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BREEDING OBJECTIVES AND BREEDING STRATEGIES FOR PHILIPPINE DAIRY BUFFALOES

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SUMMARY

The shift from selection on milk yield alone to multi-trait selection that includes milk component and fertility traits in dairy buffaloes was explored using selection index to achieve favourable responses for 4 traits. This was done in recognition of the value of milk components of dairy buffalo milk to milk processors and the need to improve reproductive performance. Economic values per trait were estimated based on a 100-cow farm production model and used these for a base Index (I_1). Three other indices were tested by varying weights applied to individual traits. Favourable responses were achieved for all objective traits in all 4 indices but were predicted to result in lower fat and protein percentage after 25 yrs. of selection. The index, I_4, gives the lowest reduction in fat and protein percentage without severely compromising milk yield and calving interval and can be an alternative to I_1 index. Three breeding strategies were simulated using I_1 index: use of progeny test bulls resulted in smallest net present value; use of young bulls or inclusion of village cows in the breeding program showed higher net present value and earlier return on investment. Positive return on investment is delayed, realized only after the 8th year at the earliest in all 3 strategies. As 99% of buffaloes are smallholder's farms, investment in genetic improvement is unlikely to be funded other than by the government in the Philippine situation.

INTRODUCTION

The Philippines is home to some 2.98 million water buffaloes composed mainly of swamp type water buffalo. They are traditionally a source of draft power, and of milk and meat. The milk production of a swamp buffalo is very low at 1.5kg/day/lactation but there is a small population of dairy type of riverine buffaloes in the Philippines with an average milk production of 4-8kg/day/lactation. There is a growing interest for buffalo dairying with the establishment of dairy buffalo cooperatives and production of crossbred cows using riverine bulls on swamp buffaloes. A government initiated breeding program for dairy buffaloes was implemented with the establishment of a semen station and several herds participating in performance recording. Frozen semen and live bulls for breeding are made available to dairy cooperatives and other buffalo farmers from the nucleus.

Currently, milk yield is the only trait being selected on. Milk is priced and sold by volume. However, milk component traits are the more valuable traits for processing into dairy products. The increase in the number of milking crossbred cows has put attention to valuing the milk components as crossbred cows have lower milk volume produced but have higher milk fat and protein yield. Experience in dairy cattle breeding has shown that the selection for milk yield alone will bring about a decrease in milk fat and protein percentage (Wilcox *et al.* 2003). It was also reported to have an undesirable effect on fertility and functional traits (Esslemont and Kossaibati 2001; Nielsen and Christensen 2005). The dairy buffalo has been reported to have inherently poor reproductive performance (Barile 2005) with long days to first post-partum service, long calving interval and low AI conception rate. The average milk, fat, and protein yields, milk fat and protein percentage of dairy buffaloes in the Philippines is 1,537.7 kg., 109.1 kg., 62.5 kg, 7.5% and 4.1%, respectively. Average calving interval and age at first calving were reported to be 480.8 d and 42.2 m. respectively (Maramba 2009). Compared with reported figures from other countries (Rosati and Van Vleck 2002; Khan *et al.* 2005; Aspilcueta-Borquis *et al.* 2010), these figures are lower except milk fat percentage, and suggests these traits should be selected on. Given the unfavourable correlation between milk yield and milk components and fertility traits, the use of selection index is an appropriate strategy to balance responses and maximize genetic progress (Beard 1987). Multi-trait selection to include milk components and fertility traits means additional cost in recording and breeding program implementation. This paper therefore, aims to look into a selection index for Philippine dairy buffaloes that will balance weight applied to production and fertility traits and evaluate the cost of genetic improvement using alternative breeding strategies.

MATERIALS AND METHODS

Estimation of economic values. A production model was simulated to estimate profit of a 100-cow herd where profit is equal to returns minus costs. Returns include sale of milk, dairy products, breeding animals, culls and farm by-products. Costs include animal maintenance, feed, management and professional fees, fixed costs (building and pasture maintenance). Calculation of the cost per kilogram of milk fat and protein was based on the formula by Van den Berg (1990). Economic value was computed as the change in profit (returns minus costs) per unit increase in each trait (Php/unit of trait) while keeping the means of other traits constant.

Selection index. The traits in the selection index were consistent with the breeding objectives of increasing milk yield and milk component traits and improved fertility. Index traits include 305 days milk yield (MY305), fat yield (MF305), protein yield (MP305) and calving interval (CI). Genetic and phenotypic parameters (Table 1) were taken from published papers (Tonhati *et al.* 2000; Aspilcueta-Borquis *et al.* 2010) or, if these were not available, from a local source.

Table 1. Assumed heritabilities (diagonal), phenotypic correlation (above diagonal) genetic correlation (below diagonal and phenotypic standard deviation (SD_p) of traits in selection criteria

Traits	MY305, kg.	MP305, kg.	MF305, kg	CI, days	SDp
MY305, kg.	0.26	0.96	0.88	0.30	547.7
MP305, kg.	0.94	0.18	0.88	0.30	13.6
MF305, kg	0.75	0.78	0.21	0.25	46.2
CI, days	0.07	0.08	0.07	0.14	81.19

MY305 – milk yield, MP305 – milk protein yield, MF305 – milk fat yield, CI – calving interval

The economic values along with genetic parameters were used to derive the selection index weights, $b = P^{-1}Gv$ (Rewe *et al.* 2006) where ***b*** is a vector containing the weights of the index traits; ***P*** is the phenotypic variance-covariance matrix of the traits in the index; ***G*** is the genetic variance-covariance matrix between traits in the index and the traits in the breeding objective; **v** is a vector of economic values for the traits in the breeding objective. Sires were assumed to have records on 3 half-sib cows and 12 progeny. Index I_1 used production model derived economic values and was compared with alternative indices with increased weights applied to component traits and calving interval: i) I_2 with twice the weight applied to MP305, MF305 and CI; ii) I_3 with 1.75, 2.5 and 2.75 times the weight applied to MP305, MF305 and CI; iii) I_4 with a 3-fold weight applied to MP305 and MF305, a 2.5-fold weight for CI and a 3-fold reduction in weight for MF305. Corresponding response per trait per year, predicted means, and resulting fat and protein percentage after 25 yrs. were observed.

Breeding strategies. Three breeding strategies were evaluated in terms of predicted economic response using I_1 index in selection: 1) use of progeny tested bulls (PT), 2) use of young bulls (YB) 3) double the number of young bulls recruited from the riverine cows from the dairy cooperatives (CC) in the villages. In the PT strategy we considered a breeding nucleus of 450 cows and 550 cows in the lower tier. In the CC strategy, we assume the lower tier to be expanded to

2,200 with 1,550 cows from the villages included. PT assumes 6 bulls with 12 progeny/yr tested, requiring 360 test matings in the lower tier and 3 AI bulls every year for the nucleus and remaining matings. The YB strategy uses 6 young bulls every year for all matings. The CC strategy use 3 young bulls for elite matings and 6 young bulls for all other matings. These bulls are selected from 227 male progeny of elite dams produced every year. Net present value (NPV) with 5% discount rate in a 25-yr horizon was used as criteria for ranking of the breeding strategies (Tobias *et al.* 2010). Costs include expenses in recording, milk testing, mobilization of artificial insemination (AI) technicians, frozen semen processing and bull maintenance.

RESULTS AND DISCUSSION

Economic values (in PhP) derived were 2.2/kg, 665/kg, 169/kg and –79.6/d for MY305, MP305, MF305 and CI respectively. Predicted responses were favourable for each of the 4 traits in all 4 indices (Table 2). However, predicted means after 25 yrs of selection with I_1 resulted in a 17.9% and 3.4% reduction in protein and fat percentages, respectively. Selection on alternative indices I_2, I_3 or I_4 will reduce the deterioration in fat and protein percentage but will reduce gains in milk yield compared with I_1 after 25 yrs. Economic response per year (in PhP, using actual economic values as in I_1) is highest with I_1 (1,564) compared with 1,275, 1,195 and 1,305 for I_2, I_3 and I_4 , respectively. The I_2 index will result in more reduction in fat and protein percentage compared with I_3 and I_4. The I_3 index holds fat percentage almost steady, but will also have the least milk yield. The I_4 index puts emphasis on fat and protein yields compared with I_1 with slight reduction in economic response.

Table 2. Predicted response per trait using 4 selection indices with varying economic weights

Index	Response/yr				Predicted means in 25 yrs.					
	MY305,kg.	MP305,kg	MF305,kg	CI,d	MY305,kg.	MP305,kg	MF305,kg	CI,d	MP%	MF%
I_1	54.5	1.03	3.67	-1.8	2.316	78.2	170	457	3.37	7.25
I_2	53.8	1.02	3.68	-1.8	2,300	78.0	170	455	3.38	7.28
I_3	50.6	0.96	3.68	-2.2	2,262	77.2	170	450	3.41	7.43
I_4	53.9	1.03	3.74	-1.6	2,308	78.2	171	459	3.38	7.32

MY305 - milk yield, MP305 - milk protein yield, MF305 - milk fat yield, CI - calving interval, MP% - milk protein percentage, MF% - milk fat percentage, I_1 *- 2.2MY305 + 665MP305 + 169MF305 + -79.6CI,* I_2 *- 2.2MY305 + 1330MP305 + 338MF305 + -159CI,* I_3 *- 1.1MY305 + 1164MP305 + 423MF305 + -219CI,* I_4 *- 0.6MY305 + 1995MP305 + 507MF305 + -199CI, 1AUD = 44PhP*

Cost and profit/benefit from improved genetics using I_1 index for three breeding strategies is presented in Table 3. The net present value (NPV) calculated from applying the three breeding strategies indicates that the use of progeny tested bulls (PT) has smallest NPV and delayed positive return on investment. Positive return was realized in year 13 compared with year 9 for YB and CC strategies due to the longer generation interval for PT (6 yrs versus 4 yrs for YB and CC).

Table 3. Predicted genetic and economic response per year per breeding strategy evaluated

Breeding strategy	Description of breeding strategy	Predicted response based on I_1 index			
		Cost of genetic improvement/yr, PhP	Units of SD_G/yr	Profit/yr, PhP	Net profit,25 yrs NPV, PhP
PT	Progeny testing on limited number of cows in various herds	804,764	0.13	-457,963	86,642
YB	Use of young, unproven bulls in place of proven bulls	366,764	0.135	2,889	16,934,317
CC	Double the number of young bulls recruited and enrolment of village cows in breeding program	933,411	0.15	893,901	92,683,896

NPV – net present value, SD_G *– genetic standard deviation*

The negative profit/yr and small NPV using PT supports the report of Tobias, *et al.* (2010) that progeny testing as a strategy may not be suitable for developing countries as the cost of program implementation may be greater if not equal to the benefit derived from improved genetics. The use of YB may be better due to shorter generation interval and absence of additional cost for waiting bulls seen with PT. However, selection of young bulls would be based on pedigree and inbreeding avoidance can be an issue. Predicted response may be lower if inbreeding avoidance is taken into account. More selection response is seen if the village cows are enrolled into the breeding program due to higher selection intensity and this scenario would likely have less inbreeding. This option is however more expensive due to additional recording, milk testing and AI costs. Benefits are not felt in the immediate term for all three breeding strategies however. As 99% (BAS 2011) of buffaloes are in smallholder's farms, it is only the government that has the resources to invest in genetic improvement.

CONCLUSIONS

The use of an economic index has shown that fertility and milk component yield traits can be selected in dairy buffaloes but milk protein and fat percentage are predicted to deteriorate after 25 yrs of selection. $\boldsymbol{I_4}$ index will minimize this deterioration in fat and protein percentage at a small cost of a reduced increase in yield and could be an alternative index. With milk currently paid based on volume, adoption of payment scheme that includes premium on protein percentage concurrently with use of $\boldsymbol{I_1}$ or $\boldsymbol{I_4}$ index in selection can be a transition strategy before shifting to protein yield based payment scheme. The favourable NPV for breeding strategies suggests investment in genetic improvement is feasible. YB scheme may be more profitable than PT scheme. There are more economic benefits when more commercial cows are involved in selection, but require more investment. Investment in genetic improvement should be taken on a national perspective and is unlikely to be funded from sources other than the government.

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