UNIVERSITI PUTRA MALAYSIA

GENETIC PARAMETERS AND POLYORPHISM IN CANDIDATE GENES FOR GROWTH AND CONFORMATION TRAITS IN BOER GOATS

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By

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Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirements for the Degree of Doctor of Philosophy

March 2012

The stars are always there, even in the daylight.
Sometimes we just can't see them."

(Marian Keyes)

DEDICATIONS

I dedicate this dissertation to my father and mother who have sacrificed their good life for my progress in the field of science.

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Doctor of Philosophy

GENETIC PARAMETERS AND POLYMORPHISM IN CANDIDATE GENES FOR GROWTH AND CONFORMATION TRAITS IN BOER GOATS

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ARASH JAVANMARD

March 2012

Chair: **Professor Dr. Jothi Malar Panandam, PhD**

Faculty: **Agriculture**

The Boer goat, one of the most popular meat type breed in the world, has many remarkable characteristics such as a fast growing rate, good carcass quality and excellent body conformation. Malaysia has imported large numbers of Boer goats to develop goat farming in the country. In this respect, it is important to identify factors influencing the growth and reproductive performance of the Boer goat in order to design optimal breeding and selection programs. The objective of this study was to evaluate the growth and reproductive performance of Boer goats using quantitative and molecular approaches. Three independent studies were carried out. In the first study, kid growth and doe reproductive

performance were evaluated based on non-genetic factors including the year of birth, sex of the kid, litter type, parity and their interactions, and genetic factors which were related to growth, reproductive and body conformation traits. Data for this study were obtained from a commercial farm (iVision Bio Farm) in Janda Baik, Pahang. The project began in 2006 with 397 purebred Boer offsprings born in Malaysia and 174 does and 16 bucks as a base population imported from Australia. The research and data collection from the farm continued until 2010, during which the pedigree information on 1000 goats was obtained. Heritability estimates for growth and performance traits were determined using several different univariate and multivariate animal models with the derivative-free approach of restricted maximum likelihood algorithm. The average weight at birth, weaning (3 months) and at 6 months of age was 3.12±0.77 kg, 10.98±2.99 kg and 21.98±0.30 kg, respectively. The average daily gain for different periods, namely from 0-3, 3-6 and 0-6 months of age were 87.91±33.2 g, 104.62±47.15 g and 108.32±18.3 g, respectively. The average litter size was 1.64±0.67 per birth. The average body length, height at withers, heart girth and chest depth at weaning were 43.5±5.84 cm, 44.3±12.00 cm, 47.24±6.32 cm, and 20.8±2.37 cm, respectively. The values of the same body conformation traits at six months of age were 59.1±7.45 cm, 56.6±5.46 cm, 58.7±6.08 cm, and 22.49±2.89 cm, respectively. Direct heritabilities (h^2) in single trait analyses were 0.29±0.09, 0.27±0.00, and

0.69±0.07 weights at birth, weaning and 6 months, respectively and 0.05±0.00, 0.83±0.02, and 0.57±0.08, for average daily gain from birth to three months, three to six months of age and from birth to six months of age, respectively. The effects of the year of birth, sex of kid and litter type were significant ($p<0.01$) for most of the measured growth traits. Heritability estimates for most of the performance traits revealed a moderate level of genetic variability in these traits.

In the second study, an investigation was carried out to determine the polymorphism in eight candidate genes in Boer does. The investigated genes were calpastatin, insulin-like growth factor binding protein 3, kappa-casein, leptin, myostatin, pituitary-specific transcription factor, stearoyl-CoA desaturase, and s-casein. Polymerase chain reaction restriction fragment length polymorphism (PCR-RFLP) assays were used to genotype these candidate genes in each animal. The observed allele size at the 12 loci investigated was similar to that reported in the literature. Overall, most of the genes showed polymorphism except for the IGFBP3 and kappa-casein genes. The Boer goats showed a high frequency of allele B for calpastatin (0.54), allele T for leptin1 (0.55), allele A for leptin2 (0.85), allele T for leptin3 (0.65), and allele T for POUF1 (0.62).

In the third study, a partial genome scan was carried out to identify the quantitative trait loci (QTL) controlling performance and body conformation. To map the QTL for live body weight, growth and body conformation traits in a purebred Boer goat population, multiple QTL analyses using 45 microsatellite markers spanning 605 centimorgan on chromosome 1, 2, 5, 6 and 26 were conducted. Data were analyzed using the half sib experimental design and the online QTL Express program. Two QTLs associated with birth weight were identified, which were located between markers BMC1009 and RM029 in chromosome 5, and near marker INRABEN172 on chromosome 26 ($p<0.01$). Other chromosomal regions did not show any QTL on the growth trait. Two QTLs for the body conformation traits were located only in chromosome 1 and 26.

In conclusion, it is clear that there is an additive genetic variation in Boer goats in Malaysia. Medium to high heritability estimates for early growth traits observed may be considered when designing an effective program to improve growth characteristics. The magnitude of the heritability estimates for weaning and post weaning weights indicated that those traits would respond to mass selection. However, the low heritability of litter size was caused by not only a low genetic variance but also by other random or unidentified environmental factors. Therefore, the

improvement of these traits is likely to be achieved through crossbreeding or improved feeding and management practices. The adequate genetic variation makes it possible to improve the Boer goat productivity in Malaysia. In this study, the Boer goat also showed a medium level of polymorphism in the candidate genes investigated. However, an evaluation of the phenotypic records for growth, meat quality and test of the association between alleles/genotypes and the traits have to be carried out before any allele at these loci may be considered as a favorable allele in selection programs for the Boer goats. Identifying genes affecting QTL of growth are important and has the potential to significantly increase the rate of genetic improvement through the use of marker-assisted selection. The results of the candidate genes and QTL analyses in this study will serve as reference for future studies on QTL mapping to enhance goat productivity.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Doktor Falsafah

PARAMETER GENETIK DAN POLIMORFISM DALAM GEN CALON UNTUK CIRI PERTUMBUHAN DAN KONFORMASI PADA KAMBING BOER

Oleh

ARASH JAVANMARD

Mac 2012

Pengerusi : Professor Dr. Jothi Malar Panandam, PhD

Fakulti : Pertanian

Kambing Boer, satu daripada baka pedaging yang popular sedunia, mempunyai banyak ciri menarik seperti kadar pertumbuhan yang cepat, kualiti karkas yang tinggi dan konformosi badan yang cemerlang. Kambing Boer telah diimpot dalam jumlah yang besar ke Malaysia dan ia menjadi tulang belakang dalam aktiviti peternakan kambing. Pemahaman faktor-faktor yang mempengaruhi ciri pertumbuhan diperlukan untuk melaksanakan pembiakan dan program pemilihan yang optimum. Objektif kajian ini adalah untuk menilai prestasi pembiakan kambing Boer dengan menggunakan pendekatan kuantitatif dan molekular. Tiga kajian berasingan telah dijalankan. Dalam kajian

pertama, pertumbuhan anak kambing dan prestasi pembiakan kambing Boer betina telah dinilai berdasarkan terutamanya kesan bukan faktor genetik (tahun lahir, jantina anak, bilangan anak yang dilahirkan, pariti dan interaksi antara satu sama lain) dan faktor-faktor genetik berhubung dengan pertumbuhan, ciri-ciri pembiakan dan pembentukan badan kambing Boer. Data untuk kajian ini diperolehi daripada satu ladang komersial (Vision Bio Farm) di Janda Baik, Pahang, Malaysia. Projek ini bermula pada tahun 2006 dengan 397 ekor anak Boer tulen yang dilahirkan di Malaysia dan 174 ekor betina dan 16 ekor jantan sebagai populasi asas diimport dari Australia. Penyelidikan dan koleksi data dari ladang tersebut diteruskan hingga tahun 2010 dimana makluman pedigree daripada 1000 ekor kambing telah diperolehi. Anggaran heritabiliti untuk kebanyakan ciri pertumbuhan dan prestasi telah ditentukan menggunakan beberapa model haiwan univariat dan multivariat dengan pendekatan bebas derivatif bagi algorithma kemungkinan maksimum terhad. Purata keseluruhan berat badan lahir, disapih dan pada enam bulan masing-masing adalah 3.12±0.77 kg, 10.9±2.99 kg dan 21.98±0.30 kg. Purata keseluruhan penambahan berat harian untuk tempoh yang berbeza (lahir - hingga tiga bulan, tiga hingga enam bulan dan lahir hingga enam bulan) masing-masing adalah 87.91±33.2 g, 104.62±47.1 g dan 108.32±18.3 g. Purata keseluruhan saiz kelahiran adalah 1.64±0.6 setiap kelahiran. Purata panjang badan, tinggi

pada bahu, ukurlilit dada dan kedalaman dada semasa disapih masing-masing adalah 43.5±5.84 cm, 44.3±12 cm, 47.24±6.32 cm dan 20.87±2.37 cm. Nilai-nilai yang sama bagi ciri pembentukan badan pada usia enam bulan masing-masing adalah 59.11±7.45 cm, 56.6±5.46 cm, 58.7±6.08 cm dan 22.4±2.89 cm,. Heritabiliti langsung (h^2) dalam analisa sifat tunggal masing-masing adalah 0.29±0.09, 0.27±0.00 dan 0.69±0.07 untuk berat lahir, berat disapih dan berat pada 6 bulan. Heritabiliti langsung (h^2) dalam analisis sifat tunggal masing-masing adalah 0.05±0.00, 0.83±0.02 dan 0.57±0.08 bagi purata penambahan berat harian pada peringkat kelahiran-tiga bulan, 3-6 bulan dan lahir-6 bulan. Kesan faktor bukan genetik yang dikaji (tahun lahir, jantina anak kambing dan saiz kelahiran) adalah bererti ($p<0.01$) bagi kebanyakan sifat-sifat yang dikaji. Anggaran heritabiliti bagi kebanyakan ciri prestasi mendedahkan perbezaan ciri genetik bertahap sederhana. Dalam kajian kedua, penyiasatan telah dijalankan untuk menentukan polimorfism dalam lapan gen calon dalam kambing betina Boer. Gen-gen yang dikaji ialah kalpastatin, faktor pertumbuhan menggabung protein 3 menyerupai insulin, kasein-kappa, leptin, miostatin, faktor transkripsi spesifik pituitari, desatures stearoyl-CoA, dan kasein-s. Ujian polimorfisme chain reaction restriction fragment length (PCR-RFLP) telah digunakan untuk mengenotip haiwan. Saiz alel pada 12 loki yang dikaji adalah sama seperti yang telah dilaporkan. Secara keseluruhannya, kebanyakan gen

menunjukkan polimorfisme kecuali IGFBP3 dan gen-gen kappa kasein. Kambing Boer menunjukkan kekerapan tinggi bagi alel B untuk kalpastatin (0.54), alel T bagi leptin 1 (0.55), alel A untuk leptin 2 (0.85), alel A untuk leptin 3 (0.65), dan alel T bagi POUF1 (0.67).

Dalam kajian ketiga, imbasan separa genom dijalankan untuk mengenalpasti lokus sifat kuantitatif (QTL) yang mengawal prestasi dan pembentukan badan. Untuk memetakan QTL bagi berat badan hidup, pertumbuhan, dan ciri-ciri pembentukan badan dalam populasi kambing Boer baka tulen, pelbagai analisis QTL menggunakan 45 penanda mikrosatelit merangkumi 605 cM pada kromosom 1, 2, 5, 6 dan 26 telah dijalankan. Data dianalisis menggunakan rekabentuk eksperimental adik beradik sebapa dan program *online QTL Express*. Dua QTL berkaitan dengan berat badan lahir telah dikenalpasti; terletak diantara penanda BMC1009 dan RM029 pada kromosom 5, dan berdekatan dengan penanda INRABEN172 dalam kromosom 26 ($p<0.01$). Kawasan kromosom lain tidak menunjukkan QTL pada ciri-ciri pertumbuhan. Dua QTL untuk ciri pembentukan badan ditemui hanya terletak dalam kromosom 1 dan 26. Pada kesimpulannya, adalah jelas bahawa terdapat variasi genetik aditif dalam kambing Boer di Malaysia. Anggaran heritabiliti pada tahap sederhana hingga tinggi untuk ciri pertumbuhan awal yang diperhatikan boleh dipertimbangkan untuk mereka program

yang efektif bagi meningkatkan ciri pertumbuhan. Tahap heritabiliti bagi berat disapih dan selepas disapih menunjukkan ciri ini akan bertindak kepada pemilihan. Walaubagaimanapun, heritabiliti yang rendah untuk saiz kelahiran bukan sahaja disebabkan oleh variasi genetik rendah tetapi faktor lain seperti faktor persekitaran yang tidak dikenalpasti. Variasi genetik yang mencukupi membolehkan produktiviti kambing Boer di Malaysia ditingkatkan. Dalam kajian ini, kambing Boer menunjukkan tahap polimorfism yang sesuai dalam gen-gen calon yang dikaji. Walaubagaimanapun, satu penilaian terhadap rekod fenotaip untuk pertumbuhan dan kualiti daging dan ujian hubungan antara alel/genotip dan ciri-ciri perlu dijalankan sebelum sebarang alel pada lokus-lokus ini boleh dipertimbangkan untuk digunakan dalam program pemilihan kambing Boer. Mengenalpasti gen-gen yang mempengaruhi ciri-ciri kuantitatif (QTL) pertumbuhan adalah penting dan mempunyai potensi untuk meningkatkan kadar peningkatan genetik dengan ketara melalui pemilihan menggunakan penanda. Keputusan calon-calon gen dan analisis QTL dalam kajian ini boleh menjadi rujukan untuk kajian masa depan dalam pemetaan QTL untuk meningkatkan produktiviti kambing.

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My sincere gratitude goes to the members of my supervisory committee, especially Professor Dr. Datin Paduka Khatijah Yusoff, who had kindly accepted to co-supervise me and this work would not have been possible without her immense help and her permission to use her laboratory facilities.

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I certify that an Examination Committee has met on **date of viva voce** to conduct the final examination of **Arash Javanmard** on his Doctor of Philosophy thesis entitled "Genetic parameters and polymorphism in candidate genes for growth and conformation traits in Boer goats" Act 1980 and Universiti Pertanian Malaysia (Higher Degree) Regulations 1981. The Committee recommends that the candidate be awarded the relevant degree. Members of the Examination Committee are as follow:

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This thesis was submitted to the Senate of Universiti Putra Malaysia has been accepted as fulfilment of the requirement for the degree of Doctor of Philosophy. The members of the Supervisory Committee were as follows:

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Date:

DECLARATION

I declare that the thesis is based on my original work except for quotations and citations, which have been duly acknowledged. I also declare that it has not been previously, and is not currently, submitted for any other degree at Universiti Putra Malaysia or other institutions.

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ARASH JAVANMARD

Date:9 March 2012

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