Diversity and management of wild mammals in tea gardens in the rainforest regions of the Western Ghats, India: A case study from a tea estate in the Anaimalai Hills

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In many places in the Western Ghats hill ranges of southern India, rainforest has been clear-felled in order to grow tea plantations. Such plantations now exist as islands of agriculture surrounded by forest tracts, most of which are protected as wildlife sanctuaries. We report a case study from one such tea garden. We observed a diversity of wild mammals, both herbivores and carnivores, using open grass patches, swamps and vegetation along streams in the tea garden. Large mammals were observed to forage in such areas and return to the adjoining forests. Small mammals were either resident or used stream vegetation as a corridor to move from one side of the forest to the opposite side. Dhole (*Cuon alpinus*) often preyed on sambar (*Cervus unicolor*) and even denned twice in the estate. We also observed a minimal human–animal conflict in the area. Problems such as stealing of meat from sambar kills made by dhole, could be overcome by awareness. We propose that such areas can be effectively managed such that it could facilitate movement of wild mammals with least damage to the commercial activity related to tea. Such a wildlife management strategy can become a model that could be followed in tea-growing areas throughout the Western Ghats.

THE Western Ghats hill ranges in southern India are one of the unique biological regions in the world. These hills have been recognized as one of the eight hottest hotspots of biodiversity[1]. Agriculture is one of the primary factors, which has caused considerable loss of primary rainforests that once covered the landscape of the Western Ghats[2]. Most of the remaining rainforest is now found in a fragmented state[3]. In the Anaimalai Hill ranges, Valparai plateau is one such example. On this plateau, more than 200 km^2 of land is cultivated primarily for tea and also for coffee by private owners (Figure 1). Large tracts of contiguous rainforests were clear-felled for such plantations[4] during 1880s. The forests around these gardens are now protected and form wildlife sanctuaries (Figure 1). The cultivated plateau region is a mosaic structure because of some rainforest fragments of varying size still found inside tea and coffee gardens[5]. Wild mammals from the nearby forest areas frequently use these forest fragments and also move through commercial plantations. Since the plantation area has many human settlements scattered throughout, the region is expected to be prone to human–animal conflict.

In the present communication, we report diversity of mammals in a privately owned tea garden, Waterfall Estates, located inside Indira Gandhi Wildlife Sanctuary, Tamil Nadu (Figure 2). The garden is surrounded by rainforest on all sides. In order to understand the complexity of the ecosystem through prey–predator relations, we also report a case study of the movement of dholes (*Cuon alpinus*) and sambar (*Cervus unicolor*) in the estate, the practice of meat-stealing by local people from the kills made by dholes, and the probable consequence of such meat-stealing on the dhole and sambar population. Unlike other members of Canidae, dholes are forest-living animals[6–8]. Compared with other major south Indian carnivores such as tiger (*Panthera tigris*), leopard (*Panthera pardus*) and wolf (*Canis lupus*), dholes are rarely known for human–animal conflict. Tiger, leopard and dhole are the major carnivores present in the whole Western Ghats region and are found at all altitudinal ranges[9–11]. Most of the field studies on dholes[12,13] were restricted to deciduous and moist deciduous forests in protected areas. These studies mainly focused on the ecology of dholes. Studies that could address conservation and management issues in different regions and habitats of dholes are not available. The results of the present study, therefore, have implications for management of wild mammals in such regions which are close to or surrounded by protected forests, but where human activity is intense.

The study is reported from Waterfall Estates (Figure 2). The ecological and biological features of the sanctuary

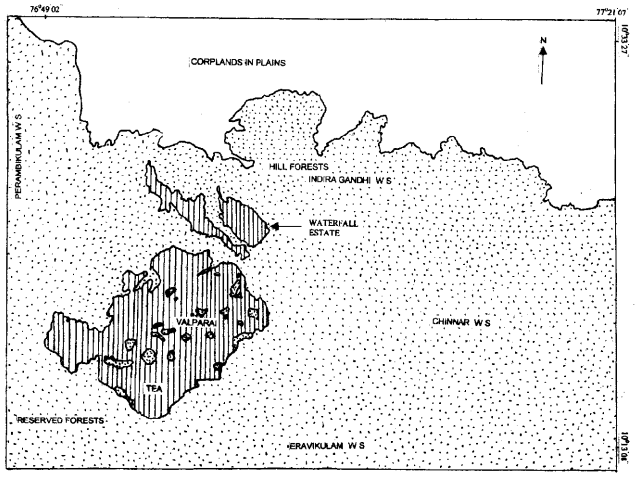

Figure 1. Map of Anaimalai Hills ecosystem comprising several wildlife sanctuaries, reserved forests and tea gardens of the Valparai plateau. Dotted area indicates forests and striped area indicates tea gardens. Small dotted patches inside tea gardens are rainforest fragments. WS, Wildlife sanctuary.

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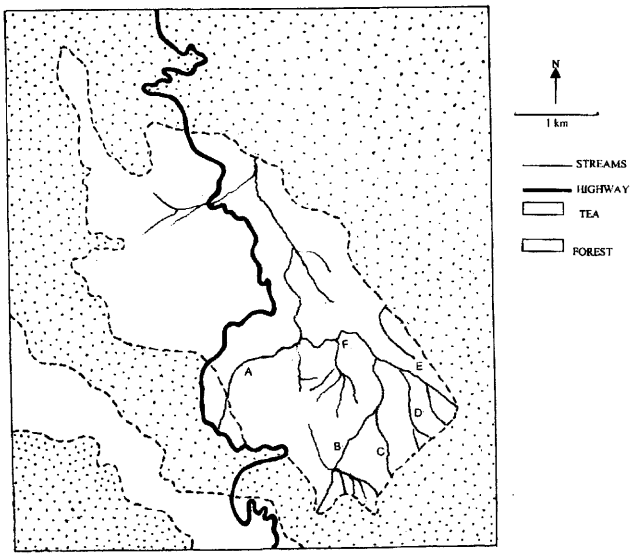

Figure 2. Map of the Waterfall Estates. A–F are various streams where vegetation identification was carried out.

are described elsewhere in detail[14–16]. The study was conducted in an area of around 200 ha of the total estate area of 368 ha. The study area lies at 10°24′N–76°59′E. Altitude of the estate varies between 1200 and 1400 m asl and the area receives more than 3500 mm of rainfall per annum from both southwest and northeast monsoons. A typical evergreen rainforest around the estate continues with montane shola forests at higher elevations.

The study site contained 133 ha of tea (*Camellia thea*), 13 ha of eucalyptus (*Eucalyptus grandis*), 45 ha of good grass patches without any cultivation, and 6 ha under vegetation on stream banks. The estate also had 2.93 ha of prime rainforest cover, which was continuous with shola forest of the sanctuary. Several perennial streams passed through the estate from adjacent forest areas. Dense vegetation characterized by pioneer species and weeds (Table 1) was present on the banks of these streams. The streams were the main source of water for all domestic purposes for the local inhabitants. During the dry season, water from these streams was also used for irrigation through sprinklers.

The estate had 440 households clustered in 12 colonies with a total population of about 2000. Ninety per cent of the families had a minimum of two persons employed as estate workers. Apart from daily wages, the workers also enjoyed other facilities such as ration for all families at subsidized prices, free housing and education for children. Most of the people in the estate consumed meat.

We began our study primarily on non-human primates in 1994 in the Anaimalai Hills. In January 1995, we setup a field station in Waterfall Estates. In order to reach our primate study areas, we had to walk a distance of 3 km between 6.00 and 7.00 a.m. and another 3 km back in the evening between 5.00 and 7.00 p.m. through the estate everyday. Up to December 1999, the total distance we walked inside the estate amounted to more than 10,000 km. During this period, we systematically documented all animals encountered and also kept notes on related events such as scats seen on the roadside and kills made by dholes. The data collected during this period were used to determine the relative abundance (determined only on the basis of opportunistic sampling) of different mammalian species inside the estate. On many occasions, we made observations on several mammalian species for longer durations. Additional information on human–animal conflict, kills made by predators, presence of animal, meat stealing by local inhabitants, etc. was also gathered from two assistants who were regular estate workers and had access to vital information. Wherever found necessary, we personally checked the spots, especially where predators made kills, and gathered information on predator species, age and sex of the prey species, and to some extent about the amount of meat stolen by the estate workers.

Data on dholes were obtained from a single pack, which operated in this region. The pack was identified on the basis of a few individuals in the pack. The pack had 15 animals, which included four pups born in March 1996. At that time, dholes were also followed whenever they were sighted. We spent nearly 25 h near the den where the pups were laid, and also made long observations near kills of sambar made by dholes.

Information on area under vegetation and extent of grass patches was collected from the estate officials and checked with the office records. In 1997, the estate management removed some vegetation along the streams as a routine practice to maintain proper shading for tea. Per cent loss in vegetation was calculated from the areas opened up by the vegetation removal.

The study area had four large streams with 7–12 m wide vegetation cover along their banks, and 13 smaller streams with less than 7 m wide vegetation cover. These streams passed through the estate from one side of the forest to the opposite side. Several swamps, some of them with vegetation cover, were also present in the valleys. The type of vegetation around streams (six sampled streams; A–F in Figure 2) is shown in Table 1. Exotic weeds and shrubs dominated the vegetation. However, several fruiting trees were also present. During March–April 1997, the estate management removed about 50 and 80% vegetation around large and small streams respectively, which amounted to about 73% of vegetation loss along the streams. By May–June 1998, about 50% regeneration of vegetation around streams was observed.

All major carnivores of the Anaimalai ecosystem, including tiger, leopard, dhole, jackal (*Canis aureus*) and smaller cats (jungle cat, *Felis chaus* and leopard cat, *Felis bengalensis*) were recorded in the study area (Table 2). Although pugmarks and scats of tigers were seen frequently in the adjacent forests, their presence was rare inside the estate. During our study period, leopards and dholes were more frequently sighted inside the estate. The rela-

Table 1. Plant species around streams in the study area

Plant species	A	B	C	D	E	F
Debregesia velutina	+++	+++	+++	+++	+++	+++
Rubus Sp.	+++	++	++	–	++	++
Polygonus chinense	+++	+++	+++	+++	+++	–
Villebrunea integrifolia	+	++	++	–	++	–
Mallotus tetracoccus	+	+++	+	+	++	–
Elettaria cardamomum	+	+	++	–	–	–
Clerodendron infortunatum	++	+	++	++	++	–
Eupatorium sp.	+++	–	–	–	–	–
Lantana camara	+++	++	++	++	++	++
Ficus hispida	–	++	–	–	++	++
Elaeocarpus tuberculatus	–	+	++	–	–	–
Holigarna nigra	–	+	+	–	–	–
Macaranga peltata	–	++	+	++	–	–
Dendrocalamus vochlandra	–	++	–	–	–	–
Spathodia campanulata	–	+	–	–	–	–
Musa pardisiara	–	–	++	++	–	–
Eucalyptus grandis	–	–	++	–	–	–
Nettle	–	–	++	–	–	–
Psidium guajava	–	–	++	–	–	–
Persea macrantha	–	–	–	–	–	–
Erythrina sp.	–	–	–	–	–	++

A–F are streams (see Figure 2).
+++, Dominant; ++, Common; +, Sparse; – , Absent

Table 2. Number of encounters and relative abundance of large carnivores in the study area

Animal	Number of encounters	Relative abundance
Tiger	1	0.016
Leopard	9	0.143
Dhole pack	45	0.714
Jackal	4	0.063
Small cat	4	0.063
	$N = 63$	

Table 3. Number of encounters and relative abundance of other mammals in the study area

Animal	Number of encounters	Relative abundance
Gaur herds	15	0.13
Sambar	26	0.23
Barking deer	13	0.11
Wild pig herds	2	0.02
Sloth bear	7	0.06
Mouse deer	4	0.04
Stripednecked mongoose	21	0.18
Small Indian civet	24	0.21
Porcupine	2	0.02
	$N = 114$	

tive abundance of dholes was high (0.714) compared to leopards (0.143). Jackals and smaller cats were seen only occasionally.

Table 3 presents information on the occurrence and relative abundance of other mammals in the estate. Among large mammals, sambar was observed with the highest relative abundance (0.23), followed by gaur (*Bos gaurus*; 0.13) and barking deer (*Muntiacus muntjak*; 0.11). There was no direct sighting of elephants (*Elephas maximus*) inside the estate, but the presence of dung revealed their regular movement along the estate borders with forest areas. Elephants did occasionally visit human settlements to feed on plantains (*Musa paradisica*). Among other mammals, sloth bear (*Melursus ursinus*) was less common, followed by wild pig (*Sus scrofa*), mouse deer (*Tragulus meminna*) and porcupine (*Hystrix indica*). Bears were sighted only from January 1999 onwards. The activity of porcupine was more common in adjacent forest areas. Among small carnivores, stripednecked mongoose (*Herpestes vitticollis*) and small Indian civet (*Viverricula indica*) were common, with a relative abundance of 0.18 and 0.21 respectively. Direct sightings of smaller cats were few, but frequent sighting of fresh scats revealed their regular movement in the estate. Most of the mammals were seen in the vegetation along the streams, followed by swamps and open grass patches.

Table 4 presents information on sightings of dhole pack, sambar, sambar kills by dholes, and meat-stealing cases by local inhabitants between 1995 and 1999. During March 1995 and February–March 1996, the dhole pack along with pups made a den inside the estate. In 1995, the den was inside an estate forest patch close to a stream with eucalyptus and some native trees around. They denned beneath a rock surface. In 1996, the den was beneath a rocky surface in a valley close to a stream vegetation. During this period, dholes were frequently sighted and their behavi-

our was observed. In the later years, dholes never denned inside the estate and their sightings had become rare.

Sambar was quite common during 1995. Though the number of sambar kills made by dholes was high during 1996, direct sightings of sambar were poor inside the estate during that year. During the denning period (1995 and 1996), 29 (85.3%) sambar kills were recorded. All of the 21 kills made by dholes during 1996 were either close to the stream vegetation or in the streams where sambar usually occurred due to availability of cover. During this period, we twice observed three kills made within a span of two days. In one instance, two adult female sambar were killed on the same day, and one adult male with fully grown antlers was killed the next day. Such a high frequency of killings was probably due to meat-stealing. In most cases, the kills were made during morning hours. Out of a total of 34 kills recorded during 1995–1999, local people stole meat 28 times (82.35%).

We observed considerable change in the mode of meat-stealing by people over the years. Initially, people used to chase dholes away from the kill, if the dholes were fewer in number. Later, they started following dhole tracts and chased them soon after the dholes had made a kill. Cases were also observed when people chased away dholes even before the latter had completed a kill and had only incapacitated a sambar. During long periods of observations near the den in 1996, we observed four attempts by people to steal dhole pups. The attempts involved throwing stones at the den to chase away the adults. However, no attempt to steal pups was successful. After this incident, dholes left the study area and their subsequent sightings became infrequent inside the estate.

The data reported in the present study reveal a high abundance and diversity of mammalian species in the estate. Since the estate has a unique location of being surrounded by rainforest of a protected wildlife sanctuary, it becomes an interesting case study for the management of wild mammals in all such areas, which are aplenty throughout the Western Ghats. The presence of swamps, open grass patches, and most importantly, the vegetation along the stream banks provided not only fodder but also shelter for small and medium-sized mammals. A rainforest usually has a dense crown cover. Because of the low penetration of light through such a canopy, the rainforests do not offer much grass for grazers. On the other hand, a tea garden is almost totally open, with largely spaced oak trees. Because of the high elevation, medium temperature and high rainfall in such areas, effusive grass grows in all open spaces, including roadsides. This provides excellent grazing grounds and attracts grazers from the nearby rainforests to visit such areas for feeding. Large herbivores such as gaurs were observed to visit the estate grasslands only after dusk and they always returned to the forests before sunrise. On the other hand, smaller and medium-sized mammals such as sambar, sloth bear, barking deer, mouse deer, etc. would even stay in the estate during the day, finding shelter in the stream vegetation. Such animals also used the stream vegetation as a corridor to move from one side of the forest to the opposite side. Small mammals such as mouse deer, small Indian civet and stripednecked mongoose were probably residents in the estate, using rocks and tree holes near stream vegetation as shelters. All these observations indicated that the mini habitats in the estate were attractive to these mammals.

Table 4. Dhole and sambar sightings, sambar kills and meat-stealing cases in the study area from 1995 to 1999

	1995	1996	1997	1998	1999
Number of times dhole pack was sighted	7	25	4	4	5
Number of sambar sighted	16	7	2	0	1
Number of sambar killed by dholes	8	21	2	2	1
Recorded meat-stealing cases	7	19	0	1	1

The proposition that these habitats are attractive is further strengthened by the regular activity of dholes, especially during 1995–96. The dhole is a shy animal and avoids places that are usually disturbed. The fact that dholes were seen in the estate regularly, they often made kills there, and above all, denned with pups twice inside the estate, clearly points out the attractiveness of the habitat. Further, the prey–predator relationship of dhole and sambar reflected an activity typical of a rainforest of the Western Ghats. In the lower altitude deciduous forests such as those in Bandipur and Nagarhole in southern peninsular India, chital (*Axis axis*) is the main prey of the dholes[12,13]. Sambar probably is energetically the most profitable prey species as measured by the ratio of energy gain to handling time for a predator[17]. Sambar is a major prey species for leopards and tigers in mature forests[11,18] and the same may be true in the Anaimalai ecosystem. The major part of the Anaimalai ecosystem is devoid of chital, except for few populations at Top Slip and Amaravathi regions[14]. In Nagarhole[13] and Bandipur[12,19], dholes showed a high preference for particular age and sex of the prey species, favouring mostly yearlings, fawns and subadult of sambar and adult males of chital. Fox and Johnsingh[19] are of the opinion that sambar is a large, powerful and difficult animal for dholes to bring down. In contrast to this opinion, during our study period in 1996, we observed that 18 of 21 kills of sambar made by dholes were adults and among them, four were fully grown adult males. One possible reason for this could be that sambar fawns strayed into the estate with a lesser frequency than the adults.

The existing stream vegetation in the estate poorly supports elephants for foraging and movement. They were seen to move only inside forests along the estate borders. Only occasionally did the elephants visit the estate roads adjacent to the forest, and nearby human settlements to feed on plantains. Neither elephant nor any other herbivore ever fed on leaves of tea plants. Gaurs were never

observed moving from one end of the estate to the other. Tigers never attacked domestic livestock. Although leopards preyed upon stray street dogs, attacks on domestic livestock were almost negligible. These observations indicate that the human–animal conflict was almost absent in the estate. The only negative impact of wild mammals for planters was the damage done to the root systems of plants because of digging by sloth bears, wild pigs and porcupines.

We suspect that the reduced frequency of sambar and dhole sightings from 1997 onwards was a result of two factors: the estate workers stealing sambar meat from kills made by dhole, and clearing of vegetation along the streams. Since sambar yields large amount of meat, people became accustomed to steal kills, and developed new strategies to get maximum amount of meat. Johnsingh[12] reported that such stealing practices resulted in more number of kills made by dholes in short periods. Johnsingh[12] also speculated that if 50% of the fawn kills were stolen, it may seriously suppress the sambar population of a region. Since sambar used stream vegetation as a cover, 73% loss of this vegetation due to clearing may also be another factor that resulted in the reduced sambar population in the study area. Though the vegetation had recovered almost 50% by 1999, the sighting frequency of sambar still remained low. It shows that once there is a significant reduction in the number of a wild mammals in an area, it may require quite sometime for a population to re-establish itself.

In most of the Western Ghats, rainforests were felled to grow tea plantations. Most of such plantations are still surrounded by or adjoin forest areas, which come either under wildlife sanctuaries or reserved forest systems. Our study area is a typical example of such gardens. The mammalian management strategy for this estate, therefore, can serve as a model for all such areas in the Western Ghats.

Before proposing a management strategy, we must illustrate a few facts regarding such regions. If not all, most of the places where forests were felled to cultivate tea are plateau lands. Before the felling of forests, these plateaus must have been regularly used by mammals to move from one forest patch to another. This is evident from the fact that in spite of intense human activity, these plateaus are frequently used by mammals even today. Wildlife conservation is not only an ethical issue, but also a necessity by law. Planters, therefore, must consider the fact that animal movement through tea gardens needs to be facilitated. On the other hand, tea planting is a commercial activity involving a large number of people. The wildlife management strategy also has to be such that minimum damage is caused to the commercial activity and human–animal conflict is minimized. In order to realize such a goal, we suggest the following management strategies, which can be achieved through a minimal effort and awareness.

Although we could not quantify adverse impact of clearance of stream vegetation on mammalian activities, it was apparent that such vegetation had an important role in supporting medium-and small-sized mammals to forage, shelter and move. It has been observed in the Valparai plateau that when the stream vegetation and privately owned small rainforest fragments inside the estates are manipulated or logged, it only aggravates human–animal conflict, especially with large mammals such as gaur, elephant and leopard (unpublished data). It indicates the need for maintaining such vegetation. If canopy contiguity is maintained in stream vegetation by planting fruit trees, it will even facilitate the movement of arboreal mammals which are already isolated in forest fragments[14] and will facilitate inbreeding avoidance. Selected saplings can be given by the Forest Department to estate managements for restoration and improvement of the quality of stream vegetation. The achievement would be facilitation of mammalian movement and minimization of human–animal conflict. The vegetation would also conserve moisture along the stream banks, which would otherwise dry up in summer and result in increased water loss. Retaining such vegetation, therefore, is beneficial to the planters themselves for various reasons. Although we have not included any data on amphibians and reptiles here, a continuity of vegetation along streams would also link such populations between the forest areas separated by tea gardens.

Despite the fact that the estate workers receive higher wages and other incentives than labourers in most other industries, stealing of wild meat from kills shows lack of awareness. It is necessary that the estate management in coordination with the wildlife and forest officials, makes workers aware of the Wildlife Conservation Act and lets them know that stealing wild meat is an illegal activity punishable under the Law. Considering the control the tea gardens managers generally have over the workers, a strict warning by these managers against meat stealing could be really effective. Over a decade of interactions with people in these hills, we have realized that the higher level managers in these tea gardens actually have a positive attitude towards wildlife conservation as long as the human–animal conflict is minimal. The establishment of Anaimalai Biodiversity Conservation Association by the planters is a positive step towards conservation.

Since tea gardens do not come under the direct jurisdiction of the Forest Department, they do not usually consider it necessary to appoint enough staff to look after such areas. On the other hand, the management of wildlife in the surrounding protected areas makes it necessary to manage the movement corridors that go through the tea gardens. Further, problems such as illegal killing and meat stealing are more in tea gardens than in the protected areas. Only a staff of two is looking after the entire Valparai plateau which is planted with tea. This has resulted in the lack of information regarding any illegal activity reaching the staff. Considering the diversity of wildlife in tea gardens, the significance of these areas as corridors, the illegal activities that take place there, and the inability of the Forest

Department to recruit staff, a cordial relationship between the Forest Department and the managements of tea gardens can prove to be effective to carry out wildlife conservation activities.

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Thidiazuron-induced high-frequency shoot proliferation in *Cineraria maritima* Linn.

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***Cineraria maritima* Linn. is an important medicinal plant of known therapeutic value for the treatment of cataract and corneal opacity. An *in vitro* regeneration protocol has been standardized for large-scale supply of planting material of this otherwise scarce medicinal plant species. The medium for propagation contained MS salts, B_5 vitamins, 30 g l^{-1} sucrose and 8.0 g l^{-1} agar (designated as MSB medium). Addition of thidiazuron [TDZ: N-phenyl-N′-(1,2,3-thidiazol-5-yl) urea] in the culture medium proved superior to the combined treatments of 6-benzyladenine and *a*-naphthaleneacetic acid. The highest adventitious shoot bud (36 ± 2.34) induction, per nodal explant used, occurred at 4.54 µM TDZ after 6 weeks of incubation. The number of shoots formed per explant increased significantly upon sub-culture of the responding explants on plant growth regulator-free MSB medium, after 8 weeks of culture initiation. *In vitro* produced shoots exhibited good rooting response on half strength MSB medium containing 4.92 µM indole 3-butyric acid. After 3 weeks of hardening of plantlets as hydrophonic cultures, almost 95% of 300 rooted plants could be successfully transferred and acclimatized *ex vitro* under glass-house conditions, followed by their establishment in the field.**

CINERARIA maritima Linn. (Asteraceae), an important annual exotic medicinal herb, is commonly known as 'Dusty Miller' or 'Silver dust' due to its characteristic wooly, silvery-grey foliage and a low mound-like habit. This plant is cultivated in Europe and cooler areas of USA[1]. In India, recently, limited cultivation of *C. maritima* has been taken-up in the Nilgiri Hills of southern India. The plant is used in the preparation of homeopathic drops, applied in various eye ailments[1,2], particularly for treating cataract and corneal opacity[3]. On account of its therapeutic value, the plant is in great demand in the pharmaceutical industry. Due to limited availability of raw materials of *C. maritima* in India, the national requirement is met solely by importing the prepared drug formulations from other countries. In order to meet the internal requirements of our country and at the same time to keep pace with the growing demand of this herb in the global commercial markets, there is an urgent need to develop an efficient multiplication protocol suitable for commercial use. Plant tissue culture techniques have

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