Pertanika J. Trop. Agric. Sci. 37 (2): 249 - 261 (2014)

PERTANIKA JOURNALS

TROPICAL AGRICULTURAL SCIENCE

Journal homepage: http://www.pertanika.upm.edu.my/

Cattle Grazing Effect on *Mimosa pudica* L. in Tropical Pasture System

Majid Ajorlo[1]*, Ramdzani Abdullah[2], Ridzwan Abdul Halim[3] and Mahboubeh Ebrahimian[4]

[1]*Faculty of Natural Resources, University of Zabol, 98615 Zabol, Iran*
[2]*Faculty of Environmental Studies, Universiti Putra Malaysia, 43400 Serdang, Selangor, Malaysia*
[3]*Faculty of Agriculture, Universiti Putra Malaysia, 43400 Serdang, Selangor, Malaysia*
[4]*Faculty of Forestry, Universiti Putra Malaysia, 43400 Serdang, Selangor, Malaysia*

ABSTRACT

Mimosa pudica is the most abundant and problematic invasive species in tropical pastures. This study investigates the effects of two cattle grazing systems, long-term moderate grazing (LTG, 2.7 animal unit/ha/yr for 33 years) and short-term heavy grazing (STG, 5 animal unit/ha/yr for 2 years) compared with ungrazed exclosure pasture on the invasion of *M. pudica* and its relationship with herbage production in tropical pasture. *M. pudica* and pasture production were concurrently sampled four times at the end of grass growing period at both grazed and ungrazed pastures. Mean density of *M. pudica* was 56% greater (P<0.05) in the LTG pasture than that in the ungrazed exclosure although it did not vary (P>0.05) between the STG pasture and ungrazed exclosure. Mean importance value (IV) of *M. pudica* in the LTG pasture was 46% lower (P<0.05) than that in the ungrazed exclosure, and this was 220% greater (P<0.05) in the STG pasture than that in the ungrazed exclosure. Pasture herbage production was unrelated (P>0.05) to the density, IV and dry matter (DM) of *M. pudica* in either pasture system. An insignificant negative relationship was found between the density and DM of *M. pudica* with pasture production. In contrast, a positive but insignificant relationship was observed between %IV of *M. pudica* and pasture production in both pasture sites. The LTG system had adverse effect on *M. pudica* population, whereas STG system supplied relatively desirable conditions for *M. pudica* establishment and infestation.

Keywords: heavy grazing, invasive species, Malaysia, *Mimosa pudica*, moderate grazing, pasture production

ARTICLE INFO

Article history:
Received: 21 March 2013
Accepted: 4 December 2013

E-mail addresses:
ajorlo_m54@yahoo.com (Majid Ajorlo),
ramdzani@upm.edu.my (Ramdzani Abdullah),
ridzwan@upm.edu.my (Ridzwan Abdul Halim),
m_ebrahimian81@yahoo.com (Mahboubeh Ebrahimian)
* Corresponding author

ISSN: 1511-3701

INTRODUCTION

Sensitive plant (*Mimosa pudica* L.) is a small, perennial and ligneous invasive species which is widely distributed in tropical regions, especially in south-eastern Asia (Galinato *et al*., 1999) and has become a pantropical weed (Magda *et at*., 2006; Stur & Shelton, 1990). *M. pudica* blooms all year round and reproduces only by seed throughout the year in tropical regions. An adult plant can produce about 675 seeds/ plant/ year (Holm *et al*., 1997; Chauhan & Johnson, 2009a). The plant grows both vertically and horizontally, and an individual adult can cover an area of 1 m and 2 m, respectively. *M. pudica* is the most prevalent, abundant and problematic invasive species in either improved or native tropical pastures (Chauhan & Johnson, 2009a). This particular species can decrease both the quantity and quality of forage (Wardle *et al*., 1995), pasture lifetime and increase weeding and pasture renovation costs. Adult plants may decrease animal performance indirectly through impaired grazing of adjacent forage plants making grazing difficult because of its thorny structure (Grekul & Bork, 2004; Chauhan & Johnson, 2009a). This invasive plant is not grazed by cattle in its adult stage and may always be considered detrimental plant in pastures.

The problem of invasive woody species, *M. pudica*, in pastures is often unresolved (Magda *et al*., 2006). Prescribed burning, mechanical shredding, manual weeding and herbicides application are common strategies to control invasive species in pastures. However, these methods are rather complex to manage, expensive and have further adverse impacts on environmental resources. Meanwhile, manual weeding of spiny weeds is difficult as thorns penetrate and lacerate the hands. Burning can increase soil temperature which favours *M. pudica* seeds to release from dormancy and stimulate germination (Chauhan & Johnson, 2009b). Burning may encourage *M. pudica* to spread in pastures (Siregar *et al*., 1990). Chemical and mechanical control measures are financially and environmentally unsustainable in long term.

Simonet (1990) reported that grazing can reduce the dominance of *M. pudica* in pastures. Appropriate grazing intensity may slow down or control *M. pudica* population directly through ingestion of young seedlings biomass and reduction in the number of reproductive buds (Magda *et al*., 2006) and indirectly by hoof actions such as treading, sitting, pawing, jumping, and running only under appropriate grazing system (Harker *et al*., 2000). Despite the importance of *M. pudica* in tropical pastures, no published documents are available on the effects of cattle grazing on *M. pudica* population at present. The primary objective of this study was to determine the effects of cattle grazing on the attributes of *M. pudica* in tropical native and improved pastures with short-term heavy (for 2-year) and long-term moderate (for 33-year) rotational grazing systems, respectively. The secondary objective was to determine the relationships between the attributes of

M. pudica with pasture herbage production to predict pasture herbage loss. This was achieved by measuring density, importance value (IV) and dry matter (DM) production of *M. pudica,* as well as pasture herbage production. This study aimed to test the hypothesis that cattle grazing would affect the invasion of *M. pudica* and pasture herbage production would be related to *M. pudica* invasion.

MATERIALS AND METHODS

Study Area

This study was conducted at the Universiti Putra Malaysia Livestock Section, about 20 km south of Kuala Lumpur, Malaysia. Two study sites, Taman Pertanian Universiti (TPU) catchment (2º 58' 53" N; 101º 43' 38" E) and the Ladang site (3° 00' 28" N; 101° 42' 10" E), were assessed indicating a perennial improved and native pastures, respectively. The area has humid tropical climate; with mean annual rainfall of 2471 mm and mean annual temperature of 24.5°C.

The soil type was classified as *Typic Hapludox* (Munchong series) representing the Oxisols with >35% clay at the TPU catchment. The Ladang site is on a tin mine that had been abandoned in the 1950s and the soils are sandy clay in texture.

Vegetation of the TPU site consisted of improved pasture with a dominant cover of introduced tropical grasses such as signal grass (*Brachiaria decumbens* Stapf.) and guinea grass (*Panicum maximum* Jacq.) at the TPU site. The Ladang site, both grazed and ungrazed sites, was useless native grassland before establishment mainly dominated by carpet grass (*Axonopus compressus* (Sw.) Beauv.), hillo grass (*Paspalum conjugatum* Berg.) and slender panicgrass (*Ottochloa nodosa* Kunth). *M. pudica* was the only invasive species in both sites. The density of *M. pudica* in grazed and ungrazed pastures was 3.6 and 1.94 (plants/m^2) in the TPU site, whereas its density was 1.7 and 2.8 (plants/m^2) in grazed and ungrazed pastures of the Ladang site, respectively, before the initiation of grazing trials in this study.

The TPU site (180 ha) consists of improved pasture with introduced tropical grasses representing a long-term moderate (LTG, 2.7 animal unit (AU)/ha/year for 33 years) rotational grazing system with cattle from its establishment in 1975 and the Ladang site (4 ha) representing a short-term heavy (STG, 5 AU/ha/year for 2 years) rotational grazing systems with cattle since its establishment in 2007. The TPU site was divided into 9 paddocks ranging in sizes from 5 to 30 ha and the site was divided into four paddocks of similar size (1 ha). Grazing exclosures were also constructed in 1975 (20 ha) and 2007 (4 ha) at the TPU and Ladang sites, respectively. Exclosures are laid just beside the grazed paddocks on a terrain with similar soils and vegetation as the grazed area in both sites. In this study, breed, age and sex of cattle were Kedah-Kelantan (KK), about 5 years old and female, respectively. AU is defined as one mature local cow weighing about 250 kg with or without suckling calf. The rotational grazing system consisted of moving the cattle according to the forage quantity into a new paddock for grazing. In this study, moderate grazing means 45-55% use of pasture herbage that allows the palatable species to maintain themselves. Heavy grazing involves 55-70% use of pasture herbage.

Experimental Design and Grazing Treatment

Each site was treated as an experiment. At the TPU site, four areas (6, 6.6, 8 and 9.5 ha) that had a homogeneous distribution of vegetation and uniform topography were selected in different paddocks. Each paddock at the Ladang site was considered to be a replicate. Four replicates were also defined in each grazing exclosure. The exclosures had no anthropogenic manipulation such as fertilizer application, ploughing and grazing since their construction and provided a control to compare the grazing effects. Therefore, for the TPU site, the treatments were (1) no grazing by cattle and (2) grazing at a moderate stocking rate under rotational grazing system for 33 years. For the Ladang site, the treatments included (1) no grazing by cattle and (2) grazing at a heavy stocking rate under rotational grazing system for 2 years.

Measurement of M. pudica Attributes

A combination of both systematic and randomized methods was used to measure the attributes of weed and forage plants. The systematic sampling design was used in the location of transect lines, while the random sampling design was used in establishing the quadrats (Kamaruzaman & Nik, 1992; Mesdaghi, 2004). A set of four 10 m transect lines spaced 100 m apart was established at each replicate at the TPU site, and two 10 m transect lines spaced 20 m apart were made at each replicate in the Ladang site. A quadrat (0.25 m^2) was randomly placed in each transect line. An exclosure cage technique was used to protect weed and pasture plants in grazed treatments (Mannetje, 1978). Both grazed and exclosures were sampled four times at the end of grass growing period in 2010. As such, measurement was performed every six weeks in the native pastures of the Ladang (namely, 19 March, 09 May, 06 July, 19 August 2010) and at eight-week intervals at improved pastures of the TPU site (namely, 13 May, 15 July, 04 September, 15 November 2010). Measurements in grazed treatment and in the exclosure were carried out in an identical way. No mechanical or chemical weeding operations were practiced to control invasive species population since establishment date in the Ladang site and one year before trial in the TPU site.

Mimosa pudica density, percent cover, importance value (IV), dry matter (DM) production and its proportion to pasture herbage production were determined across the four sampling events. After each sampling event, all transects were relocated systematically in new places within the replicate and quadrats were re-randomized on each transect. *M. pudica* density (plant/m^2) was determined by counting the number of individual plants separately within quadrats using equation 1 (Tauseef *et al.*, 2012). The percent cover of *M. pudica* was assessed visually in each quadrat. Importance value of *M. pudica* presence in the pasture was also determined by calculating importance value percent (%IV) (Tracy & Sanderson, 2004). Percent IV gives an index of the relative importance of each species in the pasture by measuring its frequency and cover. Percent IV was calculated from the summation of relative frequency and cover values for *M. pudica* measured in the 0.25 m^2 quadrat using the equations 2 to 6 (Tracy & Sanderson, 2004; Pragada *et al*., 2011). Clipped *M. pudica* biomass in each quadrat was bagged in a perforated paper sack separately and subsequently was oven dried at 65°C for 48 hr to constant weight and weighed to determine DM production.

$$\text{Density (plants m}^{2}) = \frac{\text{Total number of individuals of a species in all quadrants}}{\text{Total numbers of quadrants}} \quad (1)$$

$$\text{Frequency (\%)} = \frac{\text{Numbers of quadrats in which species occured}}{\text{Total number of quadrats}} \times 100 \quad (2)$$

$$\text{Relative frequency} = \frac{\text{Frequency of individuals of a species}}{\text{total frequency of all species}} \times 100 \quad (3)$$

$$\text{Relative cover} = \frac{\text{cover of individual of a species}}{\text{total cover of all species}} \times 100 \quad (4)$$

$$\text{Importance value (\%)} = \frac{\text{Relative Frequency + relative cover}}{2} \quad (5)$$

Measurement of Pasture Herbage Production

In each quadrat, forage plants were cut to a 5 cm stubble height and subsequently hand-separated into live and dead material fractions. Green herbage was placed in a perforated paper bag and dried in a forced air oven at 65°C for 48 hr to constant weight and then weighed for DM determination (MAFF, 1986).

Statistical Analysis

For the analysis, it assumed that the replicates were independent. The treatments of the study were not replicated in space and it was made the assumption that replicates, which were nested within the treatments, provided an approximation of the experimental error. The present experimental approach was also used by other researchers (Frank *et al*., 1995; Wienhold *et al*., 2001; Liebig *et al*., 2006; Li *et al*., 2009). The use of pseudo-replications was justified based on the duration of given treatments that were greater than 2 years old. Site differences were expected due to differences in their management, pasture type, soil type and treatment period. Thus, TPU and Ladang sites were evaluated separately.

Assumptions of normality and homogeneity of variance were checked and log-transformed as appropriate. For log-transformed variables, the mean of the untransformed data was used to express central tendency and the standard error derived from log-transformed data was used to express precision. Multivariate analysis of variance (MANOVA) (SPSS release 16.0.1, SPSS Inc. 2007) was applied to assess grazing treatments effects on *M. pudica* attributes. Adjustment for multiple comparisons between means was done by Least Significant Difference (LSD) test. Differences were assessed at the significance level of $P<0.05$.

Additionally, the study was aimed to determine whether the density, %IV and

DM (independent variables) of *M. pudica* vary in their ability to present loss in pasture herbage production (dependent variable) and determining which variable has the most significant correlation with pasture herbage loss as explained by Grekul and Bork (2004). Relationships between the attributes of *M. pudica* and pasture production were analyzed by site using linear regression and Pearson correlation coefficient.

RESULTS

Grazing Effect on M. pudica Attributes

Cattle grazing had no effect (P>0.05) on the percent cover of *M. pudica* in either LTG or STG system (Tables 1 and 2). Nonetheless, the percent cover of *M. pudica* in LTG and STG grazing systems was about 96 and 36% lower (P>0.05) than that in the grazing exclosures, respectively, albeit insignificant.

The LTG system led to greater (P<0.05) density of *M. pudica* in the improved pasture (Table 1) but it did not vary between STG system and its ungrazed exclosure (Table 2). Meanwhile, the density of *M. pudica* in LTG system was 56% greater than that in ungrazed exclosure.

Percent IV of *M. pudica* in the LTG system was 46% lower (P<0.05) than that in the ungrazed exclosure (Table 1). In the STG system, however, it was 220% greater (P<0.05) than that in the ungrazed exclosure (Table 2).

TABLE 1
Effects of long-term moderate grazing system (LTG) on *Mimosa pudica* attributes in tropical improved pasture (TPU site)

M. pudica attribute	Grazed	Ungrazed	SE†	*F*	*P*
Cover (%)	3.16	7.50	0.292	0.31	0.57
Density (plants/m^2)	4.33a	2.78b	0.786	4.20	0.04
Importance value (%)	18.92a	34.98b	5.22	8.09	0.009
Dry matter (g DM/m^2)	12.82	24.50	0.234	0.012	0.98
Proportion to total herbage production (%)	12.67	17.33	0.222	0.057	0.80

Means in a row with unlike lower case letters significantly differ at P<0.05
†Standard error

TABLE 2
Effects of short-term heavy grazing system (STG) on *Mimosa pudica* attributes in tropical native pastures (Ladang site)

M. pudica attribute	Grazed	Ungrazed	SE†	*F*	*P*
Cover (%)	1.26	1.97	0.547	1.20	0.28
Density (plants/m^2)	4.00	3.20	1.23	2.03	0.16
Importance value (%)	45.67a	14.25b	5.40	28.72	00
Dry matter (g DM/m^2)	7.60	7.50	2.70	0.51	0.48
Proportion to total herbage production (%)	5.61	7.85	1.89	0.65	0.42

Means in a row with unlike lower case letters significantly differ at P<0.05
†Standard error

Dry matter production (g DM/m^2) of *M. pudica* was generally similar (*P*>0.05) between the grazed and ungrazed sites in either grazing system (Tables 1 and 2). The proportion (%) of *M. pudica* DM to pasture production did not vary (*P*>0.05) between the grazed and ungrazed sites in either grazing system (Tables 1 and 2). The results indicated that the proportion of *M. pudica* DM to pasture production in the grazed sites was lower than that in the ungrazed exclosures, albeit insignificant. For example, in the LTG system, *M. pudica* contribution to herbage production was about 27% lower than that in the ungrazed exclosure (Table 1).

Relationships between M. pudica Attribute and Pasture Production

Pasture production was unrelated (*P*>0.0.05) to *M. pudica* attributes such as density, percent IV and DM production in both the LTG and STG systems (Tables 3 and 4). An insignificant negative relationship was found between the density and DM of *M. pudica* with pasture production. In contrast, a positive but insignificant relationship was observed between %IV of *M. pudica* and pasture production in both pasture sites (Tables 3 and 4).

DISCUSSION

Grazing Effect on M. pudica Attributes

Relatively lower density of *M. pudica* in ungrazed exclosures compared with grazed pastures in both sites may be attributable to high accumulated litter and light competition. Accumulated litter can reduce seed germination and seedling emergence of plants through providing mechanical barrier, releasing allelochemicals and reducing light transmittance (Li *et al*., 2009; Chauhan & Johnson, 2009b). The mean value of litter biomass was 10.99 and 22.65 g/m^2 in the grazed pasture and ungrazed exclosure of the TPU site, and this was 10.79 and 18.2 g/m^2 in the grazed pasture and ungrazed exclosure of the Ladang site. On the other hand, ungrazed exclosures had tall pasture height and therefore competition for light

TABLE 3
Relationships between the attributes of *Mimosa pudica* (X) and pasture herbage production (Y) in tropical improved pastures (TPU site)

M. pudica attributes	Empirical relationship	*r*	*F*	*P*
IV	Y = 87.97 (±4.98) + 1.87 (±0.29) X	0.31	2.32	0.09 *
Density	Y = 157.81 (±24.25) – 3.81 (±9.55) X	–0.08	0.16	0.69 NS
DM	Y = 136.02 (±21.09) + 0.45 (±0.63) X	–0.15	0.51	0.48 NS

IV: importance value; DM: dry matter
Means (± standard error) are presented for equation intercepts (a) and slope (b).
r: Correlation coefficient. Correlations were either not significant (NS) or significantly different at *P*<0.10 (*), *P*<0.05 (**).

is greater in such pasture. Average pasture plants height was 35.4 and 74.8 cm in the grazed pasture and ungrazed exclosure of the TPU site, and 14.1 and 57.5 cm in the grazed pasture and ungrazed exclosure of the Ladang site. *M. pudica* is a short and shade intolerant plant. The amount of radiation received by juveniles of *M. pudica* in a tall grass pasture (at a height of about 50 cm), typically is low in lower layer (Magda *et al*., 2006). Magda *et al*. (2006) indicated that shading had significant negative effects on branching, mortality and flowering rate of seedlings of *M. pudica*. This species will be out-competed in such environment due to its inability to compete with tall grasses. Consequently, high competition for light in ungrazed exclosures might be another reason for low population of *M. pudica* in grazing exclosures. In Canada, Harker *et al*. (2000) found that increasing levels of cattle grazing intensity led to greater densities of shepherd purse (*Capsella bursa-pastoris*) and dandelion (*Taraxacum officinale*) in the perennial pastures.

The importance value (IV) was calculated to compare the ecological significance of *M. pudica* in pastures with and without cattle grazing (Tauseef *et al*., 2012). It provides knowledge on overall importance of each species in a plant community (Giliba *et al*., 2011). Greater IV of *M. pudica* in the STG system (45.67%) compared with ungrazed exclosure (14.25%) indicates that it has become more important species after 2 years of heavy grazing in native pastures of Ladang site. This finding highlights the ability of *M. pudica* to withstand defoliation and treading activities by cattle. *M. pudica* with high importance value in pastures of Ladang site has poor grazing value and it is an indicator of disturbance. However, lower IV of *M. pudica* in the LTG system (18.92%) compared with ungrazed exclosure (34.98%) indicates that moderate grazing was a more appropriate system in inhibiting *M. pudica* infestation in improved pastures of the TPU site. Consequently, different trend of *M. pudica* population, i.e. an upward trend in the STG system and a downward trend in

TABLE 4
Relationships between the attributes of *Mimosa pudica* (X) and pasture herbage production (Y) in tropical native pastures (Ladang site)

M. pudica attributes	Empirical relationship†	*r*	*F*	*P*
IV	Y = 96.45 (±7.32) + 0.82 (±0.63) X	0.27	1.66	0.10 NS
Density	Y = 122.94 (±18.02) + 1.95 (±4.52) X	−0.09	0.19	0.67 NS
DM	Y = 112.31 (±18.19) + 2.26 (±2.04) X	−0.23	1.23	0.27 NS

IV: importance value; DM: dry matter
Means (± standard error) are presented for equation intercepts (a) and slope (b).
r: Correlation coefficient. Correlations were either not significant (NS) or significantly different at *P*<0.10 (*), *P*<0.05 (**).

the LTG system can be related to direct and indirect impacts of cattle grazing.

Dry matter (DM) production of *M. pudica* in the LTG system was about two times lower than that in ungrazed exclosure (Table 1), indicating that the DM production of *M. pudica* was adversely affected by the LTG system. It is expected that the DM production of *M. pudica* should be reduced in native pasture of Ladang site due to heavy grazing by cattle for 2 years. However, Table 2 shows no difference between the grazed site and ungrazed exclosure with regard to DM production values. This indicates that even under heavy grazing condition *M. pudica* was able to produce dry matter as much as ungrazed exclosure. Consequently, it can be concluded that the STG system supplied relatively desirable conditions for DM production in *M. pudica*. Stur and Shelton (1990) also stated that *M. pudica* withstands heavy grazing pressure. Heavy grazing substantially weakens the perennial grasses (Harker *et al*., 2000). As cattle grazing pressure increases, grazing sensitive species become less abundant and are replaced by grazing tolerant and invasive species (Yates *et al*., 2000) which are more resistant to cattle trampling and better adapted to compacted topsoil (Martinez & Zinck, 2004).

Defoliation has a slight effect on seedling, juvenile mortality, and flowering rate of *M. pudica*, in comparison with shading (Magda *et al*. 2006). Defoliation can enhance branching and production of new branches in *M. pudica*, except when defoliation takes place after shading and high competition for light. The establishment and survival of seedlings of *M. pudica* is chiefly controlled by the indirect effect of grazing, i.e., hoof actions such as treading, sitting, pawing, jumping, and running (Harker *et al*., 2000). Appropriate grazing management system can influence *M. pudica* by creating competitive conditions by maintaining enough pasture plants height and/or facilitating population recruitment through removing adjacent grasses rather than direct defoliation by animals (Van Der Wal *et al*., 2000). In fact, competition is a factor that controls plant invasion particularly in nutrient limiting environments (Lopez-Zamora *et al*., 2004).

In heavily grazed pastures, the negative shading effect on juvenile plants of *M. pudica* decrease largely, as grazing opens the dense cover of pasture through removing upper parts of grass plants. Grazing intensity and duration are main determinants in residual pasture height and the extent of subsequent effect on juvenile plants. If pasture plants are grazed to ground surface, which happens in heavy grazing system, juvenile plants will not be subjected to hard competition for light from adjacent grass plants. This enhances favourable conditions for growth of young stages of this species and increase recruitment to *M. pudica* population. This issue was remarkable in native pastures of the Ladang site with heavy grazing system.

Additionally, *M. pudica* is a seismonastic plant in which the leaves (pinna) close and the petiole falls down in response to wind, vibration and touch as a defence mechanism for protection from animals and insects (Volkov *et al*., 2010). Thigmonastic movement (response of a plant to touch) in *M. pudica*, associated with fast response to environmental stimuli such as animal biting and grazing, appear to enhance plant survival and establishment in pastures with heavy grazing.

Relationships between the Attributes of M. pudica and Pasture Production

In general, the relationships between *M. pudica* attributes and pasture production were insignificant in this study (Tables 3 and 4). Percent IV and density of *M. pudica* had the highest positive and the lowest negative insignificant relationships with pasture production in both pasture types, respectively (see Tables 3 and 4). Insignificant relationships between measured variables can be mainly related to small population and low magnitude of *M. pudica* in the studied pastures. However, this study revealed the negative relationship between *M. pudica* DM production and density with pasture production (Tables 3 and 4), indicating negative effects of biomass and numbers per unit area of *M. pudica* on tropical pasture production. In USA, Tracy and Sanderson (2004) and Ferrell *et al*. (2006) reported a negative relationship between weed density and herbage production. Ferrell *et al*. (2006) reported that bahiagrass (*Paspalum notatum*) herbage production reduced by increasing giant smutgrass (*Sporobolus indicus*) density. Hume (1985) stated that weed dry matter estimates relative spring wheat (*Criticum aestivum*) production loss better than density. Grekul and Bork (2004) results from perennial pastures showed no difference between Canada thistle (*Circium arevens*) density and DM production for predicting herbage production loss in pastures. Harker *et al*. (2000) contended that pasture production–weed interaction may have been detected accurately if weed dry matter rather than density is used in the analysis. This study concluded that neither DM production nor the density of *M. pudica* was a good indicator for predicting herbage production loss in tropical pastures because no significant relationship was found between *M. pudica* attributes and pasture herbage production (Tables 3 and 4).

CONCLUSION

Moderate grazing (LTG) system had adverse effect on *M. pudica* population; whereas heavy grazing (STG) supplied relatively desirable conditions for *M. pudica* establishment and infestation. Percent IV of *M. pudica* in LTG system was 46% lower than that in the grazing exclosure, whereas it was about three folds greater (220%) in the STG system than that in the ungrazed exclosure. DM production of *M. pudica* was generally similar between STG and ungrazed exclosure, whereas in the LTG system, it was 48% lower than that in the ungrazed exclosure. Proportion of *M. pudica* dry matter to pasture herbage production did not vary between grazed and ungrazed pastures in both LTG and STG systems. Neither DM production nor the density of *M. pudica* was a good indicator for predicting herbage production loss in studied tropical pastures.

The findings of this study have a number of important implications for farmers and managers in tropical pastures. The intensity of grazing should not exceed moderate grazing of total biomass in tropical native and improved pastures in order to avoid loss in pasture productivity. The stocking density of 1 and 2.5–2.7 animal unit/ha can be appropriate cattle density per unit area in terms of minimal negative impacts on *M. pudica* invasion and maximum production in tropical native and improved pastures, respectively.

ACKNOWLEDGEMENTS

Funding for this project was provided by Universiti Putra Malaysia (UPM). The authors wish to thank the Department of Environmental Management of Universiti Putra Malaysia for facilitating the fieldwork.

REFERENCES

Chauhan, B. S., & Johnson, D. E. (2009a). Germination, emergence, and dormancy of Mimosa pudica. *Weed Biology and Management, 9,* 38−45.

Chauhan, B. S., & Johnson. D. E. (2009b). Influence of environmental factors on seed germination and seedling emergence of eclipta (*Eclipta prostrata*) in a tropical environment. *Weed Science*, *56,* 383–388.

Ferrell, J. A., Mullahey, J. J., Dusky, J. A., & Roka, F. M. (2006). Competition of giant smutgrass (*Sporobolus indicus*) in a bahiagrass pasture. *Weed Science, 54,* 100–105.

Frank, A. B., Tanaka, D. L., Hofmann, L., & Follett, R. F. (1995). Soil carbon and nitrogen of northern Great Plains grasslands as influenced by long term grazing. *Journal of Range Management*, *48,* 470–474.

Galinato, M. I., Moody, K., & Piggin, C. M. (1999). *Upland rice weeds of south and southeast Asia*. International Rice Research Institute, Makati, the Philippines.

Giliba, R. A., Boon, E. K., Kayombo, C. J., Musamba, E. B., Kashindye, A. M, & Shayo, P. F. (2011). Species composition, richness and diversity in Miombo woodland of Bereku Forest Reserve, Tanzania. *Journal of Biodiversity, 2*(1), 1–7.

Grekul, C. W., & Bork, E. W. (2004). Herbage yield losses in perennial pasture due to Canada Thistle (*Cirsium arvense*). *Weed Technology*, *18,* 784–794.

Harker, K. N., Baron, V. S., Chanasyk, D. S., Naeth, M. A., & Stevenson, F. C. (2000). Grazing intensity effects on weed populations in annual and perennial pasture systems. *Weed Science, 48,* 231-238.

Holm, L. G., Plucknett, D. L., Paucho, J. V. M., & Herberger, J. P. (1997). *The world's worst weeds, distribution and biology*. East-West Centre, University Press of Hawaii, Honolulu. 609 pp.

Hume, L. (1985). Crop losses in wheat (*Triticum aestivum*) as determined using weeded and non-weeded quadrats. *Weed Science, 33,* 734–740.

Kamaruzaman, J., & Nik, M. M. (1992). An analysis of soil disturbance from logging operation in a hill forest of Peninsular Malaysia. *Forest Ecology and Management, 47,* 323−333.

Li, C., Hao, X., Willms, W. D., Zhao, M., & Han, G. (2009). Seasonal response of herbage production and its nutrient and mineral contents to long-term cattle grazing on a rough fescue grassland. *Agriculture, Ecosystems and Environment, 132,* 32–38.

Liebig, M. A., Gross, J. R., Kronberg, S. L., Hanson, J. D., Frank, A. B., & Phillips, R. L. (2006). Soil response to long term grazing in the northern Great Plains of North America. *Agriculture, Ecosystems and Environment, 115,* 270–276.

Lopez-Zamora, I., Comerford, N. B., & Muchovej, R. M. (2004). Root development and competitive ability of the invasive species *Melaleuca quinquenervia* (Cav.) S. T. Blake in the South Florida flatwoods. *Plant and Soil, 263,* 239–247.

MAFF. (Ministry of Agriculture, Fisheries, and Food) (1986). *The analysis of agricultural materials (3rd edn.).* Reference Book 427. Her Majesty's Stationery Office, London, United Kingdom.

Magda, D., Duru, M., Huguenin, J., & Gleizes, B. (2006). Impact of shading and cutting on the demography and composition of *Mimosa pudica* L., a ligneous weed species of tropical grasslands. *Grass and Forage Science*, *61,* 89–96.

Mannetje, L. (1978). *Measurement of grassland vegetation and animal production*. Commonwealth Agricultural Bureaux, Bulletin 52, Hurley. Berkshire, England.

Martınez, L. J., & Zinck, J. A. (2004). Temporal variation of soil compaction and deterioration of soil quality in pasture areas of Colombian Amazonia. *Soil and Tillage Research*, *75,* 3–17.

Mesdaghi, M. (2004). *Range Management in Iran*. Imam Reza University Press, Mashhad, Iran (In Persian).

Pragada, P. M., Padal, S. B., Krishna, B. R., Rao, D. S., & Narayana, V. (2011). Ecological aspects of weed flora of turmeric (*Curcuma longa* L.) fields of Visakhapatnam District, A.P., India. *Journal of Biodiversity and Environmental Sciences, 1*(6) 30-38.

Simonet, P. (1990). Sheep flock management in a tropical environment under coconut. *Oleagineux, 45,* 451–456.

Siregar, M. E., Haryanto, B., & Tjitrosemito, S. (1990). A review of weed management in Indonesian pastures. *BIOTROP*, *38,* 229–235.

SPSS Inc. (2007). *SPSS 16.0 for Windows, Release 16.0.1*. SPSS Inc. and IBM company, Chicago, Illinois.

Stohlgren, T. J., Bull, K. A., Otsuki, Y., Villa, C. A., & Lee, M. (1998). Riparian zones as havens for exotic plant species in the central grasslands. *Plant Ecology, 138,* 113–125.

Stur, W. W., & Shelton, H. M. (1990). Review of Forage Resources in Plantation Crops of Southeast Asia and the Pacific. *Forages for plantation crops workshop*. 27-29 June, Bali, Indonesia.

Tauseef, M., Ihsan, F., Nazir, W., & Farooq, J. (2012). Weed flora and importance value index (IVI) of the weeds in cotton crop fields in the region of Khanewal, Pakistan. *Pakistan Journal of Weed Science and Research*, *18,* 319–330.

Tracy, B. F., Renne, I. J., Gerrish, J., & Sanderson, M. A. (2004). Effects of plant diversity on invasion of weed species in experimental pasture communities. *Basic and Applied Ecology*, *5,* 543-50.

Tracy, B. F., & Sanderson, M. A. (2004). Forage productivity, species evenness and weed invasion in pasture communities. *Agriculture, Ecosystems and Environment, 102,* 175–183.

Van Der Wal, R., Egas, M., Van Der Veen, A., & Bakker, J. (2000). Effects of resource competition and herbivory on plant performance along a natural productivity gradient. *Journal of Ecology, 88,* 317–330.

Volkov, A. G., Foster, J. C., Ashby, T. A., Walker, R. K., Johnson, J. A., & Markin, V. S. (2010). *Mimosa pudica*: Electrical and mechanical stimulation of plant movements. *Plant, Cell and Environment, 33,* 163–173.

Wardle, D. A., Nicholson, K. S., & Rahman, A. (1995). Ecological effects of the invasive weed species *Senecio jacobaea* L. (ragwort) in a New Zealand pasture. *Agriculture, Ecosystems and Environment*, *56,* 19-28.

Wienhold, B. J., Hendrickson, J. R., & Karn, J. F. (2001). Pasture management influences on soil properties in the northern Great Plains. *Journal of Soil and Water Conservation, 56,* 27–31.

Yates, C. J., Norton, D. A., & Hobbs, R. J. (2000). Grazing effects on plant cover, soil and microclimate in fragmented woodlands in south-western Australia: implications for restoration. *Austral Ecology*, *25*, 36–47.