Estimation of Conformation Score in Relation to Body Measurements Using 3D Scanner in Swamp Buffaloes

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Abstracts: The objective of this study was to develop the appropriate equations to estimate the conformation score both in male and female swamp buffaloes using body part measurements from 3D scanner. The buffaloes' conformation was evaluated using 3D scanning technique in 72 males and 78 females at Surin, Uthaithanee, Bangkok, Nakornpanom and Sakaew provinces of Thailand. Height (A), heart girth (B), shoulder width (C), iliac width (D), ischial tuberosity width (E), the length between shoulder and ileal wing (F, G), the length between ileal wing to ischial tuberosity (H, I), the length between shoulder to ischial tuberosity (J1, J2), tail length (K), knee circumference (L), the width measuring between the tip (M), the middle (N) and the base of horns (O), the horn length (P) and the length measured from the base to the tip of the horn on the same site (Q) were measured. The results found that A B, D, E, FG, J1J2, L and P were significantly higher along with age in both males and females. The scores obtained currently between academics and the philosophers were closely correlated in every categories in both male and females buffaloes over four and three years of age, respectively, except for the reproductive organ in females. The coefficient of determination (R^2) for score prediction in male buffaloes under 4 years old was highest when body length and knee circumference were included in the equation: Score = [(0.568 J1J2) + (1.584 L) – 77.89] (R^2 = 0.57, n = 19). The prime factor affecting score in male over 4 years of age was heart girth (R^2 = 0.70). However, R^2 was rise up to 0.85 when girdle width was included into the equation: Score = [(0.485 B) + (1.892 D) – 156.54] (n = 53). In females under 3 years old, the R^2 were low in all type of equation (one traits to four traits equation; 0.25-0.42, n = 21). However, in females over 3 years of age the R^2 is high (0.66) when girdle width was included in the equation : Score = [2.655 D – 91.52] (n = 57). Therefore, different traits should be used to evaluate the conformation in immature and mature males and females.

Keywords: Conformation score, body measurements, 3D scanner, swamp buffaloes.

INTRODUCTION

The visual image analysis has been used in Thai swamp buffaloes recently to evaluate the conformation body weight and surface area [1]. The device, although inconvenient to installed, is superior to create the three dimensional photographic image of animals within a few seconds and can be recorded in the computer program. Therefore, the estimation of body parts can be performed later using mathematical analysis procedures from the data recorded in the system and the results had shown that the body parts measured by 3D scanner is accurate compare to manual measurement by ruler [1]. In dairy cattle, the assessment of body parts or conformation related to production, health, and longevity has been widely used to provide the conformation score as an indicator of the efficiency of a cow [2-4]. This is what so called "Linear type traits assessment" or "Linear type traits classification" or "conformation scoring". Recently, the international standard has been setup for ideal conformation in many species worldwide and being used for genetic study to improve those traits that proved to be significant for economic traits e.g. milk production, disease tolerance, longevity and etc. Genetic and phenotypic parameters for conformation such as stature, heart girth, body depth, rump width in three Swiss dairy cattle breeds were studied [5]. The results show that R^2 of the linear type traits ranged from 0.3 to 0.5, for all breeds. Genetic correlations with production traits (milk, fat and protein yield) and SCS (somatic cell score) differed between the dairy breeds. Most markedly, stronger correlations were found between SCS and some conformation traits [5].

In Nili-Ravi buffaloes, the conformation traits and milk production were investigated in 100 days and 305 day yields [6]. The milk yield was positively related to paunch girth, heart girth, body length and distance between hock and pin bone. Since swamp buffaloes in Southeast Asia were raise for the working purpose and later on for meat production, the selection criteria for conformation are therefore far more different than those of river buffaloes. The conformation scoring for ideal swamp buffalo is normally done by philosophers and academic people base on visualization. The bias

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ISSN: 1927-5196 / E-ISSN: 1927-520X/13

might be happen depending on the expertise of the judgers. As the result, using scoring estimation from measurement of body parts by 3D scanner is considered to be more accurate alternative method to determine elite swamp buffaloes in Thailand. In order to achieve the accurate information, the 3D scanner was developed as part of Her Royal Highness Princess Maha Chakri Sirindhorn Initiative Project to conserve the good conformation of swamp buffaloes in Thailand. The objective of this study was to develop the appropriate equations to estimate the conformation score both in male and female swamp buffaloes using body part measurements from 3D scanner.

MATERIALS AND METHODS

The study was performed in accordance with institutional guideline and conformed to the Faculty of Veterinary Science, Chulalongkorn University. The 3D scanning was performed in 72 males and 78 non-pregnant females at Surin, Uthaithanee, Bangkok, Nakornpanom and Sakaew provinces of Thailand. Buffaloes were divided into 4 groups according to sex and age: - young male (< 3 years old), adult males (> 3 years old), young female (< 4 years old) and adults female (> 4 years old). The 3D scanning was carried out on each buffalo using stereocamera technique [1]. The body part measurements obtained from 3D scanner were body height (A), heart girth (B), shoulder width (C), iliac width (D), ischial tuberosity width (E), the average length between left and right shoulder to ileal wing (FG), the average length between left and right ileal wing to ischial tuberosity (HI) and the average length between left and right shoulder to ischial tuberosity (J1J2), the tail length (K), the knee circumference (L), the three interhorn spaces or width measuring between the tip (M), the middle (N) and the base of horns (O), the horn length along the shaft of the horn from base to tip (P) and the length measured from the base to the tip of the horn on the same site (Q) (Figure **1**).

The conformation scores of each buffalo were obtained by at least 2 persons, academics and philosophers. The academics are person who are acceptable to become buffalo specialists from the Department of Livestock Development or the one who has been elected as a buffalo judging committee in the annual buffalo competition in Thailand. The philosophers are the rural farmers who had high reputation for evaluating the goodness of buffaloes by visualization in those villages.

The scores were obtained from the average scores of both academics and philosophers and were divided into 6 categories as follows, general appearance (20

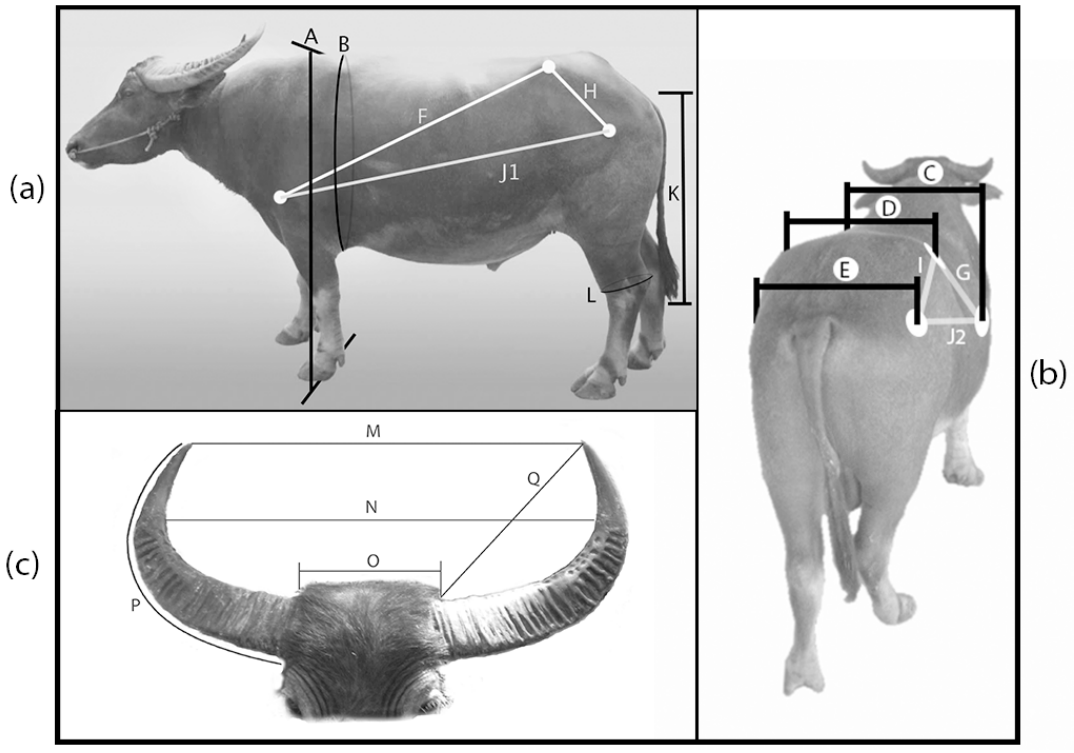

Figure 1: The conformation traits obtained from 3D scanner by measuring different points of the body surface (**a** and **b**) and the horns (**c**).

points), head and neck (10 points), front body part (20 points), middle body part (12 points), rear body part (30 points) and reproductive organ (8 points) according to the recommendation of the Department of Livestock Development, Thailand. The relationships between average conformation score and body conformation traits in male and female buffaloes were evaluated.

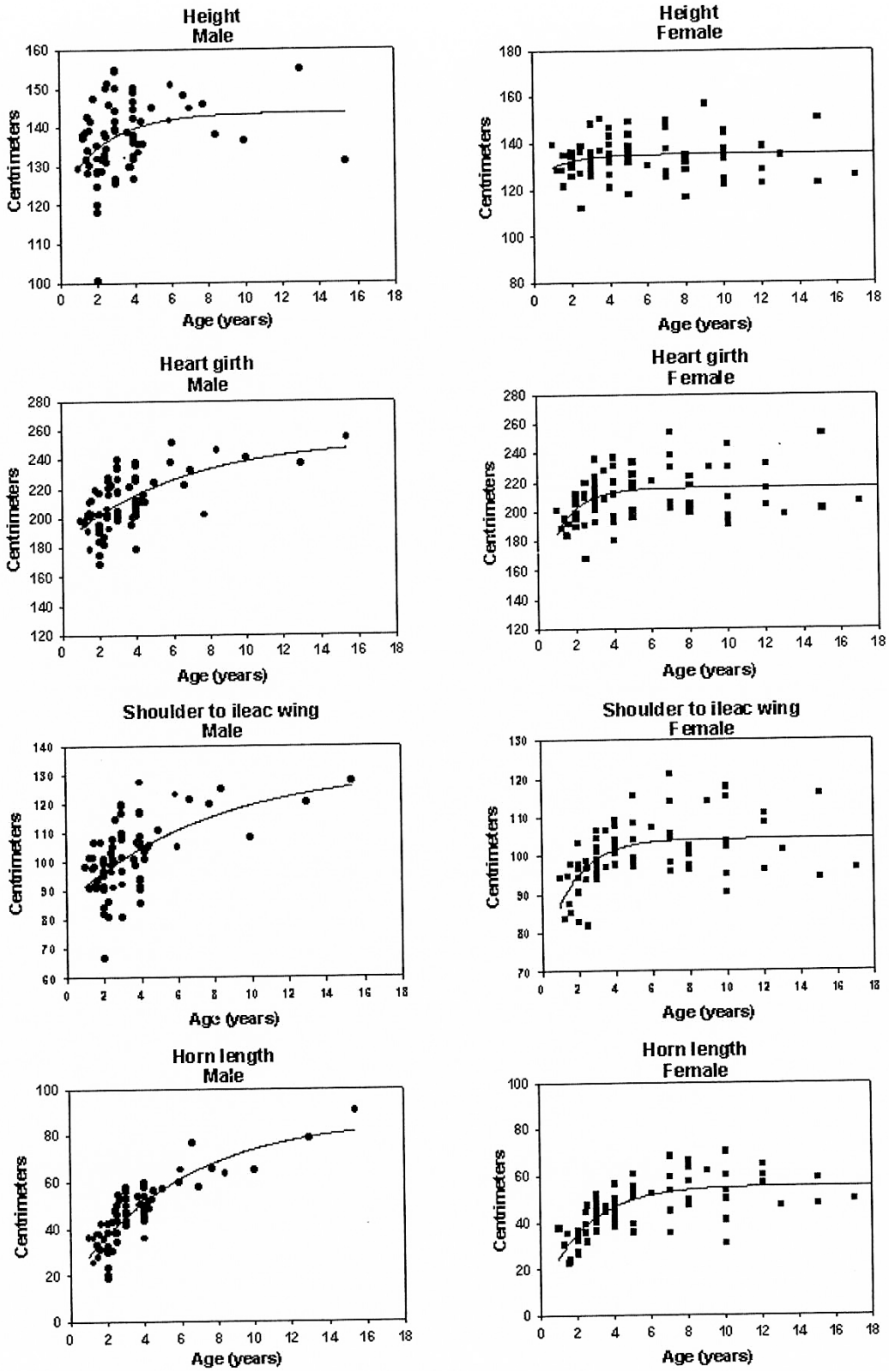

Figure 2: Changes in some traits in male and female buffaloes along with age.

Statistical Analysis

The score obtained by academics and philosophers in male and female buffaloes over 4 and 3 years of age, respectively, were related using Pearson correlation. The linear regression calculated from the average conformation score from both academics and philosophers and the body part measurements from 3D scanner was used to determine the appropriate equation for conformation score prediction in four groups of buffaloes using SAS program version 9.0. The equations of highest R^2 with $p<0.01$ were presented.

RESULTS

The rate of increase in many traits was investigated (Figure **2**). It was noticed that the height, heart girth, body length and horn length increased along with age in both male and female. However, the growth rate in male was more dramatic than in female and was not sustained even in old age. The heights in male and female were slowed down around 4 and 3 years old, respectively.

The Relationship Between Score Obtained from Academics and Philosophers

The total scores obtained from both Academics and Philosophers showed high significant correlation in all six conformation categories of male over 4 years of age ($r = 0.68$, $P<0.001$, $n = 53$) and females over 3 years of age ($r = 0.49$, $P<0.001$, $n = 57$) as shown in Figure **3**.

Conformation scores from individual judger for each category were shown in Table **1**. The highest correlation was shown in the score of general appearance (male, $R^2 = 0.66$; female, $R^2 = 0.56$). The lowest correlation in male and female was the score of the front body part ($R^2 =0.47$) and reproductive organ ($R^2 =0.23$), respectively.

Prediction of Body Conformation Score Using Linear Regression Analysis

The equations were estimated in 4 groups of buffaloes; male under and over 4 years and female under and over 3 years of age (Table **2**).

In male younger than 4 years of age, high correlation coefficient was found when 2 variables were included in the equation. However, the higher R^2 were determined in the equation with three and four variables of different body measurements ($R^2 = 0.65$ and 0.67) including of J1J2, L, P and B

In male buffaloes over 4 years of age, the conformation score predicting equation using two or three variables of body part measurements yielded similar R^2 of 0.85 and 0.89. The highest R^2 (0.92) was found in the equation with four variables of body measurements including A, B, D and E.

In female buffaloes under 3 years of age, the R^2 in all equations were low (0.25-0.42) even in 4 independent variables equation. The width at the base of horns (O) was found in all equations.

In female over 3 years old with single variable of body part measurements, the highest R^2 (0.66) was found in the equation containing the girdle width (D). The R^2 was slightly higher when two, three and four variables of body measurements were included into the equations (0.71, 0.72 and 0.75, respectively).

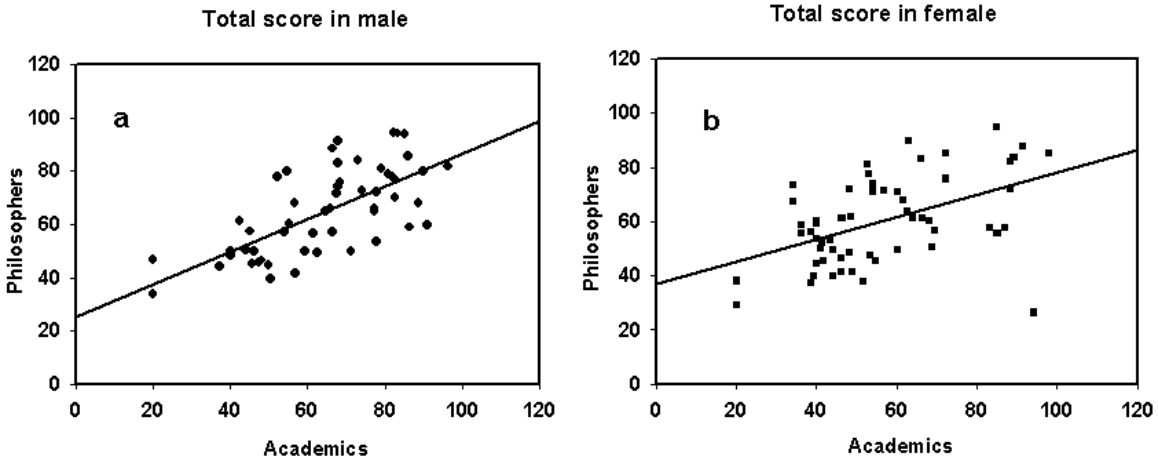

Figure 3: Relationship between total score obtained from Academics and Philosophers in male (**a**) and female (**b**) buffaloes.

Table 1: The Conformation Scores Given by Philosophers and Academics and their Relationship in Male and Female Buffaloes

Male	A			P			R^2	P-value
	Mean	±	SEM	Mean	±	SEM		
General appearance 20 points	13.035	±	0.531	13.906	±	0.464	0.66	<0.001
Head and neck 10 points	6.512	±	0.28	6.487	±	0.269	0.62	<0.001
Front body part 20 points	13.205	±	0.562	13.007	±	0.537	0.47	<0.001
Main body part 12 points	8.096	±	0.331	8.038	±	0.313	0.64	<0.001
Rear body part 30 points	18.531	±	0.816	18.278	±	0.697	0.56	<0.001
Reproductive system 12 points	5.073	±	0.201	5.14	±	0.176	0.49	<0.001
Total score 100 points	64.451	±	2.47	64.856	±	2.213	0.68	<0.001
Female	**A**			**P**			R^2	P-value
	Mean	±	SEM	Mean	±	SEM		
General appearance 20 points	11.534	±	0.529	12.404	±	0.442	0.56	<0.001
Head and neck 10 points	5.661	±	0.26	5.965	±	0.238	0.46	<0.001
Front body part 20 points	10.985	±	0.54	11.862	±	0.467	0.42	<0.01
Main body part 12 points	7.254	±	0.338	7.484	±	0.291	0.49	<0.001
Rear body part 30 points	16.125	±	0.826	17.483	±	0.694	0.37	<0.01
Reproductive system 12 points	4.846	±	0.204	5.056	±	0.208	0.23	>0.05
Total score 100 points	56.405	±	2.526	60.254	±	2.147	0.49	<0.001

Data are presented as mean ± standard error of mean, A = Academics, P=Philosophers.

Table 2: Regression Analysis for Conformation Score in Swamp Buffaloes

No. of traits	Parameters	R^2	a	b_1	b_2	b_3	b_4
Male under 4 years old							
1	0.46	L	-41.76497	2.25076			
2	0.57	(J1J2) L	-77.8905	0.5678	1.58415		
3	0.65	(J1J2) L P	-94.21291	0.98814	1.48192	-0.68402	
4	0.67	B (J1J2) L P	-110.44981	0.25301	0.77224	1.32988	-0.75851
Male over 4 years old							
1	0.70	B	-104.7607	0.7593			
2	0.85	B D	-156.5396	0.4848	1.8916		
3	0.89	B D M	-198.5093	0.5997	1.6981	0.4173	
4	0.92	A B D E	-251.2098	1.2254	0.6607	1.7928	-2.1694
Female under 3 years old							
1	0.25	O	-7.8331	2.7336			
2	0.30	C O	13.5955	-0.6299	2.8815		
3	0.34	C L O	-4.5607	-0.6846	0.7213	2.4192	
4	0.42	D N O Q	24.8974	-1.0527	1.8351	2.0535	-1.6144
Female over 3 years old							
1	0.66	D	-91.5127	2.6554			
2	0.71	D (FG)	-132.7482	1.7291	0.9038		
3	0.73	D (FG) P	-148.9928	1.7585	1.1838	-0.2641	
4	0.75	D FG HI P	-134.2027	1.8093	1.2745	-1.0449	-0.2136

p<0.01.

DISCUSSION

In swamp buffaloes, conformation traits were studied in Assam at different age group [7]. Various conformation traits were positively correlated with age. The highest correlation was found in case of pouch girth regardless of sex differentiation. In Egyptian buffaloes, conformation was controlled by height at hip and wither, rump width and uniqueness [8]. The study also showed that common variability in body dimensions could be accounted by factors representing general size, body depth, height and head width and could be used to predict the body weight. In our study. many conformation traits or points of measurement were increased along with age. Heart girth, body length and girdle width and more prominently, horn length, increased along with age especially in male even in old animals (>16 years). The height of the animals increased and was maintained at the age of approximately 4 and 3 years old in male and female, respectively. These ages were corresponded to the age used for male and female buffaloes competition in Thailand. Thus, the conformation traits in this study were grouped base upon the sex and age differences as mention earlier.

The conformation scores of mature male and female buffaloes obtained from Academics and Philosophers were closely related. In male, all conformation score correlations between Academics and Philosophers were highly significant. In females, only the correlation on reproductive system was not statistical significant. However, when considering the whole body conformation, the scores from both Academics and Philosophers were highly correlated. These results suggested that judging the ideal type buffaloes in Thailand was primarily based on the farmers. Therefore, knowhow collected from farmers can be used as one of buffaloes breeding stock selection criteria.

In male buffaloes under 4 years of age, when considering single parameters, the highest R^2 (0.46) was found in the equation including knee circumference (L). With the two parameters equation, body length (J1J2) and knee circumference (L), the higher R^2 (0.57) was obtained. The present study showed that only in the males, the knee circumference was increased as animals grown up. The bigger knee circumference seems to be related to body conformation score. When the outer horn circumference was included into the equation, the higher R^2 was yielded. However, since the horn appearance had high variation among all traits, it should not be considered for conformation score. Therefore, the phenotypic traits that represent the large body conformation (J1J2) and strong hind limbs for firm gaiting movement (L) were most proper in young male conformation score estimation. The appropriate equation for young male conformation score estimation is: Score = [(0.568 x J1J2) + (1.584 x L) – 77.89].

In male buffaloes over 4 years old, considering single parameters, the highest R^2 (0.70) was found in the equation including heart girth (B). Including one more parameter of girdle width into the equation yielded higher R^2 (0.85). The R^2 of the three and four parameters could increase only slightly (0.89 and 0.92, respectively). Therefore, the recommended equation of conformation score estimation in adult male is two parameter equation including heart girth and girdle width. Surprisingly, these two parameters were prime variables used to estimate body weight [1]. Thus, ideal male buffaloes are primarily relied on the large body conformation. Moreover, these parameters were correspond to the standard for judging body conformation in which the score from the front and rear body parts which accounting for 50% of the total score formally given by the committee in the buffaloes competition.

In female buffaloes under 3 years old, the R^2 was considering low even though the four parameters were added into the equation (0.42). The width at the base of the horn was found in all equations and was suspected that the wider skull may be an important indication of conformation score by Academics and Philosophers. Judgment of conformation score in young female had high variation and may not be related to the body conformation in adult females.

In females older than 3 years of age, the highest R^2 was found with iliac width (D). Adding the second parameter, body length (FG) into the equation yielded a slightly higher R^2 (0.71) while adding the third and fourth parameters did not affect R^2. Thus, the recommended equation was Score = [2.655 x D – 91.52]. The iliac width may be an important parameter which indicates the good fertility in females. Previous study in cows showed that the rump width was positively correlated with milk yield traits in Holstein and Red & White but negative in Brown Swiss cows [5]. Thus, the specific traits may be used as predictors for different species or different breeds of animals. The body length and the body width or thickness were

related to body weight in female while in male, the heart girth is more prominence.

For the horn length in both male and female buffaloes, the variation in horn shape was accounted for the width or the length of animals. However, the length of the horn was progressively increased along with age especially in male. The results was similar to those reported by Kalita *et al*. [7] which showed the highest R^2 in swamp buffaloes when considering as dependent variable on the age. The length and space between the horn in swamp, river and their crossbred was investigated and compared [9]. The actual length of the horn (P) in swamp buffaloes was higher than in Murrah type or their crossbreds while the visual length (Q) in swamp buffaloes was 5 fold higher. The interhorn spaces at the middle and the tip were higher in swamp buffaloes while the space was lower when measuring at the base. However, no age was clarified for the buffaloes in this study.

Although body conformation score obtained from equation created from parameters traits may be obtained easily in the field practice. Other phenotypic traits that cannot be measured directly by 3D scanner such as color of a skin, movement, emotion, claw, teats or testis are included into the conformation score in animal competition. Thus, the R^2 could not reach 100%. The 3D scanner can be supplemented in addition to the visualization of human for breeding selection.

ACKNOWLEDGEMENT

This work was supported by a grant from Ratchadaphiseksompot Endowment Fund, Chulalongkorn University, Bangkok, Thailand. The authors would like to thank Mr. Tongtawee Deemakarn, Mr. Supornchai Pharee and Mr. Goonlapatt phothikanit from the Department of Livestock Development, Ministry of Agriculture and Cooperatives, Thailand for judging the buffalo's conformation score and for research assistance in the field. The Thanks are also extended to the staffs in the National Electronics and Computer Technology Center (NECTEC), National Science and Technology Development Agency (NSTDA), Ministry of Science and Technology, Thailand for providing the technical assistance during measurement using 3D scanner.

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Received on 20-01-2013 Accepted on 20-04-2013 Published on 18-06-2013

DOI: http://dx.doi.org/10.6000/1927-520X.2013.02.02.6