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Mineral status of Java thin-tailed sheep grazed in Mijen agriculture area, Semarang, Indonesia

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ABSTRAK

Penelitian ini bertujuan mengkaji status mineral domba Jawa ekor tipis (JET) yang digembalakan di daerah Mijen-Semarang, Jawa Tengah. Sebanyak 15 ekor domba JET jantan berumur sekitar 6 bulan dan petak penggembalaan dengan vegetasi rumput lapangan, digunakan sebagai bahan percobaan. Domba percobaan dibagi 3 kelompok, masing-masing terdiri atas 5 ekor sebagai ulangan dan digembalakan selama 2 bulan (masing-masing dalam musim hujan awal, hujan akhir dan kemarau). Variabel penelitian meliputi konsumsi pakan, bahan organik tercerna, kadar mineral (Ca, P, Mg, Cu, Zn) hijauan, feses, darah dan pertambahan bobot hidup harian domba. Data diolah dengan analisis ragam, dalam pola searah. Status Mg dan Zn domba memadai, sedangkan status P defisien dalam semua musim. Status Ca defisien pada musim hujan awal dan musim hujan akhir, masing-masing dengan kadar Ca plasma darah: 7,37 dan 7,86 mg/100 mL, sedangkan pada musim kemarau 8,70 mg/100 mL. Defisiensi Cu dijumpai pada musim kemarau dan musim hujan akhir (dengan kadar Cu serum darah, masing-masing 0,62 dan 0,51 μg/mL), serta pada batas defisiensi dalam musim hujan awal (64,7 μg/mL). Kadar Cu serum darah pada musim hujan akhir lebih rendah ($P<0,05$) daripada kadarnya dalam musim hujan awal dan kemarau. Terdapat variasi status mineral ternak domba JET yang digembalakan di kawasan pertanian Mijen-Semarang, sejalan dengan perubahan musim.
Kata Kunci : *digembalakan, domba ekor tipis, jantan, musim, status mineral*

ABSTRACT

The objective of this study was to study the mineral status of Java thin-tailed (JTT) sheep grazed in Mijen-Semarang, Central Java. Six month old of male JTT sheep and paddock with field grass vegetation were used in the research. Fifteen male JTT sheeps were divided into three groups consisting of 5 heads per group, and grazing for 2 month (in early rainy season, late rainy season and dry season, respectively). The measured variables were feed consumption, digested organic matter, mineral (calcium, phosphorus, magnesium, copper, zinc) level in forage, feces, blood, and daily body weight gain. The data were analyzed by analysis of variance with one-way classification. Magnesium and zinc status of JTT sheep were adequate, whereas phosphorus status was deficient in all season. Calcium in early and late rainy season were deficient (7.37 and 7.86 mg/100 mL, respectively), whereas in the dry season was adequate (8.70 mg/100 mL). The copper deficiency was found in dry and late rainy season (with the Serum copper level was 0.62 and 0.51 μg/mL, respectively, and borderline in early rainy season (64.7 μg/mL). Serum copper in the late rainy season was lower ($P<0.05$) than it in early rainy season and dry season. There were seasonal variation of mineral status of Java thin-tailed (JTT) sheep grazed in Mijen agricultural area, Semarang, Central Java.
Keywords : grazing, male, Java thin-tailed sheep, season, mineral status

INTRODUCTION

Frequently the grazing sheep performance are unsatisfactory, although the protein and energy consumption are adequate. That phenomenon can be becaused by mineral deficiency in the forage which derived from the soil where the forage grow, mainly at the upland area such as the Mijen agriculture area. Mijen was the area with altitude 253 m above sea level and average precipitation was 2761 mm, while average annual temperature was 25.6°C (BPSS, 2015). The upland area is land with good natural drainage and utilized without irrigation (Notohadinegoro, 1997). Mijen agriculture area has a hilly and bumpy topography. Sebastian and Prasad (2015) stated that the mineral deficiency tend to occur in the hilly upland area due to errosion and leaching. Errosion and leaching are influenced among other by drainfall and topography. McDowell *et al.* (1993) stated that mineral deficiency often found in the tropical countries upland area, including Indonesia. The most occurrence of mineral deficiency cover phosphorus (P), calcium (Ca), magnesium (Mg), copper (Cu), and zinc (Zn). Rainfall also influences on speed of forage maturity and turn the forage mineral and its availability.

The broad and its essential role of mineral in livestock development, put the mineral as important nutrient, mainly as a structural component and activator of enzymes and hormones (Soetan *et al*., 2010). Mineral deficiency and/or imbalance may cause various acute metabolic disorder with pathological symptomsas well as subclinical case which can be reflected by the decrease of livestock productivity (Radwinska and Zarczynska, 2014). Special attention should be given on the subclinical case because usually the farmer does not aware upon that case. On the other hand, that case can cover the wide area with the big population of livestock and the big economic loss. The decrease of livestock productivity caused by mineral deficiency can be occurred due to decreasing of feed digestion capability and nutrient utilization in several production process along with decreasing of metabolic rate.

Indirect mineral supplementation through paddock fertilization or directly through feeding as well as free choice mineral allowance, is often less effective. On the other hand, mineral supplementation also may cause contraproductive occurrences, due to mineral imbalance and toxicity. To obtain the high efficiency and effectiveness of mineral supplementation it is importance to arrange the proper formula of mix mineral and the proper time of its supplementation.

In relation to that reason, it is important to obtain basic information about livestock mineral status and its interrelationship with forage mineral status and season. That mineral interrelationship needs to be investigated comprehensively relating to the livestock performance through the conscientious research, especially in tropical area. Mijen-Semarang, Central Java is the tropical upland agriculture area with hilly topography.

MATERIALS AND METHODS

Materials

The materials used in this investigation consisted of 15 heads of male Java thin-tailed (JTT) sheep about 6 months old, with average body weight 13.66 ± 1.73 kg, and paddock with field grass vegetation (the paddocks area were 5,000 m^2). The main equipments used were needle with venoject tube, atomic absorption spectrophotometer (ASS), analytical scales, weighing scales for feedstuff and animal, centrifuge and one unit equipment for determination of *in vitro* digestibility and proximate analysis.

Methods

Grazing periods as source of variation was categorized into 3 periods, namely dry season, late rainy season and early rainy season. The fifteen heads of male JTT sheep were divided into 3 groups consisting of 5 heads per group, as replication. Each group of JTT sheep grazed for 2 month, in dry season, late rainy season and early rainy season, respectively. Sampling was conducted at the end of each grazing period. Forage sampling was conducted by hand-plucked method according to Lebdosoekojo *et al*. (1980). Blood sample was taken from jugular vein of each experimental sheep with needle and venoject tube containing lithium heparin as anticoagulant to obtain blood plasm and without anticoagulant to obtain blood serum. Feces sample was taken with feces bag attached to each experimental sheep.

Chemical analysis

The measured variables were the level of calcium (Ca), phosphorus (P), magnesium (Mg), potasium (K), Copper (Cu), and zinc (Zn) in forage and feces, level of Ca and P in blood plasma and level of Mg, Cu and Zn in blood serum of experimental sheep. Determination of forage, feces, blood plasma and serum mineral level were conducted by spectrophotometry with atomic absorption spectrophotometer (AAS) (Fick *et al*., 1979). Forage dry matter intake was estimated according to Ramirez-Perez *et al.* (2000), that was using the chromic oxide as external indicator and the result of *invitro* dry matter digestibility determination with two stage digestion (Tilley and Terry, 1963). Rumen fluid was taken from the experimental sheep as source of rumen microbial innoculant. That was taken by inserting a tube through the mouth, then vacuumed with a pump. Nutrient composition of forage (Table 1), were obtained by Wendee proximate analysis method (Galyean, 1980).

Data Analysis

The collected data were statistically analyzed by analysis of variance with one-way classification and 5 replications. The difference of mean between groups were tested by Duncan's new multiple-range test (Snedecor and Cochran, 1980).

RESULTS AND DISCUSSION

According to NRC (1985) and McDowell *et al*. (1993) about feeding standard of sheep, the requirement of mineral stated in proportion of dietary intake. In this case, diet for grazing sheep was single feed, namely forage which grazed from paddock. Thus the level of mineral in forage were used as reference of mineral proportion in dietary intake.

Phosphorus (P) Status

Blood plasma level from three sampling periods, namely dry season, late rainy season and early rainy season were 3.83, 3.03 and3.94 mg/100 mL, respectively (Table 2). It showed that grazing sheep in three periods were in state of P deficiency. Phosphorus critical level of sheep blood plasma was 4.5 mg/100mL (McDowell *et al*., 1993). Occurring that condition was due to inadequate forage P level in three sampling periods (Abarghani *et al*., 2013). Forage P level in dry season, late rainy season and early rainy season were 0.151, 0.167 and 0.194% (Table 5), whereas P requirement of growing sheep was 0.29% (NRC, 1985). Calculation based on DM consumption and forage P level showed that P intake in dry season, late and early rainy season were 0.71, 0.67 and 0.91 g, respectively.

Statistical analysis showed that sheep blood plasma P level in early rainy season did not higher ($P<0.05$) than that in dry season. Consumption of digested organic matter (DOM) and crude protein (CP) increased in early rainy season, along with increasing of dry matter (DM) intake, *in vitro* dry matter digestibility (IVoDMD), *in vitro* organic matter digestibility (IvoOMD) (Table 4) with higher forage crude protein (CP) level than that in dry season as well as in late rainy season. That condition can increase P utilization, because enhancement of metabolic rate (Dias *et al*., 2013). According to Al-Doski (2015), enhancement of metabolic rate was reflected, among other in average daily body weight gain (ADBWG) of animal. Table 4. showed that increasing of sheep ADBWG in early rainy season was higher ($P<0.05$) than that in dry season as well as late rainy season, namely 83 g *vs* 21 and 65 g.

Blood plasma P level in late rainy season was lower ($P<0.05$) than that in dry season, although forage P level in late rainy season tended higher than that in dry season, namely 0.167 *vs* 0.151% (Table 5). Metabolic rate of sheeps grazed in late rainy season was still higher than that in dry season, even if lower than that of grazing sheeps in early rainy season. That condition occurred because its higher DM consumption,

Table 1. Nutrient Composition of Forage from Three Grazing Periods (Dry Matter Basis)

Season	CP (%)	CF (%)	NFE (%)	EE (%)	Ash (%)
Dry	8.27	30.56	43.51	2.25	15.41
Late rainy	9.94	28.03	45.87	2.14	14.02
Early rainy	11.05	25.60	48.93	2.09	12.33

CP: crude protein, CF: crude fiber, NFE: nitrogen free extract, EE: ether extract

Table 2. Blood Mineral Content of Experimental Sheep in Three Grazing Periods

Grazing Period	Blood				
	P plasma (mg/100mL)	Ca plasma (mg/100 mL)	Mg serum (mg/100 mL)	Cu serum (ug/mL)	Zn serum (ug/ mL)
Dry season	3.83±0.021[a]	8.70±0.41	1.83±0.14	0.62±0.00[a]	0.99±0.10 [a]
Late rainy season	3.03±0.068[b]	7.86±1.08	1.97±0.13	0.51±0.02[b]	0.85±0.04[b]
Early rainy season	3.94±0.061[a]	7.37±0.75	2.03±0.42	0.64±0.01[a]	0.79±0.17[b]

a,b,c: the different superscript in the same column showed the significant difference (P<0.05%). Results are means ± standart deviation (n=5)

with higer DOM and CP level, which showed the available nutrient supply and reflected in higher ADBWG of grazing sheeps in late rainy season than that in dry season (65 *vs* 21 g/day) (Table 4). Utilization of P as structural component and metabolic support on sheep in late rainy season was higher than that in dry season, thus its blood plasma P was lower than that in grazing sheep in dry season. The lower blood plasma P level in late rainy season compared to that in early rainy season also caused by the lower of P forage level in late rainy season (P<0.05) than that in early rainy season (0.167 *vs* 0.194% , Table 5).

There were not significant difference in feces P level between three sampling periods namely: 0.193, 0.163 and 0.184, in dry season, late rainy season and early rainy season, respectively (Tabel 3), even if forage P level in early and late rainy season were higher than that in in dry season. That phenomenon can be occurred because forage digestibility in early and late rainy season were higher (P<0.05) than that in dry season, that was 58.23 and 51.34 *vs* 43.14% (Table 4).

Calcium (Ca) Status

Blood plasma Ca level of sheep in dry season, late and early rainy season were 8.70, 7.86 and 7.37 mg/100 mL, respectively (Table 2). Statistical analysis showed that there were no significant difference between above blood plasma Ca level, although there were significant difference in Ca forage level among three grazing periods. Forage Ca level in dry season was higher (P<0.05) than that in late and early rainy season (0.243 *vs* 0.194 and 0.175%), while forage Ca level in late rainy season was higher (P<0.05) than that in early rainy season (Table 5). According to McDowell *et al*. (1993), an adequate forage Ca level to meet requirement for sheep grazed was 0.20 – 0.82%. The average Ca intake per head of sheep in dry season, late and early rainy season were 1.11, 0.77 and 0.82 g, respectively.

The low of forage DM intake and its digestibility in dry season and its impact on the low of Ca supply and its availability, suspected to be the cause, why the blood plasma Ca level of grazing sheep in dry season was not significantly different from that in late and early rainy season. Above argumentation also supported by feces Ca level data, in which showed that feces Ca level of grazing sheep in dry season was higher (P<0.05) than that in late and early rainy season, namely 0.299 *vs* 0.186 and 0.166% (Table 3.)

Calcium level of forage in early rainy season did not significantly different from that in late rainy season, with higher in CP level, IVoDMD, IVoOMD and DOM. On the other hand, feces Ca level in early rainy season was lower (P<0.05) than that in late rainy season. That condition did not result in increasing of blood plasma Ca level in early rainy season grazing sheep, even tended lower than that in late rainy season. That phenomenon occurred allegedly because the higher of Ca plasma utilization to support the higher metabolic process along with increasing of available substrate level on sheep grazed in early rainy season. That phenomenon also reflected in higher (P<0.05) ADBWG of grazing sheep in early rainy season than that in late rainy season (83 *vs* 65 g/day, Table 4).

Other factors which probable cause the absence of significant differences of sheep blood plasma Ca level between grazing periods was homeostasis mechanism that controlled the blood plasma Ca level (Herm *et al*., 2015). Statistically,

Table 3. Feces Mineral Content of Experimental Sheep in Three Grazing Periods

Grazing Period	P (%)	Ca (%)	Mg (%)	Cu (ppm)	Zn (ppm)
Dry season	0.193±0.01	0.299±0.02[a]	0.281±0.005[a]	10.74±1.04[a]	137.75±4.40[a]
Late rainy season	0.163±0.04	0.186±0.03[b]	0.209±0.01[b]	9.60±1.15[ab]	126.37±3.46[b]
Early rainy season	0.184±0.03	0.166±0.03[b]	0.278±0.004[a]	9.04±0.16[b]	90.24±4.64[c]

a,b,c: the different superscript in the same column showed the significant difference ($P<0.05\%$). Results are means ± standart deviation (n=5)

Table4. Dry Matter Consumption, *in vitro* Digestibility, Digested Organic Matter, Average Daily Body Weight Gain of Experimental Sheep

Grazing Periods	DM Consumption (g)	IVoDMD (%)	IvoOMD (%)	DOM (g)
Dry season	370±20.2[c]	43.14±3.86[c]	51.59±1.37[c]	162±11.45[c]
Late rainy season	415±14.8[b]	51.34±1.39[b]	59.46±1.09[b]	212±11.17[b]
Early rainy season	497±11.3[a]	58.23±1.78[a]	63.57±0.77[a]	277±11.87[a]

a,b,c : different superscript in the same column showed the significant difference. ($P< 0.05$). DM: dry matter, IVoDMD: *in vitro* dry matter digestibility; IVoOMD: *in vitro* organic matter digestibility, DOM: digested organic matter.ADBWG: average daily body weight gain. Results are means ± standart deviation (n=5)

there were not significant differences in levels of blood plasma Ca of sheep between grazing periods, but in biochemistry judgement there were important phenomenon. This was reflected in the blood plasma Ca levels in above the critical level in sheep grazed in the dry season, while the blood plasma Ca levels of sheep grazed in the early rainy season and late rainy season showed the Ca deficiency status. According to McDowell *et al*. (1993), the critical level of sheep blood plasma was 8 mg/100 mL.

Magnesium (Mg) Status

Grazing sheep in dry season, late and early rainy season had a blood serum Mg levels, that was 1.83, 1.97 and 2.03%, respectively (Table 2). According to McDowell *et al*. (1993), normal Mg status in sheep was 1-2 mg/100 mL. Statistical analysis showed that there were no significant difference in blood serum Mg levels between grazing periods, although there were significant difference ($P<0.05$) in forage Mg levels between that periods, that was 0.285, 0.156 and 0.251%, in dry season, late and early rainy season, respectively (Table 5). Forage Mg level in dry season was higher ($P<0.05$) than that in late and early rainy season, but blood serum Mg level in dry season was not significantly different from that in two other season. It is presumably because the diffenrence of forage Mg availability (Abarghani *et al*., 2013; Khan *et al*., 2017). Alleygedly the forage Mg availability in dry season was lower than that in late rainy season, along with the lower ($P<0.05$) of forage IVoDMD in dry season than that in late rainy season (43.14 *vs* 51.34 %) (Table 4.). It was also reflected in the higher ($P<0.05$) of feces Mg level in dry season than that in late rainy season (0.281 *vs* 0.209%) (Table 3).

The forage Mg level in early rainy season was higher than that in late rainy season. The DM consumption and its digestibility of early rainy season forage was also higher than that in other season, but blood serum Mg level in that grazing period was not significantly different from the other periods. It was because of the higher Mg

Table 5. Mineral Content of Forage in Three Grazing Periods

Grazing Periods	P (%)	Ca (%)	Mg (%)	Cu (ppm)	Zn (ppm)
Dry season	0.151 ± 0.05^b	0.243 ± 0.02^a	0.285 ± 0.01^a	6.93 ± 0.23^b	25.21 ± 1.83^b
Late rainy season	0.167 ± 0.03^b	0.194 ± 0.00^b	0.156 ± 0.02^c	7.18 ± 0.42^b	27.82 ± 4.37^b
Early rainy season	0.194 ± 0.004^a	0.175 ± 0.01^c	0.251 ± 0.03^b	9.73 ± 0.45^a	35.46 ± 3.76^a

a,b,c : different superscript in the same column showed the significant difference. (P< 0,05). P: phosphorus, Ca: calcium, Mg: magnesium, Cu: copper, Zn: zinc, ADBWG: average daily body weight gain. Results are means ± standart deviation (n=5

utilization for metabolism in tissue along with increasing of available nutrient (protein and DOM) in early rainy season (Sowande *et al*., 2008). Level of Mg intake in dry season was 1.04 g, in late rainy season was 0.77 g, whereas in early rainy season was 0.82 g. The higher Mg supply in early rainy season resulted in the higher feces Mg level than that in late rainy season (Table 3).

Copper (Cu) Status

Critical level of sheep blood serum Cu was 0.65µg/mL (McDowell *et al.* (1993). The analysis result of sheep blood serum, sheep grazed in dry season and late rainy season suffered the Cu deficiency (0.62 and 0.51 µg/mL, respectively). Blood serum Cu level in early rainy season was 0.64 µg/mL showing that sheep in borderline of Cu deficiency. It was presumably due to the forage Cu content was below the adequate level, namely 11 ppm (McDowell *et al*., 1993). Forage Cu content in dry season, late and early rainy season, were only 6.93, 7.18 and 9.73 ppm (Table 5). The Cu intake in above seasons were 3.97, 3.98 and 4.49 µg, respectively.

Copper is very important among other as activator of several enzyme, in which the structural component in synthesis was hemoglobin, cartilage and bone (Hilal *et al.,* 2016; Tarhan *et al*., 2016). The use of a relatively low Cu in animal tissue for dry season compared to late rainy season (reflected in the lower ADBWG), resulted in higher blood serum Cu level than that in late rainy season (Mohammed *et al*., 2016). In the early rainy season, Cu utilization increased along with the higher its ADBWG (P<0.05) than that in dry as well as late rainy season (83 *vs* 21 and 65 g/day) as presented in Table 4. On the other hand, blood serum Cu level in early rainy season was not significantly different from that in dry season, and higher (P<0.05) than that in late rainy season. That phenomenon may occur because the forage Cu level in early rainy season was higher (P< 0.05) than that in dry season as well as late rainy season (Table 3). The seasonal variation in blood serum Cu related to that mineral status changes in forage, also stated by Dar *et al*. (2014).

The feces Cu level in dry season was higher (P<0.05) than that in early rainy season (Table 3), because forage digestibility in dry season was lower (P<0.05) than that in early rainy season. The feces Cu level in dry season, late and early rainy season were 10.74, 9.60 and 9.04 ppm. According to Khan *et al*. (2003), the feces Cu level which reflected the adequate Cu supply was higher than 11 ppm.

Zinc (Zn) Status

The normal range of sheep blood serum Zn was 0.6-0.8 µg/mL (McDowell *et al*., 1993). Analysis result of blood serum Zn level showed that blood serum Zn level in dry season and late rainy season were higher than normal blood serum Zn level (0.99 and 0.85 µg/mL, Table 2). The blood serum Zn level in early rainy season (0.79 µg/mL) was within the normal range of blood serum Zn level. That condition was possible because the forage Zn level in three grazing periods were adequate to meet the requirement for growing sheep, namely 20 – 40 ppm (McDowell *et al.*, 1993). The forage Zn level in dry season, late and early rainy season, were 25.21, 27.82, and 35.46 ppm, respectively (Table 5).

Consumption of forage DM and DOM by sheep grazed in early rainy season was higher (P<0.05) than those by grazing sheep in late rainy and dry season (497 *vs* 415 and 370 g for DM and

277 *vs* 212 and 162 g for DOM), also with higher in CP and Zn levels (Table 4). It showed that consumption of protein, energy, and other digestible nutrient by grazing sheep in early rainy season also higher than that in other treatment groups. Daily average Zn intake by sheep in dry season, late rainy season and early rainy season were 50.96, 52.44 and 44.84 µg, respectively. Through the circulation system, Zn were uptake by several tissue for biological and biochemistry process, among other for component and cofactor several enzyme, tissue protein synthesis and bone formation which reflected in ADBWG (Soetan *et al*., 2010; Radwinska and Zarczynska, 2014; Schweinzer *et al.*, 2017).

The ADBWG of sheep grazed in early rainy season was higher than that in late rainy and dry season (83 *vs* 65 and 21 g/day, Table 4). That phenomenon was suitable to Zn utilization in metabolim processes of sheep grazed in early rainy season, in which higher than that in the other treatment groups. It was reflected in its blood serum Zn level, which lower ($P<0.05$) than that in dry season, and tended lower than that in late rainy season. It was supported by feces Zn level data which lower ($P<0.05$) than that in dry season and late rainy season, namely 90.24 ppm *vs* 137.75 and 126.37 ppm (Table 2). According to Khan *et al.*(2003), the feces Zn levels in three grazing periods showed the adequate Zn supply, namely higher than 13 ppm. The same phenomenon also found between grazing sheep in late rainy season and grazing sheep in dry season.

CONCLUSSION

Mineral status of grazing JTT sheep in Mijen agriculture area-Semarang, varied along with season changes, namely early rainy season, late rainy season and dry season. Sheep Mg and Zn status were adequate, while P status was deficient in all seasons. Calcium status was deficient in early and late rainy season, whereas Cu was deficient in dry season an late rainy season and on the border line in early rainy season. Mineral supplementation need to be conducted, mainly P and Cu in all seasons. The Ca mineral supplementation to be required, especially in early and late rainy season.

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