



Population ecology, threats, status and conservation of natural populations of *Crotalaria longipes* - an endangered plant

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Abstract

Crotalaria longipes is an endangered plant endemic to Kolli hills. It is one of the fifteen species listed in the Red Data Book of Indian plants. Initially field visits were made to locate the plant at Kolli hills. The general field observations revealed that the distribution of this species is limited to a very narrow range, the Kolli Hills, Tamil Nadu, India. *C. longipes* was found in association mostly with *Lantana camara*, and *Solanum pubescens*. The extent of occurrence and the area of occupancy of *C. longipes* were calculated from the map. The extent of occurrence was found to be 24-sq. km. and the area of occupancy was approximately 4 sq. km. Two populations of Kolli hills, were taken up for a detailed population study. Hundred plants from both populations were sampled. It was found that nearly twice the number of seedlings was found in population 2 than in population 1. There were no plants of height more than 4 m in population 2. Seekuparaipatti population was denser than the Solakadu population. Mature plants were 13 and 22 in number in Solakadu and Seekuparaipatti populations respectively. The lepidoteran insects associated with these plants indicated to the presence of pyrrolizidine alkaloids in these plants. Germination of seeds at the site was very low. Seeds were brought to the laboratory and acid scarified which helped in germination. The germination percentage obtained was 85.3 and 86.6 in population 1 and population 2 respectively. The gene bank stored seed (germinated after scarification after a year) exhibited a slight reduction in the germination (79 and 81 in population 1 and 2 respectively). The status of *C. longipes* was analyzed using the IUCN criteria (Mace and Stuart, 1994). The probability of extinction was calculated based on the population reduction, extent of occurrence, number of mature individuals and the population estimates. The plant was given the status of critically endangered. Human influences on populations were also studied. The local perception about this plant was studied and the locals were encouraged to conserve this plant.

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Introduction

In India until a couple of years back the Red Data Books published by the Botanical Survey of India (Nayar and Sastry, 1987, 1988, 1990) were the only sources of information on threatened plants. The genus *Crotalaria* has the largest number of threatened species listed in the Red Data Book. This is the genus known for the presence of pyrrolizidine alkaloids. 24 alkaloids have been isolated from 18 different species of *Crotalaria*s. *C. longipes* is one among the 15 species listed in the red data books. It is a woody shrub growing upto 4m tall with bright yellow flowers endemic to Nilgiris and Kolli hills. During our visits to Nilgiris, we could not locate this plant. But we were able to locate a few populations at Kolli hills. Conservation efforts in an effective manner depend on basic information such as geographical distribution of the species, population ecology and the possible threats to the population. Unfortunately none of these data is available in this endangered species. Hence this present study was undertaken to find out the extent of occurrence and area of occupancy of this species at Kolli hills. Two populations found in strikingly different microhabitats were taken up for a detailed population study.

Materials and methods

Study site

The study site, Kolli Hills belongs to the state of Tamil Nadu. The State lies between 8°5' and 13°35' N and 76°5' and 80°20' E situated in the eastern part of the southernmost part of Indian Peninsula. The Kolli hill ranges (Kollimalais) having an area of 490 sq.km. is situated in Namakkal Taluk of Salem district. Kollimalai's are a block of hills on the southwestern part of Eastern Ghats. The altitude ranges from 1000 to 1300m and reaches a maximum of 1450m at a place called Kuzhivalaivu. The vegetation is that of the hill category with semi-evergreen and dry deciduous type forests, found in patches. The dominant trees are *Artocarpus heterophyllous*, *A. hirsutus*, *Diospyros* spp., *Melia dubia*, *Syzygium cumini*, *Vernonia arborea*, *Ficus* spp. etc. The

important shrubs are *Solanum pubescens*, *Leea indica*, *Strobilanthes* spp., *Rubus fulvus*, etc., There are plenty of orchids (epiphytic) occurring in certain pockets, particularly in Solakadu and Kuzhivalavu. The foothill region is with dense bamboo (*Bambusa arundinacea*) brakes. Degraded open forests have appeared in succession to grasslands and these could be seen in patches. The tribal group called the Malayalis inhabits Kolli hills. Their main occupation is agriculture. Paddy cultivation is prevalent here. Among millets they grow Kevru (*Eleusine coracana*), Varagu (*Panicum miliaceum*), Samai (*Panicum miliare*), Cumbu (*Pennisetum typhoides*) and Tenai (*Setaria italica*). Crops like Cholam (*Sorghum vulgare*) and wheat (*Triticum aestivum*) are also cultivated. However, Tapioca and Pineapple are invariably replacing these crops.

Distribution of *C. longipes* and population studies

The distribution and field studies on *C. longipes* at Kolli hills were done by direct field survey. The distribution of this species is localized on these hills and the populations were found in patches. Kolli hills have about 243 villages and they are coming under the panchayats or nadus. Hence for easy identification, the place where *C. longipes* was found is marked on the Kolli hills map according to the name of the village. Several field trips of duration ranging from 2 days to 10 days were made at regular intervals to the study site extending over a period of more than 2 years. The first step of our study was to find out the distribution of *C. longipes* in these hills. The distribution study was done by direct site survey. Two fairly good populations found at Seekuparaipatti and Solakadu were taken up for a detailed survey. Solakadu population was found amidst a heavily disturbed site, on the roadside where there is constant human interference, while the Seekuparaipatti population was found on an interior hillside in a relatively undisturbed area. Parameters studied were altitude, habitat, associated species, pests and predators occurring on this plant. The human influence on the survival of this species was also observed. Samples were studied by walking

along a transect for a distance of 4 km. Height, girth, interplant distance were calculated for all the 3 sites, percentage maturity and percentage infestation were also calculated. The percentage of flowers produced, percentage flowers infested and mean numbers of seeds that are produced were found out from the data taken from these plants during flowering and fruiting season (March-June). With all the data obtained in the field study the status of *C. longipes* was assessed using the latest IUCN criteria (Mace and Stuart, 1994).

Seed germination studies and ex situ conservation

Seeds were collected from both the populations and planted in poly-bags with soil from the site and kept at the site itself. Another set of seeds was brought to the laboratory for germination studies. 25 seeds in three replications were planted in sterile soil. Same numbers of seeds in three replications was scarified using concentrated sulphuric acid. Mechanical scarification was also tried in 25 seeds in three replications. One set of seeds was placed in the Gene bank of MSSRF for one year after which they were taken out and germinated. Germination percentage obtained in all the experiments was noted down. The germinated seedlings were maintained in the growth chamber for one month at MSSRF and then later planted at a protected site.

Local people interaction

During the entire course of this study discussions were made with the local people about *C. longipes*. Tribal responses were noted. Three principal villages viz. Perumparappupatti, Solakadu and Seekuparaipatti (where *C. longipes* is found as a fairly good population) were visited and the local people were explained about the importance of *C. longipes* by the use of charts and pamphlets in local language. The points in the chart brought out the importance of the plant, its high degree of threat, its medicinal value and its need to be protected. After the informal interactions, charts were displayed and pamphlets were distributed to the five selected persons (Conservation Corps) from each of these

villages. These Conservation Corps were encouraged to share this information with the other tribal people of their village. Seedlings were distributed to about 25 families in each of these villages. The tribal people showed interest in taking this plant and planting them in their own land.

Results

Field observations

C. longipes is a perennial mesophyllous phanerophyte, restricted to usually one type of community but occasionally found in others. Species mostly found along roadsides, waysides on hills, especially in exposed degraded forests, forest fringes and in grasslands, usually at an altitude above 1100 m. The plant grows singly and usually prefers moderate heat and moisture conditions. It requires bright sunlight. Plant prefers to grow in slightly coarse red acidic (pH 6.4) soil moderately supplied with mineral nutrients. Plants rarely found in large numbers. The average number of individuals per area sampled is strikingly very low. The species is with no definite distribution pattern, dispersed irregularly. In a broad sense *C. longipes* is confined to the Oriental bio-geographic zone of the world. The distribution of this species is primarily controlled by climatic conditions and edaphic conditions and thus limited to a very narrow range, the Kolli Hills, Tamil Nadu, India. Kolli hills are the type locality of *C. longipes*. Distribution is that of sympatric type in which closely related species, *C. beteroana* is occupying the same area. *C. longipes* was found in association mostly with *Lantana camara*, and *Solanum pubescens*. Many other edge species were also found associated with *Crotalaria*. These species are *Lantana camera*, *Stobilanthes spp.*, *Justicia gendarisha*, *Callicarpa tomentosa*, *Pinus spp.*, *Eucalyptus spp.*, *Urena lobata*, *Sida cordifolia*, *Grewelia robusta*, *Artocarpus indegrifolia*, *Ficus glomerata*, *Syzygium cuminii*, *Parsiflora edulis*, *Acacia spp.*, *Melia dubia*, *Gmelina arborea*, *Murraya exotica*, *Agave sisalana*, *Cassia occidentalis*, *Solanum pubescens*, *Solanum torvum*. Reproduction in this plant is amphimixis, involving union of two gametes. Budding, flowering,

and fruiting usually are between months of January to April. Dispersal of seeds is by wind. Pollination is usually by moths and butterflies. Butterflies like *Euploea core core* and *Danaus limnaceae* were found to be the major pollinators and they are found in large numbers during the flowering season.

Table 1. Characteristics of two *C. longipes* populations studied at Kolli hills.

Parameters	Population 1	Population 2
Location name	Solakadu	Seekuparaipatti
Altitude	1100m	1300
No. of plants sampled	100	100
Mean number of pest infested plants	62	32
Number of flowering plants	13	22
Mean number of flowers produced	208	255
Mean number of flowers infested	183	142
Mean number of seeds produced	8.1	8.4

Table 2. Germination percentages obtained with *C. longipes* under different.

	% ± S.D	% ± S.D
At site	17.3±2.08	16.0±1.53
In soil	18.7±0.58	20.0±1.53
Acid scarification	85.3±0.58	86.6±1.15
Mechanical scarification	82.6±1.15	84.0±1.00
Gene bank	79.7±2.00	81.3±1.53

Population studies

About 5 villages were located where a fairly good population of *C. longipes* was found. These five populations are depicted on the map and they are Solakadu, Ariyursolakadu, Seekuparaipatti, Perumparapupatti and Senkadu. The extent of occurrence and the area of occupancy of *C. longipes* were calculated from the map. The extent of occurrence was found to be 24-sq. km. and the area of occupancy was approximately 4 sq. km. In Solakadu and Ariyursolakadu the plants are on

roadsides and these are highly disturbed areas. In other places the plants are found in open hilly lands. Fairly large number of plants was found only in Solakadu and Seekuparaipatti and hence these two places were selected for a detailed population study. Hundred plants from both populations were sampled. It was found that nearly twice the number of seedlings was found in population 2 than in population 1. There were no plants of height more than 4 m in population 2. Population 1 had only 16 plants with interplant distance less than 1 m and had 26 plants with inter plant distance more than 3m, which indicates that plants are denser in Seekuparaipatti population. Mature plants (with flowers) were only 13 and 22 in number in Solakadu and Seekuparaipatti populations respectively (Table 1). Large numbers of caterpillars were found in population 1 when compared to population 2, both in the case of leaves and flowers. Caterpillars that was found to be feeding on the leaves were the caterpillars of *Utetheisa pulchella* and those damaging flowers were *Argynus syringae*. These are found in both populations throughout the year. Germination was very poor at the site as well as in soil in seeds of both the populations. Acid scarification gave the maximum germination percentage in both the populations (85.3 and 86.6 in population 1 and population 2 respectively). Slight reduction in germination was seen in gene bank stored seeds. However the percentage germination was more than 75% in both the populations (Table 2). The germinated plants after a month of hardening in the growth chamber were transferred to the mist chamber for two weeks. These plants were taken to a protected site at Kolli hills and planted with the help of the Forest Department.

The status of *C. longipes* was analyzed using the IUCN criteria (Mace and Stuart,1994) and the plant was given the status of critically endangered. The details are given in Table 3.

Discussion

Population studies and threats to C. longipes

C. longipes, the focus of present study is restricted to an active area of just 24 sq. km in Kolli hills. The habitat of this endemic taxon is extremely narrow. It always grows above 1500 m altitude in open forest areas in heliophilous conditions along the forest fringes in coarse gravely soil. A study of the vegetative characters has shown that there are significant differences between plants growing on disturbed areas and undisturbed areas. The plants found on roadsides are taller. Some of the plants are showing an unusual height of more than 3m. This may be because the plants compete for sunlight and in turn grow tall. The interplant distance is also high in the case of roadside plants, whereas the plants found in undisturbed areas are much more dense. On the roadsides *C. longipes* was mostly associated with *Lantana camara*, an aggressive weed in mountains. It is a major competitor for *C. longipes*. Especially after the rains the growth of *L. camara* is very vigorous and the seedlings of *C. longipes* have to compete with it for sunlight and nutrients. Mature seeds are hard seeded and do not germinate readily. 2-3% of the seedlings that germinate on the roadsides are crushed to death mainly by moving vehicles. The plants of *C. longipes* were infested with *Utetheisa pulchella* during the vegetative stage. Caterpillars of *Argynus syringae* damage more than 80% of the flowers produced. The arctiid moth *Utetheisa pulchella* is also reported as a pest of the cultivated sunhemp *Crotalaria juncea*. In *C. juncea* also it has been reported that the eggs are laid on the leaves and flowers and *U. pulchella* extensively damages the sunhemp plant (Saini and Verma, 1994). The percentage infestation in *C. longipes* is high in places where the density is less, i.e. on roadsides, than in undisturbed areas. The percentage maturity is low in both the groups studied. The number of mature individuals of *C. longipes* ranged from 13 to 28. This number is very less since breeding is taking place only between these individuals. According to the minimum viable population (mvp) concept (Schaffer, 1981), a

minimum of 50 individuals is recommended for the maintenance of a population. But here it was found that only a maximum of 28 mature individuals occurred in these populations. For long term evolutionary flexibility the population should be able to counteract the effects of stochasticity for which a minimum viable population of 500 individuals has been suggested (Menges, 1991). But in this study it was found that, there is no population of *C. longipes* with more than 250 individuals. It has been reported that the plant breeding system is an important determinant of genetic variations among plant populations (Daniel and Jayanthi, 1996). Plants that primarily reproduce through self-fertilization may have more genetic homogeneity. Those that predominantly outcross may have as much as 90% of variation within population. Apart from all this, there are several other ways by which the plant is destroyed. The human influence on the plant cannot be ignored. During one of our visits, we found that the more than 50-60 roadside plants of Solakkadu region were wiped out due to the road widening process. Road widening was carried out before a festival at Kolli hills. The tribals of the area used to uproot the plant for fuel wood. The flowers being very attractive on the roadsides capture the attention of passersby and they remove it. The goats too graze this plant. Wherever the leaves are used as fodder the leaves are cut and given. All this prevents pod formation and further seed set. The only way to protect the roadside plants will be to collect seeds and plant them in other areas.

Seed germination

The seed germination percentage in both populations was tested and they did not differ much in germination percentage. Seeds were recognized as hard seeded because they failed to swell on soaking. Seeds of leguminous plants have this major problem of hard seediness and also a problem of dormancy (Ellis *et al.*, 1985). Experiments with seeds of *C. juncea*, *C. lanceolata*, *C. mucronata*, *C. pallida* and *C. spectabilis* revealed the problem of dormancy. In *C. longipes* mechanical injury to the seed coat or

partial digestion of seed coat by sulphuric acid was enough for the seeds to germinate. Since the mechanical scarification is a laborious process, scarification by sulphuric acid is a feasible method. But in this method also the time for which the seed is soaked in sulphuric acid is a major factor affecting germination. Ten-minute scarification in sulphuric acid is optimal and gives a good germination percentage. Seeds that were stored for a year in the gene bank were germinated after acid scarification. The results did not differ from the original germination results. Hence it is found that conditions under which the seeds were stored in the Community Gene Bank of MSSRF are conducive to maintaining seed viability

Local people interaction

An understanding of the ethnic perceptions of any taxon is critical to the *in situ* and *ex situ* conservation projects. This helps to enhance the effectiveness of educational efforts (Burgess, 1994). This was found true in this study. When the importance of *C. longipes* was understood by the youth, they explained it to other neighbors. They were thrilled to see the seedlings of *C. longipes* taken for reintroduction. They have taken the plants from us and planted in their respective fields. They were quite impressed that so much effort has been taken for saving a plant of their locality. Interactions with tribal families brought out several interesting facts. Almost all the tribals, men, women and children were aware of the presence of this plant in their locality, but they were not aware of the fact that it is an endemic to Kolli hills. The tribals of Neduvalampatti and Thindurpatti use it as fodder, green manure, and fuel wood. They said that it served as an excellent fodder for goats and also served as an excellent fuel wood since it burns very well. However the tribals of Perumparappatti and Ariyursolakadu said that the goats do not prefer it. But they also said that it serves as an excellent fuel wood. There appears to exist some chemical variation in this plant because in some localities it can be used as fodder whereas in other places the animals don't prefer it. This needs

analysis. Once they were made aware of the threat of extinction to this plant, the tribals came forward to save it by growing them in their own garden/farm land. If this could be domesticated it could serve as a beautiful ornamental plant, as a green manure plant and a fuel wood. The tribals wanted to know more about this plant and some of them suggested that we bring out publications in the local language on *C. longipes*. All those who got seedlings planted *C. longipes* in their garden. This process itself will increase the number of plants at Kolli hills. Plants of *C. longipes* were also planted in and around the Solakadu region and it were found that the survival rate was about 65%. Though Kolli hills is known to be a repository of medicinal plants, the tribals of that area do not use any of the medicinal plants that are available there, except for minor ailments like cough, cold etc. Outsiders collect most of the medicinal plants. Tribals are engaged in the process of collection but they are not aware of the ailments for which they are used. A tribal man at Periyakoilur village, who collected *C. longipes* for a Siddha medicine man at Salem, said he has been collecting flowers and fruits of *C. longipes* for quite some years though he doesn't know their medicinal value. All that he knew was that it was used as one of the ingredients in medicinal preparations. A non-tribal man who was collecting medicinal plants also said that he has been collecting *C. longipes* flowers but doesn't know the purpose for which it is being used.

C. longipes, is just one among the hundreds of endangered plants in India that require conservation action. A recent estimate shows that in India about 3,000 to 4,000 plants are in one way or the other threatened, and many are facing severe danger to their existence in near or immediate future. Mace and Stuart (1994) have modified the definitions of Red list categories, for the IUCN, based on well-defined criteria. According to that, an endangered taxon is the one facing a very high probability of extinction in the wild in the near future. The probability of extinction is at least 20 % within 20 years or 5 generations whichever is the longest. This

Table 3. Threat status assessments of *C. longipes* using IUCN criteria.

IUCN criteria for CRITICALLY ENDANGERED	Observations on <i>C. longipes</i>
<p>Criteria A</p> <p>Population reduction ≥ 80% decline in last 10 yrs based on</p> <p>a) direct observation b) decline in area of occupancy, occurrence and/or habitat quality OR c) actual or potential levels of exploitation OR d) introduced taxa, hybridization, pathogens, pollutants, e) competitors or parasites OR</p> <p>Criteria B</p> <p>Extent of occurrence Est. < 100 km² or area of occupancy est. < 10 km², AND TWO of the following</p> <p>1. Severely fragmented OR single location</p> <p>2. Decline in ANY of the following</p> <p>a) extent of occurrence b) area of occupancy c) area, extent, and/or quality of habitat d) # of locations or subpopulations e) # of mature individuals</p> <p>Criteria C</p> <p>Population estimates Est. < 250 mature indivs. AND:</p> <p>1. Decline ≥ 25% within 3 yrs or one generation, whichever is longer OR 2. Decline in mature individuals AND population structure EITHER</p> <p>a) no pop. w/>50 mature indivs. OR b) all indivs. in single subpop.</p> <p>Criteria D</p> <p># of mature individuals Est. < 50 mature individuals</p> <p>Criteria E</p> <p>Probability of extinction ≥ 50% within 5 yrs or 2 generations</p>	<p>Criteria A</p> <p>a) There has been a severe decline in the population during the past five years, which was observed directly during our field studies and interactions with the local people. The main reason for this decline was anthropogenic pressure. b) There has also been a severe decline in the extent of occurrence and the area of occupancy of this species. c) There is a lot of competition for survival because of the introduced weed <i>Lantana camara</i>. d) <i>C. longipes</i> plants are severely attacked by pests like <i>Utethesia pulchella</i> and <i>Argynus syringae</i> all year through.</p> <p>Criteria B</p> <p>The extent of occurrence is only 24 sq.km. as observed and calculated from the map and the active area of occupancy is only 4 sq. km.</p> <p>Severely fragmented</p> <p>There has been a decline in the extent of occurrence, area of occupancy and the number of mature individuals because of habitat destruction. Tribals of Kolli hills are swiftly shifting to cultivation of cash crops like Tapioca and Pineapple for which they are converting these habitats into cultivable lands. The roadside <i>C. longipes</i> plants are destroyed during road widening process</p> <p>Criteria C</p> <p>The number of mature individuals in all populations does not even exceed 30 in number.</p> <p>There has been a continued decline in the number of mature individuals in the Solakadu population. This was evident from my study. The individuals are destroyed during the road widening process.</p> <p>All the populations observed had less than 50 mature individuals</p> <p>Criteria E</p> <p>>50% within 5 years</p>

IUCN criteria provide a system that facilitates comparisons across widely different taxa and are based both on population attributes and distribution. These criteria can be applied to any taxonomic unit at or below the species level, with the exception of microorganisms. For determining the degree of threat, the information on the population size, its dynamism, number of mature individuals, the extent of occurrence (whether fragmented or continuous), biology and potential value of species are essential. Taking these parameters into consideration, *C.*

longipes may be classified under the category of critically endangered.

In conclusion, we need systematic eco-geographical surveying for developing *in situ* conservation strategies. Today, virtually all-contemporary *in situ* conservation of plant genetic resources is very much under the paradigms of conservation biology and landscape ecology. We should promote systematic data collection and then set up specific goals for species survival, long-term fitness and higher levels

of protection of intra specific variation where there are potentially valuable genotype, adaptive complexes and alleles. For example, the divergent viewpoints on the fodder value of *C. longipes* at different locations are indicative of variability in the presence of toxins. Hence, there is a need for as much attention to the conservation of intraspecific variability as to species conservation. An integrated and people centered conservation strategy will have to be developed, to start with, in tribal and biodiversity rich areas. In such work, the principles emphasized by scientists like Frankel and Soule, (1981), de Castri and Hansen, (1992), Batisse, (1982) and the Global Biodiversity Assessment, (1995) should be kept in view. Above all, there is an urgent need to harmonize the goals of conservation and commercialization. Today, most of the source of raw material for the medicinal plant industry comes from the collections from the wild. Unsustainable exploitation of genetic wealth leads to genetic erosion and species and variety extinction. Hence, the corporate sector interested in medicinal and other economic plants should foster the cultivation of such material by tribal and rural families on the basis of a buy-back arrangement. This will also result in the creation of an economic stake in conservation. Conservation and commercialization will then become mutually reinforcing.

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