EXECUTIVE SUMMARY

Elettaria cardomomum var. *major*, indigenous to Sri Lanka and the Western Ghats is an under utilized forest species. The use of its seeds as a spice, in medicine and perfumery has led to its exploitation from the wild by villagers living in the periphery of these forests, which if not managed on a scientific basis could result in genetic erosion of its natural populations. Cultivation in the buffer zone and village home gardens surrounding these forests would certainly alleviate the pressure on wild populations by providing an alternative source for harvesting its fruits. Further, the species has potential as a valuable gene pool for future improvement of the cultivated variety. If this species is to be exploited to its maximum, an understanding of its natural habitat and habit, population biology, phenology, pollination and breeding systems is imperative.

This report documents the results of preliminary investigations carried out on the above aspects of *E. cardamomum* var. *major* in the Sinharaja Man and Biosphere Reserve and are summarised below:

1. NATURAL HABITAT AND HABIT OF THE PLANT

The species inhabits forest fringes along the main access road of the Sinharaja Reserve, apparantly on humus rich, well drained soils. Individuals of this herbaceous

perennial comprise an aggregation of upto 3.5m tall fronds or leafy shoots, each having 2-12 leaves, originating from an underground rhizome. Separate vegetative and reproductive fronds are present. The latter bear at their swollen bases at least one inflorescence, at most three.

2. POPULATION BIOLOGY

Four populations (1EE-4EE), adjacent ones 0.2-2.7km apart, of this speices were demarcated along the main access road of the Sinharaja Man and Biosphere Reserve for preliminary investigations on its population biology which differed among and within them as follows:

i) Variation Among Populations

a) Composition of Populations

The four populations, 1EE-4EE, comprised 24, 25, 15 and 10 bushes respectively at the beginning of the sampling period, July/October 1985, but reduced to 21, 22, 13 and 9 at its end, November 1987, due to natural death of some individuals in each of them.

b) Bush Size Variation Among Populations

The tallest bushes reaching 3-3.4m were observed in population 3EE, and the shortest in 1EE (2-2.4m). Frond density per bush was lowest in 1EE (12.9+5.7) and highest in 2EE (16.7+15.0).

c) Inflorescence and Fruit Production Among Populations

The proportion of bushes in each population that produced inflorescences over the entire sampling period was 92, 96, 46 and 88% while that for each of the three years studied (1985-1987) varied between 62-76%, 59-88%, 3-38% and 33-66% for populations 1EE-4EE respectively. Proportion of bushes that set fruit on the other hand varied between 48-67, 45-77, 11-66 and 8-23% in populations 1EE-4EE between those years. Thus, populations 1EE and 2EE were reproductively more successful than populations 3EE and 4EE. In general, a year when a large proportion of bushes produced inflorescences and fruits was almost always followed by one or sometimes two years when only a small proportion of the population was productive. The size of individuals, based on frond density per bush, examined in relation to inflorescence and fruit production in the four populations showed that, individuals with 10 or less fronds per bush were less productive than those with larger frond densities. The highest production of 103 inflorescences and 87 fruits per bush during the entire sampling period was observed in one individual of population 2EE.

d) Fruit Predation Among Populations

Fruit predators of this species were found to be an Aphis sp. and a weevil, Prodioctus haematicus Chevr. The latter bore into the fruits and aphids entered them via these openings sucking the soft tissues within. Such damaged

fruits were abscised 10-14 days later. In addition, rodents and porcupines predated upon ripe fruits destroying whole infructescences and were much more destructive than the former insects.

Of the bushes in populations 1EE, 2EE and 4EE that set fruit in 1985, only 25-40% escaped insect predation. Of the total number of fruits borne by individual bushes, 10% was predated in each of the populations 1EE and 4EE and 22% in 2EE. On the whole young fruits less than 2cm in length were damaged much more than larger ones.

ii) Variations Within Populations

Variations within populations were investigated by examining the same aspects, as ia-d given above in three individuals each of population 1EE and 2EE and 2 individuals each of population 3EE and 4EE.

a) Bush Size, Height and Longevity of Reproductive and Vegetative Fronds, Their Abortion and Predation

Bush size determined by frond density during the entire sampling period varied between 33-87, 61-142, 220-232 and 139-177 in these 10 individuals sampled in populations 1EE-4EE. The proportion of vegetative fronds in them was found to be 18-34, 35-54, 42-45 and 49-57%, reproductive fronds was 21-49, 6-9, 10-14 and 8-18% and the remainder in each case could not be differentiated into these two categories in populations 1EE-4EE respectively.

Reproductive fronds on the whole were taller, had a longer life time and more leaves as compared to vegetative fronds of the same individual. Frond longevity was found to increase with increase in leaf number.

Rodents and Porcupines damaged both vegetative and reproductive fronds, particularly developing ones between 0.5-2.0m in height. Such damage, highest in population 2EE and least in 1EE, did not set back the growth of the individual but appeared to produce more vegetative fronds as compared to those that were not damaged. Inflorescences were not predated upon.

In all bushes examined, a certain proportion of fronds aborted at an early stage before they reached a height of 1.5m. The causal factor for abortion is yet unknown and is neither influenced by its position in the bush nor the degree of shading it may be subject to.

b) Inflorescence and Fruit Production

An examination of inflorescence length and fruit density per inflorescence showed that the larger inflorescences produced more fruits as compared to shorter ones. This relationship was particularly true for inflorescences longer than 75cm in length.

c) Fruit Predation by Insects

The mean number of fruits predated by insects in individual bushes of populations 1EE, 2EE and 4EE were found to be 2.3+0.7, 4.1+3.1 and 3.4+2.8 respectively. The number of fruits damaged per bush was not influenced by its fruit density nor the proximity of bushes to those showing fruit damage.

3. PHENOLOGICAL VARIATIONS AMONG AND WITHIN POPULATIONS

In the four populations of E. cardamomum var. major demarcated, the timing, duration and frequency of flushing, flowering and fruiting examined at the inter and intra population levels as well as within individuals, showed the following.

i) Flushing, Flowering and Fruiting Among Populations

In each of the four populations, flushing though continuous throughout the year, varied in intensity and did not show a clear-cut pattern both within and between consecutive calander years. In contrast, flowering occured throughout the year but showed one distinct peak period of about 6 months between April to October. 1986 was a good flowering year for all four populations as compared to 1987, when it was about half that of 1986 in population 1EE and 2EE and about one fourth/fifth in 3EE and 4EE.

The pattern of fruiting followed that of flowering, but fruiting episodes of consecutive years were quite distinct and not continuous. In each of the populations, there was at least a period of few days when fruits were absent marking the end of one and beginning of the next fruiting episode. The pattern of flowering was similar in all four pouplations but in populations 3EE and 4EE their intensity was poor in 1987 as compared to that of 1EE and 2EE. The relationship between flushing, flowering and fruiting was not obvious.

ii) Flushing, Flowering and Fruiting Within Populations

The phenological events exhibited by different individuals within each pouplation showed much variation. Individuals of populations 1EE and 4EE based on the frequency and intensity of these events in each of them during the entire study period, were classified into 10 and 5 separate groups respectively. As expected, this manifests the diversity of flowering and fruiting patterns among individuals within populations. Of the two populations studied in depth population 1EE depicted a much greater heterogeneity than that in 4EE. Three individuals of population 1EE were found to be far superior with respect to inflorescence and fruit production, than the remaining individuals of its own population and all those of population 4EE. The intensity of inflorescence production at the individual level alternated between high and low in consecutive years.

iii) Flushing, Flowering and Fruiting Within Individuals

Four bushes monitored throughout the sampling period showed that fronds were produced throughout. The life time of fronds, from first emergence to yellowing and withering, varied between 140-600 days. Some fronds which emerged between October 1985 - January 1986 developed inflorescences more or less synchronously between March-April 1986, and almost always produced fruits. Reproductive fronds that emerged in April-May produced inflorescences only after fruits of the previous crop of inflorescences were fully developed, but they themselves often did not set fruit.

Inflorescence initiation appears to be more or less synchronised among fronds of one individual and between individuals in each population. Phenological information from these four individuals shows that vegetative shoots are produced continuously but reproductive ones which bear fruits are restricted to every other year, suggesting a fruiting frequency of once every two years, in them. This pattern however, was not always true for other individuals, again indicating the great diversity among individuals of this species.

4. POLLINATION AND BREEDING BIOLOGY

i) Flower Morphology

Flowers of *E. cardamomum*, borne on 20-125cm long racemose inflorescences that arise at the base of leafy shoots and trail the ground, are hermophrodite, open between 3.00am - 6.30am, and have a longevity of 18 hours. Anthers dehisce around 6.00am. Stigma receptivity was best between 6.00am - 8.00am and progressively decreased till 22.00 hrs.

ii) Flower Visitors

Flower visitors included, both pollen and nectar feeding *Amegilla subinsularis* (Hymenoptera), only pollen feeding *Drosophila* sp. and an unidentified species (Diptera), only nectar feeding *Notocrypta paralysos* and *Jamides alecto meilichius* (Lepidoptera) and cell sap feeding *Prodioctus haematicus* (Coleoptera). These insects visited flowers through out the day. Of them the Hymenopteran was identified as the only efficient pollinator.

iii) Breeding Systems

Breeding experiments (open pollinated, artificially crossed or selfed and bagged only) carried out using emasculated and non-emasuculated flowers showed much less fruit set in all the emasculated treatments as compared to the corresponding non-emasculated ones. In the latter treatments average fruit success on the 40th day after pollination from two individuals gave the following results: open pollinated 17%, artificially crossed 37%, artificially

selfed 20% and bagged only 11%. These studies indicate that (i) fruitset in nature is limited possibly by the activity of the pollinators but in their absence fruiting may take place to a small degree, (ii) the species is self compatible but the degree of selfing is controlled by the plant, (iii) crossing doubles the extent of fruitset, and (iv) apomixis may be absent as suggested by 0% fruitset in the emasculated and bagged treatments. Of the two individual bushes studied, one yielded more fruit than the other.

5. Information from this study that will be useful for domestication of E. cardamomum var. major has also been high lighted.