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A case study on compensatory growth of emaciated cattle fed on total mixed ration

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A study was conducted in Thailand with the aim of evaluating compensatory growth of emaciated cattle fed on *ad libitum* total mixed rations (TMR) under smallholder feedlot management. Two farms were identified where 121 cattle of various degrees of emaciation were bought for fattening trial. Cattle were grouped according to the degree of emaciation within respective pens and were fed on same type of feed throughout the feeding period. Feed intake was estimated on daily basis and was noted to be low during the start of the feeding trial but gradually increased in an increased rate up to the end of feeding period. The cattle with low weights and body condition scores at the beginning of feeding trial gained more weights than their counterparts which started with high body weights and high body condition scores. There was a significant (P < 0.01) difference between treatments in both weight gains and body condition scores. Final weight gains for bulls in a mixed pen under same feedlot environment were also significantly (P < 0.01) different. A positive linear correlation (r = 0.54) was also observed between weight gains of cattle and feed intake. It was concluded that degree of emaciation, feed intake, breed difference and sex significantly influenced compensatory growth.

Key words: Compensatory growth, *ad libitum,* feedlot, live weight, body condition score.

INTRODUCTION

A number of mechanisms are involved that enable cattle to adapt metabolically to periods of nutrition restriction, and to subsequently exhibit compensatory growth once *ad libitum* access to high energy diets are provided (Carstens et al., 1991). Reduction in energy density for growth and energy requirement for maintenance increases in net efficiency of growth, feed intake and gut fill have been shown to contribute towards compensatory growth in cattle (Abdalla et al., 1988). Knowledge of compensatory growth has assisted some cattle farmers to modify livestock raising systems with the aim of maximizing profits (Tapki, 2012). Beef cattle are generally raised following two systems; the first one is called on-farm production system, where cattle are raised and finished on the same farm (Boxler, 2013). The other system is referred to as speculator system, where cattle are raised and finished on two different farms (Forbes, 2007). In speculator system, a farmer called speculator, goes to different farms and/ or cattle markets to search and buy cattle that are brought to the farm for fattening (Abdalla et al., 1988). The speculators generally buy cattle in poor body condition and put them on good nutritive feeds to finish them within short period of time possible. The speculators take advantage of the concept

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of compensatory growth; a condition of an accelerated growth of cattle following a period of slowed growth particularly as a result of nutrients deprivation.

The speculators buy cattle mainly during dry season when animal feeds (pasture) are in short supply and consequently cattle are in poor body condition (Roche et al., 2004). Compensatory growth is markedly pronounced in semi-arid regions where cattle become bony during dry season when pastures become scarce (Boxler, 2015). In winter, cattle in Thailand are generally in poor body condition and the prices of cattle at cattle markets are generally low but still farmers have to sell their cattle to get enough money to use in their farms. Winters are lean periods to rice farmers in Thailand but this is also a period when money is needed much to use in paddy fields hence selling cattle becomes the only alternative source of cash to farmers with livestock.

Beyond marketing, profitability in cattle feeding business is dependent upon optimizing the utilization of available feed and cattle resources (Abdalla et al., 1988). Since ruminants use microorganisms to derive nutrients from poor quality grass, crop residues are therefore, the best available feed for cattle because they are cheap and are always in plenty during harvest period.

Several studies on compensatory growth have been conducted by many scholars in some universities but such studies were mostly done in animals which were deliberately starved to match with study outcome. The current study realizes that every animal undergoes a period of starvation in its life time so compensatory growth was studied under natural condition. Therefore, the current study was conducted in Thailand on demand by smallholder livestock farmers with the aim of generating and validating locally available information on compensatory growth for domestic use. The results of this study are expected to be utilized by farmers in Phanom Thuan Province in livestock cooperatives for better management decision of their feedlot business.

MATERIALS AND METHODS

This study was conducted in PhanomThuan district, one of the districts of Kanchanaburi Province, in Thailand. The province is regarded as the most significant zone for smallholder beef cattle feedlot business. This Province is located 14°1' North and 99°32' East and is 19,483 Km^2 in area. The province is one of the areas in Thailand where farmers depend on agriculture for living. Farmers grow a lot of baby corns, sugarcane, pineapples and bananas in this area hence beef farmers take advantage of the by-products such as molasses, corn stalks, banana and pineapple peals, from these crops to feed cattle. Farmers who participated in this study used corn stalks and pineapple peals for making silage mainly because these by-products are sold at a relatively cheap price. The study province has agro-industry factories, where farmers buy agro-by-products as raw materials for concentrate feeds.

Study design

Cattle were placed on the two farms after segregating them based on degree of emaciation. Selection of cattle into groups was done in a complete randomized manner since cattle were bought from different farmers and different locations. Body condition score was the main key factor used to determine degree of emaciation when placing the cattle into different groups. All cattle were exposed to same feedlot conditions during the entire period of feeding and data were collected based on the groups or category of cattle within the pens. Data on feed intake were done on daily basis while that on weight gains and body condition scores were done fortnightly.

Feed analysis

Prior to commencement of feeding study, feed samples were collected from the two farms for laboratory analysis in order to know the nutritive values of the feed used mainly energy and protein which are crucial for cattle fattening. The chemical composition of feed was determined by methods described by Association of Official Analytical Chemists (AOAC, 1990) and the fiber fractions of neutral detergent fiber (NDF) and acid detergent fiber (ADF) by method described by Van Soest et al. (1991). The gross energy (GE) was estimated by Ballistic Bomb Calorimeter (Gallen Kamp) as recommended by Harvey (1960).

Animals and animal pens

One hundred twenty one cattle of various ages and various degrees of emaciation were identified from two farms for this study. Most of the cattle were crossbreed of Hindu Brazil and local Thai breeds, which are characterized by big body frame and large ears. The first farm had 19 cattle while the second had 102 cattle. There were three cattle pens in the second farm while the first farm had only one. The cattle pens were open-sided barn constructed from wooden poles and galvanized metal roofs. Feed and water were provided *ad libitum* in well-constructed troughs.

Feed and water Intake

In both farms, cattle were fed twice a day whereby 9 kg per cattle of TMR was given in the morning and 3 kg per cattle of TMR was supplied in the afternoon during the first month. Feed was gradually increased from 10^{th} week, from 12 kg per animal up to 15 kg per animal at the last weeks of the study but no leftovers were collected the following feeding time. The feed was supplied in common feed troughs where all cattle in a kraal came to eat as a group hence feed intake was estimated. Water was also provided in a common water trough and it was replenished once a day during feeding time. It was difficult to estimate water intake since all cattle were drinking from one water trough. Feed was weighed before being supplied to cattle in *ad libitum*. The leftovers were carefully collected and weighed too. Hence, feed intake was roughly estimated per day by dividing the amount of feed taken by the number of cattle in the pen.

Live weight measurement

A single visit per fortnight, multiple-subject survey was carried out using face-to-face farmer interviews during the three months of the study (mid September to beginning of December, 2013). A weigh tape (Giss Marketing Thailand) was used to measure live weights of all cattle at the two farms before and after the period of the study. The exercise was conducted with full participation of the owners of the farms. They were involved in restraining the animals when the weights were being taken. The weights of individual animals were estimated and the data were collected and recorded securely.

Table 1. Composition of experimental diet from Farm 1 and 2.

Parameter	Farm 1		Farm 2	
	Concentrates	Silage	Concentrates	Silage
Moisture (%)	7.7	75.47	8.38	75.47
Crude protein (%)	14.24	8.28	9.32	8.28
Ether extract (%)	4.67	2.84	4.68	2.84
Ash (%)	6.33	6.58	5.70	6.58
NDF (%)		67.72		67.72
ADF (%)		47.75		47.75
Gross energy (kcal)	3910.58	3642.47	3794.85	3602.55

Table 2. Mean (+SD) initial weight, final weight and weight gain (kg) from Farms 1and 2.

ID number of animal	Description	Mean initial weight	Mean final weight	Mean weight gains	P-values
Pen 1 (F1)	Severe emaciation	364.47±22^{a}	580.89±10^{a}	216.42±20^{c}	0.01321
Pen 1 (F2)	Severe emaciation	426.74±21^{b}	634.30±32^{b}	207.57±27^{c}	0.03504
Pen 2 (F2)	Moderate emaciation	367.43±27^{c}	559.54±42^{c}	192.11±31^{c}	0.04194
Pen 3 (F2)	Fairly fat	353.91±43^{c}	544.52±47^{d}	191.61±23^{d}	0.04732

Means within column with different superscripts differ significantly (P<0.05).

Animals were weighed in random manner without segregating them by neither sex nor age.

Body condition scoring

A scale of 1 to 9 adapted from Herd and Sprott (1986) was used to monitor body condition scoring where 4 major segments were classified. The classes were 1 to 3 as thin, 4 as borderline, 5 to 7 as optimum and 8 to 9 as fat. During body condition scoring, brisket and back/flunks of cattle were thoroughly scrutinized for detectable fats while ribs, hooks, pins, and tail heads were observed for visibility and projection for determination of degree of fatness. The exercise involved actual palpation of the body parts of the animal and/ or visual observation.

Typical gross margin for beef cattle fattening in Thailand

Data used to calculate gross margin for cattle in this survey were collected from farm records and farmer interviews in addition to field observations. Data included variables as number of cattle bought, feed cost, veterinary cost, asset, bank interest rate, labor cost and the purchase/selling prices. However, there was no breakdown of how many cattle bought at higher cost or low cost than others instead calculation was based on live weight and the fixed purchase and selling prices. The live weight varied from one animal to another but purchase and selling prices were constant throughout the calculation.

Cattle market transactions for the study beef cattle

The cattle were sold through a bidding cattle market system where buyers and cattle owners came together to decide on the selling price. Cattle were trekked from the farm to a nearby cattle market where different buyers patronized the market transaction. Cattle buyers were pre-identified and terms and conditions for sale were agreed upon by the seller and the buyer before the market day hence, cattle were consigned. The buyers weighed individual cattle and recorded the weight for price calculation.

Data analysis

Data on live weights, body condition score were analyzed by using GLM procedure of SAS for windows program on a personal computer. Initial body weights were used as covariate in data analysis. However, feed intake was not statistically analyzed due to group feeding where it was difficult to measure feed intake by individual animal.

RESULTS AND DISCUSSION

Nutrient composition of cattle feed

The cattle feed was found to have high energy levels of above 3900 kilocalories and low protein content of 14.24% and below (Tables 1 and 2). The feed was ideal for beef cattle fattening program because the high energy levels were required for fast growth and multiplication of rumen microorganisms. As was noted by findings by Eroldogan (2008) protein level for grown cattle is not as important as the energy. It was also stated by Lunn (2006) that growing cattle generally need 13 to 14% protein levels while finishing cattle requirements are closer to 11 to 12%, therefore the feed was within the requirement for fast cattle fattening.

The high moisture content of silage (Table 1) was due

to the fact that the agricultural by-products were freshly bought straight from corn and sugarcane farms and brought to the feedlots for silage making.

Feed intake

The feed intake was low during the first two fortnights of the study as witnessed by amounts of leftovers collected every morning feed time that is, 0.9 and 0.3 kg/head estimated during the first and second fortnights respectively. The study commenced towards the end of rainy season in Thailand so the cattle pens were muddy but the situation improved within the first month of study. During this rainy season feed intake was low and therefore, the study attributed this low feed intake to period of acclimatization of animals in a new environment.

The study also revealed that feed intake increased at an increased rate every subsequent week of feeding as witnessed by the fact that there were no leftovers during the subsequent period of feeding despite increasing amount of feed weekly. The increase in feed intake is deduced to be due to effect of compensatory growth since these cattle experienced nutrient restriction during grazing but were now given good nutritive feed in *ad libitum*. It can therefore be argued that feed intake had a bearing on compensatory growth and feed intake was found to have positive correlation to compensatory growth ($r = 0.54$).

Live weight

Further statistical analysis of the study findings showed a significant difference in weight gains ($P < 0.05$) due to high energy levels of the feed (Table 3). With high levels of energy, rumen microbes multiplied very fast and produced more microbial proteins (Smith et al, 1986) in addition to protein from feeds and the animal added on weight very fast. However, individual cattle registered different weight gains at the end of the study due to differences in levels of gene inheritability levels since these were cross bred cattle. To some extent the variation in weight may be attributed to the degree of emaciation since cattle started feed experiment with different degrees of emaciation. Degree of emaciation was found to have a bearing on compensatory growth in the sense that cattle which entered feeding trial with low live weights gained more weights than those which had good weights at the start of the feeding trial.

Cattle commenced feeding trial with different live weights and degree of emaciation. Findings showed that the cattle gained different live weights at the end of experiment. It was noted that most severely emaciated cattle gained more live weights at the end of the trial than the fairly fat ones (Table 2). The study found out that the extent of emaciation had an effect on the final weight gains of cattle. The rapid weight gains in severely emaciated cattle were attributed to feed intake which was found to be more in severely emaciated cattle than in fairly fat cattle. Hence, it can be argued that live weights had an effect on compensatory growth. The study also found out that degree of emaciation had a positive correlation to live weights ($r = 0.5$).

Body condition

Cattle entered the feeding program with different live-weights and body condition scores (Table 3). The study found that initial and final body condition scores were significantly ($P < 0.001$) different. Most of the cattle managed to attain BSC 8 which was the ideal score for beef cattle but still some could not attain the desired BSC at the end of the study. As noted by Tapki (2012) severe emaciation may not be a result of only nutritional status but also disease condition. However, this survey found that the low body condition scored cattle added more weight than those with good condition scores.

Final BCS and daily weight gains were affected by initial body condition score. It was also observed that individual big-framed cattle of low BCS attained the highest live weight gains as compared to the small framed cattle. The study attributed this difference to the extent of crossbreeding since there was no data to quantify whether the crossbred cattle had different blood levels of crossbreeding.

In both farms steers and bulls had achieved higher body condition scores than cows. The higher initial body condition score seemed to have been affected by feed intake and consequently caused the lesser daily weight gain in some cattle. The high BCS in bulls and steers was mainly due to the fact that bulls and steers commenced the feeding program with higher BCS than cows. Esterhuiizen et al. (2008) in their study with cows and bulls discovered that sex had great impact on daily weight gains and body condition scores of cattle after realimatation period. This was explained with reference to physiological difference between female and male cattle in the sense that many cows lose weight not only because of nutritional problems but also lactation period of nursing calves.

In this study, it was further observed that 80% of cattle achieved desired weight and body scores while 20% did not. This was noted by Carstens et al. (1991) who stated that cattle on same ration gained different amounts of live weights for same period of fattening. Carstens et al. (1991) further observed that not all cattle under their study gained same live weights at the end of the study period. There were some variations in weight gains from individual cattle under same feed treatment. The variations were explained as due to gene differences since the study could not trace the genetic make-up of all

Table 3. Mean initial and final body condition scores from Farm 1 and 2.

Farm ID	Initial BCS	Mean initial BCS	Final BCS	Mean final BCS	P-Value
Farm 1	BCS 3 = 8 BCS 3 = 11	3[a]	BCS 7 = 7 BCS 8 =12	8[A]	0.00754
Farm 2 Pen1	BCS 3 = 5 BCS 4 =18	4[b]	BCS 8 = 1 BCS 8 = 22	8[B]	0.00984
Farm 2 Pen 2	BCS 3 = 21 BCS 3 =25	3[c]	BCS 7 = 20 BCS 8 =26	8[C]	0.00719
Farm 2 Pen 3	BCS 4 = 11 BCS 4=22	4[d]	BCS 7 = 9 BCS 7 =24	7[D]	0.02782

Means with different letter case superscripts differ significantly ($P < 0.001$).

Table 4. Gross Margin results for cattle in Farm 1.

Item description	Unit price/Baht	Amount
Income		
11 cows, 580.89 kg (24 - 36 months)	92	587,860.68
8 bulls, 580.89 kg (20 - 30 months)	92	427,535.04
Total income		**1,015,395.72**
Variable cost		
11 cows, 364.74 kg (24 - 36 months)	84	337,019.76
8 bulls, 364.74 kg (20 - 30 months)	84	245,105.28
Feed cost	6,000	114,000
Veterinary cost	350	6,650
Interest cost	95	1,805
Total variable cost		**704,580.04**
Gross margin	(A) - (B)	**270,815.68**

the cattle under study as was also explained by Sahin et al. (2009). It was therefore concluded that age, sex, breed and extent of emaciation had a bearing on the results of the study. The current study is also attributing the difference in weight gains to gene variability, sex, age and degree of emaciation.

This study also showed few cases of severely emaciated cattle that did not respond positively to feeding in the second farm. It was found out that 3 cattle out of 102 in the second farm were found to have gained below 100 kg for a fattening period of 107 days. Since all cattle in the second farm had the same diet, the study concluded that the cattle were over emaciated and this agrees with what Fox et al. (1988) noted. Therefore, this study has revealed that severely emaciated cattle cannot achieve full potential of compensatory growth even if they were given good nutritive diet. This is in line with what Eroldogan et al. (2008) noted that growth compensation response is species-dependent. It depends on type of cattle, length and severity of feed restriction, being more effective when duration and severity of restriction are short.

Gross margin results of cattle in farm 1

The gross margin calculations for the Farms 1 are shown in Table 4. Since the farms followed the same system of raising cattle, the gross margin calculations represent the scenarios in both farms. Data presented in Table 4 demonstrate that the farmer invested 704,580.04 baht in the business and made a profit of 270.715.68. This profit came about because the farmers used agricultural by-products such as corn stalks, pineapple peals, molasses to feed cattle which reduced feed cost by over a quarter of normal feeding cost. In feedlot business feed cost accounts for 60 to 70% of production costs therefore, by reducing feed costs the farmer were able to realize big profits. The other contributing factor to the high profit was that the farmer used family labor which the farmers said is part of their strategy to build capital and that the farm did not experience any death of cattle during the period of

study, so all these contributed to realization of the high profit as was also noted by Kazito et al. (2011). Furthermore, the final calculations showed that bulls scored high income than cows in all mixed pens hence, it can be concluded that sex had effect on income.

One of the limitations of this study was that the research was hampered by the inability to compare the previous calculated gross margin from both farms with the present calculation because the farms do not usually calculate detailed gross margins. The farms generally calculate the simple profit and loss as noted by Lambertz et al. (2012). However, interviews from the two farms have indicated that the feedlots have been generally profitable over the past five-year period they have been in operational. To get precise estimates of gross margin in feedlot business, additional data are needed although this has implications of additional costs.

Conclusion

The study showed that the lower body condition scored cattle were the best to be used in min-feedlot operation because the expected weight at the end of feeding period was found to be higher in lower body condition scored cattle than that of higher body condition scored ones. Since farmers sell their cattle on live weight basis the final weight is very important because it determines the levels of income farmers get at the end of fattening period. However, the study noted that severely emaciated cattle took very long to fatten and therefore, not ideal for feedlot business. The study also revealed that the knowledge of compensatory growth of cattle was practical and not like other theoretical concepts which had been researched by many scholars.

Use of agricultural farm by-products and agro-industry by-products has shown to be very efficient in reducing production costs, therefore, farmers should always take advantage of them where they are found in proximity to the farm. The study has also shown that knowledge of compensatory growth will really assist feedlot owners in Kanchanaburi Province in deciding projected final weight of finished cattle and determining the best types of cattle for fattening. It has also been revealed that all cattle on pastures undergo compensatory growth in their life cycle so they require compensatory growth if they are to be profitable at the market.

Based on the sample gross margin of cattle fattening in Kanchanaburi Province in Thailand, it is concluded that mini-feedlot operation is one of the lucrative businesses in the area because of availability of agro-industry by-products which are available at low cost and throughout the year.

Conflict of Interest

The authors have not declared any conflict of interest.

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REFERENCES

Abdalla HD, Fox DG, Tonney ML (1988). Compensatory gain by Holstein calves after underfeeding protein. J. Anim. Sci. 66:2687-2689.

Carstens GE, Johnson DE, Ellenberger MA (1991). Energy metabolism and composition of gain in beef steers exhibiting normal and compensatory growth. J. Anim. Sci. 69:3250.

Eroldogan OT, Tasbozan O., Tabakoglu S (2008). Effects of restricted feeding regimes on growth and feed utilization of juvenile gilthead sea bream, Sparusaurata. J. World Aqua. Soc. 39:267-274.

Esterhuiizen J, Groenewald IB, Strydom PE, Hugo A (2008). The performance and meat quality of Bonsmara steers raised in a feedlot, on conventional pastures or organic pastures. S. Afr. J. Anim. Sci. 38(4):303-314.

Forbes JM (2007). Voluntary Food Intake and Diet Selection in Farm Animals.2nd Ed. CAB International, CABI Head Office Nosworth Way Wallingford Oxfordshire OX10 8 DE UK.

Fox DG, RR Sniffen, JD O' Connor (1988). Adjusting nutrient requirements of beef cattle for animal and environmental variations. J. Anim. Sci. 66:1475. Harvey WR (1960). Least square analysis of data with unequal number. J. Food Sci. 42(3):711-715

Kazato O, Hajime K, Hiroyuki H (2011). Application of the modified feed formulation to optimize economic and environmental criteria in beef cattle fattening systems with food by-products. J. Anim. Feed Sci. Technol. 165:38-50.

Lambertz C, Chakrapong C. Jan M, Eva S, Matthias G (2012). Characteristics, Socioeconomic benefits and Household livelihoods of beef buffaloand beef cattle farming in North Thailand. JARTS 113(2):155-164.

Roche JR, Dillon PG, Stockdale CR, Baumgarard LH, VavBaala MJ (2004). Relationships among international body condition scoring systems. J. Dairy Sci. 87:3077-3079.

Sahin A, Miran B, Ibrahim YI, Onence A, Alcicek A (2009). Fattening cost of beef breeds reared under controlled conditions and determination of optimum fattening period. Turk. J. Anim Sci. 33(6):485-492.

Tapki I (2012). Initial body condition score at the fattening effects on the behavior and physiological responses of Holstein Friesian steers under heat stress. Asian J. Anim. Vet. Adv. 7(8):674-680.