A GENETIC IMPROVEMENT PROGRAMME FOR KEDAH-KELANTAN CATTLE

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ABSTRACT. Kedah-Kelantan cattle (KK) being an indigenous breed are highly adapted to the hot-humid Malaysian climate and can survive in harsh, marginal environments. This makes the KK a valuable genetic resource, given the challenges of climate change and the changing demands of the livestock sector. Hitherto there is no comprehensive programme to genetically improve the purebred KK. Genetic improvement of the KK would be to fulfill the breeding objectives of increasing lean meat growth rate, enhancing meat quality, raising feed efficiency, improving fertility and maintaining adaptability. The breeding structure proposed is a 2-tier breeding structure, with a nucleus tier followed by a commercial tier below it. The nucleus tier would comprise of a number of pedigree farms run as a community breeding project. A sire reference scheme is proposed, where progeny of reference sires are used as genetic links between pedigree herds and between years. Some guidelines are offered on the establishment and implementation of the scheme. Modern breeding technology such as BLUP using an Animal Model, artificial insemination, embryo transfer, tissue scanning, MAS and MAI could be used as tools to support the KK genetic improvement programme. To address the problem of genetic erosion, emphasis should be given to the conservation and sustainable utilization of the KK. The programme is expected to have a high impact on the livestock sector. Substantial investments are needed to develop infrastructure and human capital associated with the KK breeding programme. The establishment of a KK breed society will improve awareness concerning the KK and protect the interests of the KK breeding community.

Keywords: Kedah-Kelantan cattle, genetic improvement, pedigree breeders, conservation, sustainable utilization

INTRODUCTION

Kedah-Kelantan cattle (KK) are Zebu type (or *Bos indicus*) cattle and are distinguished by a fatty hump and sizeable dewlap. KK's are considered indigenous to Malaysia, are very similar to local Thai cattle and have great resemblance to the Yellow Cattle of Southern China. According to Mustaffa-Babjee (1994), they were probably brought by migrating ancient people who journeyed to the Malaya peninsula from areas of Southern China. In Malaysia, KKs are particularly numerous in the northern states of Peninsular Malaysia, particularly in Kedah, Kelantan and Terengganu. The KK is a valuable genetic resource and can be considered a national heritage. They are normally found around villages and feed on poor quality grasses and backyard residues. They are owned by traditional farmers, who usually practice free grazing and tethering.

While most KK individuals have a fawn to dark brown coat, they are also found with black, brownish gray and grayish white coloration. They have a broad and short head and small, pointed and drooping ears. Their horns are small and of variable shape. The neck is narrow and deep. The dewlap is poorly developed. The skin is tight. The hump is moderately developed in males and small in females. The tail is long with the switch almost reaching the ground. The body is long, small and compact, and well-proportioned with well-sprung ribs, although the hindquarters are poorly developed (Maule, 1982). They are highly fertile (Johari *et al*., 1994). Adult females have small udders and teats. They have good mothering ability. KK's are well adapted to the tropical environment, are extremely hardy with low nutrient requirements and ability to subsist on poor quality roughage. These characteristics make the KK a valuable genetic resource, being able to thrive in the harsh equatorial environment.

Although the KK is a beef-type breed, its growth rate has been considered to be low as compared to commercial zebu breeds such as the Brahman, Nelore and Improved Boran. According to Dahlan (1985) the mean birth weight of male and female KK is a mere 15.6 kg and 15.1 kg respectively. The 30-month weight is 217.4 kg for males and 212.8 kg for females. The average daily gain (ADG, 12–18 months) is 224 g/day. According to Devendra and Lee (1975), with feed supplementation, ADG can be increased by almost 50 percent. By comparison, Nellore steers in Brazil fed on grass gain on average 0.69 kg/day (Herling *et al*., 2011). The poor growth rate of the KK does not however mean that it has poor carcass characteristics. On the contrary, comparing the pure KK and its crossbreds with exotic breeds, Dahlan (1985) showed that pure KK had the lowest percentage bone, highest percentage lean and the highest meat to bone ratio. This explains why butchers consider KK as a breed of choice, given their high carcass yield. Broad perspectives on the genetic improvement of the KK have been previously described by Raymond and Abu-Hassan (2011). This paper describes in considerable detail the proposed breeding scheme for the genetic improvement of purebred Kedah-Kelantan cattle.

THE NEED FOR GENETIC IMPROVEMENT

In the developing world, population growth, urbanization and income growth is fueling a massive demand for food of animal origin. This phenomenon is called the Livestock Revolution (Delgado *et al*., 1999) and in Malaysia it will entail the farming of increasing more efficient animals to meet the ever increasing demand for livestock products. Beef cattle will need to grow faster and more efficiently, yielding larger carcasses. Coupled with these challenges caused by changing consumer demand, there are also challenges due to changes in climate and the environment. Breeding better KK cattle able to withstand harsher climates and environment will ensure the sustainability of our beef industry. Hence KK cattle have to be genetically improved to both meet market demands for beef and to ensure its long-term relevance and survivability. A recent study by Hafiz *et al*. (2009) concluded that there has not been any consistent improvement in the growth performance of the KK. Given that the KK breed has not undergone intensive selective breeding, there is good genetic development potential and initial genetic improvement efforts should result in a significant "genetic lift". By way of example, Korea embarked on a programme to improve their native Hanwoo cattle in the 1970's. In terms of 18-month body weight change over years, Hanwoo bulls increased from 290 kg in 1974 to 477 kg in 1992, an increase of 64.5 percent in 18 years (Na, 1994). In the case of Japan, they developed their now famous Wagyu cattle not only for growth rate but also for meat quality (Kahi and Hirooka, 2005). These success stories should provide the impetus to embark on a comprehensive purebred KK cattle improvement programme. As with Hanwoo cattle, specialized farming areas could be established for purebred KK so that genetic improvement can be achieved through community breeding programmes. The establishment of a breed society for KK breeders will increase awareness about the KK and safeguard the interests of the KK breeding community.

BREEDING OBJECTIVE

The ultimate aim of the KK Improvement Scheme would be to develop the beef industry and to secure a positive return on investment. This would be possible only through customer satisfaction achieved by producing quality KK beef and other by-products. The scheme will have a positive economic impact on the Beef Industry, generating substantial income for beef farmers and having a spillover effect on other industries such as feed suppliers, leather and tannery businesses and transport corporations. The scheme would also be of social and political importance by providing considerable job opportunities. The economic viability of the KK Improvement Scheme would be dependent on the production of large quantities of beef, which are of high quality. To the producer, meat production, reproductive traits and hardiness would be of importance. In view of the above considerations and to secure rapid genetic improvement on traits of high economic importance the following selection objectives are stated:

1. To increase lean meat growth rate
2. To enhance meat quality, especially that of marbling

3. To raise feed conversion efficiency
4. To improve on reproductive traits such as calving age and calving interval
5. To maintain adaptability to the tropical climate and environment

SELECTION CRITERIA

The yield of quality beef from KK cattle may be broadly thought of as a function of growth, carcass traits, feed efficiency, fertility and adaptability. Nowadays selection for growth of lean tissue is preferred as compared to weight gain per se, as this would result in an animal with higher lean tissue growth rate while restricting fat growth rate. Estimation of lean tissue is afforded by the use of tissue scanning equipment such as Ultra-sound scanners or X-ray tomography. Meat traits are important for beef quality and include marbling scores; meat and fat texture, softness, color and flavor; eye muscle size and shape; external fat thickness, rib thickness, etc. Feed efficiency is difficult to determine as it entails the measurement of daily feed intake of individual animals. It however is highly correlated with growth rate, which is easier to measure, and so selecting for strong growth rate invariably results in higher feed efficiency. Fertility is very important as it would determine the sustainability of the project. Higher fertility usually results in greater selection intensity and consequently higher genetic improvement. In the tropics, adaptability is of extreme importance. The KK when bred pure will continue to be adaptable in the hot-humid tropics. Other traits of importance are longevity, type traits, calving ease, mothering ability and docility. It is not prudent to select for all possible traits as the genetic gains on individual traits will be constrained. Due to these considerations, the core measurements which need to be taken on individual KK animals are:

- Body weight at 200, 400 and 600 days
- Estimate of lean tissue weight at 200, 400 and 600 days
- Marbling score
- Age at first calving and calving-conception interval
- Calving ease and docility

Most of these traits are moderately to highly heritable and are reasonably correlated with the breeding objectives. Although traits associated with reproductive performance (measured in terms of age at first calving and calving-conception interval) are expected to be lowly heritable, these traits are important for the viability of the project and some monitoring of these traits need to be emphasized. Where possible, animals with very poor temperament need to be eliminated from the programme.

STRUCTURE OF SCHEME

After considering several breeding structures for the propagation and improvement of KK stock, the Reference Sire Scheme (RSS) (Simm *et al.*, 2001) was determined to be the most suitable option for selecting KK cattle. The RSS would be a community breeding scheme which would be composed of a nucleus tier with a commercial tier below it. The nucleus tier would be composed of individual pedigree KK herds with a pedigree breeder managing each herd. The progeny of a set of reference sires would be used to create genetic links between pedigree herds and between years. The nucleus would be operated as an open nucleus. Different pedigree herds may be exposed to microclimatic variation, have slightly different management and feeding regimes and certainly would use different stud males. The RSS would allow comparisons of KK males across pedigree (nucleus) herds and across years. To effectively disentangle genetic and non-genetic differences between herds and years, the performance of related animals in different herds and years will be used as a benchmark. The RSS is diagrammatically illustrated in Figure 1.

Pure breeding would be practiced at the nucleus level. To benefit from hybrid vigor, crossbreeding can be practiced at the commercial tier. The pedigree herds would represent the highest health level as compared to the commercial tier, so as to prevent health breakdown in the nucleus. The pedigree herds will be serviced by a team of trained technicians providing centralized performance recording, artificial insemination and herd health services. Artificial insemination using semen from reference sires will be used to form genetic links between pedigree herds in the nucleus. This will enable all sires used to be compared and evaluated across herds. No intermediate multiplication tier is included in the breeding structure since cattle are not very prolific breeders and hence this extra tier would not increase the influence of the selection herds (nucleus). This allows the added advantage of not introducing extra genetic lag. The best

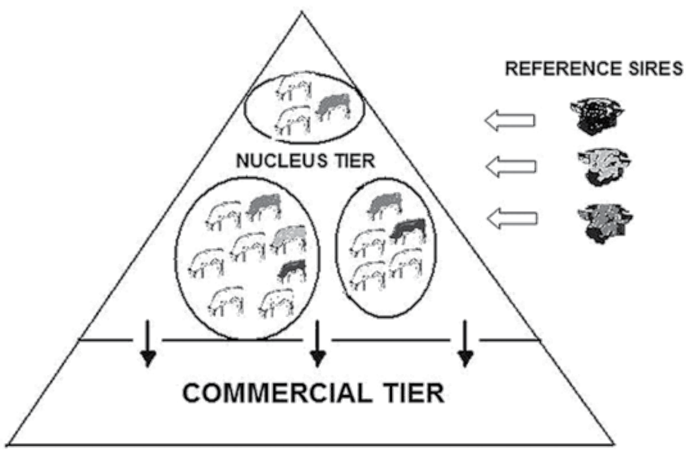

Figure 1. Schematic diagram illustrating an open nucleus Sire Referencing Scheme for KK cattle

replacement animals from the nucleus would be retained in the nucleus so that the nucleus would improve in genetic quality over time. Commercial farmers may procure their purebred stock from the pedigree herds.

ESTABLISHMENT AND IMPLEMENTATION OF SCHEME

Pedigree farms should be stocked with the very best of KK breeding stock, procured from traditional farmers. This will increase genetic variation in the nucleus, reduce inbreeding and leapfrog the genetic development process for the KK. Individual pedigree farms should be located far from other farms, especially farms raising cattle. This is to minimize the risk of contracting diseases. Considering genotype-environment interaction (G × E), the area and production system (i.e. the selection regime) selected for pedigree herds should be similar to the commercial herds. The ability of the KK to utilise residues and by-products of agriculture and native pastures and forages can be tested by adjusting the environment under which the KK is selected. It is prudent also to breed KK cattle for the future, assuming a trend of improving management and nutritional levels, while factoring in the effects of climate change. An operational office cum Central Data Recording Center should be established and strategically located with reference to pedigree herds. All animals in the nucleus should be given unique identifications. The recording system established should be computerised and able to record individual animal biodata and performance. Data should be easily extractable to enable further analysis and genetic evaluation of individual males and females. The population needs to be of sufficient size to permit useful selection response without excessive inbreeding. Artificial insemination may be undertaken using frozen semen or chilled semen of reference sires. The use of chilled semen will afford better conception rates. Annually, a pool of 5–10 sires may be made available for the artificial insemination service. Each pedigree farm would use at least 2 sires from a pool of reference sires. Reference sires will be used as a benchmark to identify animals of outstanding genetic merit across herds. Some reference sires will be used across years to create genetic links across years, enabling the determination of genetic trends over years. Reference sires would be replaced by superior sires from time to time, identified by their EBVs (Estimated Breeding Values). Thus, the reference sires have a dual role of creating genetic links across herds and years and of producing more rapid dissemination of genetic improvement. Where appropriate, embryo transfer technology can be employed to multiply superior females. Inbreeding should be effectively managed and this can be done by using appropriate software to determine the sires to be used in the mating of individual female breeders. Higher genetic gains can be obtained through the employment of Marker-Assisted Selection

(MAS) and Marker-Assisted Introgression (MAI), particularly by taking advantage of the recent establishment of the Malaysian Center for Marker Discovery & Validation (CMDV).

EVALUATION OF GENETIC MERIT

BLUP (Best Linear Unbiased Prediction) using an animal model (Henderson, 1975; Xu-Qing Liu *et al.*, 2008) would be used for assessing individual animal merit. BLUP estimates breeding values and environmental effects simultaneously, making full use of records of performance from all related animals, whether in the same or different herds. BLUP would furnish the most accurate of EBVs (Estimated Breeding Value) as compared to any other method of breeding value estimation. As long as there are reasonable numbers of related animals in different herds and in different years, then BLUP EBVs can be compared across herds and years.

The general form of the BLUP model is:

$$y = X_g + Z_a + e$$

where:

X is the incidence matrix relating observations to fixed effects, g

Z is an incidence matrix relating observations to the random effects, a

e is the random residual variance

Fixed effects which would need to be considered in the model would include sex, age, herd (climatic and management differences between pedigree herds), year (climatic variations and other trends from year to year), parity or dam age, and season (classified as hot-mild or dry-wet). All of these effects could be included in the model and non-significant terms removed in a step-down procedure to obtain a reduced model. Since the economic performance of the KK depends on several characteristics, EBVs for individual traits could be combined into a single score for overall merit by using relative economic weightings for each characteristic. Males of top rank based on EBVs should be retained as replacements. However, care must be taken to avoid co-selection of relatives, since this would raise inbreeding levels. Since females are also ranked, it is possible to practice sequential culling of KK females based on EBVs. It is imperative to periodically monitor the breeding programme and performance of individual pedigree farms to provide indications of problems or G × E as well as providing signals for future directions. Certainly genetic trends over years and level of inbreeding build-up need to be closely monitored and where there are problems, corrective action needs to be taken.

CONSERVATION & SUSTAINABLE UTILISATION

Kedah-Kelantan cattle being an indigenous breed are extremely hardy and well adapted to high temperatures and humidity. They have excellent disease and parasite resistance. They can also subsist on poor quality roughage. Their numbers are however decreasing as a large proportion of this breed has been crossed with exotic breeds to produce a larger, faster growing beef animal. To address this genetic erosion issue, Kedah-Kelantan cattle are already being conserved *in situ* at the Pantai Timor Cattle Breeding facility in Kelantan. The conservation herd can be further developed by infusion of purebred KK genetics obtained from traditional farmers. For *ex situ* conservation, semen from a diversity of sires is being kept in the Semen Bank at the National Institute of Veterinary Biodiversity in Jerantut, Pahang. As conservation is closely associated with utilization, attempts are being made to promote the sustainable utilization of purebred Kedah-Kelantan cattle. In the past, Kedah-Kelantan cattle were used as draught animals for ploughing paddy fields and as beasts of burden. However with the advent of mechanisation, they are more used as beef-type cattle. Other uses are for hides and dung for manure. As KK cattle are highly adapted to our hot-humid climate and to marginal environments, they are being promoted for economic beef production under a cattle-tree crop integration system, which is an extensive, low-input production system. In fact, there is presently a great demand by cattle integration schemes for KK cattle. Plans are also afoot to improve the KK for meat quality (such as with the Wagyu cattle of Japan) to increase their utilisation in supplying the quality beef market, thus contributing to the breed's conservation. The KK is also slated for studies on adaptation to climate and environmental change.

CONCLUSION

Kedah-Kelantan cattle are highly adapted to the Malaysian environment and should be able to thrive well in the tropics, vis-à-vis climate change and other issues faced by the Livestock Industry. As the breed is popular among some traditional farmers and is in demand by the cattle-tree crop integration schemes, it will not be a great challenge to increase its numbers. As with the Korean and Japanese experiences in developing their native cattle breeds, the economic potential of the KK can be realised, but only by undertaking strategic genetic improvement initiatives to improve the animal for its beef production characteristics. Lean growth rate, meat quality and sustainability would feature strongly in the improvement programme. While the genetic improvement programme for the KK is implemented, due consideration should be given to improving the conservation and sustainable utilisation of the KK. The KK cattle development programme on the whole would need substantial investment to develop infrastructure. Focus must also be given to human resource development, particularly that of raising local expertise in genetic resource management.

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