

VEGETATION AND THE REGENERATION OF MOIST DECIDUOUS FORESTS AT SIGIRIYA, SRI LANKA

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Abstract

Study of the vegetation, seed rain, soil seed bank and the seedling bank of two moist deciduous forest patches at Sigiriya area reveals that most of the plants those grow in them forests were shrubs or treelets but very few individuals of large valuable timber trees were present. Both seed rain and soil seed bank contained large quantities of seeds of agricultural weeds. Seeds of forest tree and shrub species were present only in their fruiting season. Seedling bank also contained many understory shrub species. Because of this poor seed rain, soil seed bank and the seedling bank and unplanned uncontrolled human activities, the natural regeneration of these forests is very poor. Therefore it is necessary to conserve and manage these forests in a sustainable way. As these forests inhabit many valuable timber tree species, there is a possibility for sustainable timber production. However, it is necessary to rehabilitate these forests first before implementing any sustainable management practices.

Key words: Moist deciduous forests, Sigiriya, regeneration, soil seed bank, seedling bank

Introduction

Although the dry land of Sri Lanka extends over about 60% of the total island area and bears nearly 80% of the natural forests of the island (Anon, 1991), they have not received adequate scientific attention. These forests have been selectively logged since the Dutch colonial time and are still highly used by rural local people.

In the past, the physiognomy and species composition of these dry forests have been studied by a few scientists (de Rosayro, 1950, 1958 and 1961; Koelmeyer, 1958, 1959; Grellier and Balasubramaniam, 1980). Despite the fact that the species composition of dry zone forests is mainly determined by rainfall and temperature, it may slightly vary from one place to the other depending on the variations of soil type and soil moisture levels, the nature and degree of disturbances taking place. Therefore, different scientists have observed slight differences in the species composition and abundance of these forests and have used different terminology in naming them [Dry Mixed evergreen forests (de Rosayro, 1950), Moist deciduous forests (Koelmeyer, 1957), Semi-evergreen forests (Dittus, 1977) and as *Vitex*, *Berrya*, *Schleichera*, *Chloroxylon*, *Manilkara*, *Drypetes* zone (Grellier and Balasubramaniam, 1980)].

The species diversity of these studied forests is found to be low while the habitat diversity is very high (Perera, 1998) but the natural regeneration in these dry forests has been found to be very poor (Holmes, 1956 and 1957; de Rosayro, 1961). Root competition and lack of adequate soil moisture especially in the dry season are cited as reasons for this. There can be many other factors which result in poor forest regeneration and these are yet to be studied. However, these early studies have mainly focused on the regeneration of valuable timber species.

Therefore, in this paper, I describe the physiognomy of dry deciduous forests in the Sigiriya area of Sri Lanka and discuss some of the factors which affect their natural regeneration.

Methods and Material

Study site

This study was carried out in the high forest of the Sigiriya sanctuary and at Gallinda high forest of the Minneriya-Giritale Nature reserve (7°57'N; 80°45'E). The mean annual rain fall of the area is about 1700 mm and the mean annual temperature is around 27°C. The major dry season is from May to September and the major rainy season begins in October and continues until February in the next year.

Gallinda high forest is a mature high forest which is situated on a hilly site and is the catchment to several ancient tanks (reservoirs) (e.g. Minneriya tank, Mahawewa tank). In contrast, Sigiriya high forest is situated on a flat area in a historical site near the small town, Sigiriya. It has had some anthropogenic influence in the past. Although any documented historical evidence could not prove the idea,¹ the existence of some archaeological monuments (stone columns) within the forest, presence of only a few emergent species and the presence of tree species such as *Dimocarpus longan* in the upper canopy reflects its secondary nature. These two forest patches are connected by secondary forests at different ages of succession.

Sampling

Establishment of experimental plots

In the selected forest patches at Sigiriya and Gallinda, six 20 x 20 m² experimental plots were established. For this, the length across each forest stand was measured using a compass and a tape and an access path was cut along the line when necessary. Then, new access paths were cut from randomly chosen points along the first access path to the edges of the forest stand. According to the protocol described by Alder and Synnott (1992), experimental plots were established at randomly chosen points on these secondary access paths.

Vegetation sampling

The standing vegetation in the 20 x 20 m² plots was enumerated by counting the number of individuals taller than 60 cm, by species. The diameter of trees =5 cm at breast height (dbh) was measured. If an individual plant has several stems, only the tallest stem was measured. Voucher specimens of all species were collected and identified by comparing with those in the National Herbarium of the Royal Botanical Gardens, Peradeniya, Sri Lanka.

Sampling the soil seed bank

Soil samples for this study were collected from the established 20x20 m² experimental plots. The first sampling was done in the early part of the long dry period (July, 1995). A random location was selected (using a random number generator) on one of the axes of each experimental plot. A string was pulled from the randomly chosen point across each plot. Ten soil samples to 4 cm depth (surface area = 15x15 cm²) were carefully removed at 2 m intervals along the line and put in labelled polythene bags. The soil samples were taken to the shade house at Mahailuppallama where they were mixed together, spread over prepared sand beds (that had been heat sterilized) and kept well watered using a hand-held sprayer. Sixty days after the original spreading, the soil layer was scarified in order to expose any buried seeds. Germinants were marked and recorded (code number and the date of germination) every two days for 110 days from the date of spreading. Most germinants were identified, but most of those that could not were potted and identified 10-12 months later. Grasses and ferns were not identified to the species level. Five sand beds were left without any soil in order to detect contamination, if any.

This procedure was repeated on two further occasions, at the beginning of the long rainy period (November, 1995) and at the end of it (February, 1996). One month old forest was only sampled in February because the shifting cultivation areas are abandoned in late January or in early February but are not available between July and October. The same procedure was followed for soil samples collected at 4-8 cm depth. The sampling was done in July, 1995 at the same time as sampling at 0-4 cm soil depth.

Sampling seedling bank dynamics

2 x 2 m quadrats were established at randomly chosen points in each experimental plot and seedlings in them were tagged and recorded in every month. In this study, individuals shorter than 60 cm were considered as seedlings.

¹ According to the officers of the Cultural Triangle, Sri Lanka, who have authority over the forest at present.

Results and Discussion

In the study area, 55 plant species were found in the vegetation. In both forest patches, there were many seeds of grass species in the soil but these were not identified to the species level. Total number of seeds found in the soil seed bank of Sigiriya forest under the area sampled was 493 and there were 25 dicot species. In the Gallinda forests, there were 182 seeds in the soil seed bank in sample of the same size and there were 25 dicot species. In the seedling bank, twenty two tree and shrub species were found.

Density and Species Abundance

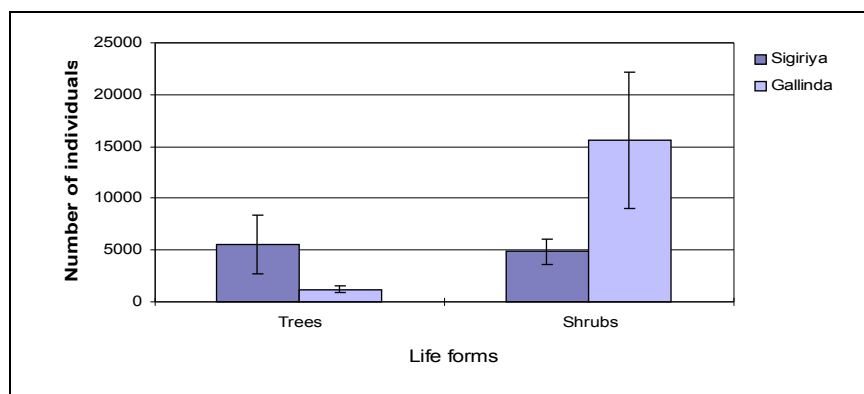


Figure 1. Density of tree and shrub species at Sigiriya and Gallinda high forests with 95% confidence limits

The total number of individuals in the Gallinda forest was higher than that of Sigiriya (t test: $p = 0.17$). This is due to the presence of many smaller shrub species at Gallinda forest (Figure 1). The most common tree species were estimated by counting the individuals of the most abundant tree species which comprised 75% of all trees. The most common shrub species were estimated by counting the individuals of most abundant shrub species which comprised 95% of all shrubs (Table 1).

Species richness at the Sigiriya forest is slightly higher than that of Gallinda forest but almost all the species that grow at Gallinda forest also grow at Sigiriya forest except the shrub *Stenosiphonium cordifolium* which is only present at Gallinda forest. *Stenosiphonium cordifolium* is a semi-woody species which grows up to about 2 m. It does not produce prominent branches and therefore, the crown periphery of the species is smaller compared to many other shrubs such as *Glycosmis mauritiana* and *Polyalthia korinti*. Therefore, many individuals of the species inhabit the forest floor at Gallinda forest and as a result, the density of shrubs is higher at Gallinda than Sigiriya (Table 1).

Table 1. Most common tree and shrub species at Sigiriya and Gallinda

Sigiriya	Gallinda
Trees	
<i>Dimocarpus longan</i>	<i>Drypetes sepiaria</i>
<i>Diospyros ovalifolia</i>	<i>Diospyros ovalifolia</i>
<i>Dimorphocalyx glabellus</i>	<i>Tricalysia dalzellii</i>
<i>Eugenia bracteata</i>	<i>Pterospermum suberifolium</i>
<i>Diplodiscus verrucosus</i>	
<i>Pterospermum suberifolium</i>	
<i>Tarenna asiatica</i>	
<i>Drypetes sepiaria</i>	

Shrubs

Glycosmis mauritiana
Polyalthia korinti
Memecylon umbellatum
Salacia oblonga
Croton laccifer

Stenosiphonium cordifolium
Glycosmis mauritiana
Polyalthia korinti

Although there were some slight differences in species composition, ordination analyses have already proved that the species composition and abundance of the vegetation of the two forest patches are not drastic to categorize these as two different communities (Perera, 1998). Slight differences in species composition or abundance is inherent to any forest community and it is an inherent property of habitat diversity. It has been found that, although the alpha diversity (species richness and evenness of their distribution) is low in these two sites, the habitat diversity is very high (Perera, 1998).

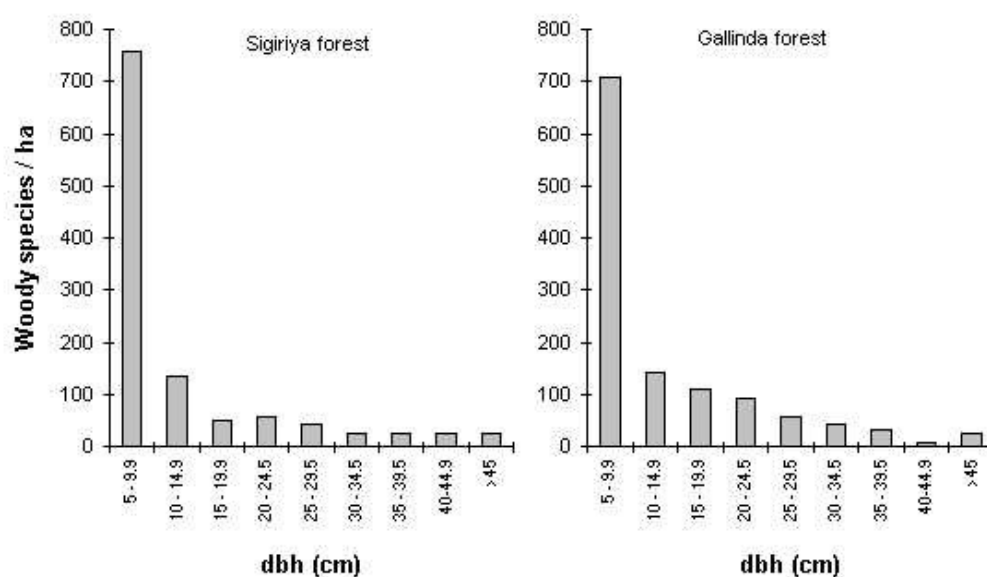


Figure 2. Diameter distribution of individuals where the diameter is >5 cm.

It is also evident from Figure 1 that the density of trees is higher at Sigiriya forest than that in Gallinda forest (t test: $p = 0.11$). This is due to the presence of some small trees and tree saplings in the understorey of Sigiriya forests. For instance, small trees such as *Acronychia pedunculata* and *Dimorphocalyx glabellus* and the saplings of *Dimocarpus longan* are very common at Sigiriya forest. However, the density of mature canopy and dominant trees are more less the same in both forests (Figure 3).

Figure 2 shows the size-class distribution of those individuals which have diameters at breast height greater than 5 cm. In both forests, there are very few very large trees and the majority have smaller diameters. It is because there are many tall shrubs and small trees in these forests.

Soil seed bank

The soil seed bank significantly varied with the site as well as with the time of the year. (General linear model: probability for two sites = 0.002; probability for the time of the year = 0.015). As shown in Figure 3, the seed bank is mainly dominated by seeds of grass and agricultural weed species in both forest patches. However, the seed bank of Sigiriya forest contained more grass seeds than the Gallinda forest. Seeds were mainly available in the major rainy season (October-January) but a small number of species including a few climax forest species (e.g. *Drypetes sepiaria*) produced seeds during the short rainy period

(April - May). It was also observed that seeds of some climax forest species were found only in their fruiting season. However, seeds of climax forest species are recalcitrant and do not remain viable in the soil seed bank for a long period. Also, these seeds were highly predated by rodents and insects (Personal observation).

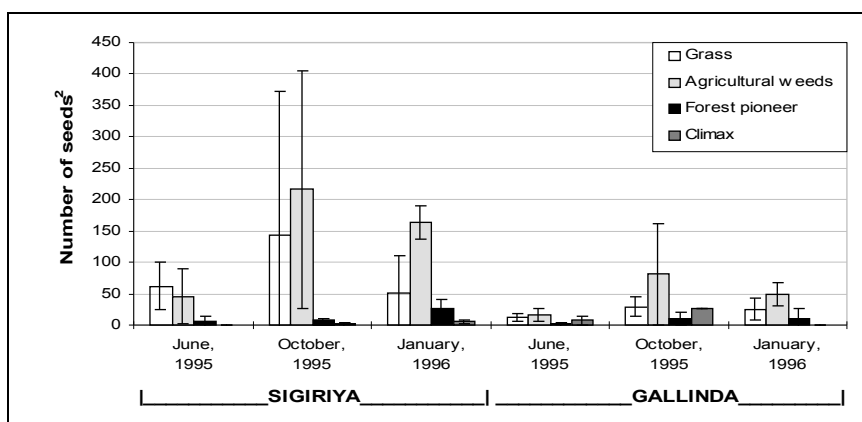


Figure 3. Number of seeds in the seed bank at Sigiriya and Gallinda forests at three different times of the year with 95% confidence limits.

Thus it is clear that seeds in the soil seed bank would not be a good source of forest regeneration. If a disturbance takes place in such forests, seeds of grasses and agricultural weeds may germinate and establish unless the seedlings in the seedling bank occupy the gap. This will lead to a gradual degradation of forests.

Selective removal of mature good quality timber species is one major reason for the lack of climax forest timber tree species in the soil seed bank. However, pre- and post-dispersal seed predation, inadequate propagule distribution and natural and artificial disturbances also affect this. These artificial disturbances include swidden agriculture, removal of forest products (both timber and non-timber), damage by large herbivores (e.g. elephants), high soil erosion after selective logging, grazing by domestic cattle and goats and fire effect in reducing the natural regeneration in different localities.

Seedling composition and abundance

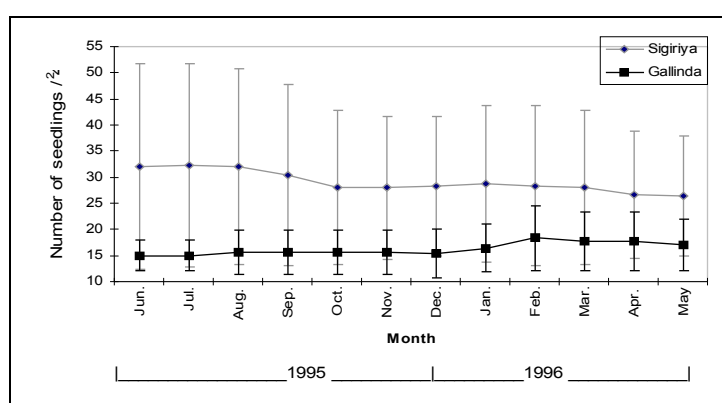


Figure 4. Number of seedlings over a period of 11 months with 95 % confidence limits.

It is evident from Figure 4 that the number of seedlings in the forest floor was more or less the same through out the study period. However, the total number of seedlings / m² was always higher at Sigiriya forest than that in Gallinda forest. Some seedlings died mainly in dry periods while some others recruited especially in the wet period. Drought, intermittent rain during the wet period, termite attacks and herbivory were responsible for the death of

seedlings. Die back of seedlings was also common in the dry season. As a result, the upper part of the shoot dries up but the root survives to make sprouts in the wet season. Soil excavation by wild animals (e.g. wild boar, pocupines etc.) was higher during the major rainy season, uprooting many of the seedlings.

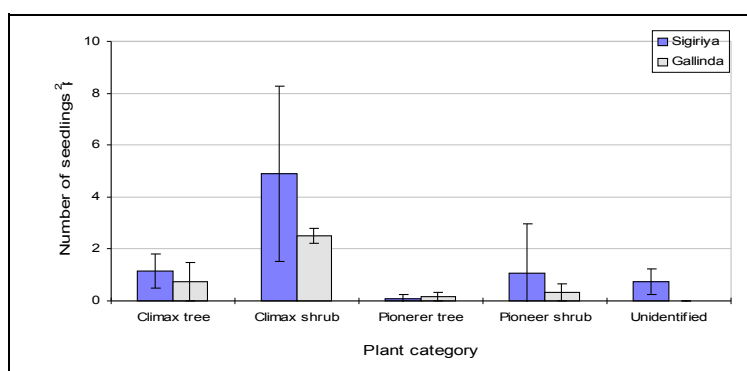


Figure 5. Number of seedlings per m² at Sigiriya and Gallinda forests in the month June, 1995 with 95% confidence limits.

Figure 5 depicts the abundance of seedlings in the month of June, 1995. There the seedlings were categorized into four groups by considering their life form and ecological significance as climax tree, climax shrub, forest pioneer tree and forest pioneer shrub. Nine out of all the tagged seedlings could not be identified as they died at very young stages. In both forest patches, the seedling bank was dominated by climax shrub species and there was no significant difference between the number of climax shrub species in both forests (t test: $p = 0.24$). Seedlings of pioneer tree and shrub species were not very common in the seedling bank. The amount of sunlight reaching the forest floor is very low due to the dense forest understory (Perera, 1998) and therefore, seeds of forests pioneers may not be able to germinate or grow as they germinate and establish only in open sites.

There were many seedlings of climax shrub species while seedlings of climax forest tree species were rare in both forests. If a canopy gap is formed after a disturbance, it will fill with species other than climax tree species. Therefore, there is a possibility of change in the composition of the vegetation. However, it depends on whether new climax forest seeds would come to the site with the seed rain, their successful germination and establishment under the shrub canopy. If not, these climax shrub species may be replaced with forest pioneer species or with grasses and agricultural weeds.

Conclusion

1. These two forest patches belong to a same community. Slight differences between the two forest patches were observed but they may be due to slight differences in topography or due to differences in human influences in two sites.
2. The quality of the forest soil seed bank is very poor and seeds of many agricultural weeds are present in high numbers. As a result of this, soil seed bank is not a good source for natural regeneration in both sites.
3. Quality and quantity of the seedling bank is poor. Many climax forest shrub species germinate and establish in the seedling bank but very few climax tree species were present in the seedling bank.
4. These forests should be protected from unplanned, uncontrolled human activities, and steps taken to restore and assist natural regeneration and manage them in a sustainable way. However, the methods of restoration and sustainable management should be further experimented.

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Appendix 1

Box 1 - Characters of ecological groups that were used in categorizing forest species.
<i>Early seral Species</i> - germinate and establish in large forest gaps or in man—made clearings - small seeded - shade intolerant - fast growing - reproduce annually or continuously
<i>Late seral species</i> - germinate in sun - reproduce annually or super-annually - shade intolerant - fast growing - live longer than early seral species and thereby grow in mature secondary or high forests

Primary (Climax) forest species

large seeded

slow growing

long—lived species that reproduce annually or super-annually

frequently occur in undisturbed high forests but not on disturbed sites (according to local people)