# UNIVERSITI PUTRA MALAYSIA

# IMPACT OF CATTLE GRAZING ON SELECTED ENVIRONMENTAL VARIABLES IN PASTURE-BASED LIVESTOCK PRODUCTION SYSTEM

MAJID AJORLO

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# IMPACT OF CATTLE GRAZING ON SELECTED ENVIRONMENTAL VARIABLES IN PASTURE-BASED LIVESTOCK PRODUCTION SYSTEM

**By**

**MAJID AJORLO**

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

**December 2010**

*To*

*My wife Mahboubeh for her love, patience and wholehearted support*

*My lovely son Ahoora for making everything worthwhile*

*The soul of my beloved father-in-law in heaven*

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

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**Chairman: Associate Professor Ramdzani b. Abdullah, PhD**

**Faculty: Environmental Studies**

Livestock production system has been developed to meet the increasing demand for ruminant products in Malaysia, however, few studies have focused on the assessment of the impact of such production system on the environmental variables such as soil, vegetation and surface water. With increasing demand for livestock products which resulted in the development of livestock production system, quantification and understanding of the environmental impacts of livestock production are necessary prerequisites for any effective planning to enhance environmental quality. This study aims to assess the impacts of short-term (2-year) heavy and long-term (33-year) moderate grazing by cattle on the quality of soil, vegetation and surface water in communal native and commercial improved tropical pasture ecosystem at both the farm and catchment scales. The study was conducted at the Universiti Putra Malaysia Livestock Section, about 20 km south of Kuala Lumpur, Malaysia. Two study sites, the Ladang 2 farm (3° 00’ 28"N; 101° 42’ 10"E) and the TPU catchment (2º 58' 53"N; 101º 43' 38"E), represented a native and improved pastures, respectively. Water samples from a year-round monitoring of streams in the pastures with cattle grazing and

ungrazed exclosure were analyzed for water quality parameters of EC, DO, pH, $NH_3$-N, COD, TSS, Fecal Coliform (FC), and *E. coli*. Soil chemical characteristics such as pH, EC, OC, TN, AP, exchangeable cations, and heavy metals (Cd, Pb, Cu, Cr, Fe, Zn, and Mn) were analyzed. Infiltration rate, bulk density, penetration resistance, moisture content and porosity were determined to assess alterations in soil physical properties. A combination of both systematic and randomized method was used to measure pasture vegetation and invasive species. Root morphological and distribution characteristics were measured using soil coring approach. Water quality data were analyzed with the multivariate analysis of variance, multivariate statistical techniques and the Harkins' index. Soil chemical and physical properties and root morphological data were analyzed with the repeated measures analysis of variance. The multivariate analysis of variance was used to analyze pasture vegetation and invasive species data. The results showed that the streams of the TPU catchment were classified as classes II and I in the grazed and ungrazed pastures, respectively. Streams in both the grazed and ungrazed sites were classified as class II in 'Ladang 2' farm. Significant difference between the grazed and ungrazed treatments was observed for water quality variables of TSS, COD and FC at the Ladang 2 farm. DO, BOD, pH, EC, TSS, COD, NH3-N, FC and *E. coli* varied significantly between the grazed and ungrazed pasture in the TPU catchment. The study also revealed that the moderate grazing led to higher soil pH, EC, AP and $Mg^{+2}$ and lower TN, OC, $Ca^{+2}$ and $K^{+}$ at the improved pasture. Higher levels of pH, EC, OC and lower concentrations of AP, TN, $Ca^{+2}$ and $Mg^{+2}$ were observed at the native pasture. Moderate grazing had significant effect on heavy metal concentrations in soils, but heavy grazing did not lead to a significant accumulation of heavy metals in the soils. Contrary to the heavy grazing, moderate grazing had no negative impacts on soil physical properties. Moderate grazing increased grasses

regrowth rate and herbage mass yield; while heavy grazing had no significant effect on those characteristics. Moderate grazing affected the invasive species population adversely; however heavy grazing provided relatively desirable condition for their establishment and infestation. Mean root diameter, surface area and volume densities were not affected by moderate grazing in the improved pasture. However, root surface area and mass densities were affected at heavily grazed native pasture. Grass roots were significantly affected by heavy grazing at native pasture, but unaffected by moderate grazing at the improved pasture. The results indicated that cattle grazing affect the surface water in pasture ecosystem adversely. Cattle grazing effects on soil chemical characteristics depend on the type of elements, which may increase or decrease over time. Soil heavy metals content can increase in pastures where cattle have been grazing for a long-term. Moderate grazing can influence pasture production positively and decrease the invasive species. Pasture plant roots were not adversely affected by either short-term heavy or long-term moderate grazing intensities.

**Keywords:** Water quality, Vegetation cover, Invasive species, Root morphology, Soil chemical properties, Soil physical properties, Heavy grazing, Moderate grazing

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

**KESAN PENGELUARAN TERNAKAN LEMBU MELALUI SITEM YANG BERASASKAN PADANG RAGUT TERHADAP ALAM SEKITAR**

Oleh

**MAJID AJORLO**

**Disember 2010**

**Pengerusi: Profesor Madya Ramdzani b. Abdullah, PhD**

**Fakulti: Pengajian Alam Sekitar**

Berikutan peningkatan di dalam permintaan untuk produk ternakan yang dihasilkan melalui pembangunan sistem pengeluaran ternakan adalah sangat penting untuk mencari keseimbangan yang bersesuaian antara pengeluaran ternakan dan persekitarannya. Kajian ini bertujuan untuk menilai kesan pemeliharaan ternakan di atas padang ragut dalam jangkamasa pendek (2-tahun) secara berlebihan dan kesan jangkamasa panjang secara sederhana (33-tahun) terhadap kualiti tanah, tumbuh-tumbuhan dan kualiti air permukaan tanah di kawasan padang rumput asli dan juga peningkatan ekosistem padang ragut tropika di kedua-dua peringkat ladang dan kawasan tadahan. Kajian ini telah dijalankan di Bahagian Ternakan, Universiti Putra Malaysia, sekitar 20 km ke selatan Kuala Lumpur, Malaysia. Dua lokasi kajian iaitu kawasan Tadahan TPU (2º 58' 53"N; 101º 43' 38"E) dan kawasan Ladang 2 (3° 00’ 28"N; 101° 42’ 10"E) telah dinilaikan dan masing-masing telah menunjukkan peningkatan yang berterusan di padang ragut yang ditingkatkan dan juga di padang ragut asli. Persampelan air telah diambil dari alur di padang ragut sepanjang tahun di

kawasan ragut dan di kawasan ragut yang terkepung dan dianalisis bagi parameter kualiti air seperti EC, DO, pH, $NH_3$-N, COD, TSS, Fecal Coliform (FC), E. Coli dan sebagainya. Ciri-ciri kimia tanah juga telah dianalisis seperti pH, EC, OC, TN, AP, kation boleh tukar dan logam-logam berat (Cd, Pb, Cu, Cr, Fe, Zn, and Mn). Bagi mengukur perubahan di dalam ciri-ciri fizik tanah, kadar penyusupan, ketumpatan pukal, rintangan penusukan, kandungan lembapan dan keliangan telah diambilkira. Kombinasi kaedah secara sistematik dan rawak telah digunakan bagi mengukur ciri-ciri tumbuh-tumbuhan serta spesis penceroboh di padang ragut tersebut. Ciri-ciri morfologi akar dan juga pengagihannya telah diukur menggunakan pendekatan penerasan tanah. Keputusan kajian telah menunjukkan bahawa alur di kawasan tadahan TPU tergolong di dalam kelas II dan kelas I (mengikut indeks Harkin) masing-masing di kawasan ragut dan di kawasan tidak diragut. Alur di kawasan ragut dan tidak diragut pula tergolong di dalam kelas II di Ladang 2. Perbezaan yang signifikan diperolehi di kawasan yang diragut dan tidak diragut terhadap tiga pembolehubah untuk kualiti air di Ladang 2 iaitu TSS, COD dan FC. Manakala DO, BOD, pH, EC, TSS, COD, NH3-N, FC dan E. Coli menunjukkan perbezaan yang signifikan di antara padang yang diragut dan padang yang tidak diragut di kawasan tadahan TPU. Penggembalaan ternakan dalam jangkamasa panjang secara sederhana boleh mengakibatkan ciri-ciri tanah seperti pH, EC, AP dan $Mg^{+2}$ meningkat tetapi sebaliknya berlaku (iaitu penurunan) untuk kepekatan TN, OC, $Ca^{+2}$ dan $K^{+}$ di padang ragut yang ditingkatkan. Pemerhatian di padang ragut asli menunjukkan kepekatan yang tinggi bagi pH, EC dan OC, tetapi sebaliknya kepekatan yang rendah telah didapati bagi AP, TN, $Ca^{+2}$ dan $Mg^{+2.}$ Penggembalaan ternakan dalam jangkamasa panjang telah memberi kesan terhadap kepekatan logam-logam berat di dalam tanah. Sebaliknya, penggembalaan ternakan dalam jangkamasa pendek secara berlebihan

tidak mengakibatkan pengumpulan logam-logam berat secara signifikan di dalam tanah. Berbeza dengan penggembalaan secara berlebihan, penggembalaan secara sederhana tidak memberi kesan negatif terhadap ciri-ciri fizik tanah di dalam kajian ini. Penggembalaan secara sederhana boleh meningkatkan kadar pertumbuhan semula rumput dan penghasilan herba yang banyak; manakala penggembalaan secara sederhana tidak memberi kesan terhadap ciri-ciri tersebut. Penggembalaan secara sederhana memberi kesan buruk terhadap populasi spesis penceroboh; bagaimanapun secara relatifnya penggembalaan secara berlebihan menyediakan keadaan yang bersesesuaian untuk pembentukan dan serangan spesis penceroboh. Disamping itu, penggembalaan secara sederhana di padang ragut yang sudah ditingkatkan tidak memberi kesan terhadap min garispusat akar, luas permukaan dan ketumpatan isipadu. Namun begitu, penggembalaan secara berlebihan di padang ragut asli memberi kesan kepada luas permukaan akar dan ketumpatan jisim. Bahagian rumput bawah tanah secara signifikannya dipengaruhi oleh penggembalaan secara berleluasa di padang ragut asli, tetapi tidak dipengaruhi oleh penggembalaan secara sederhana di padang ragut yang ditingkatkan.

**Kata kunci:** kualiti air, tumbuh-tumbuhan penutup bumi, spesis penceroboh, morfologi akar, sifat kimia tanah, sifat fizik tanah, penggembalaan secara berlebihan, penggembalaan secara sederhana.

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I certify that a Thesis Examination Committee has met on 09 December 2010 to conduct the final examination of Majid Ajorlo on his thesis entitled "Impact of Cattle Grazing on Selected Environmental Variables in Pasture-based Livestock Production System" in accordance with the Universities and University Colleges Act 1971 and the constitution of the Universiti Putra Malaysia [P.U.(A) 106] 15 March 1998. The committee recommends that the student be awarded the Doctor of Philosophy.

Members of the Thesis Examination Committee were as follows:

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Date: 22 February 2011

This thesis was submitted to the Senate of Universiti Putra Malaysia and 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: 22 February 2011

## Declaration

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

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**MAJID AJORLO**

Date: 9 December 2010

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