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Present status of small-scale exploitation of mangroves in Rekawa Lagoon, Sri Lanka

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Abstract

Small-scale forest exploitation is reported to have significant impacts on the composition, structure, and regeneration of terrestrial forest types nevertheless, only a few studies have examined mangroves in this respect. Although information related to small-scale harvesting activities in mangroves helps management and conservation initiatives, such information is scanty for Sri Lanka. In order to address this knowledge gap, mangrove cutting/removal data were collected from Boraluwa mangrove community of Rekawa Lagoon (6°03'N 80°50'E), Sri Lanka from 4 transects (30m long, 10m wide; divided into 10 m x 10 m sub-plots) laid perpendicular to the shoreline, in July -December, 2012. The percentage cutting observed during the time ranged from 0% to 17% between the sub-plots while *Aegiceras corniculatum* and *Lumnitzera racemosa* were found to be cut at a higher intensity (10% and 21% respectively). Other mangrove species: *Rhizophora mucronata*, *Excoecaria agallocha* and *Bruguiera gymnorrhiza* reported only 1.0%, 1.3% and 4.2% cutting intensities respectively. Thus the highly vulnerable species for cuttings were *A .corniculatum* and *L. Racemosa.* However, Kruskal–Wallis test did not show a significant difference of cutting intensities between the sub-plots (S = 2.20, $p > 0.05$). The mean height of stems removed by cutting was 48.5 cm (±34.8) and 62.9 cm (±44.7) for *A. corniculatum* and *L. Racemosa* respectively while 5.7 cm (±3.35) and 5.2 cm (±2.5) were their mean diameters respectively. The mean % sprouting of the cut stumps in the transects were 42%, for *A. corniculatum* and it was 68% for *L. racemosa*. The mean number of sprouts (±SD) per stump were 5.9 (±4.5) and 4.3 (±3.2) for *A. corniculatum* and *L. racemosa* respectively. Only 8% of intact trees of both *A. corniculatum* and *L. racemosa* were with diameters larger than 8 cm indicating that larger stems of these two species have been selectively cut in the recent past. As the tree diameter is proportional to the age of the trees, even small scale cutting could affect the age composition and reproductive capacity of the mangrove forests in Rekawa lagoon.

Keywords: Mangrove cutting, Sprouting, Rekawa lagoon, Sri Lanka

Introduction

Mangroves form ecosystems characteristic to inter-tidal areas of tropical and sub-tropical coasts, and they are composed of variety of exclusive and associated species of plants as well as aquatic, semi-aquatic, terrestrial and aerial fauna. (Hogarth 1999; Kathiresan and Bingham 2001). Coastal inhabitants are variously benefited with ecological services generated by functions of mangrove ecosystems, such as production function in relation to provisioning food, medicine and timber, and regulatory function in erosion control, protection from extreme climatic events and habitat function that provides feeding, breeding, resting and protection services for various fauna (Hamilton and Snedaker 1984; Leh and Sasekumar 1984; Robertson and Blaber 1992; Sasekumar et al. 1992; Bennett and Reynolds 1993; Ruitenbeek 1994; Costanza et al. 1997; Bandaranayake 1998; Ronnback 1999). Small-scale mangrove exploitations cause significant impacts on forest structure but only a few studies (Eusebio *et al*. 1986; Smith and Berkes 1993; Walters 2005a, 2005b; Longonje and Dave 2012) have examined the effects of small scale cutting of mangroves on ecosystem structure and functioning. In the Philippines the size selective cutting has been responsible for almost 90% of stem mortality (Walters 2005a, 2005b). In Mida Creek, Kenya, selective removal of small sized poles by the users has stimulated forest regeneration (Kario et al. 2002). Thus, studies on mangrove harvesting can provide valuable information for forestry management and conservation initiatives.

Mangrove distribution in Sri Lanka is patchy and confined to narrow stands along estuaries and lagoons (CCD 1986; Karunathilake 2003). Although small scale cutting of mangroves is practiced in various Sri Lankan mangrove areas (Dahdouh-Guebas *et al*. 2000; Dayananda 2004; Atapattu and Nissanka 2005; Satyanarayana *et al*. 2013) its ecological impacts have poorly been studied.

The objectives of the present study therefore were to determine the intensity of mangrove removal and the potential effect of small scale mangrove cutting on vegetation structure of a selected mangrove stand in Rekawa lagoon.

Materials and methods

Four mangrove transects (30m long, 10m wide) were selected from Boraluwa mangrove community of Rekawa Lagoon (6°03' N; 80°50' E), Sri Lanka and each transect was divided into three 10 m × 10 m study blocks (Figure 1). Mangrove species present, diameter at breast height (dbh), species that have been cut and the condition of stumps (dead/alive/sprouting) were recorded at each block. The dbh was measured at the highest point possible in cases where stumps were cut below 1.3 m (Walters 2005a). The condition, height, dbh and the species of all the intact trees within the plots also were reported. All field data collections were completed between July and December, 2012.

Mean values were calculated for the stem densities (number ha^{-1}), number of cut stumps, height and diameter of the stem at the point of cutting, the %

sprouting of cut stems, % cutting intensities (calculated summing all the species) along with standard deviations.

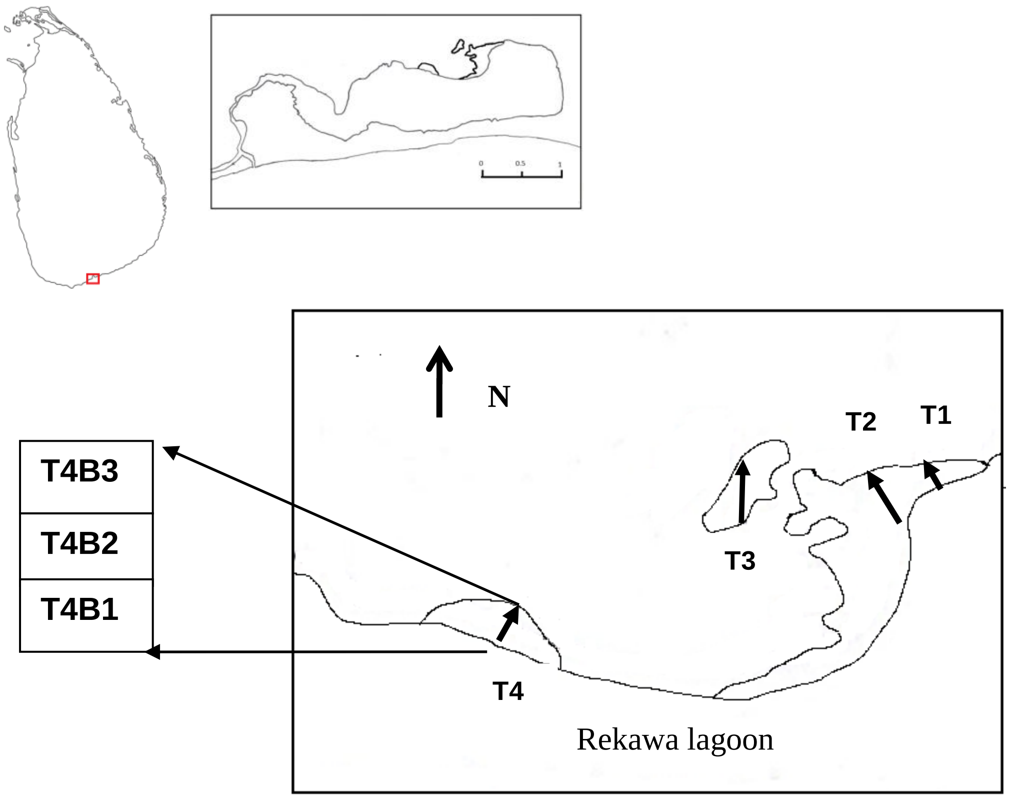

Figure 1. The study sites in Rekawa lagoon and location of the lagoon in Sri Lanka. T1-T4 are the locations of four transects. There are four blocks in each transect. The four blocks in the T4 transect are indicated as T4B1 – T4B3.

The relationship between the height at which the stems have been cut and the number of sprouts per stump were determined using regression analyses. Percentage cutting intensity and relative density (RD) were calculated as;

Percentage cutting intensity = [number of cut trees/number of total (cut and intact) trees] ×100

RD = [Density of the selected species/total density of all species]×100

As data were not normally distributed, the mean values were compared between the transects by Kruskal–Wallis tests for differences.

Results

Mangrove species recorded from the studied transects were *Lumnitzera racemosa, Aegiceras corniculatum, Bruguiera gymnorrhiza, Excoecaria agallocha, Rhizophora mcronata*, *Avicennia marina*, *Avicennia officinalis*.

The values of % cutting intensities calculated summing all the species were not significantly different (Kruskal–Wallis tests: S = 2.20, p = 0.532) between the transects (Table 1). The values of % cutting intensities ranged from 0% to 17.1% between the blocks (Figure 2), while the maximum and minimum cutting intensities were recorded in T2B2 and T2B1 blocks respectively. T2B1 was observed to have higher relative density (75.8%) of *R. mucronata* that resulted 0% cutting intensity (Table 2).

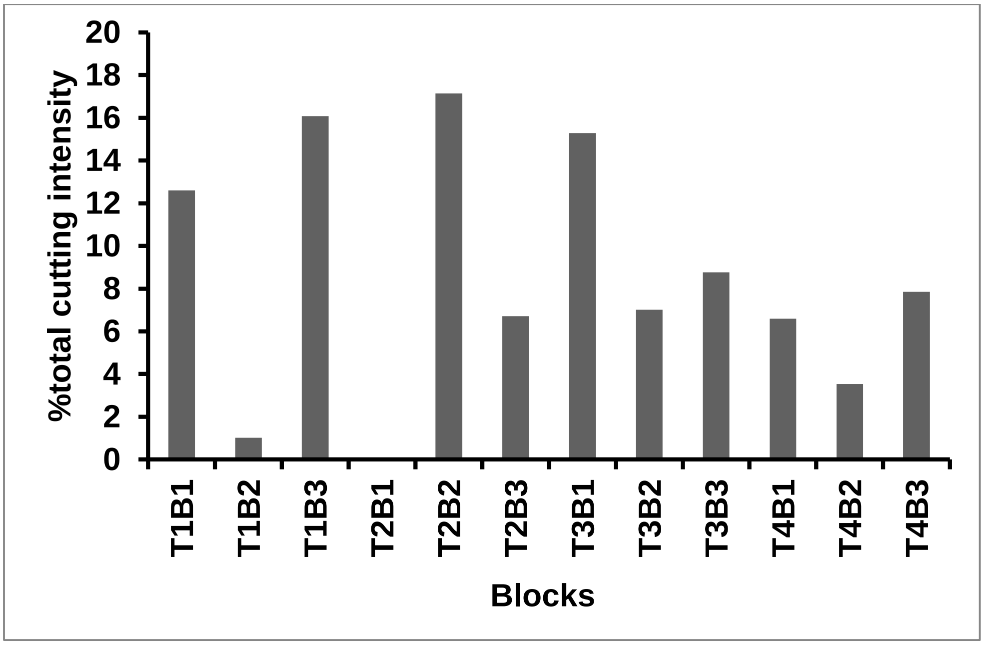

Figure 2. Percentage total cutting intensity between blocks

Table 1. Total % cutting intensity and total stem density of non-cut trees.

	Transect Number			
	1	2	3	4
Cutting intensity %	9.90±7.90	7.93±8.62	10.37±4.37	5.97±2.22
Stem density of non-cut trees	16267±6361	926 ±2991	15800±9597	8033±3126

Table 2. Relative density of species between blocks (cut+non-cut trees).

Transect	Block	Rm	Lr	Ea	Ac	Am	Bg	Ao
T 1	B 1	9.1	57.9	26.4	6.7	0.0	0.0	0.0
T 1	B 2	1.0	15.3	61.2	16.3	6.1	0.0	0.0
T 1	B 3	0.0	53.3	0.0	46.7	0.0	0.0	0.0
T 2	B 1	75.8	12.1	10.6	0.0	0.0	1.5	0.0
T 2	B 2	3.8	36.2	50.5	1.9	0.0	7.6	0.0
T 2	B 3	2.2	20.1	50.7	17.2	0.0	9.7	0.0
T 3	B 1	0.0	0.9	26.4	70.4	0.0	0.0	2.3
T 3	B 2	0.0	12.5	22.6	65.0	0.0	0.0	0.0
T 3	B 3	0.0	7.0	12.3	78.9	0.0	1.8	0.0
T 4	B 1	17.6	25.3	30.8	24.2	1.1	1.1	0.0
T 4	B 2	0.0	3.5	44.2	50.4	1.8	0.0	0.0
T 4	B 3	2.0	21.6	41.2	27.5	7.8	0.0	0.0

Rm=*Rhizophora mcronata,* Lr=*Lumnitzera racemosa, ,* Ea=*Excoecaria agallocha,* Ac=*Aegiceras corniculatum,* Am=*Avicennia marina*, Bg=*Bruguiera gymnorrhiza* Ao=*Avicennia officinalis*

The species-wise % cutting intensity averaged for all the transects ranged from 0 (*A. marina* and *A. officinalis*) to 21.3 (*L. racemosa*) (Table 3; Figure 3). The total intact stem densities (Kruskal–Wallis tests: S = 3.40, p = 0.334) were not significantly differed between the transects (Table 1).

Table 3. Species-wise % cutting intensity and relative density.

Species	% Cutting intensity	Relative Density (cut+non-cut trees)
L. racemosa	21.3	25.4
A.corniculatum	10.4	37.1
B. gymnorrhiza	4.2	1.5
E. agallocha	1.3	29.0
R. mucronata	1.0	6.0
A. marina,	0.0	0.8
A. officinalis	0.0	0.3

The mean height at which trees were cut ranged between 48.5 cm and 62.9 cm for the *A. corniculatum* and *L. racemosa* respectively while mean diameters (±SD) were found to be 5.7 cm (±3.35) and 5.2 cm (±2.5) for the *A. corniculatum* and *L. racemosa* respectively. Ninety five percent of cut stumps in the transects were *L. racemosa* (56%) and *A. corniculatum* (39%). The sprouting percentages of the cut stumps within the blocks were 42.3% (n=59), and 68.1% (n=94) for *A. corniculatum* and *L. racemosa* respectively. The mean number of sprouts (±SD) per stump was 5.9 (±4.5) and 4.3 (±3.2) for *A. corniculatum* and *L. racemosa* respectively. The mean % sprouting of the cut stumps within the transects was 42.3%, and 68.1% for *A. corniculatum* and *L. racemosa* respectively. The number of sprouts per stump significantly increased with increasing cutting height for species.

Within the sub-plots, 91.9% of intact trees had diameter < 8 cm (Figure 4). Among the intact live trees in the sub-plots, 99.6 % of *A. corniculatum* and 76.8% of *L. racemosa* trees had diameter <8 cm (Figures 5 and 6).

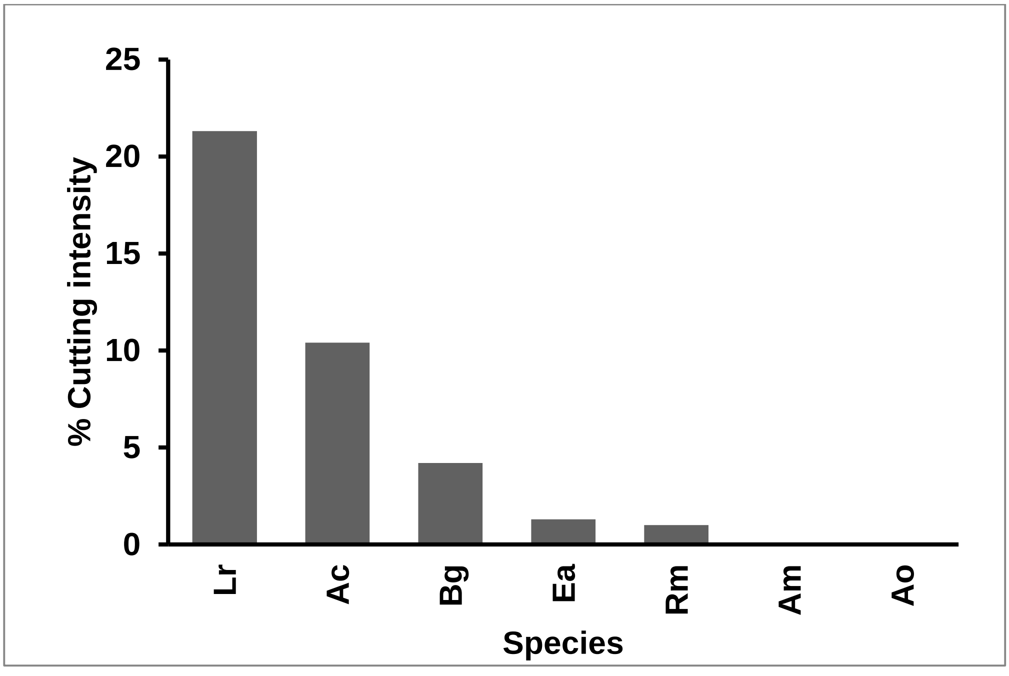

Figure 3. Species-wise cutting intensities averaged for the 4 transects. Lr=*Lumnitzera racemosa,* Ac=*Aegiceras corniculatum,* Bg=*Bruguiera gymnorrhiza,* Ea=*Excoecaria agallocha,* Rm=*Rhizophora mcronata,* Am=*Avicennia marina,* Ao=*Avicennia officinalis*.

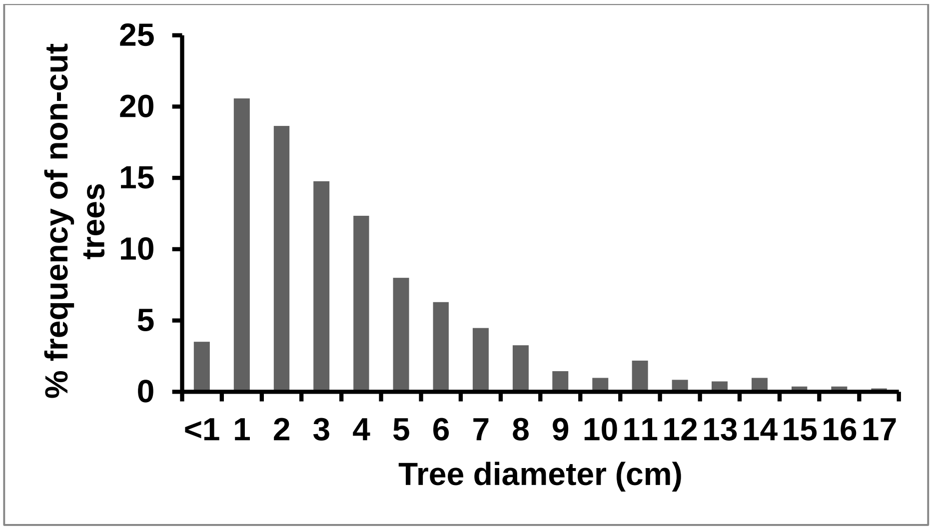

Figure 4. Diameter distribution of non-cut trees of *A. corniculatum* and *L. tacemosa.*

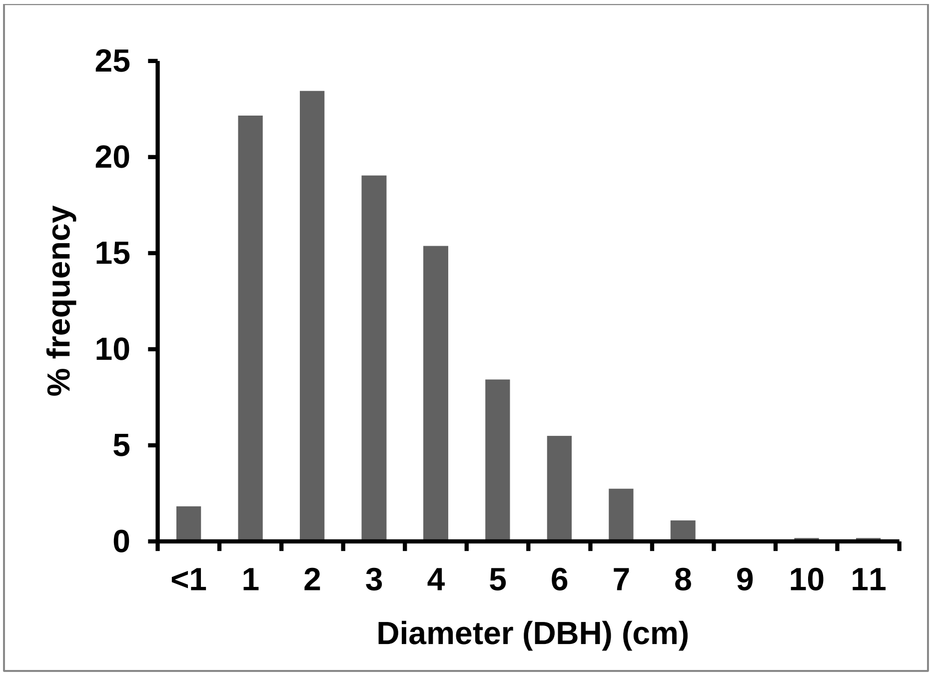

Figure 5. Diameter distribution of non-cut *A. corniculatum* trees.

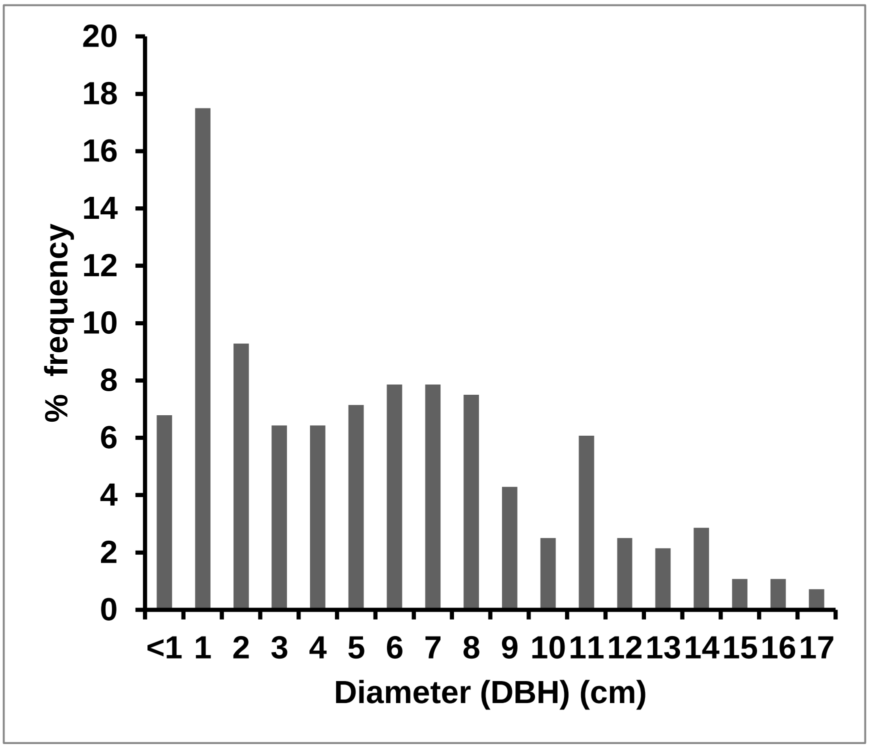

Figure 6. Diameter distribution of non-cut *L. racemosa* trees.

Among the trees that were cut, the highest percentage frequency was recorded at a diameter range of 4-5 cm for *L. racemosa* (22.6%) and *A. corniculatum* (28.1%) while 79.6% of *L. racemosa* and 91.2% of *A. corniculatum* trees that were cut (stumps) were within the diameter classes 3-8 cm (Figure 7). *L. racemosa* showed a significant relationship between total number of intact and cut trees (Figure 8). However, *A. corniculatum* did not show such a relationship.

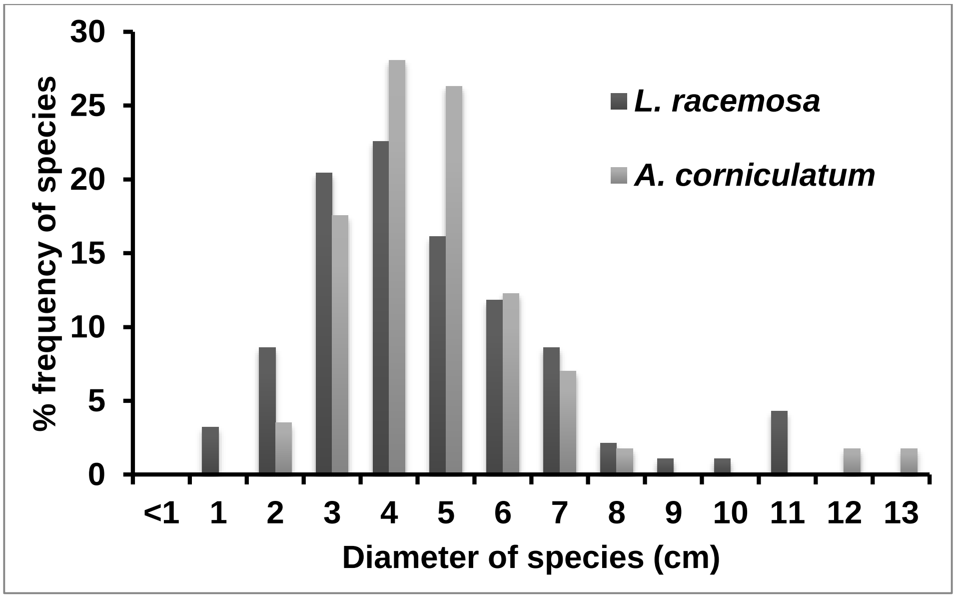

Figure 7. Diameter distribution of cut trees of *L. racemosa* and *A. corniculatum*.

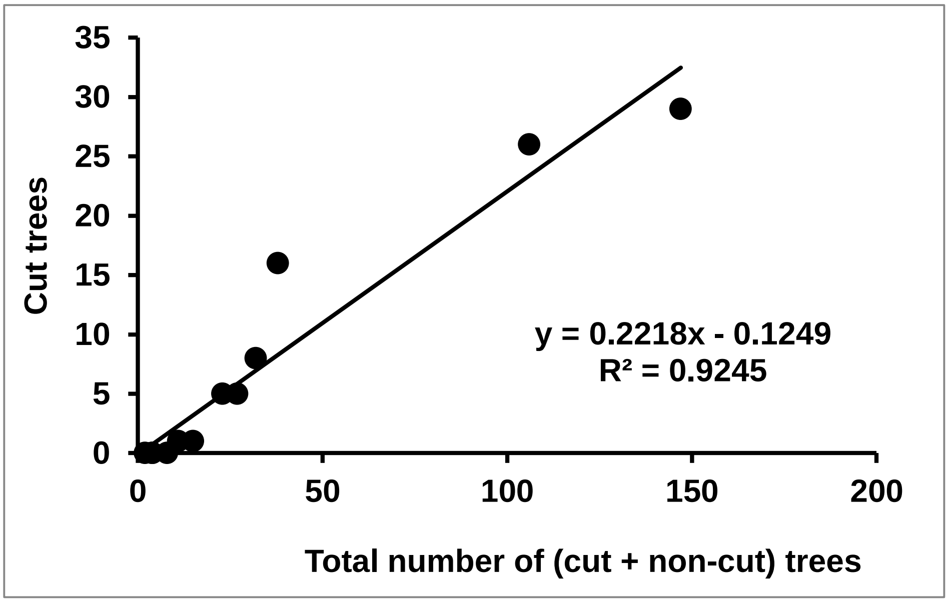

Figure 8. Relationship between the number of total (cut+non-cut) and cut *L. racemosa* in trees.

Discussion

In terms of the % cutting intensity, *A .corniculatum* and *L. racemosa* were highly vulnerable to small-scale harvesting among which the highest vulnerable species was *L. racemosa*. High wood density (0.738 g cm^{-3}) and the slender-erect nature of the stems of *L. racemosa* is preferred for poles for fencing, handles of mamoties, rafts, and constructing frames for wattle and daub houses and to make wooden handles of utensils. Higher abundance of trees as indicated by higher relative densities (37.1 for *A. corniculatum* and 25.4 for *L. racemosa*) may also have attracted cutters towards the study area. A statistically significant relationship that was observed between the number of trees cut and the total (cut+intact) number of *L. racemosa* trees (Figure 8) indicates that people tend to cut mangroves from dense mangrove areas.

Although *E. agallocha* also had higher relative density (29.0), its low wood density (0.390 g cm^{-3}), poor wood quality and the poisonous latex may have distracted people from cutting these trees. In general, higher relative densities of low vulnerable species reduce the total % cutting intensity in some blocks while higher relative densities of high vulnerable species increase % cutting intensity in some other blocks. There are certain areas where there is mangrove cutting (e.g., *R. mucronata* in Plot T2B1; Table 2), but is not clear whether this is due to poor accessibility to the area or due to the reason that the people give relatively a higher value for *R. mucronata* as a mangrove species and hence refrain from cutting them or any other reason.

Dominance of low diameter (<8 cm) of *A. corniculatum* and *L. racemosa* tree stumps in the study area implies that the previous selective cutting operations have mainly focused on bigger trees. Since the tree diameter is proportionate to the age of the trees, small scale harvesting by the villagers appears to have removed mature trees that have higher reproductive capacity. Since the mature trees are the seed producers for natural regeneration process, removal of older trees would directly affect the regeneration potential of the forest. Species and size selective harvesting of mangroves also would affect the species composition of the forest affecting the structure and functioning of the forest.

Observation that 79.6% of *L. racemosa* and 91.2% of *A. corniculatum* trees that were cut had 3 – 8 cm diameter indicates that the villagers continue to harvest the younger trees of these species. Walters (2005a, 2005b) found that the cutting can lead to 90% of tree mortality in mangroves. The tree mortality for the current study was 57.3% and 31.9% for *L. racemosa* and *A. corniculatum* respectively. This indicates that the coppicing rate (from the stumps) of these two species is high. The number of sprouts per stump appeared to increase in *A. corniculatum* and *L. racemosa*, when the stump length is high, i.e. when trees are cut at a greater height above ground, they are able to produce more new sprouts. However, this relationship was not statistically significant ($p>0.05$). The tree bark plays an important role during sprouting of cut stumps and presence of greater extent of intact bark in stumps appears to result higher number of sprouts. However, more studies with a large sample sizes are needed to confirm this.

A. corniculatum and *L. racemosa* are the most exploited, especially as light timber, species in the mangrove vegetation at Boraluwa area of Rekawa lagoon. The level of exploitation of mangrove species appear to differ from one area to another, even in the same lagoon, depending on their habitat, utility value, abundance and growth characteristics.

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