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Protein Requirement of Thai Native Cattle Compared with Meta-Analysis of *Bos indicus* Cattle

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Abstract: The objective of this study was to determine protein requirement of Thai native cattle compared with the meta-analysis of *Bos indicus*. The 24 Thai native cattle with body weight of 134 + 11.2 kg were arranged in a randomized block design with 8 replications and 3 treatments. Cattle were fed with total mixed ratio consisted 3 levels of protein (6.0, 9.0 and 12.0%). The meta-analysis of protein requirement for maintenance and for growth of Thai native and Brahman cattle were used to compare with the experiment. A database from 48 observations of trials conducted under diverse feeding condition in Thailand was subjected to regression analysis using a linear model. Dry matter, organic mater, crude protein and Neutral Detergent Fiber (NDF) digestibility, N absorption and N retention increased ($p<0.05$) with increasing levels of CP. Prediction equation CP intake (CPI, gCP kg^{-1} $BW^{0.75}$) with relation to Average Daily Gain (ADG, g kg^{-1} $BW^{0.75}$) was CPI = 0.413+4.28 (R^2 = 0.896, SE = 0.774, $p<0.05$, n = 24). It can be explained that the CP for maintenance of Thai native cattle is 4.28 gCP kg^{-1} $BW^{0.75}$. Results from the meta-analysis, the relation between Nitrogen Intake (NI, g kg^{-1} $BW^{0.75}$) and Nitrogen Retention (NR, g kg^{-1} $BW^{0.75}$) of Thai native were NR = -0.41 (SE = 0.16)+0.58 (SE = 0.10) NI (n = 26, R^2 = 0.57, RSD = 0.27, $p<0.05$) and Brahman were NR = -0.34 (SE = 0.1)+ 0.70 (SE = 0.04) NI (n = 14, R^2 = 0.96, RSD = 0.20, $p<0.05$). The relation between NI and Dry Matte Digestibility (DMD, %) for Thai native were DMD = 48.90 (SE = 4.92)+11.10 (SE = 3.02) NI (n = 12, R^2 = 0.57, RSD = 4.90, $p<0.05$) and Brahman were DMD = 48.55 (SE = 6.44)+7.16 (SE = 1.94) NI (n = 11, R^2 = 0.60, RSD = 7.47, $p<0.05$). The relation between NI and Organic Matter Digestibility (OMD, %) for Thai native were OMD = 56.68 (SE = 2.75) + 5.27 (SE = 1.72) NI (n = 12, R^2 = 0.48, RSD = 2.78, $p<0.05$), Brahman were OMD = 5 0.79 (SE = 3.75)+6.18 (SE = 1.13) NI (n = 11, R^2 = 0.77, RSD = 4.35, $p<0.05$). The relation between NI and NDF Digestibility (NDFD,%) for Thai native were NDFD = 50.94 (SE = 1.16) + 4.26 (SE = 0.70) NI (n = 8, R^2 = 0.86, RSD = 1.01, $p<0.05$), Brahman were NDFD = 51.52 (SE = 2.80) + 5.60 (SE = 0.79) NI (n = 9, R^2 = 0.88, RSD = 2.80, $p<0.05$). The relationship between NI and CP digestibility (CPD, %) for Thai native were CPD = 47.86 (SE = 4.50)+13.09 (SE = 2.76) NI (n = 11, R^2 = 0.71, RSD = 4.29, $p<0.05$). The relationship between NI and Blood Urea Nitrogen (BUN, mg %) for Thai native were BUN = 7.56 (SE = 1.36) + 0.09 (SE = 0.11)NI (n = 9, R^2 = 0.08, RSD = 2.86, $p<0.05$), Brahman were BUN = 14.17 (SE = 3.04)-1.21 (SE = 0.95) NI (n = 4, R^2 = 0.45, RSD = 2.75, $p<0.05$). The relationship between NI and ruminal Ammonia Nitrogen (NH_3N, mg%) for Thai native were NH_3N = -7.99 (SE = 3.07) + 12.14 (SE = 1.84) NI (n = 7, R^2 = 0.90, RSD = 1.56, $p<0.05$. The results indicated that protein requirement by nitrogen intake of Thai native and Brahman have relation to nitrogen retention, DMD, OMD, NDFD, ADFD, CPD, BUN and NH_3N but the potential of prediction were indicated to R^2 value.

Key words: Protein requirement, nitrogen intake, Thai native cattle, meta-analysis, composition, body tissues

INTRODUCTION

The *Bos indicus* cattle and their crossbreds including Thai native are commonly used in beef production systems in tropical regions. They possess abilities to withstand hot and humid weather to tolerate intense sunshine to resist parasites and to utilize poor quality forages (Turner, 1980). The National Research Council guidelines for beef cattle production (NRC, 2000) are widely adopted to formulate diets around the world however, protein and nutrient requirements are based on *Bos taurus* data. The NRC (2000) indicates that *Bos indicus* breeds require about 10% less NE_m than beef breeds of *Bos taurus*. Additionally, it has been recognized

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that sex and castrate status influences growth of body tissues, affecting carcass composition and feed efficiency (Berg and Butterfield, 1976) and the NE_m requirement (ARC, 1980; NRC, 2000). Therefore, improvements in the beef cattle production in tropical and subtropical regions require an accurate assessment of protein requirements of cattle compare to the protein requirement of beef cattle in temperate. The objective of this study was to perform a meta-analysis to determine protein requirements for maintenance and growth of *Bos indicus* beef cattle and Thai native beef cattle from independent studies.

MATERIALS AND METHODS

Animals and management: The 24 male Thai native beef cattle (*Bos indicus*) with body weight of 134 (SD±11.2) kg were kept in individual pens and arranged in a Randomized Complete Block Design (RCBD) with 8 replications (blocks) and 3 treatments. Cattle were allowed an adjustment period of 2 weeks and treated against anthelmintics and intestinal parasites using Ivermectin. Cattle were fed dietary Crude Protein (CP) levels of 6.0, 9.0 and 12.0% CP with similar amounts of Metabolizable Energy (ME) in Total Mixed Ratio (TMR). The total feed intake was fixed at 2.5% of body weight. The daily ratios were offered to the animals in two equal portions at 0830 and 1530 h. Refusals were weighed daily prior to the morning feeding to determined daily Dry Matter Intake (DMI). Body weight of each animal was measured twice monthly immediately before the morning feeding. Drinking water was freely available. The experiment consisted of 14 weeks, 2 weeks of adaptation following by 12 weeks of experimental or feeding periods. The last week of feeding period consisted of 2 days of adaptation to the metabolic crates, 7 days of digestibility and N balance studies. Samples of feed refusal, feces and urine were collected before feeding morning to determine digestibility and N balance. Daily fecal output of each cattle was measured and a 10% sub-sample collected and stored at -20°C. The samples were dried (60°C), ground through 1 mm sieve and stored for chemical analysis. Daily urine output was collected into a plastic container, 10% of the urine were later sampled and frozen and stored at -20°C until the analysis for energy and N contents. Representative samples of feed and feces collected during the digestibility trial were analyzed according to AOAC (1984), ash and CP and fiber components (Van Soest *et al*., 1991). Apparent digestion coefficients were calculated using equations of Schneider and Flatt (1975).

Statistics: A general linear model and correlation were used to evaluate the relationship between crude protein or Nitrogen (N) intake and their excretion via feces and urine. The data was analyzed by the general linear models procedure of the Statistical Analysis System Institute SAS (1999). Using Duncan's New Multiple Range test (Steel and Torries, 1980) compare treatment means.

A meta-analysis: A database including 48 observations from 12 feeding trials of *Bos indicus*: Brahman and Thai native in Thailand. Constructed and analyzed to determine crude protein requirements for maintenance and for growth or gain (7 observations of Thai native and 5 observations of Brahman) using mixed linear model (SAS, 1999) by regressing nitrogen intake (gN kg^{-1} $BW^{0.75}$ day^{-1}) against nitrogen retention (gN kg^{-1} $BW^{0.75}$ day^{-1}) according to St-Pierre (2001):

$$Y_{ij} = B_0+B_1X_{ij}+s_i*+b_i*X_{ij}+e_{ij}$$

Where:

Y	=	The expected outcome for CPI
$B_0+B_1X_{ij}$	=	Fixed effect part of model
$s_i*+b_i*X_{ij}+e_{ij}$	=	Random effect part of model

Performance of the derived prediction equation was tested by calculating predicted values for each dataset using the prediction models and comparing those to the actual values. Degree of over or under prediction was expressed as mean proportion bias (%) which can calculated as the slope of the regression of actual on predicted values at zero intercept according to Mandal *et al*. (2005) and accuracy of prediction was analyzed using mean prediction error. Model prediction was evaluated for accuracy by paired t-test of actual and predicted values. A non-significant ($p>0.05$) paired t-test between actual and predicted values indicated good match between values calculated using the derived prediction model and actual values (Paul *et al*., 2003).

RESULTS AND DISCUSSION

Publications of database used in protein requirement for maintenance and gain estimation are shown in Table 1. Total dry matter feed intake, nutrients digestibility and ADG in cattle fed with different levels of CP are shown in Table 2. There were no effects of crude protein levels on total dry matter intake (kg, BW% and g kg^{-1} $BW^{0.75}$). Dry matter, OM, CP and NDF digestibility in cattle fed with 12% CP was the highest and significantly higher ($p<0.05$) than those fed 9 and 6% CP. Moreover, all nutrients digestibility of cattle fed with 9% CP was significantly higher ($p<0.05$) than that of cattle fed with 6% CP (Table 3).

Table 1: Publications of database used in protein requirement for maintenance and gain estimation

References	Breed	N	Body weight (kg)	DM intake (g B^{-1} $Wkg^{0.75}$ day^{-1})
Thai Native beef cattle				
Chantiratikul and Chumpawadee (2009)	Thai native	4	132.00	64.43
Paengkoum and Tatsapong (2009)	Thai native	8	104.00	90.53
Senarath *et al.* (2009)	Thai native	4	105.00	49.65
Otsuka *et al.* (2010)	Thai native	4	132.00	21.12
Paengkoum (2010)	Thai native	18	125.00	84.30
Shengchang *et al.* (2010)	Thai native	6	154.00	80.18
Paengkoum (2010)	Thai native	4	104.00	80.55
Brahman cattle				
Khuamankgorn *et al.* (2009)	Brahman	4	350.00	68.04
Chaokaur *et al.* (2009)	Brahman	16	343.94	36.48
Chaokaur *et al.* (2009)	Brahman	16	276.47	35.98
Yuangklang (2009)	Brahman	8	204.50	124.49
Kawashima *et al.* (2006)	Brahman	4	336.00	52.23

Table 2: Effect of crude protein levels on feed intake, digestibility, ruminal ammonia-nitrogen (NH_3-N), Blood Urea Nitrogen (BUN) and Average Daily Gain (ADG) of Thai native cattle

	Dietary protein (%)			
Variables	6.0	9.0	12.0	SEM
Dry matter intake				
kg day^{-1}	4.10	4.00	4.10	0.05
BW%	3.10	3.00	3.10	0.03
g kg^{-1} $BW^{0.75}$	103.80	102.30	105.70	1.00
Digestibility (%)				
Dry matter	58.60^c	64.50^b	69.20^a	1.14
Organic matter	59.80^c	65.70^b	70.60^a	1.17
Crude protein	55.20^c	66.80^b	68.90^a	1.22
Neutral detergent fiber	54.60^c	58.70^b	62.30^a	1.18
Ruminal NH_3-N (mg%)	7.80^c	12.70^b	15.60^a	0.87
Blood urea nitrogen (mg%)	10.30^c	15.80^b	17.70^a	0.76
Average daily gain (kg day^{-1})	0.05^c	0.10^b	0.15^a	0.08

$^{a-c}$Values on the same row under each main effect with different superscripts differ significantly (p<0.05)

Table 3: Summary database for prediction of protein requirements for maintenance and for gain

Item	n	Mean	Minimum	Maximum
Thai Native cattle				
Body weight (kg)	48	122.290	104.000	154.00
N intake (N kg^{-1} $BW^{0.75}$ day^{-1})	48	1.420	0.600	2.32
N retained (g B^{-1} $Wkg^{0.75}$)	48	0.410	-0.180	13.17
DM digestibility (%)	36	66.380	54.660	75.83
OM digestibility (%)	36	65.070	57.050	70.07
CP digestibility (%)	30	68.340	53.600	81.88
NDF digestibility (%)	36	59.020	52.300	66.00
ADF digestibility (%)	10	51.970	46.250	61.05
pH	18	6.750	6.460	7.07
NH_3N (mg%)	18	10.880	6.550	19.77
Blood urea nitrogen (mg%)	8	20.540	2.810	12.38
Brahman cattle				
Body weight (kg)	48	285.895	276.470	350.00
N intake (N kg^{-1} $BW^{0.75}$ day^{-1})	48	2.380	0.435	4.63
N retained (g B^{-1} $Wkg^{0.75}$)	44	0.940	-1.950	2.89
DM digestibility (%)	16	70.850	49.600	80.90
OM digestibility (%)	16	70.040	51.800	75.20
NDF digestibility (%)	12	70.130	51.800	76.10
ADF digestibility (%)	12	57.120	42.900	59.80
Blood urea nitrogen (mg%)	8	9.670	5.500	14.48

The relation between nitrogen intake (NI, g kg^{-1} $BW^{0.75}$) and nitrogen retention (NR, g kg^{-1} $BW^{0.75}$) for

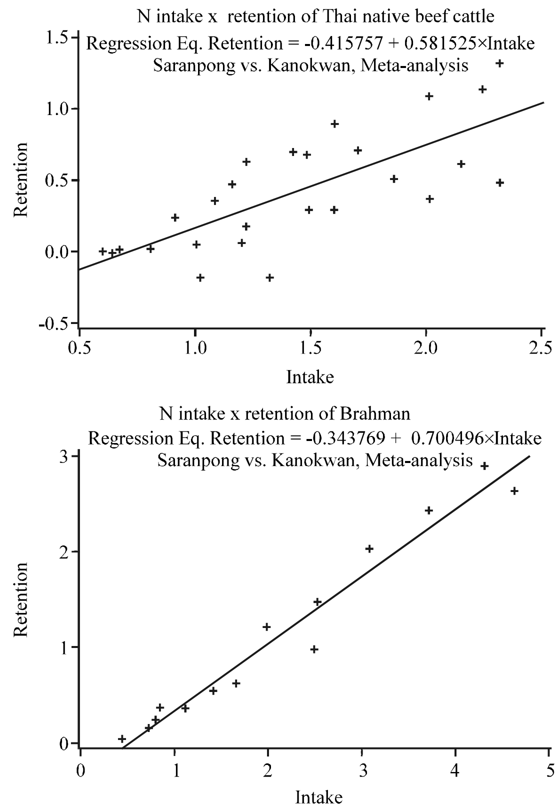

Fig. 1: Relationship between Nitrogen Intake (NI, g kg^{-1} $BW^{0.75}$) and Nitrogen Retention (NR, g kg^{-1} $BW^{0.75}$) for Thai native beef cattle (a) describes equation; NR = -0.42 (SE = 0.16) + 0.58 (SE = 0.10) NI (n = 26, R^2 = 0.57, RSD = 0.27, p<0.01), Brahman cattle (b) describes equation; NR = -0.34 (SE = 0.1) + 0.70 (SE = 0.04) NI (n = 14, R^2 = 0.96, RSD = 0.20, p<0.01)

Thai native were NR = $-0.41_{(SE=0.16)} + 0.58_{(SE=0.10)}$ NI (n = 26, R^2 = 0.57, RSD = 0.27, p<0.01), Brahman were NR = $-0.34_{(SE=0.1)} + 0.70_{(SE=0.04)}$ NI (n = 14, R^2 = 0.96, RSD = 0.20, p<0.01) (Fig. 1). The relation between NI and Dry Matte Digestibility (DMD%) for Thai native were DMD = $48.90_{(SE=4.92)} + 11.10_{(SE=3.02)}$ NI (n = 12, R^2 = 0.57, RSD = 4.90, p<0.01), Brahman were DMD = $48.55_{(SE=6.44)} + 7.16_{(SE=1.94)}$ NI (n = 11, R^2 = 0.60, RSD = 7.47, p<0.01) (Fig. 2).

The relation between NI and Organic Matter Digestibility (OMD, %) for Thai native were OMD = $56.68_{(SE=2.75)} + 5.27_{(SE=1.72)}$NI (n = 12, R^2 = 0.48, RSD = 2.78, p<0.01), Brahman were OMD = $50.79_{(SE=3.75)} + 6.18_{(SE=1.13)}$ NI (n = 11, R^2 = 0.77, RSD = 4.35, p<0.01) (Fig. 3). The relation between NI and NDF digestibility (NDFD, %) for Thai native were NDFD = $50.94_{(SE=1.16)} + 4.26_{(SE=0.70)}$NI (n = 8, R^2 = 0.86, RSD = 1.01, p<0.01), Brahman were NDFD = $51.52_{(SE=2.80)} + 5.60_{(SE=0.79)}$ NI (n = 9, R^2 = 0.88,

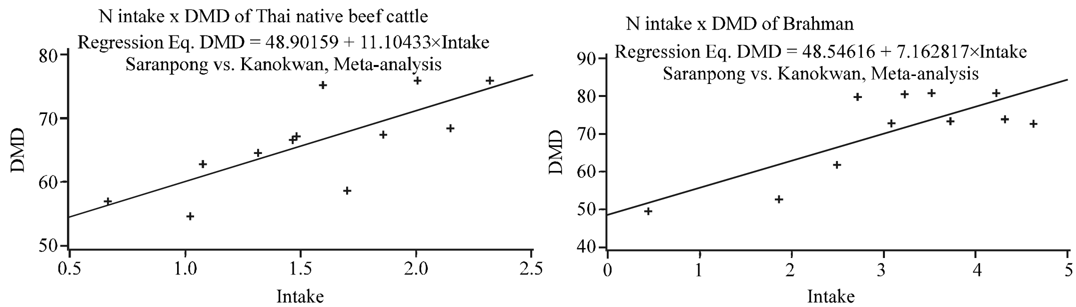

Fig. 2: Relationship between Nitrogen Intake (NI, g kg^{-1} $BW^{0.75}$) and DM Digestibility (DMD%) for Thai native beef cattle (a) describes equation; DMD = 48.90 (SE = 4.92)+11.10 (SE = 3.02) NI (n = 12, R^2 = 0.57, RSD = 4.90, p<0.01), Brahman cattle (b) describes equation: DMD = 48.55 (SE = 6.44)+7.16 (SE = 1.94) NI (n = 11, R^2 = 0.60, RSD = 7.47, p<0.01)

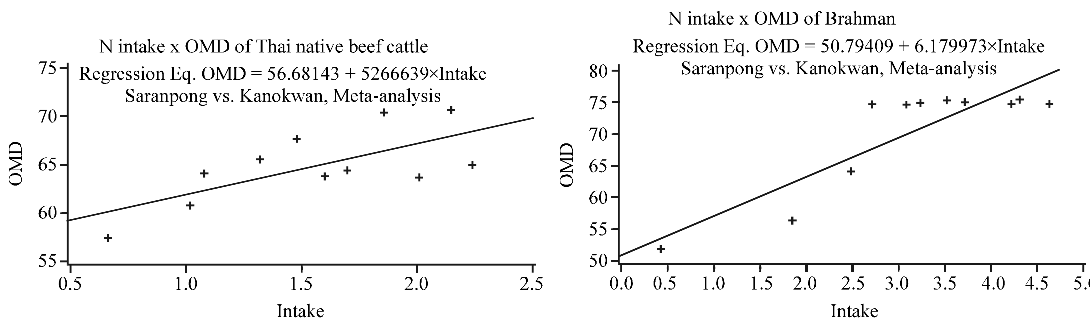

Fig. 3: Relationship between Nitrogen Intake (NI, g kg^{-1} $BW^{0.75}$) and OM Digestibility (OMD%) for Thai native beef cattle (a) describes equation; OMD = 56.68 (SE = 2.75)+5.27 (SE = 1.72) NI (n = 12, R^2 = 0.48, RSD = 2.78, p<0.01), Brahman cattle (b) describes equation; OMD = 50.79 (SE = 3.75)+6.18 (SE = 1.13) NI (n = 11, R^2 = 0.77, RSD = 4.35, p<0.01)

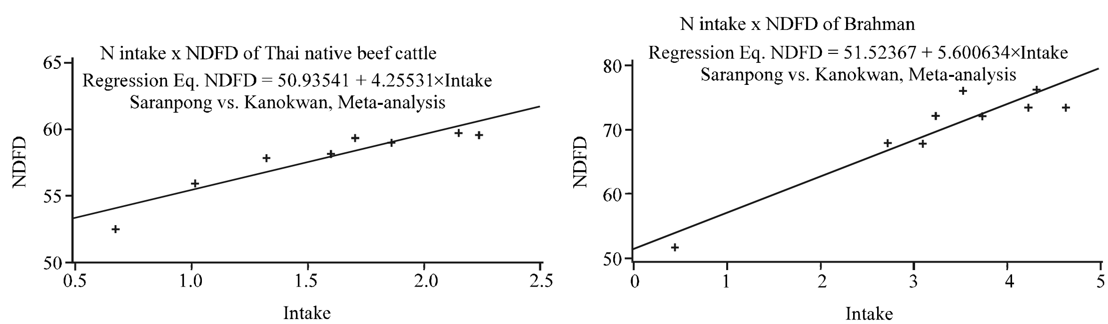

Fig. 4: Relationship between Nitrogen Intake (NI, g kg^{-1} $BW^{0.75}$) and NDF Digestibility (NDFD%) for Thai native beef cattle (a) describes equation: NDFD = 50.94 (SE = 1.16)+4.26 (SE = 0.70) NI (n = 8, R^2 = 0.86, RSD = 1.01, p<0.01), Brahman cattle (b) describes equation: NDFD = 51.52 (SE = 2.80)+5.60 (SE = 0.79) NI (n = 9, R^2 = 0.88, RSD = 2.80, p<0.01)

RSD = 2.80, p<0.01) (Fig. 4). The relation between NI and ADF Digestibility (ADFD%) for Thai native were ADFD = $68.73_{(SE = 5.31)}$ - $8.55_{(SE = 2.81)}$ NI (n = 6, R^2 = 0.70, RSD = 2.63, p<0.01), Brahman were ADFD = $44.59_{(SE = 2.80)}$ + $3.77_{(SE = 0.79)}$ NI (n = 9, R^2 = 0.76, RSD = 2.81, p<0.01) (Fig. 5). The relationship between NI and CP Digestibility (CPD, %) for Thai native were CPD = $47.86_{(SE = 4.50)}$ + $13.09_{(SE = 2.76)}$ NI (n = 11, R^2 = 0.71, RSD = 4.29, p<0.01) (Fig. 6). The relationship between NI and Blood Urea Nitrogen (BUN, mg%) for Thai native were

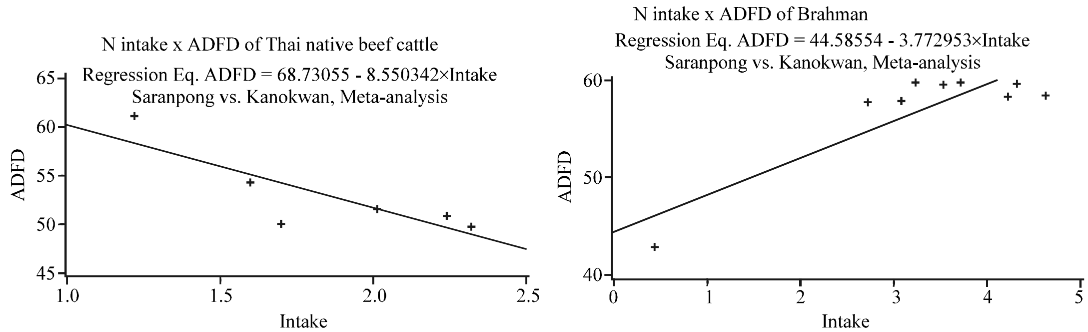

Fig. 5: Relationship between Nitrogen Intake (NI, g kg^{-1} BW$^{0.75}$) and ADF Digestibility (ADFD%) for Thai native beef cattle (a) describes equation: ADFD = 68.73 (SE = 5.31)-8.55(SE = 2.81) NI (n = 6, R^2 = 0.70, RSD = 2.63, p<0.01), Brahman cattle (b) describes equation: ADFD = 44.59 (SE = 2.80)+3.77 (SE = 0.79) NI (n = 9, R^2 = 0.76, RSD = 2.81, p<0.01)

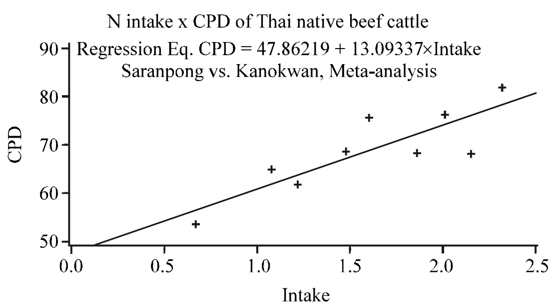

Fig. 6: Relationship between Nitrogen Intake (NI, g kg^{-1} BW$^{0.75}$) and CP Digestibility (CPD%) for Thai native beef cattle (a) describes equation: CPD = 47.86 (SE = 4.50) +13.09 (SE = 2.76) NI (n = 11, R^2 = 0.71, RSD = 4.29, p<0.01)

$BUN = 7.56_{(SE=1.36)} + 0.09_{(SE=0.11)}$ NI (n = 9, R^2 = 0.08, RSD = 2.86, p<0.01), Brahman were $BUN = 14.17_{(SE = 3.04)} - 1.21_{(SE=0.95)}$ NI (n = 4, R^2 = 0.45, RSD = 2.75, p<0.05) (Fig. 7).

The relationship between NI and ammonia nitrogen (NH_3N, mg%) for Thai native were $NH_3N = -7.99_{(SE = 3.07)} + 12.14_{(SE = 1.84)}$ NI (n = 7, R^2 = 0.90, RSD = 1.56, p<0.05) and the relationship between NI and pH for Thai native were $pH = 6.97_{(SE = 4.920.28)} - 0.12_{(SE = 0.16)}$NI (n = 11, R^2 = 0.065, RSD = 0.22, p<0.01) (Fig. 8 and 9). Prediction equation CP intake (CPI, gCP kg^{-1} BW$^{0.75}$) with relation to average daily gain (ADG, g kg^{-1} BW$^{0.75}$) was CPI = 0.413 + 4.28 (R^2 = 0.896, SE = 0.774, p<0.05, n = 24) (Table 4). It can be explained that the CP for maintenance of Thai native cattle is 4.28 g CP kg^{-1} BW$^{0.75}$. From these equations, it can be explained that the CP requirement for the maintenance of Thai native cattle is 4.28 g CP kg^{-1} BW$^{0.75}$.

This value was similar to Senarath *et al.* (2009) who reported that yearling Thai native cattle required CP for maintenance 4.36 g CP kg^{-1} BW$^{0.75}$. This value is approximately 20.38% lower than the NRC

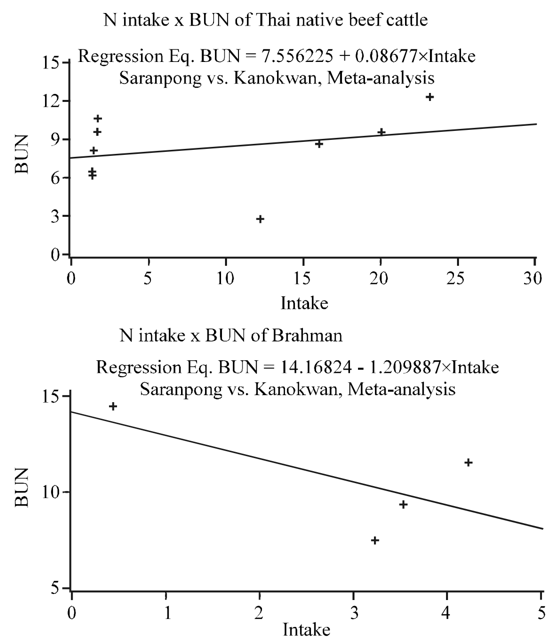

Fig. 7: Relationship between Nitrogen Intake (NI, g kg^{-1} BW$^{0.75}$) and Blood Urea Nitrogen (BUN, mg%) for Thai native beef cattle (a) describes equation; BUN = 7.56 (SE = 1.36)+0.09 (SE = 0.11) NI (n = 9, R^2 = 0.08, RSD = 2.86, p<0.01), Brahman cattle (b) describes equation: BUN = 14.17 (SE = 3.04)-1.21 (SE = 0.95) NI (n = 4, R^2 = 0.45, RSD = 2.75, p<0.05)

recommendation (5.3 g CP kg^{-1} BW$^{0.75}$) and was lower than Tangjitwattanachai and Sommart (2009) (5.03 g CP kg^{-1} BW$^{0.75}$) and Wilkerson *et al.* (1993) (5.94 g CP kg^{-1} BW$^{0.75}$). Kearl (1982) who reported that (beef cattle 150-300 kg) required 5.35-5.38 this value is approximately 20.38% lower than the NRC recommendation (5.3 g CP kg^{-1} BW$^{0.75}$).

Table 4: Accuracy evaluation of equations for predicted CP requirement for maintenance and gain of Thai native beef cattle and Brahman cattle

Item	Intercept	Slope	Coefficients	n	p-value Intercept	p-value Slope
Thai native beef cattle						
NI and NR	-0.42±0.16	0.58±0.10	66.35	26	0.0140	<0.0001
NI and DMD	48.90±4.92	11.10±3.02	7.40	12	<0.0001	0.0043
NI and OMD	56.68±2.75	5.27±1.72	4.30	12	<0.0001	0.0121
NI and NDFD	50.94±1.16	4.26±0.70	1.75	8	<0.0001	0.0009
NI and ADFD	68.73±5.31	-8.55±2.81	4.98	6	0.0002	0.0383
NI and CPD	47.86±4.50	13.09±2.76	6.28	11	<0.0001	0.0010
NI and BUN	7.56±1.36	0.09±0.11	34.35	9	0.0009	0.4586
NI and NH_3N	-7.99±3.07	12.14±1.84	13.17	7	0.0480	0.0012
NI and pH	6.97±0.28	-0.12±0.16	3.20	11	<0.0001	0.4494
Brahman cattle						
NI and NR	-0.34±0.10	0.70±0.04	17.11	14	0.0045	<0.0001
NI and DMD	48.55±6.44	7.16±1.94	10.54	11	<0.0001	0.0050
NI and OMD	50.79±3.75	6.18±1.13	6.20	11	<0.0001	0.0004
NI and NDFD	51.52±2.80	5.60±0.80	4.00	9	<0.0001	0.0002
NI and ADFD	44.59±2.80	3.77±0.79	4.92	9	<0.0001	0.0021
NI and BUN	14.17±3.04	-1.21±0.95	25.65	4	0.0432	0.3313

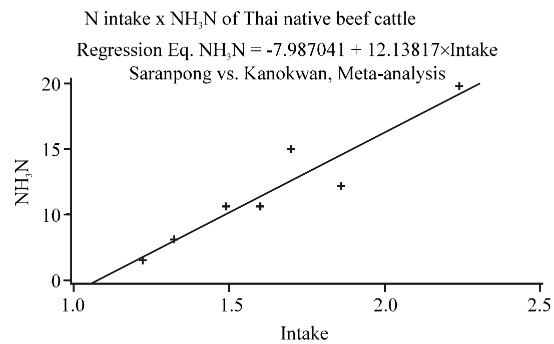

Fig. 8: Relationship between Nitrogen Intake (NI, g kg^{-1} $BW^{0.75}$) and ammonia nitrogen (NH_3N, mg%) for Thai native beef cattle (a) describes equation; NH_3N = -7.99 (SE = 3.07) + 12.14 (SE = 1.84) NI (n = 7, R^2 = 0.90, RSD = 1.56, p<0.05)

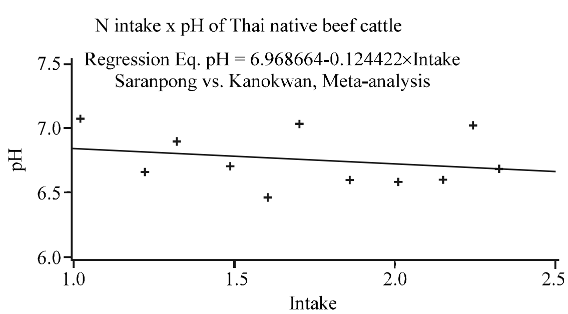

Fig. 9: Relationship between Nitrogen Intake (NI, g kg^{-1} $BW^{0.75}$) and pH for Thai native beef cattle (a) describes equation; pH = 6.97 (SE = 4.920.28)-0.12 (SE = 0.16) NI (n = 11, R^2 = 0.065, RSD = 0.22, p<0.01)

CONCLUSION

In this study, nutrients digestibility and ADG increased (p<0.05) as CP level increased. The results from this study indicate that the CP requirement for the maintenance of Thai native cattle is 4.28 g CP kg^{-1} $BW^{0.75}$. The results from this study were similarly to the results from meta-analysis in Thai native, Brahman cattle or in *Bos indicus* cattle in terms of feed intake, nutrient digestibility, ruminal NH_3-N and blood urea nitrogen. If cattle in the topics are utilized more in order to exploit available low quality feed, it may contribute to the sustainable development of agriculture as well as animal production. Thai native is clearly suitable to utilize low quality roughage. Well-balanced introduction of these animals would contribute to sustainable development of not only animal production but also crop production in Thailand.

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