. pigra* and *S. exasperata*. Samples for each species were washed with distilled water, chopped and dried at 50 °C. The oven-dried samples were pooled within the subarea and then coarsely milled to pass 1 mm screen for mineral analyses.

Mineral analyses

Representative samples (in duplicate) were digested stepwise with nitric acid (HNO_3). Concentrations of minerals in the forage samples were analyzed by using inductively coupled plasma emission spectrophotometer (SPS7700, Seiko Instruments Inc., Chiba, Japan) in the Laboratory of Feed Technology and Dairy Nutrition, Faculty of Animal Husbandry, Bogor Agricultural University.

Statistical analyses

Data were analyzed using StatView SAS (1999). The differences in means between seasons were determined using an unpaired t-test and were considered significant if $P<0.05$.

Results

While season had a significant effect ($P<0.05$) on concentrations of Ca, P, Mg and S, the effects were

Table 1. Concentrations of macro- and micro-minerals in forages in swamps in South Sumatra during flooded and dry seasons.

Species	Season	Macro-mineral (% DM)				Micro-mineral (ppm DM)			
		Ca	P	Mg	S	Cu	Fe	Zn	Mn
Poaceae									
Urochloa mutica	dry	0.62b[1]	0.10b	1.59b	0.50b	11.6b	105a	41.8a	366b
	flooded	0.11a	0.01a	0.86a	0.04a	9.6a	107a	60.2a	128a
Leersia hexandra	dry	0.08a	0.16b	1.01b	0.13a	15.3a	193a	128.0b	274a
	flooded	0.12b	0.09a	0.84a	0.14a	12.3a	806b	97.8a	283a
Hymenachne amplexicaulis	dry	0.07a	0.11b	1.02a	0.17a	15.5a	139a	40.9a	225a
	flooded	0.19b	0.08a	1.09b	0.09a	17.5a	208b	56.8b	252a
Ischaemum rugosum	dry	0.08a	0.04a	1.03a	0.06a	13.2a	184b	57.0a	125a
	flooded	0.14b	0.07b	1.11b	0.38b	12.2a	121a	78.1a	297b
Oryza rufipogon	dry	0.12a	0.05a	1.19b	0.03a	16.8a	499b	45.8b	906a
	flooded	0.16b	0.08a	0.95a	0.03a	13.6a	188a	26.1a	1,044b
Leguminosae									
Mimosa pigra	dry	0.32a	0.14b	1.68b	0.30b	22.1b	206a	76.9b	252a
	flooded	0.39b	0.10a	1.54a	0.14a	8.6a	317a	33.7a	342a
Sesbania exasperata	dry	0.42a	0.17b	1.41b	0.30b	23.4a	100a	76.4a	153a
	flooded	0.64b	0.15a	1.17a	0.23a	21.3a	181b	64.3a	128a
Neptunia oleracea	dry	0.66b	0.07a	1.80a	0.05a	43.3b	202a	176.0b	1,076b
	flooded	0.43a	0.14b	2.01b	0.18b	21.7a	358b	43.2a	402a
Aeschynomene sensitiva	dry	0.46a	0.12a	1.98a	0.43a	29.2a	129a	86.7a	407b
	flooded	0.48b	0.13a	2.35b	0.40a	42.1b	145a	94.4a	286a
Cyperaceae									
Actinoscirpus grossus	dry	0.08a	0.21b	0.65a	0.31a	14.3b	89a	49.6b	291a
	flooded	0.20b	0.11a	1.32b	0.33a	9.9a	318b	43.3a	568b
Scleria gaertneri	dry	0.25b	0.06a	0.89b	0.05a	14.7b	69a	48.1a	487b
	flooded	0.10a	0.08a	0.74a	0.08b	9.6a	151b	62.3a	210a
Eleocharis dulcis	dry	0.08b	0.14a	1.01b	0.29a	20.1a	936a	55.1b	231b
	flooded	0.03a	0.20a	0.17a	0.49b	19.1a	1,629b	28.0a	34a
Onagraceae									
Ludwigia peploides	dry	0.56b	0.16a	2.62b	0.16a	31.2a	728a	198.0a	969b
	flooded	0.33a	0.21b	2.06a	0.15a	244.0b	926b	207.0a	691a
Critical level[2]		0.30	0.25	0.20	0.26	11	50	33	40
Toxic level[3]						25	500	750	1,000

[1]Means followed by different letters within a species between seasons are significantly different ($P<0.05$).
[2]Levels for growth and production of ruminant animals (McDowell et al. 1997).
[3]Levels suggested to produce toxic symptoms in ruminant animals (McDowell et al. 1997).

inconsistent across species (Table 1). Calcium concentrations in most forages were higher in the flooded season than in the dry season except for *U. mutica*, *N. oleracea*, *S. gaertneri*, *E. dulcis* and *L. peploides*. With the exception of *U. mutica*, Ca concentrations in Poaceae and Cyperaceae were lower than those in Leguminosae. Concentrations of P in most forages also varied ($P<0.05$) between seasons with the exception of *O. rufipogon*, *A. sensitiva*, *S. gaertneri* and *E. dulcis*. Some species had higher P concentrations in the dry while others had higher concentrations during flooding. As opposed to Ca concentrations, Mg concentrations in most forages were higher during the dry than in the flooded season.

Concentrations of micro-minerals also varied ($P<0.05$) between seasons and among species (Table 1). In most Poaceae species, Cu concentrations did not differ significantly between seasons, while Fe concentrations were usually higher during flooding periods and Zn and Mn concentrations were usually higher in the dry season.

Discussion

Macro-minerals

The variation between species in occurrence of peak concentrations of nutrients could be due to a combination of main growth periods, time of maturity and genetic variation (Minson 1990; Underwood and Suttle 1999).

The higher Ca concentrations in Leguminosae and most Poaceae during the flooded season than in the dry season differ from results of previous studies in tropical regions (Espinoza et al. 1991; Pastrana et al. 1991; Lundu et al. 2012). The higher concentrations in legumes than in grasses agree with the findings of Nasrullah et al. (2004) in dry land of South Sulawesi of 0.3 (*Cenchrus ciliaris* L.) to 4.0% [*Desmanthus virgatus* (L.) Willd.]. Results of the current study showed that the range of Ca concentrations was similar to the range in the study of Pastrana et al. (1991) but lower than in previous studies (Espinoza et al. 1991; Nasrullah et al. 2004; Lundu et al. 2012). Calcium concentration in the Leguminosae and Onagraceae species exceeded the 0.30% which meets the requirements of ruminants (McDowell et al. 1997).

Phosphorus concentrations in all forages in this study were lower than the critical level for ruminants (0.25%; McDowell et al. 1997) and fluctuated in both seasons. At the early heading stage, Nasrullah et al. (2004) reported that P concentration ranged from 0.20 (*Z. mays* subsp. *mexicana*, syn. *E. mexicana*) to 1.80% [*Centrosema plumieri* (Turpin ex Pers.) Benth.] and was not significantly affected by season. A higher P content in rainy season than in dry season was found in acid soil of Paramo region Colombia (Pastrana et al. 1991) while Lundu et al. (2012) found that P concentration was higher in the hot dry season than in the wet season and ranged from 0.02 to 1.57%.

The low concentrations of Ca and P in forage in our study would be a function of acid soil conditions at this location with low availability of Ca and P for plants (Ali et al. 2014). Jumba et al. (1995) showed a significant positive correlation between soil P and herbage P, while Kanno et al. (2006) showed that soil pH related to not only grass growth and P uptake but also mycorrhizal dependency. Underwood and Suttle (1999) recommended that diets of livestock should have a Ca:P ratio in the range 1:1 to 2:1, and claimed this was more important than the absolute concentration for utilization by ruminants. In our study the Ca:P ratio for individual species ranged from 0.16 (*E. dulcis*) to 10.0 (*U. mutica*); thus grazing livestock would have a wide range from which to select an acceptable diet. Depending on the ability to select from available pasture, grazing buffalo, especially lactating females, could suffer from a P deficiency in the diet and would benefit from P supplementation. Studies by Jones (1990) and Miller et al. (1990) described some low-cost strategies on dryland pastures for overcoming P deficiency in grazing livestock. Direct P supplementation through the use of non-protein supplementation in urea-mineral blocks may serve as a more valuable alternative.

With the exception of *E. dulcis* in the flooded season, all forages had sufficient Mg concentration for requirements of ruminants (McDowell et al. 1997); thus buffalo consuming forages in the area are unlikely to suffer Mg deficiency. The adequacy of Mg concentration in most forages has been reported in previous studies (Nasrullah et al. 2004; Lundu et al. 2012).

Sulphur is essential for microbial protein synthesis in the rumen and its concentration in ruminant diets is important. There was wide variation between seasons and species in S concentrations in the forages examined and some species contained sufficient S to satisfy ruminant requirements for effective rumen functioning. Availability of the various species and the opportunity to select by animals would determine the need for supplementation with sulphur. Similarly, S sufficiency was found in two species of legumes consumed by goats in low land of Philippines (Uemura et al. 2014).

Micro-minerals

Based on mineral requirements (McDowell et al. 1997) concentrations of Cu, Fe, Zn and Mn in most forages in flooded pasture exceeded the critical levels for grazing ruminants in tropical regions. Very high levels of Cu were found in *N. oleracea* in the dry season and in *A. sensitiva* and *L. peploides* throughout the year. If these species formed a significant portion of the diet, Cu toxicity could possibly occur in grazing animals. The range in Cu concentration in Poaceae and Leguminosae was higher than that reported by Fariani (2008) of 5.6–10.1 ppm and 3.8–16.6 ppm in 3 species of grasses and 4 species of legumes, respectively, in dry land of South Sumatra. Khan et al. (2006) reported a range from 10.9 to 25.7 ppm in Pakistan while Evitayani and Warly (2010) reported a range from 3.8 to 16.6 ppm in West Sumatra.

The generally higher Fe concentration in most Leguminosae, Cyperaceae and Onagraceae species during the flooded season than in the dry season was probably a function of a natural dilution process and translocation of minerals to the roots as plants mature. Khan et al. (2006) also reported that all forages had higher Fe concentrations in winter than in summer with a range from 93 to 202 ppm. As in our study, Khan et al. (2006) found that Zn and Mn concentrations in all forages were above critical levels and overall concentrations were higher in winter than in summer. Similar to Cu and Fe concentrations, ranges of Zn and Mn concentrations in our study were higher than studies in dry land (Khan et al. 2006; Fariani 2008).

Our findings could probably be explained by mineral level in soils (Minson 1990; Underwood and Suttle 1999). Soil condition in the study location was characterized by low pH, low availability of Ca and P,

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Deleted: ; Mtui et al. 2006; Rubanza et al. 2006; Warly et al. 2006b and excessive micro-mineral solubility for plants (Waluyo et al. 2012; Ali et al. 2014). High micro-mineral concentrations in aquatic plants could be associated with the ability to accumulate these minerals in their tissues (Asikin and Thamrin 2012; Veschasit et al. 2012) and with excessive micro-mineral concentrations in soils and water, possibly caused by intensive agricultural practices. Research by Jan et al. (2011) showed that there were higher concentrations of Cu, Zn, Cr, Ni, Pb and Mn in meat and milk in contaminated areas than in control areas and concluded that consumption of the foods had significantly increased the mineral concentrations in human blood. Similar results have been reported by Skalická et al. (2005), Blanco-Penedo et al. (2006) and Miranda et al. (2009). Therefore, high concentrations of Cu, Fe and Mn in *N. oleracea*, *A. sensitiva*, *E. dulcis* and *O. rufipogon* might not only raise toxicity risks for grazing buffalo, when consumed in large amounts, but also contaminate meat and milk of buffalo when milked or slaughtered for human consumption. Hence, there is a need to further investigate the status of trace and toxic minerals in blood, liver, kidney, meat and milk of buffalo in the region.

Conclusion

Mineral concentrations of forages varied greatly between seasons on flooded pastures in South Sumatra. Concentrations of most minerals appeared adequate for the dietary needs of grazing buffalo given that the samples we collected were not whole plant samples but attempted to be similar to forage that buffalo would select. However, all forages had low P concentrations and grazing animals, especially lactating females, might suffer P deficiency in the diet, while stalled animals fed on a cut-and-carry basis would certainly suffer a deficiency. Feeding studies would be warranted to test benefits from supplementing animals with P.

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References

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Ali AIM; Sandi S; Muhakka; Riswandi; Budianta D. 2014. The grazing of pampangan buffaloes at non tidal swamp in South Sumatra of Indonesia. APCBEE Procedia 8:87–92. doi: 10.1016/j.apcbee.2014.03.006

Asikin S; Thamrin M. 2012. The benefits of Chinese water chestnut (*Eleocharis dulcis*) in swamp rice ecosystems. Jurnal Litbang Pertanian 31:35–42. (In Indonesian). bit.ly/2rC1mbH

Blanco-Penedo I; Cruz JM; López-Alonso M; Miranda M; Castillo C; Hernandez J; Benedito JL. 2006. Influence of copper status on the accumulation of toxic and essential metals in cattle. Environment International 32:901–906. doi: 10.1016/j.envint.2006.05.012

Camarão AP; Lourenço JB; Dutra S; Hornick JL; Silva MB da. 2004. Grazing buffalo on flooded pastures in the Brazilian Amazon region. Tropical Grasslands 38:193–203. bit.ly/2QfP8j9

Espinoza JE; McDowell LR; Wilkinson NS; Conrad JH; Martin FG. 1991. Forage and soil mineral concentrations over a three-year period in a warm climate region of central Florida. I. Macrominerals. Livestock Research for Rural Development 3 (1). http://www.lrrd.org/lrrd3/1/florida1.htm

Evitayani; Warly L. 2010. The concentration of Zn, Fe, Mn, Cu and Se in fiber fractions of legumes in Indonesia. Animal Production 12:105–110. bit.ly/2Kjxpns

Fariani A. 2008. Micro mineral distribution on fiber fraction of forages in South Sumatra, Indonesia. Journal of the Indonesian Tropical Animal Agriculture 33:79–86. eprints.undip.ac.id/18921

Hirata M; Hasegawa N; Takahashi T; Chowdappa R; Ogura S; Nogami K; Sonoda T. 2008. Grazing behaviour, diet selection and feed intake of cattle in a young tree plantation in Southern Kyushu, Japan. Tropical Grasslands 42:170–180. bit.ly/2NH5rUJ

Jan FA; Ishaq M; Khan S; Shakirullah M; Asim SM; Ahmad I; Mabood F. 2011. Bioaccumulation of metals in human blood in industrially contaminated area. Journal of Environmental Sciences 23:2069–2077. doi: 10.1016/S1001-0742(10)60616-X

Jones RJ. 1990. Phosphorus and beef production in northern Australia. 1. Phosphorus and pasture productivity - a review. Tropical Grasslands 24:131–139. goo.gl/EmHm0m

Jumba IO; Suttle NF; Hunter EA; Wandiga SOW.1995. Effects of soil origin and mineral composition of herbage species on the mineral composition of forages in the Mount Elgon region of Kenya. 1. Calcium, phosphorus, magnesium and sulphur. Tropical Grasslands 29:40–46. bit.ly/34UYLYQ

Kanno T; Saito M; Ando Y; Macedo MCM; Nakamura T; Miranda CHB. 2006. Importance of indigenous arbuscular mycorrhiza for growth and phosphorus uptake in tropical forage grasses growing on an acid, infertile soil from the Brazilian savannas. Tropical Grasslands 40: 94–101. bit.ly/2NJEwrj

Khan ZI; Hussain A; Ashraf M; McDowell LR. 2006. Mineral status of soils and forages in Southwestern Punjab-Pakistan:

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Deleted: or reviewed by Rajaganapathy et al. (2011)

Deleted: Evitayani; Warly L; Fariani A; Ichinohe T; Hayashida M; Abdul Razak SA; Fujihara T. 2006. Macro mineral distribution of forages in South Sumatra during rainy and dry seasons. Journal of Food, Agriculture and Environment 4(2):155–160

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Micro-minerals. Asian-Australasian Journal of Animal Sciences 19:1139–1147. doi: 10.5713/ajas.2006.1139

Lundu T; Choongo K; Munyinda K; Walubita K; Siulapwa NJ. 2012. A survey of seasonal macro-mineral status of soil, plants and goats in Siavonga, southern Zambia. Livestock Research for Rural Development 24 (5). http://www.lrrd.org/lrrd24/5/lund24076.htm.

McDowell LR. 1997. Minerals for grazing ruminants in tropical regions. 3rd Edn. University of Florida Press, Gainesville, FL, USA.

Minson DJ. 1990. Forage in ruminant nutrition. Academic Press Inc., San Diego, CA, USA. doi: 10.1016/B978-0-12-498310-6.X5001-9

Miller CP; Winter WH; Coates DB; Kerridge PC. 1990. Phosphorus and beef production in northern Australia. 10. Strategies for phosphorus use. Tropical Grasslands 24:239–249. bit.ly/32HEfJR

Miranda M; Benedito JL; Blanco-Penedo I; López-Lamas C; Merino A; López-Alonso M. 2009. Metal accumulation in cattle raised in a serpentine-soil area: Relationship between metal concentrations in soil, forage and animal tissues. Journal of Trace Elements in Medicine and Biology 23:231–238. doi: 10.1016/j.jtemb.2009.03.004

Nasrullah; Niimi M; Akashi R; Kawamura O. 2004. Nutritive evaluation of forage plants grown in South Sulawesi, Indonesia II. Mineral composition. Asian-Australasian Journal of Animal Sciences 17:63–67. doi: 10.5713/ajas.2004.63

Pastrana R; McDowell LR; Conrad JH; Wilkinson NS. 1991. Macromineral status of sheep in the Paramo region of Colombia. Small Ruminant Research 5(2):9-21. doi: 10.1016/0921-4488(91)90026-M

SAS. 1999. SAS/STAT users guide. SAS Institute Inc., Cary, NC, USA.

Setianah R; Jayadi S; Herman R. 2004. Eating behavior of crossed local goat pasturing in peatland: A case study in Kalampangan, Palangkaraya, Central Kalimantan. Media Peternakan 27:111–122. (In Indonesian). bit.ly/32DVH1D

Skalická M; Koréneková B; Nad P. 2005. Copper in livestock from polluted area. Bulletin of Environmental Contamination and Toxicology 74:740–744. doi: 10.1007/s00128-005-0644-9

Spears JW. 1994. Minerals in forages. In: Collins M; Mertens DR; Moser LE, eds. Proceedings of the National Conference on Forage Quality, Evaluation and Utilization. Lincoln, NB, USA, 13–15 April 1994. bit.ly/2Q9r8hT

Uemura E; Hayashida M; Orden EA; Fujihara T. 2014. Tree legume supplementation improves mineral status of grazing does and growth performance of their kids. Livestock Research for Rural Development 26 (3). http://www.lrrd.org/lrrd26/3/uemu26040.html.

Underwood EJ; Suttle NF. 1999. The mineral nutrition of livestock. 3rd Edn. CABI Publishing, Wallingford, UK.

Veschasit O; Meksumpun S; Meksumpun C. 2012. Heavy metals contamination in water and aquatic plants in the Tha Chin River, Thailand. Agriculture and Natural Resources 46:931–943. goo.gl/8naMGb

Waluyo; Alkasuma; Susilawati; Suparwoto. 2012. Spatial inventory of potential competitiveness swamp land for agricultural development in South Sumatra. Jurnal Lahan Suboptimal 1:64–71. (In Indonesian). bit.ly/2qMBA47

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Deleted: Rajaganapathy V; Xavier F; Sreekumar D; Mandal PK. 2011. Heavy metal contamination in soil, water and fodder and their presence in livestock and products. A review. Journal of Environmental Science and Technology 4:234–249. doi: 10.3923/jest.2011.234.249¶
Rubanza CDK; Shem MN; Ichinohe T; Fujihara T. 2006. Polyphenolics and minerals composition of selected browse tree species leaves native to north-western Tanzania traditional fodder banks. Journal of Food, Agriculture and Environment 4(1):328–332. bit.ly/2KisFOL¶

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Warly L; Fariani A; Evitayani; Hayashida M; Fujihara T. 2006b. Mineral status of forages and grazing goats in West Sumatra, Indonesia: 2. Micro minerals. Journal of Food, Agriculture and Environment 4(2):204–207. bit.ly/2X70asH¶

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