How the use of mesquite impacts grass availability, Wild Ass Sanctuary, India

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Abstract
We examined the impact of an exotic mesquite (*Prosopis juliflora*) on grass availability in the Wild Ass Sanctuary (WAS), Western India, which is the only habitat for the endangered Indian wild ass (*Equus hemionus khur*). These data are necessary for the management of endangered species in desert ecosystems where resources fluctuate widely. We collected information on the size of mesquite branches used by people for fuelwood and the impact of branches that were left on the ground on grass cover and biomass during 1989-1990. People preferred fuelwood branches of mesquite 5-15cm in diameter; the remaining thorny branches are left in the field, which reduces the availability of grass for foraging. Most grasses that grow under the discarded mesquite branches are protected whereas grasses without this protection are grazed. We correlated the percent grass cover with the number of twigs left on the ground ($r = 0.74$). Grasses protected due to the thorny branches leftover after mesquite collection, provide sources of seeds but reduce overall availability of forage leading to increased crop depredation by wild ass. Managing mesquite branches in WAS is important to provide more grazing areas for minimizing crop predation by wild asses and preserve seed from grazing for grassland management.

Key words
Fuelwood, grazing, India, Indian wild ass, mesquite, Rann of Kutch, semi-arid

Introduction

Concern about deforestation, desertification, and fuelwood shortages in the late 1970s and early 1980s promoted research resulting in translocation of an exotic mesquite (*Prosopis juliflora*) and other hardy tree species to new environments across the world (Mwangi and Swallow 2005). Although some exotic plant introductions were accidental, many were intentional for wildlife and habitat improvement, ornamental purposes, wood or fiber production, or for other uses (Harrod 2001). The earliest records of mesquite cultivation in the Indian subcontinent date back to 1877. In areas adjacent to the Little Rann of Kutch (LRK), Gujurat State, India, mesquite was introduced by the ruler of Radhanpur during 1899-1900 and has now spread throughout the fringe of the desert (Patel 1977). In Gujarat State, regular plantations of mesquite are grown on the saline fringes of the Rann of Kutch and on the desert border since 1953 to stop desertification.

The invasion of exotic plants like mesquite is a primary threat to the integrity and function of ecosystems (Blossey et al. 2001, Sinha et al. 2007). Livestock ranchers and pastoralists discourage mesquite because it invades pastures (Mwangi and Swallow 2005), is highly aggressive, and crowds out native vegetation (Tiwari 1999, Al-Rawai 2004). Mesquite is a drought-resistant, fast-growing, and nitrogen-fixing species able to grow in harsh conditions where native species fail (Pasiecznik et al. 2001). Mesquite is equipped with a number of biological characteristics related to seed dormancy, germination, and dispersal that can facilitate rapid invasion of new areas (Shiferaw et al. 2004). In addition mesquite has great ability to resprout with quick coppice growth from stumped or damaged trees making it a very strong competitive invader (Shiferaw et al. 2004). Mesquite is also able to cause substratum degradation in the semi-arid and arid areas of north and northwest India (Sharma and Dakshini 1998).

Several reviews reported deserts to be among the least invaded ecosystems worldwide, in terms of the number of naturalized and invasive species (Lonsdale 1999, Brooks and Pyke 2001). In desert habitats, many studies describe factors that promote plant invasions, but few investigated the impacts on biodiversity (Brooks and Pyke 2001, Sinha et al. 2008).

In India, for example, it is well documented that poor rural women in arid and semi-arid areas benefit disproportionately from selling charcoal and fuelwood made from mesquite (Andersson 2005). Most of the firewood extracted from forests is transported on the heads of villagers living adjacent to the forests. The excessive cutting of firewood has resulted in the depletion of forest cover. People use fuelwood that they gather and it is usually obtained from mesquite. Besides fuelwood, charcoal is produced in the region. Most of the charcoal supplying villages are located adjacent to the LRK. These regions are one of the major suppliers of charcoal to Ahmedabad, India (FAO 1993). At the same time vast stretches of grasslands in LRK are crucial for habitat for a number of wildlife species including the endangered Indian wild ass and fodder reserve for livestock. It has also been reported that after collection of the branches of preferred girth sizes, the remaining thorny branches are left in the field as twigs that further reduces foraging areas for wild asses.

Resources in LRK fluctuate widely over years. Therefore, our objective was to describe the impact of mesquite extraction for fuel wood by the local people on grassland habitat.

Study Area

Little Rann of Kutch, is a unique and hostile place in the Thar Desert (Fig. 1). Temperatures can rise to 50°C during day time coupled with dust storms and mirages and cool to 5°C at night. Thorny vegetation exists on the desert fringe, however no vegetation at all exists to provide shade in the mudflat. There is no habitation for miles and only saline water. Despite the hardships, working in this saline desert was an experience of a lifetime. Local villagers and nomadic pastoralists, who come to the area, are colorful and hospitable and one can strike a genuine conversation with them quickly.

Figure 1. Study area Little Rann of Kutch

The study was conducted in the Wild Ass Sanctuary (WAS) (230 10'-230 45' N; 700 45'-710 45' E), LRK (4,840 km^2). We also established an Intensive Study Area (ISA) of 100 km^2 on the southern fringe. The WAS comprise three distinct types of surface features: the exposed saline flats in which almost nothing grows, islands, and fringes of the mainland with grasses and sparse trees and shrubs. The WAS receives approximately 125 to 400 mm rainfall in a year during monsoons (July-September).

The vegetation is xerophytic, dominated by exotic mesquite (Fig. 2). The grasses growing on the islands and the shore of the mainland include kalavo (*Aleuropus lagopoides*), moth (*Cyperus* spp.), khariyu (*Sporobolus indicus*), lampro (*Aristida adscensionis*), and poongyo (*Eragrostis* spp.). Other predominant plant species are kharo jhal (*Salvadora oleoides*), pilu (*S. persica*), lano (*Suaeda* spp.), and khar (*Holoxylon salicornicum*).

Narali, a village on the southern fringe of the sanctuary within the ISA is situated 5 km from the fringe with agriculture fields and wasteland extending up to the border of the LRK. The total area of the village is 2,607 ha of which 256 ha (9.8%) is covered by mesquite forest.

Methods

We placed 4 km long transects systematically from Narali village toward the LRK in 1989-1990 to determine the distribution of mesquite. To determine the preferred girth size of fuelwood, we measured stems of mesquite in the headloads (n = 50) carried by the villagers and the fuelwood available in houses (n = 50) in the village.

To estimate the effect of mesquite on the availability of grass cover, we created systematic transects radiating from the base of each mesquite (n = 26). We placed quadrats (1x1 m) at regular intervals on the transect to estimate the height of the grass and the species. The grasses from the quadrat were clipped and weighed to determine biomass.To quantify seasonal availability of grass cover, we compared areas open to grazing with grass productivity determined from exclosures.Three 10x10 m exclosures of chain link fence of 2 m height were established to monitor grass species and height in the absence and presence of mesquite. We manually dug mesquite from two exclosures and did not remove the shrub from the other exclosure. These exclosures were regularly monitored so that native or domestic ungulates could not enter to graze.

Figure 2. Mainland around Rann (saline deserts) dominated with thickets of mesquite

To study the distribution of mesquite twigs left over after the removal of fuelwood in the ISA, 6 transects 4-5 km long were established. At every 100 m, we used 2 step methods to estimate the number of twigs left over. The number of twigs were categorized into 3 categories: low (<40), medium (41 to 100), and high (>101). We quantified the forage biomass under the twigs left over after the removal of wood for fuel and charcoal. We counted the number of old and new twigs and correlated numbers with grass cover below the twigs.

We evaluated differences in grass height from the base of the mesquite to outside the canopy and between different shrubs using Chi square tests. We used two way Analyses of Variance (ANOVA) to evaluate the effect of twigs, shrubs, and exclosures on vegetation. We used one way ANOVA to compare the number and age of mesquite twigs on grass cover.

RESULTS

Nearly a third (31%) of mesquite shrubs (n = 26) in the ISA had 1-10 cm girth size indicating that they are fresh plantation or sprouting after the main shrub has been cut. From the fuel headloads measured, 5-15 cm was the most common girth size of stems. Stems below this girth class were twigs that were left behind.

Effect of mesquite twigs, shrub, grazed areas, and exclosures on vegetation

Based on ANOVA, the ground cover under mesquite twigs, shrubs, grazed areas, and exclosures is significantly different ($P < 0.05$). There were >50% grass cover under mesquite twigs ($\bar{x} = 67.00$), mesquite shrub ($\bar{x} = 64.16$) and exclosures ($\bar{x} = 52.50$). This indicates that they are controlled from grazing by wild ass and livestock.

From the study of 2 exclosures (i.e., 1 from which mesquite was manually eradicated and 1 in which mesquite was left untouched), the percent cover of unpalatable species like lampro is high ($\bar{x}$ =43.08, SE =3.49) in the former as compared to the latter ($\bar{x}$ = 31.0, SE=5.4).

Effect of mesquite on grass

Grass attained the greatest height and biomass at the base of the shrub but decreased as distance from the base increased until it again increased with association with neighboring shrubs (Fig. 6). Grass biomass and height from the center of mesquite shrubs and these values were >2-3 times higher below the shrubs than in areas away from the shrubs (Fig. 3, 6). Mesquite protects the grass at its base from grazing but if proper pruning and thinning of the shrub is not done the area converts into impenetrable forest. Results from the vegetation study of exclosures where mesquite was eradicated, show the dominance of unpalatable species like lampro.

Effect of number and age of twigs on grass cover

Medium (41-100) and high (>101) number of twigs left on the ground yielded a higher percentage of grass cover compared to a low number of twigs left. The percentage of grass cover was significantly different in all groups. The twigs protect the grass cover from grazing but the area is not available for the wild ass because the thorny twigs clump together preventing them from foraging. The number of twigs left over after the removal of fuelwood is positively correlated ($r = 0.745$) with the percent of grass cover underneath (Fig. 7). This means that if the twigs are removed from the ground, the grass cover would increase because the twigs cover a large area and the forage is not accessible to grazing. Number of twigs does not affect the grass height or biomass. This indicates that the grass that grows under twigs after gaining height is available for livestock and wild ass to graze.

Figure 3. Grass growing under mesquite.

Figure 4. Thorny branches of mesquite left in the sanctuary after fuelwood collection

Figure 5. Collection of twigs of preferred fuelwood size from mesquite

Figure 4. Wild ass on fringe dominated with grasslands

Discussion

Several studies have shown that the ecological impacts of invasive plants include displacement of indigenous species and decline in species richness and diversity (Lonsdale 1999, Brooks and Pyke 2001, Kedzie-Webb et al. 2001, Lesica and Miles 2001, Prieur-Richard et al. 2002, Badano and Pugnaire 2004, Hoffman et al. 2004, Sinha et al 2007). We showed that thorny twigs protect ground cover and mesquite protects the grass under the shrub. In arid and semi-arid environments, where plant cover is scarce and patchy, there is a conspicuous concentration of vegetation near, and especially beneath, shrubs that form the so called "islands of fertility" (Garner and Steinberger 1989, Pugnaire et al. 1996, Hagos and Smit 2005). Grass attained height under mesquite because of protection due to the canopy compared to areas that are open to grazing by ungulates. On the contrary in their study on silvopastoral farming system in the semi-arid regions of south-east Rajasthan, India, Kothari and Jain (2003) reported the lowest mean dry grass biomass under mesquite canopies.

The LRK is being used by approximately 6,000 resident and migrant livestock during the monsoon when the estimated grass biomass is 11.02 gm/m^2 in grazed areas as compared to 202.02gm/m^2 in the exposure. During summer, when only resident livestock use the area, the biomass is 15.55kg/m^2 in the open area.

Results indicate that within 100 km^2 of the ISA area at the present state, the area required for foraging for the estimated population of 162 wild asses is approximately 4,000 km^2. This area could be reduced to approximately 700 km^2 for the same number of wild asses if protection is provided for the vegetation.

The peoples' perceptions of mesquite were favorable during the early stages of its introduction. It changed later as the negative effects of the invasion-colonization of agricultural land, its sharp thorns, suppression of grasses and crops-became more pronounced (Mwangi and Swallow 2005). Larger individual shrubs and greater densities have greater negative impacts on the associated plants (Keblawy and Rawai 2007). According to Singh (1999), the area under mesquite increased from 334 km^2 in 1983 to 428 km^2 in 1995 in the WAS, a rate of 950 ha/year.

Although the twigs protect the grass cover from grazing the area is not available for the wild ass because the thorny twigs clump together creating a physical barrier. The clumped twigs left over from fuelwood and charcoal harvesting also lead to growth of species like lampro that is not preferred by wild animals.

Our study clearly indicates that twigs left over in the study area after extraction of fuelwood reduces the overall availability of forage to wild ass and livestock. This condition has likely resulted in high crop depredation by wild ass around WAS. Therefore, we suggest a need of management of left over twigs for improving habitat availability, especially during summer when resources are scarce. Our study reveals that left over twigs should be removed during summer, to make available large forage biomass protected under twigs, to the wild asses and some grass should be protected under the twigs to create a seed bank.

Acknowledgements

We are grateful to P. R. Sinha and V. B. Mathur of the Wildlife Institute of India for their continuous encouragement and personnel of the Gujarat Forest Department for their support during this study on the Indian wild ass.

References

Al-Rawai, A. 2004. Impacts of the alien invasive *Prosopis juliflora* (Sw.) D.C. on the flora and soils of the UAE and feasibility of its use in afforestation of saline habitats. Thesis, Environmental Science, United Arab Emirates University, Al-Ain, United Arab Emirates.

Andersson, S. 2005. Spread of the introduced tree species *Prosopis juliflora* (Sw.) DC in the Lake Baringo area, Kenya. Institutionen for Skoglif Vegetationsekologi, Swedish Agricultural University, Sweden. 31 pages.

Badano, E.I., and F.I. Pugnaire, 2004. Invasion of *Agave* species (Agavaceae) in south east Spain: invader demographic parameters and impacts on native species. Divers Distributation 10:493-500.

Blossey, B., V. Nuzzo, H. Hinz, and E. Gerber. 2001. Developing biological control of *Alliaria petiolota* (M. Bieb.) Cavara and Grande (garlic mustard). Natural Areas Journal 21:357-367.

Brooks, M.L., and D.A. Pyke. 2001. Invasive plants and fire in the deserts of North America. P. 1-14 in: K.E.M. Galley, and T. P. Wilson, editors. Proceedings of the invasive species workshop: the role of fire in the control and spread of invasive species, Fire Conference 2000: the First National Congress on Fire Ecology, Prevention, and Management, Miscellaneous Publication No.11, Tall Timbers Research Station, Tallahassee, Florida, USA. 146 pages.

FAO. 1993. Charcoal production and marketing in Gujarat. Field Document No 36.

Garner, W., and Y. Steinberger. 1989. A Proposed mechanism for the formation of 'fertile islands' in desert ecosystem. Journal of Arid Environments 16:257-262.

Hagos, M.G., and G.N. Smit. 2005. Soil enrichment by *Acacia mellifera* subsp. *detinens* on nutrient poor sandy soil in a semi-arid southern African savanna. Journal of Arid Environments 61:47-59.

Harrod, R.J. 2001. The effect of invasive and noxious plants on land management in eastern Oregon and Washington. Northwest Science 75:85-90.

Hoffman, W.A., V.M.P.C. Lucatelli, F.J. Silva, I.N.C. Azeuedo, M. S. Marinho, A.M.S. Albuquerque, A.O. Lopes, and S.P. Moreira. 2004. Impact of the invasive alien grass *Melinis minutiflora* at the savanna-forest ecotone in the Brazilian Cerrado. Divers Distribution 10: 99-103.

Keblawy, Ali El, and Al Awatif Rawai. 2007. Impacts of the invasive exotic *Prosopis juliflora* (Sw.) D.C. on the native flora and soils of the UAE. Plant Ecology 190:23-25.

Kedzie-Webb, S.A., R.L. Sheeley, J. Borkowksi, and J.S. Jacobs. 2001. Relationships between *Centaurea maculosa* and indigenous plant assemblages. Western North American Naturalist 61:43-49.

Kothari, A.K., and P.M. Jain. 2003. Effect of tree species on inter space grass yield under silvopastoral system. p. 393-396 in: P, Narain, S. Kathju, A. Kar, M.P. Singh, and P. Kumar, editors. Human impact on desert environment, Arid Zone Research Association of India, Jodhpur, India.

Lesica, P., and S. Miles. 2001. Natural history and invasion of Russian olive along eastern Montana rivers. Western North American Naturalist 61:1-10.

Lonsdale, W.M. 1999. Global patterns of plant invasions and the concept of invisibility. Ecology 80:1522-1536.

Mwangi, E., and B. Swallow. 2005. Invasion of *Prosopis juliflora* and local livelihoods: case study from the Lake Baringo area of Kenya. ICRAF working paper. World Agroforestry Centre, Nairobi, Kenya.

Pasiecznik, N.M., P. Felker, P J.C. Harris, L.N. Harsh, G. Cruz, J. C. Tewari, K. Cadoret, and L.J. Maldonado. 2001. The *Prosopis juliflora-Prosopis pallida* complex: A Monograph. HDRA, Coventry, United Kingdom. 162 pages.

Patel, G.D. 1977. Gujarat State Gazetteers: Surendranagar district. Government Publication, Department, Ahmedabad, India. 730 pages.

Prieur-Richard, A.H., S. Lavorel, Y.B. Linhart, and A. Dos Santos. 2002. Plant diversity, herbivory and resistance of a plant community to invasion in Mediterranean annual communities. Oecologia 130:96-104.

Pugnaire, F.I., P. Hasse, J. Puigdefabregas, M. Cueto, S.C. Clark, and L.D. Incoll. 1996. Facilitation and succession under the canopy of a leguminous shrub, *Retam sphaerocarpa*, in a semi arid environment in south east Spain. Oikos 76:455-464.

Sharma, R., and K.M.M. Dakshini. 1998. Integration of plant and soil characteristics and the ecological success of two shape Prosopis species. Plant Ecology 139: 63-69.

Shiferaw, H., D. Teketay, S. Nemomissa, and F. Assefa. 2004. Some biological characteristics that foster the invasion of *Prosopis juliflora* (Sw) D.C. at Middle Awash Rift Valley Area, north eastern Ethiopia. Journal of Arid Environments 58:134-153.

Singh, H.S. 1999. Wild ass in Little Rann of Kutch (Ecological status of the wild ass sanctuary) Tiger Paper 26:1-6.

Sinha, Bitapi C., S.P. Goyal, and P.R. Krausman. (2009). Germination of mesquite seeds passed through gut of the Indian Wild Ass (*Equus hemionus khur*), Salt Desert, India. Journal of the Bombay Natural History Association: in press.

Tiwari, J.W.K. 1999. Exotic weed *Prosopis juliflora* in Gujarat and Rajasthan, India boon or bane. Tiger Paper 26:21-25.

Figure 5. Saline desert ecosystems with mainland on the fringes

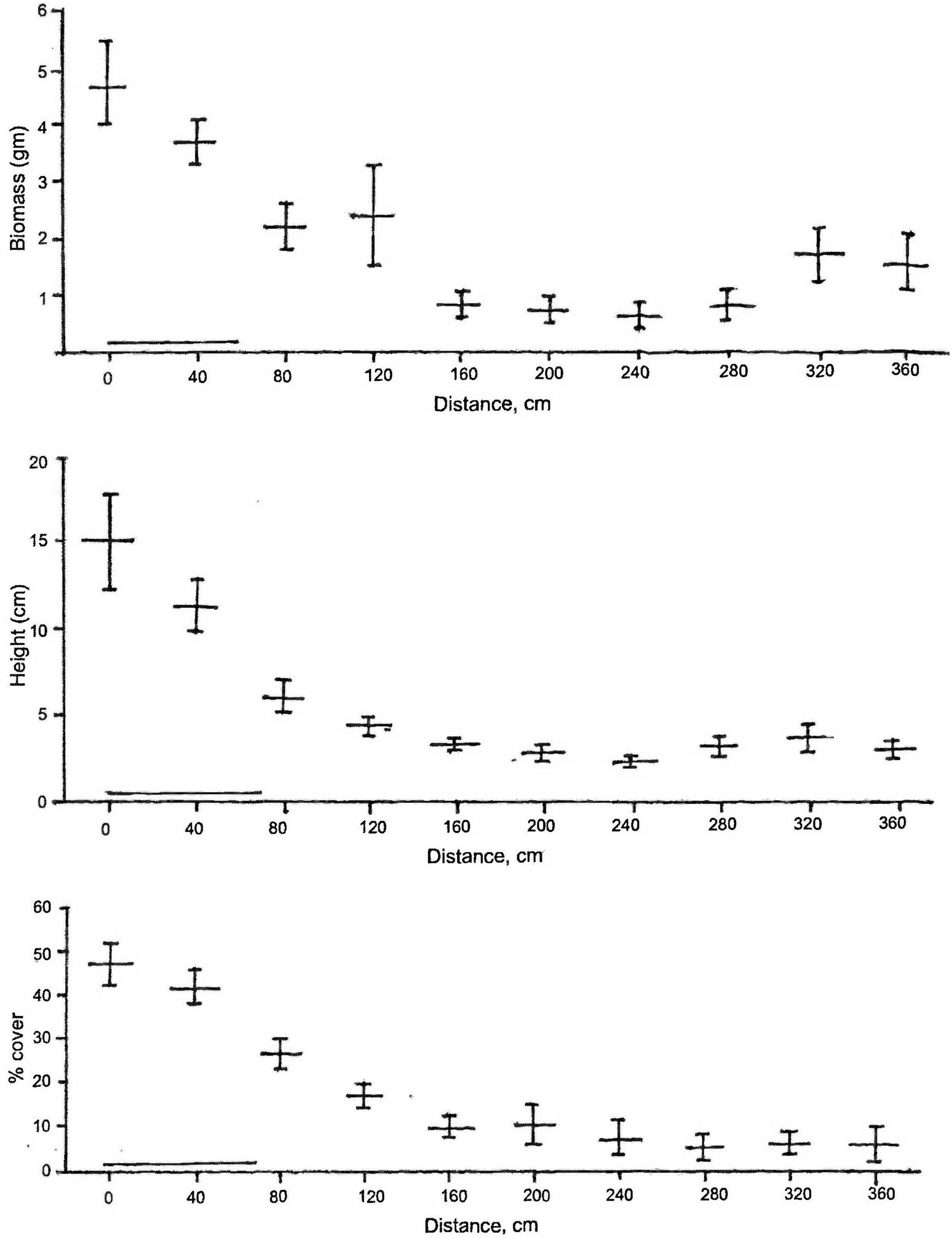

Figure 6. Changes in grass biomass, height and percent cover from the base of mesquite in Little Rann of Kutch, India.

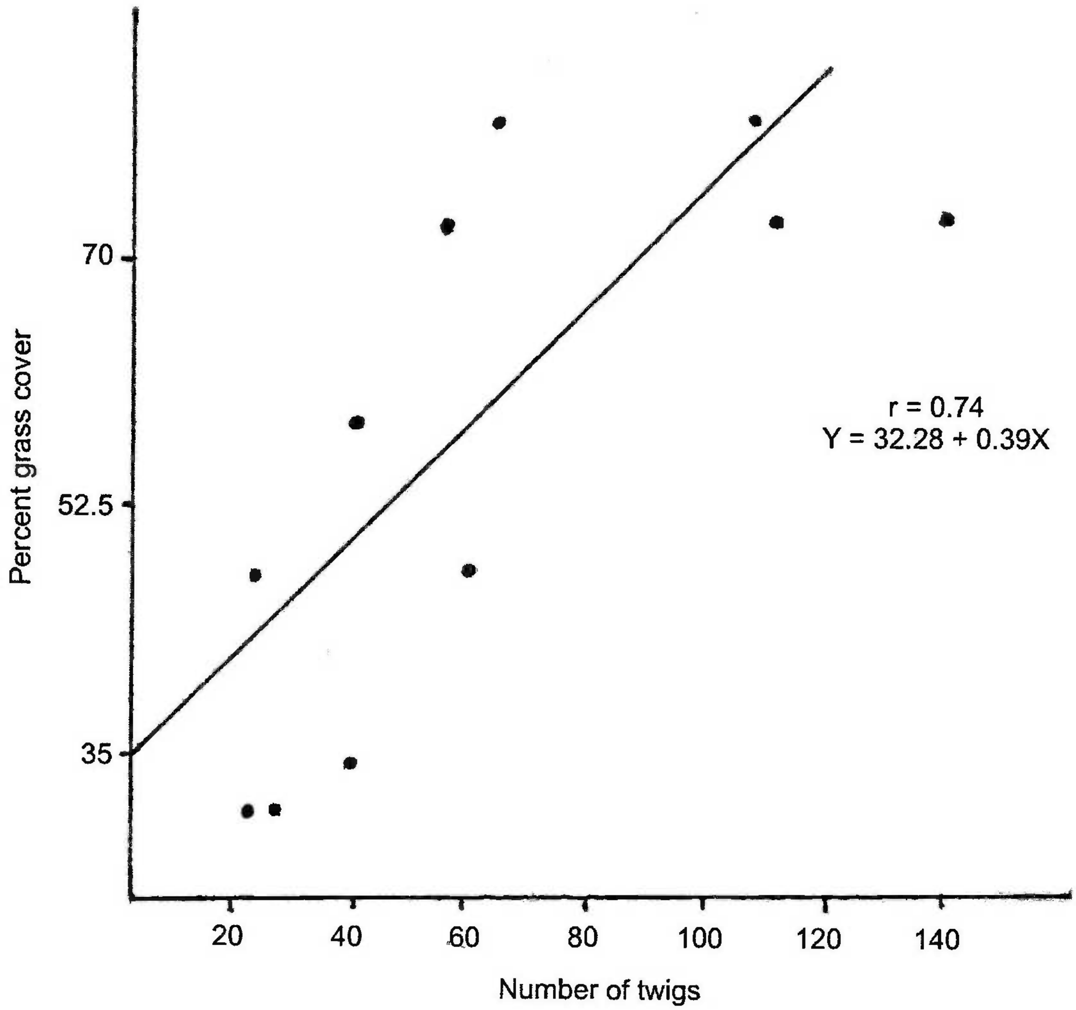

Figure 7. Relationship between percent grass cover and number of mesquite twigs in Little Rann of Kutch, India.