UNIVERSITI PUTRA MALAYSIA

CHROMOSOME DISTRIBUTION AND GROWTH CHARACTERISTICS OF CROSSBRED WATER BUFFALOES

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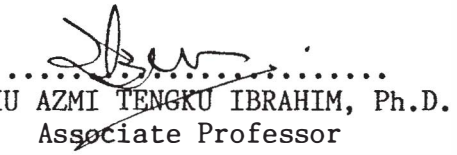

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CHROMOSOME DISTRIBUTION AND GROWTH CHARACTERISTICS OF CROSSBRED WATER BUFFALOES

by

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A thesis submitted in partial fulfilment of the requirements for the degree of Master of Science in the Faculty of Veterinary Medicine and Animal Science, Universiti Pertanian Malaysia

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CHROMOSOME DISTRIBUTION AND GROWTH CHARACTERISTICS OF CROSSBRED WATER BUFFALOES

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Water buffaloes in Asia have been traditionally classified into the swamp and the river types. Crossbreeding of these two types has been practised in many Southeast Asian countries to reap the advantages of heterosis and to optimize average genetic merit and adaptability to the harsh tropical environment.

Since both types of water buffalo have different chromosome numbers (swamp = 48, river = 50) a study was undertaken to determine the segregation patterns of mitotic chromosomes through various directions of crossbreeding. The weight gain was also estimated in the crossbreds so as to select the best crossbred

carrying a particular proportion of swamp and river blood for future breed improvement. This study also provides some information on the reproductive status of the F_1 in relation to gamete and embryo selection.

Karyotyping using the leukocyte culture method was carried out on 264 animals of which 150 were from the university buffalo unit in Serdang, Malaysia, 43 animals from two farms in the northern state of Perak in Peninsular Malaysia and 71 animals from the Philippines. The F_1 hybrid had a chromosome complement and karyotype (2n = 49) intermediate to the parental types. The F_2 generation (F_1 male x F_1 female) had three chromosome complements viz., 2n=48, 2n=49 and 2n=50 in ratios of 1:2:1. Backcross generations of F_1 x swamp (either sex) had two different chromosome complements of 2n=48 and 2n=49 in ratios of 1:1, while another backcross generation of (either sex) F_1 x river had also two different chromosome complements of 2n=49 and 2n=50 in ratios of 1:1. The results thus show that although the parental types are of different chromosomal constitution the crossbreds are "fertile" and chromosomal polymorphism exists in subsequent generations. However, based on expected gametes using a Punnet Square, the results of chromosome analysis in F_1, F_2 and backcross generations in this study suggest an overall reduction in fertility. Although both unbalanced and balanced gametes are expected via crossbreeding, only the balanced gametes survived to produce viable conceptuses.

The body weights of seven varieties of crossbred buffaloes with different percentages of swamp and river blood were analysed using General Linear Model statistical analysis. At ages of 18 and 24 months (time of slaughter), the weights of F_1 hybrids (315.8 $\pm$ 11.3 kg and 385.0 $\pm$ 11.0 kg) was significantly heavier ($P<0.05$) than the swamp type (235.2 $\pm$ 6.4 kg and 308.2 $\pm$ 6.5 kg). Similarly, the weights of the 3/4 river (317.5 $\pm$ 18.4 kg and 382.3 $\pm$ 21.9 kg) at 18 and 24 months were significantly heavier compared to the swamp ($P<0.05$). The weights of the 3/4 swamp (using F_1 sire) (281.0 $\pm$ 35.9 kg and 352.2 $\pm$ 28.9 kg) at 18 and 24 months were also heavier than the swamp type but the difference was not statistically significant ($P>0.05$). There was no statistical difference between the weights of F_2 hybrid (226.8 $\pm$ 38.0 kg and 308.2 $\pm$ 22.2 kg) versus swamp at 18 and 24 months ($P>0.05$). The results thus show that the F_1 and 3/4 river would be superior than other crossbreds for increased meat production. Although, fertility may be reduced in the $2n=49$ chromosomal constitution of the F_1, this may be compensated by good growth performance.

Thus, to make buffalo rearing for beef production more viable, it is suggested that the farmer practises terminal F_1 breeding and sells these crossbreds at slaughter age or uses the F_1 hybrids as dams to produce backcrosses.

Abstrak tesis yang dikemukakan kepada Senat Universiti Pertanian Malaysia bagi memenuhi sebahagian daripada syarat-syarat ijazah Master Sains

TABURAN KROMOSOM DAN CIRI-CIRI PERTUMBUHAN KERBAU AIR KACUKAN

oleh

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Kerbau air di Asia secara tradisinya telah dibahagikan kepada jenis sawah dan sungai. Kacukan di antara kedua-dua jenis kerbau ini telah dijalankan di kebanyakan negara-negara Asia Tenggara untuk mendapatkan kebaikan heterosis dan untuk mengoptimumkan purata merit genetik dan penyesuaian terhadap alam sekitar tropikal.

Oleh kerana kedua-dua jenis kerbau air ini mempunyai bilangan kromosom yang berbeza (jenis sawah = 48, jenis sungai = 50) satu kajian telah dijalankan untuk menentukan kemungkinan pola pengsegregatan kromosom mitosis melalui beberapa kaedah kacukan. Kenaikan berat badan bagi kerbau kacukan juga ditentukan untuk

memilih jenis baka terbaik yang mempunyai peratus darah kerbau sawah dan sungai tertentu bagi pembiakan baka untuk masa hadapan. Kajian ini juga memberi sedikit sebanyak maklumat berhubung dengan status reproduksi hibrid F_1 dari segi pemilihan gamet dan embrio.

Pengkariotipan menggunakan kaedah kultur leukosit telah dijalankan keatas 264 ekor kerbau di mana daripada jumlah ini 150 ekor diperolehi dari Unit Kerbau, Universiti Pertanian Malaysia, 43 ekor dari dua ladang ternakan di negeri Perak, Malaysia dan 71 ekor dari Filipina. Hibrid F_1 mempunyai komplemen kromosom dan kariotip (2n=49) pertengahan di antara kedua jenis ibubapanya. Generasi F_2 (F_1 jantan x F_1 betina) mempunyai tiga komplemen kromosom iaitu 2n=48, 2n=49 dan 2n=50 dalam nisbah 1:2:1. Generasi kacukan balik F_1 x jenis sawah (kedua-dua jantina) mempunyai dua komplemen kromosom yang berlainan, 2n=48 dan 2n=49 dalam nisbah 1:1, sementara generasi kacukan balik yang satu lagi F_1 x jenis sungai (kedua-dua jantina) juga mempunyai dua komplemen kromosom yang berlainan, 2n=49 dan 2n=50 dalam nisbah 1:1. Hasil kajian dengan ini menunjukkan sungguh pun ibu-bapa mempunyai jenis kromosom yang berbeza, kerbau-kerbau kacukan adalah subur dan polimorfisme kromosom wujud dalam generasi seterusnya. Walau bagaimana pun, berasaskan kepada gamet jangkaan dengan menggunakan Segiempat Punnet, hasil kajian analisis kromosom dalam F_1, F_2 dan generasi-generasi kacukan balik menunjukkan pengurangan kesuburan pada keseluruhannya.

Berat badan tujuh jenis kerbau kacukan yang mempunyai peratus darah kerbau sawah dan sungai yang berbeza telah dianalisis menggunakan Model Linear Umum. Pada umur 18 dan 24 bulan (peringkat penyembelihan), berat badan hibrid F_1 (315.8 $\pm$ 11.3 kg dan 385.0 $\pm$ 11.0 kg) adalah bererti ($P<0.05$) lebih berat daripada jenis sawah (235.2 $\pm$ 6.4 kg dan 308.2 $\pm$ 6.5 kg). Begitu juga bagi jenis 3/4 sungai (317.5 $\pm$ 18.4 kg dan 382.3 $\pm$ 21.9 kg) pada umur 18 dan 24 bulan adalah bererti ($P<0.05$) lebih berat jika dibandingkan dengan jenis sawah. Berat badan bagi jenis 3/4 sawah (menggunakan bapa F_1) (281.0 $\pm$ 35.9 kg dan 352.2 $\pm$ 28.9 kg) pada umur 18 dan 24 bulan adalah juga lebih berat daripada jenis sawah tetapi perbezaannya secara statistik adalah tidak bererti ($P>0.05$). Tidak terdapat perbezaan di antara berat hibrid F_2 (226.8 $\pm$ 38.0 kg dan 308.2 $\pm$ 22.2 kg) dan jenis sawah pada umur 18 dan 24 bulan. Berasaskan kepada data-data di atas, kajian ini menunjukkan hibrid F_1 dan jenis 3/4 sungai adalah lebih baik daripada jenis kacukan-kacukan lain bagi meninggikan pengeluaran daging. Sungguh pun kesuburan mungkin berkurang dalam hibrid F_1 yang mempunyai komplemen kromosom 2n=49, ini mungkin di pampaskan dengan prestasi pertumbuhan yang baik.

Oleh itu untuk menjadikan pembelaan kerbau bagi pengeluaran daging lebih bermakna, adalah dicadangkan supaya penternak mempraktikkan pembiakan akhir hibrid F_1 dan menjualnya pada peringkat umur sembelih atau menggunakan hibrid F_1 sebagai ibu untuk menghasilkan kacukan-kacukan balik.

CHAPTER 1

GENERAL INTRODUCTION

The water buffalo (Bubalus bubalis) is an important animal for the agricultural economy of most Asian countries. It is used as a source of milk, meat and draft power in rice fields and oil palm estates. About 98% of the buffalo population in Asia is raised by smallholders with each household usually having about five buffaloes (Momongan, 1984). Inspite of poor management systems in such environment these animals thrive well on poor quality roughage and adapt well to harsh climatic conditions.

Classification of buffaloes into two categories (river and swamp type) has been based mainly on their habitat and phenotype and to a certain extent, on their use under domestication (McGregor, 1941). Recently, it was shown by many workers that the two types can be further classified based on cytogenetic make-up. The river type had a chromosome complement of 50 while the swamp type (except those in Sri Lanka) had 48 (Fisher, 1974; Bongso et al., 1977). The swamp buffalo carries a structural rearrangement (tandem fusion) between chromosome number 4 and number 9 of the river buffalo type thus reducing the karyotype from 50 to 48 (Bongso and Hilmi, 1982).

Because of large numbers of the swamp type in Asia, improvement of the genetic potential of this type in terms of growth and milk production will provide the farmer with better economic returns especially during the non-working period since the swamp type is not used as draft power throughout the year.

Upgrading of the local swamp buffaloes by crossing them with the larger river types has been practised in Malaysia, Thailand, the Philippines and China to take advantage of heterosis and obtain the maximum genetic merit for production characteristics and adaptability to the tropical environment. There is limited information available with regards to the production traits of these crossbreds in the respective environments in which they are managed.

It was shown that the F_1 hybrid had a chromosome complement of 2n=49 which was intermediate to the swamp and river parental types (Bongso and Jainudeen, 1979). This odd chromosome number in the F_1 hybrid could pose reproductive problems in further breeding and theoretically a variety of chromosomal genotypes would be expected by *inter se* mating or backcrossing of the F_1 with sisters and brothers or to the parental types. Arbitrary breeding of the different types is the usual practice amongst most farmers in Asia.

A study was thus undertaken to (1) identify the genetic makeup of the various breedtypes of water buffaloes as a result of *inter se* and backcross matings thus providing information on the segregation patterns of 2n=48, 2n=49 and 2n=50 chromosome sets and

(2) evaluate the specific breedtypes for growth rates (body weight) in specific environments. The information gained from such a study will provide a viable basis for future genetic improvement of the swamp buffalo and to provide the farmer with a variety of alternatives to enable him to formulate a breeding policy whether for meat, milk or draft.

CHAPTER 2

REVIEW OF LITERATURE

WATER BUFFALOES - GENOTYPE IDENTIFICATION, IMPROVEMENT AND PRODUCTION PERFORMANCE

This review is aimed at providing an account of water buffaloes from the point of view of its classification, genetic improvement and production performance, with particular reference to body weight. In this review considerable emphasis is given to the segregation of mitotic chromosomes since identification of crossbred buffalo genotypes and their chromosome segregation patterns form an important part of the studies reported in this thesis. The second part of this review deals with heterosis and various factors affecting body weight.

In reviewing the above data, details will be drawn where possible from observations on the water buffalo. Information derived from other species will be used to supplement that of the buffalo where this seems necessary or helpful.

CLASSIFICATION OF THE WATER BUFFALO

In Asia, the buffalo is undeniably the most cherished and abused, worshipped and dismissed, and taken for granted beast of burden (Kee, 1987). Ninety four percent of the world's water buffalo population of 130 million are found in Asia with India having about 60.6 million, China 30 million, Pakistan 11.3 million

and Thailand 6.4 million (Momongan, 1984). The remaining 6% of the water buffalo population are found in countries of the Mediterranean region. Water buffaloes can be classified as follows:

1. Based on Habitat and Use Under Domestication

Classification of the water buffaloes into the swamp and river types based on their habitat and usage under domestication was first suggested by McGregor (1941). The swamp type prefer to wallow in swampy or marshland areas and is used mainly for draft and meat while the river type prefer to wallow in the cleaner river water and is used primarily as a dairy animal. Although water buffaloes love to wallow in the mud or river they can still survive and reproduce normally without it, provided shade are made available to keep them cool (Ruskin, 1981). Out of the total water buffalo population in Asia, 66.7% has been classified into the river type while 29.7% is the swamp type.

a. Swamp Buffaloes

The swamp buffalo is indigenous to many Southeast Asian countries. Its habitat extends northwards as far as the Yangtze valley in China and westward as far as Assam in India (Mason, 1974). In all these countries the swamp buffaloes look very much alike in their general appearance. The characteristic feature of the swamp buffalo is the massive long horns which grow out horizontally into the shape of a crescent and the light black to slate grey skin colour. In Malaysia most swamp buffaloes have a

light grey chevron below the neck on the front of the brisket (Hilmi, 1984).

Although it is generally known that there is only one breed of swamp buffalo, certain subgroups seem to have specific inherited characteristics. For example, the buffaloes of Thailand and Laos are noted for their large size, ranging from 500-600 kg, while small sized buffaloes ranging from 250-300 kg are found in China and Burma (Ruskin, 1981). Larger sized buffaloes are also found in Malaysia with the maximum weight of 800 kg for the male and 551 kg for the female (Gabriel, 1980).

Ninety percent of the draught power for agricultural operations in Southeast Asian countries is dependent on the swamp buffalo. Thus the swamp buffalo is at times referred to as the "living tractor of the East". They are put to work at the age of 3 1/2-4 years and the working life span of a buffalo is reported to be not less than 12-15 years (Chantalakhana, 1983). The low maintenance of the swamp buffalo makes this animal a very useful and important source of draught power for the Southeast Asian farmers.

The swamp buffalo is also important as a beef animal. In countries like the Philippines, Thailand and Malaysia buffalo meat constitutes nearly half the total beef consumed (Syed Ali Bakar, 1980; Eusebio, 1981; Chantalakhana, 1983).

b. River Buffaloes

River buffaloes are found mainly in India and Pakistan but they are also found further west in Egypt and some countries in

Europe. At least 18 different breedtypes of river buffalo with distinct characteristic features are known to exist and among these are the Murrah, Nili Ravi, Jafarabadi, Surti and Mehsana. The river (Nili Ravi) buffaloes are characterized by their dark black skin (Fahimuddin, 1975), white marking on the forehead and switch of the tail (Verma et al., 1986) and white stocking (Hilmi, 1984). Another distinct feature of the water buffalo is the shape of horn which is curled to form a spiral.

The river buffalo has a better developed udder compared to the swamp. This feature made the river buffalo the main dairy animal of the Indian-Pakistan subcontinent. In India, the buffalo contributes to more than 16 million of the total 24 million tons of milk produced annually. On the average it produces milk four times greater than the local zebu cow (Sundaresan, 1979). In Pakistan, Nepal, Thailand, Burma and the Philippines, river buffalo milk constitute more than 50% of the total milk production.

c. Mediterranean Buffaloes

McGregor (1941) classified the Mediterranean buffalo originating from the Mediterranean basin as the river type. They are found in Yugoslavia and other European countries and because they have been isolated in their original habitat for a long time, they have developed some unique characteristics. They are stocky animals and high yielding for beef and dairy production.

2. Based on Cytogenetic Status

In recent years, water buffaloes have also been classified according to their cytogenetic status. Using various cytogenetic