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KFRI's Tryst with the Teak Defoliator

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The teak defoliator, *Hyblaea puera* Cramer (Lepidoptera) is undoubtedly the most well known insect in Indian forestry. Exactly 100 years ago, in 1898, Bourdillon recognised it as a pest of teak plantations in Konni Forest Division of Kerala. Outbreaks of this insect have been taking place, every year, not only in Konni, but also over extensive areas of teak plantations across the country. These outbreaks have attracted the attention of foresters and others because of the spectacular nature of the damage.

Major outbreaks appear all of a sudden and cover extensive areas, producing millions of caterpillars which feed gregariously on the teak canopy. When the outbreak is in progress, the sound of falling faecal pellets, the multitude of larvae which descend on silken threads, and the chirping of birds which assemble, to feed on the larvae cannot escape anyone's attention. In a few days the trees are left leafless. The whole episode is sudden and dramatic. This year, for example, when KFRI scientists visited Konni on the 30th of March, the teak trees had fresh tender leaves, and there was no visible sign of infestation in most of the areas visited. A fortnight later, on 16th April, they found that thousands of hectares of plantations all along the Konni-Achencoil belt were totally defoliated. Where did the millions of insects which caused this outbreak originate? How did they appear at Konni all of a sudden? How to control such a devastating pest which strikes like a wild fire? These questions have engaged the attention

A defoliated teak plantation at Nilambur. The insets take a closer look at the damage and the two kinds of larvae, black and coloured

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of forest entomologists for almost a century. Some insights have been gained, but the mystery remains.

KFRI's tryst with the teak defoliator began in 1977 when we initiated a study at Nilambur to quantify the impact of defoliation on volume increment of teak trees. At that time, in spite of a lot of accumulated literature, a critical review (Nair, 1980) led to the conclusion that loss due to defoliation was still an impression. We emphasised the need for a realistic appraisal of the damage, for detailed investigations on the nature and causes of outbreaks, and cautioned against indiscriminate use of chemical insecticides which had been tested in Konni in 1965, and Raipur in Madhya Pradesh in 1978. Following the policy guidelines set forth therein, over the past two decades, KFRI took it as a challenge to address the problems and try to come up with a workable management strategy for the pest.

Although history is not to be judged by those who contributed to making it, we think that establishment of KFRI in 1975 and our initiative in teak defoliator research has marked the end of a period of complacency. This period had been characterised by the forest entomologists handing over to the foresters, a package of practices for biological cum silvicultural control of the teak defoliator, and claiming that the problem would have been solved if only the foresters had implemented the recommendations. This brief review is an attempt to examine the progress we made during the last 20 years and suggest the future course of action. An in-depth review is beyond the scope of this newsletter; for details see the KFRI publications listed at the end.

Impact of defoliation on tree volume increment

Based on a 5-year experimental study in 4-8 year old teak plantations at Nilambur, we demonstrated that defoliation caused by *Hyblaea puera* resulted in loss of about 44% of the potential volume increment of trees. It was estimated that during the study period, the protected trees put forth a mean annual volume increment of 6.7 m^3/ha compared to 3.7 m^3 /ha of unprotected trees, a gain of three cubic meters per hectare per annum. At this rate of growth, subject to other necessary inputs, protected trees will be ready for harvest in 26 years instead of the usual 60 years (Nair et al., 1985).

This study unequivocally established the economic usefulness of teak defoliator control, putting at rest the old debate and speculation on the necessity for control. Incidentally, it also showed that under Kerala conditions, the teak skeletoniser, *Eutectona machaeralis*, the other notorious pest of teak, did not cause any economic damage.

Biological control using parasites

At KFRI, we subjected the long advocated biological cum silvicultural control method to critical analysis, based on extensive field data on the dynamics of the pest and its parasites. The method proposed earlier essentially involved augmenting the natural enemies of the pest by promoting some species of plants (213 spp. were recommended), both within the plantations and in the surrounding areas. It was proposed that the planting area should be divided into blocks of 8-16 ha, leaving strips of pre-existing natural forest in between. These recommendations were reiterated in many communications and publications from the Forest Research Institute, Dehra Dun and also included in the Working Plan for the Nilambur Forest Division.

KFRI studies on the spatial dynamics of outbreaks showed that during outbreaks, successive generations of the insect do not inhabit the same place. Moths emerging from a current infestation site take off to a distant place to lay eggs, thus evading the parasite population built up locally. In outbreaks initiated by a sudden influx of large numbers of moths, the sheer immensity of host numbers simply overwhelm the resident population of parasites and predators. Due to these reasons, the proposed biological-cum-silvicultural measures for control, aimed at conservation of the endemic population of natural enemies cannot ensure protection against the teak defoliator outbreaks (see Nair et al., 1995:). In Nilambur teak plantations we found (Sudheendrakumar, 1986; Mohanadas, 1995) 15 of the 40 species of parasites recorded from in India, as well as 70 species of predators, including 6 insects, 16 spiders and 48 birds. However, the spatial separation of the host and its natural enemies during outbreaks prevents a numerical response of natural enemies to host density. Therefore they cannot be expected to make an impact on outbreak populations of

the teak defoliator although they may be playing a role in suppressing endemic populations.

Population dynamics

Contrary to the earlier belief, our studies showed that small populations of the insect are present in teak plantations and natural forests during the non-outbreak period when the food, i.e., tender foliage, is scarce. Although it was initially suspected (Nair and Sudheendrakumar, 1986a) that the outbreak population builds up slowly through multiplication of the insect over successive generations during the early part of flushing season, subsequent observations point to alternative mechanisms of outbreak initiation.

Fresh insight into the causation of outbreaks came in 1987 when it was found that in a large plantation area as in Nilambur, outbreaks began in small epicentres, 0.5 to 1.5 ha in extent and widely separated in space, before it flared up and became generally visible (Nair and Mohanadas, 1996). Observations over several years indicated that the appearance of these typical tree-top infestations as the forerunner of extensive outbreaks was strongly correlated with the arrival of pre-monsoon showers. These epicentres represented the transitional stage between very sparse endemic populations and high density outbreak populations. Over a large area, the infestation spreads, not like a rising sea level but like uplifting mountains. It is not a continuous increase in population as one would expect, but an increase in spurts and bursts.

The spatial dynamics of teak defoliator outbreaks were further studied in 1993 by placing all the nearly 10,000 ha of teak plantations at Nilambur under continuous observation over a year (Nair et al., 1998). This study confirmed the initiation of outbreaks in epicentres but showed that the epicentres are not constant over the years and do not represent highly favourable local environments. The study also showed that moth populations originating from the epicentres alone cannot account for all the subsequent outbreaks within Nilambur, indicating an influx of moths from elsewhere.

Together with our observations on the aggregation of large numbers of moths in the undergrowth soon after their emergence; synchronised flight activity of moths during dusk; sighting of characteristic, oriented movement of moths; and the evidence from literature on aerial displacement of the spruce budworm moth, *Choristoneura fumiferana* along the cloud front, in Canada, as established by radar tracing using air crafts, we have now postulated one of two hypotheses or a combination of both to explain the sudden outbreak of the teak defoliator.

(a) Monsoon-linked long-distance displacement of airborne moth populations

At the beginning of outbreaks, and perhaps also later, moth populations are brought in through the monsoon wind system from far-off places where the population was built up earlier. Thus in southern Kerala where the outbreak first appears in India, the moths could come from another country in Southeast Asia across the ocean through aerial displacement. Infestation precedes the arrival of the monsoon, and for the rest of India, moths could originate from the South. Generally outbreaks occur first in southern Kerala in April-May and slowly move northwards, reaching Madhya Pradesh in July.

(b) Wind-aided concentration of dispersed local populations of moths

Highly dispersed endemic populations of moths which are present in plantations and natural forests during the non-outbreak season may respond synchronously to the influx of moisture during the first pre-monsoon shower, and fly up in the air. These moths get concentrated in the sky through wind phenomena and get deposited on hill tops as a group. Behavioural mechanisms keep the moths together and they move and oviposit gregariously, causing the early outbreaks in small epicentres. Concentrated infestations safeguard the insects from the pressure of natural enemies, ensuring better survival, and the population multiplies fast in one or two generations to cause widespread outbreaks.

At present, these are hypotheses, but it is possible to test them. I will come back to this at the end of this article.

Search for resistant trees

An ecologically sound pest management option is to select and propagate trees resistant to pests. At KFRI, we explored this option. The general observation that many isolated trees often remain unaffected amid totally defoliated trees gave the impression that there

are trees resistant to the defoliator. However, careful search did not yield any resistant teak trees (Nair et al., 1989). We showed that the usually observed escape of some trees was not due to genetic resistance but to what may be called phenological resistance. As the moths lay eggs only on tender leaves, trees with mature leaves, often standing close to trees with tender leaves, are left unattacked. Through field observations of marked trees, we showed that a tree which is not attacked in one year may get attacked in another year. Due to asynchrony between the flushing time of trees and the insect life cycle, different trees may escape defoliation at different times.

The 'teli' variety of teak in Karnataka is credited to escape defoliation due to early flushing by about a month in advance of other trees. If the development of an outbreak is, as hypothesised above, dependant on the premonsoon wind system, there is scope for using early-flushing clones to obtain practical protection against the pest, as the pest alone cannot cause earlier outbreaks through adaptive evolution.

Artificial diet for mass rearing

For the first time, we developed an artificial diet for rearing the teak defoliator (Mathew et al. 1990). With this diet, larvae can be reared in glass tubes in the laboratory instead of on teak leaves. This facilitates continuous maintenance of laboratory cultures to produce insects for various purposes. The semisolid agar-based diet contains essential nutrients and vitamins and is simple to prepare. Using this diet, we have maintained a continuous culture of the insect over the past several years, in the KFRI laboratory. This has been of great help in many of our investigations including production of teak defoliator baculovirus for its control.

Solar light trap for population monitoring

In our attempt to develop a monitoring system to detect teak defoliator infestations, we developed a solar light trap suitable for trapping moths. The trap uses a blacklight tube, powered by a battery which is charged using a solar panel containing photovoltaic cells. This was developed in collaboration with the Agency for Nonconventional Energy and Rural Technology (ANERT), Trivandrum, another organisation under the State Committee on Science, Technology and Environment.

Biological control using baculovirus

A disease of the teak defoliator larvae, characterised by the larval body becoming flaccid and then rupturing to release the liquefied body contents has been reported for long. Studies by KFRI scientists revealed, for the first time, that this disease is caused by a baculovirus (Sudheendrakumar et al., 1988). This group of disease-causing viruses are very specific to insects and safe to other animals, and therefore is being extensively used for control of pest insects, particularly in the developed countries. In the teak defoliator, natural infection by this virus usually accounts for large-scale mortality of later generation larvae, leading to the collapse of the outbreak phase.

In research funded by the Department of Biotechnology, Govt. of India, we characterised this virus and showed it to be a DNA virus falling under the group of nuclear polyhedrosis virus, with a genome size of about 100 kbp (kilo-base pairs). Several aspects including characterisation of the virus by analysis of the polyhedrin protein, cross infectivity studies, disease transmission and epizootiology, persistence, virus production methods and field efficacy of the virus for applied control were also studied.

Field studies showed that because of the poor persistence of the viral polyhedra in the environment it will not be possible to induce disease epizootics under field conditions but disease can be induced by spraying viral polyhedra on to the foliage. Field trials at Nilambur in 1993 showed that 70 to 76% of the foliage loss caused by the infestation can be prevented by timely, one-time spray of the viral preparation during each outbreak.

Further support to these studies came in 1995 with the collaboration of the UK Forest Research Agency through a DFID (Department for International Development) programme. This gave us the opportunity to take this research to international standards, in order to develop appropriate protocols for field application of the virus to control the pest. Good progress has been made towards reaching this goal. Rigorous methods have been used to standardise each step. The lethal dosage of nuclear Polyhedral Inclusion Bodies (PIB) needed to kill each of the five instars, the PIB production potential of each instar (for mass production), persistence

of the PIB on the teak leaf when exposed to rain as well as natural UV radiation, comparative advantage of different mass production systems, etc., have been studied.

Further field trials have been carried out this year using refined methods; the data are being analysed. The aim of these studies is to develop appropriate mass production protocols for the virus, formulate the virus for storage as well as field application, and determine the optimum dosage and method of application, to achieve maximum control of the infestation.

Control using commercial formulations of B.t.

Commercial formulations of the bacterium, *Bacillus thuringiensis*, known widely as B.t. are now commonly used for control of several agricultural insect pests, because of their environmental safety. B.t. has a broad spectrum of effectiveness, particularly against lepidopteran pests. We tested a few commercial preparations of B.t. against teak defoliator larvae, both in the laboratory and in a field trial at Nilambur, and found them effective (unpublished results).

Standardisation of spraying system

In our control trial using a crude preparation of the *Hyblaea* baculovirus in 1993, we employed a high volume spray using a rocker sprayer to reach the canopy of 8 year old teak trees. About 1 litre of spray fluid was required to cover each tree by this method. Use of high volume spray is wasteful whether it contains a chemical or a biological agent, as very little of the material used reaches the target and the rest is wasted in the environment. Therefore, we standardised the use of ultra low-volume, mechanised sprayers to deliver the spray fluid with better target specificity. Using different spray application equipment, we have calibrated several parameters like rpm, flow rate, addition of carrier fluid, etc., to generate optimum droplet size from the spray fluid to deliver the desired dosage of PIBs per leaf area as well as to ensure appropriate spray coverage of the canopy. Fluorescent dyes were used to study spray coverage and a satisfactory oil based emulsion was developed to prevent rapid evaporation of the small droplets of spray fluid. A spinning-disk atomiser was found the most suitable for spray application.

Looking ahead

In the background of what KFRI has accomplished over the past two decades, the future for teak defoliator control appears very promising. We have pursued a two-pronged strategy to reach the goal.

In many ways, the teak defoliator control problem resembles a dacoity situation. Even if we have the guns ready, we cannot pull the trigger unless we know when the dacoit will strike. Similarly, even if we have a method to kill the pest, we cannot use it effectively, unless we know when and where it will strike. So at KFRI, while we have been sharpening the tools for control, on the one hand, we have also been trying to develop a method, on the other hand, to predict the onset of outbreak, by elucidating the mechanisms of outbreak initiation. Both have yielded rich dividends and we are on the march to defeat the enemy.

Among the tools for control, we have examined the prospects of insect parasitoids and other natural enemies, selection for resistance, and use of baculovirus and B.t. The latter two are the most promising. Efforts are under way, at KFRI, to mass produce and formulate the *Hyblaea* baculovirus. Use of insecticidal chemicals can be effective, but will cause irreparable environmental damage. The prospects for management by preventing development of later and larger outbreaks by controlling the epicentre populations is discussed below.

Our ability to control the teak defoliator depends on our understanding the mechanism of outbreak initiation. Are the outbreaks triggered by moths brought in from far off places by the monsoon wind? Or, by wind concentration of dispersed endemic populations of moths?

Individual researchers are not able to put these hypotheses to test. It requires interdisciplinary effort involving biological and physical sciences and co-ordinated data collection from strategic points in the Asia-Pacific region. A critical mass of funds, expertise and technological inputs are necessary to address this problem. It is hoped that KFRI will be able to catalyse such an effort. The hypotheses can be tested by modeling of back-trajectories for given floating objects, using wind field data, and examining correlation between wind field and empirical data on moth arrivals.

Recent studies (Nair, et al 1998) indicate that many of the later outbreaks may be caused by moth populations originating from the early epicentres. In a large teak area like Nilambur, it will be worthwhile to detect the early epicentres, kill all the larvae there, and examine its effect on incidence of subsequent outbreaks. Although a costly experiment, it will be of great value if this can be shown to prevent subsequent outbreaks.

If it is established that outbreak is linked with monsoon wind, we can develop methods to predict the time of its occurrence, so that timely control measures can be mounted. Again, if moths are transported mechanically by the monsoon wind, early flushing varieties can be propagated to evade outbreaks, as discussed earlier.

Thus there are several options for control, depending on how the outbreak is triggered. Understanding the mechanism of outbreak initiation is therefore crucial, because it will tell us whether we can prevent the outbreak, instead of controlling it . Preventing an outbreak is like replacing a worn out washer of a water tap to stop the leakage. Controlling an outbreak is like collecting the dripping water and pouring it away continuously. The first is removing the cause, the second is treating the symptom. I hope KFRI's tryst with the teak defoliator will end with an acceptable management strategy. In the words of Beeson, what the Executive Forest Officer needs are not learned treatises containing suggested remedies and life histories of insects, but tested remedies and death histories of insects. I trust KFRI will live up to this expectation.

KFRI Publications on the Teak Defoliator

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Sudheendrakumar, VV 1997 Evaluation of parasitoids for the biological control of the teak defoliator. No.129, 32pp.

Nair, KSS ; Sudheendrakumar ; Varma, RV and Mohanadas, K 1998 Tracing the epicentres of the teak defoliator outbreaks in Kerala. No.147.

Video (VHS)

KFRI 1993 The Teak Defoliator (A 20-min. Scientific documentary depicting the biology, outbreak and impact of the pest, with English/Malayalam commentary).

Weather data from Peechi (1997)

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Plant Physiology Division

The recording of weather parameters at KFRI station were automated from January 1997 using an automated weather station manufactured by Skye Instruments, U.K. This automation in weather recording has helped us to get more sophisticated data than before using a manual station. All the parameters are now measured at 30 seconds interval and averaged over an hour. This helps us to give a more accurate data for temperature, relative humidity and wind velocity. The hourly rainfall data is also now available which can be used to estimate the rainfall intensity. However, the major change has been made to the solar radiation recording. Instead of the sunshine hours given so far, the energy available per square meter is given in megajoules (MJ). Since this is an energy unit, the data become highly quantitative. This will be helpful in an accurate calculation of potential evaporation and other energy - related parameters. Hourly data on the various weather parameters are stored in computer disk as a DBF file.

The total rainfall at Peechi amounted to 2601.3 mm during the year which is about 108 mm more, than the previous year. The South West Monsoon contributed about 2154 mm while the North East Monsoon 447 mm. The number of rainy days, when rainfall was greater than 10 mm, was 79 days which is 18 days more than that of the previous year. Summer showers were rare, and months of January, February and March did not receive any rain. The monsoon became active from 5th June onwards. July had the maximum rainfall, raining almost all days of the month amounting to 763 mm. August, September, October and November also received good rains. Compared to previous year, the North East Monsoon was more favourable in 1997. The highlights of the weather data are shown in Table 1. The monthly averages of the various weather parameters measured at the KFRI Weather Station are presented in Table 2. The annual rainfall from 1988 onwards and the monthly rainfall for 1997 are presented graphically in Fig.1a and b respectively.

Table 1. Highlights of the weather data.

Total rainfall for the year	:	2601.3mm
Total number of rainy days	:	79 days
Day with maximum rainfall	:	7th August (142.8 mm)
Month with maximum rainfall	:	*July (763.6 mm)*
Month with maximum rainy days	:	July (22 days)
Day with maximum temperature	:	28th March (36.7°C)
Day with minimum temperature	:	3rd January (19.8°C)
Month with highest mean temperature	:	March (29.1 °C)
Day with maximum wind speed	:	4th August (9.9 m/s)
Month with maximum sunshine	:	February (705 MJ/m^2)
Month with minimum sunshine	:	July (357 MJ/m^2)

Continued ▶

Table 2. Monthly averages of weather data for 1997 at Peechi
(Latitude 10°32'N; Longitude 76°20'E; Altitude 100 m)

Month	Temp (°C)			r.h (%)			Rainfall (mm)		Wind speed (m/s)			Solar radiation (MJ/m²)
	Min	Av.	Max	Min	Av.	Max	Total	Days	Min	Av.	Max	Total
Jan	20.8	25.6	31.7	27.9	62.4	91.4	0.0	(0)	0.1	2.1	5.3	701
Feb	19.8	25.6	33.8	24.3	74.4	94.4	0.0	(0)	0.0	0.8	2.9	688
Mar	22.3	29.1	36.7	26.5	70.9	99.1	0.0	(0)	0.0	1.2	4.9	705
Apr	23.4	29.1	36.5	29.2	72.8	96.4	0.8	(0)	0.0	0.8	3.8	677
May	22.4	28.6	35.2	41.0	79.2	100	67.6	(3)	0.0	0.6	3.0	599
Jun	22.0	26.7	35.7	47.7	87.5	100	518.4	(14)	0.0	0.6	2.3	575
Jul	22.2	25.1	30.7	69.9	95.3	100	763.6	(22)	0.0	0.7	2.5	357
Aug	22.0	25.5	31.8	66.9	93.8	100	657.0	(18)	0.0	0.7	9.9	657
Sep	22.0	26.3	32.2	66.1	91.3	100	147.0	(6)	0.0	0.7	2.0	553
Oct	21.8	26.7	33.3	58.0	89.4	100	188.5	(8)	0.0	1.0	3.8	629
Nov	22.5	26.4	32.0	62.3	90.6	100	240.8	(7)	0.0	1.0	4.1	548
Dec	21.8	26.7	32.8	54.1	83.8	100	17.6	(1)	0.0	1.9	5.0	607

Note: r.h = Relative humidity; The figures in parentheses indicate the number of rainy days when rainfall was >=10 mm.

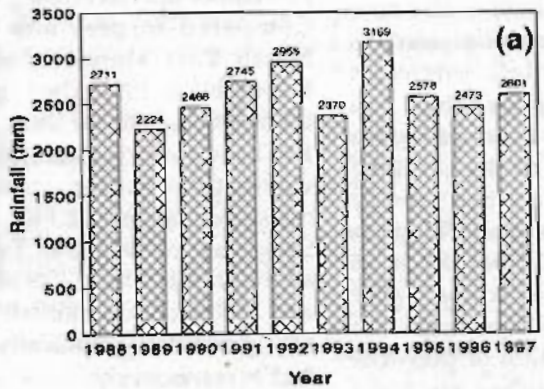
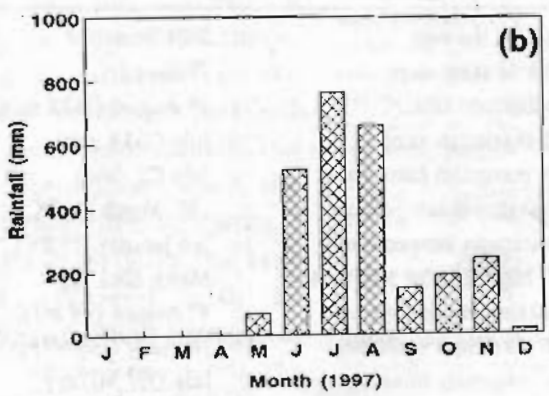


Fig.1 (a) Cumulated annual rainfall from 1988 to 1997 at Peechi.



(b) Cumulated monthly rainfall for 1997 at Peechi.

Research Highlights

Soil and Water Loss from Teak and Eucalypt Plantations quantified

In a three-year duration study, which concluded recently, the soil and water loss by surface run-off from a three-year-old teak (*Tectona grandis*) plantation at Nilambur and a two-year-old eucalypt (*Eucalyptus tereticornis*) plantation at Thrissur were found substantial. Run-off water loss from the teak plantation on lateritic soil with 8-12° slope was found to be 25-26% of the rainfall. The corresponding loss of soil was 4-15 metric tons per hectare. Loss of nitrogen varied from 5-17 kg/ha while that of potassium, 0.4-2.3 kg per hectare. The eucalypt plantation on lateritic soil with 15-20° slope was found to lose 19-20% rain water through surface run-off, which carried 31-46 metric tons of soil along with it. This study was carried out by a team of scientists from the Soil Science and Agroforestry Divisions of KFRI, Mr. Thomas P. Thomas, Dr S. Sankar and Mrs M.P. Sujatha. The study report (No.126) was submitted to the Kerala Forest Department who funded the project.

Run-off measuring device established in the field.

Fertilizer dosage recommended for Teak Plantations

With the growing interest in teak plantations, a number of private planters have shown interest in fertilizer applications.

In a project to study the effect of different nutrients N,P,K,Ca,and Mg on the growth of teak plantations belonging to different rotations, a team of scientists from KFRI, Dr M.Balagopalan, Mrs. P. Rugmini and Dr S. Chand Basha have recommended the fertiliser dosage. Among the different treatments, comparison among means test showed that N_2 P_2 K_2 Ca_2 Mg_2 treatment was found to be the best in younger plantations. This is equivalent to the application of 65 g of Urea, 150 g of Mussorie Rock phosphate, 58 g of Muriate of potash, 42 g of Quick lime and 149 g of Magnesium sulphate/tree or 163 kg of Urea, 375 kg of Mussorie Rock phosphate, 145 kg of Muriate of potash, 105 kg of Quick lime and 373 kg of Magnesium sulphate/ha.

The nutrients have to be added in split doses in the first year during South-West and North-East Monsoon periods and double the above amount in split doses in the second and third years during the two monsoon periods. However, it is always advisable to carry out site evaluation and detailed soil analyses before nutrient applications. The above recommendations have been given in a report (KFRI report No.138) submitted to the Kerala Forest Department who funded the study.

Neemcake found ineffective for termite control

Because of environmental concerns use oforganochlorines (eg. aldrin) is now being phased out. In view of this, a study was undertaken to evaluate less persistent insecticides and other ecofriendly products for control of termites attacking young plantations of eucalypts. Dr R.V. Varma and Dr K.S.S. Nair, both from the Entomology Division of KFRI who took up this study, conducted three small-scale and one large-scale trials from 1993 to 1995. An organophosphate (Chlorpyrifos), two synthetic pyrethroids (Cypermethrin and fenvalerate), a plant product (neem cake) and a bacterial broth based on Rhizobacteria were evaluated. Chlorpyrifos was found to give the best protection by prophylactic to soil in the polythene bag container (12cm X 18cm). Neem cake and the bacterial preparation were totally ineffective. Fenvalerate and cypermethrin gave varying degrees of protection at higher doses.

Chloropyrifos, at a dosage of 0.25 g active ingredient (a.i.) per plant gave effective protection. However, a dosage of 0.5 g a.i. per container is recommended for large-scale field application. This study was submitted as a report (KFRI Research Report No.127) to the Kerala Forest Department who funded the project.

Forest disturbance adversely affects insect diversity

In an effort to study the impact of forest distrubance on insect species diversity a team of scientists from KFRI, Dr George Mathew, Ms. P. Rugmini and Dr V. V. Sudheendrakumar explored four locations in the Western Ghats. The following

table shows the effect of disturbance on the insect diversity index in the study areas.

Table showing Insect diversity index in the study locations.

Location	Undisturbed	Disturbed
Silent Valley	4.76	4.65
Nelliampathy	5.21	3.91
Sholayar	4.79	3.13
Parambikulam	4.64	3.99

The research team collected 1250 species of insects belonging to 15 Orders from all localities, of which 586 species have been identified. Maximum number of species collected belonged to the Order Lepidoptera and Coleoptera. Based on the collector's curve and distribution models (log-normal distribution), it was concluded that all the areas contain more species than could be collected in this study indicating the need for further studies. Similarity index calculated for the various locations indicated that there was considerable difference between the locations and that each area was specialised with respect to its faunal elements.

Site specific conservation strategies involving fire protection (at Silent Valley); raising of fuelwood plantations and pasture areas (at Sholayar) as well as favouring recolonisation of altered habitats (at Nelliyampathy and Parambikulam) were suggested to reduce the impact of disturbance on biodiversity in these areas. The project report (No.135) has been submitted to the World Wide Fund who sponsored this study.

Faster growth will not affect timber strength of teak

Plantation managers can now plan to produce larger diameter logs with greater yield of heartwood per tree by accelerating the tree growth in short rotation plantations. Teak can produce the timber of optimum strength in relatively young rotations of 21 years. Fast growing provenances/clones can be selected for teak management without

Note the higher proportion of heartwood in fast grown 21-year old teak (top) compared to slow grown teak of the same age.

reducing timber weight/density. Selection of individual trees within the provenance can provide greater avenues than selection of provenances in breeding programmes for improvement of wood density of teak. However, wood density cannot be the best single criterion of overall genetic improvement of timber quality. Faster growth in relatively young forest plantations with judicious fertilizer application/genetic inputs can be advantageous in terms of heartwood volume per tree and timber strength. These are the conclusions drawn by DrK.M.Bhatt and Mrs. E.P.Indira, scientists from KFRI who completed a project (Report No.132) on the effect of faster growth on the timber quality of teak. However, more research is recommended on timber durability, strength and quality standards/ grading rules of fast grown teak under high input management. The above study was funded by the Kerala Forest Department.

Epiphytic Flora

A total of 255 species of vascular epiphytes have been enumerated from the Nilgiri Biosphere Reserve. Among them, 159 species belonging to 54 genera representing 12 families are angiosperms and 66 species belonging to 29 genera representing 12 families are pteridophytes. Among the angiosperms, the family Orchidaceae includes the highest number of epiphytes with 129 species. Eight angiosperm taxa of epiphytes are new to India and 4 taxa new records to Kerala. Among the pteridophytes, 5 species are also new records to Kerala. Among the lower group of plants, 17 species of Macrolichens are found to be new records to Kerala and two species new to South India. Dr M.S. Muktesh Kumar of Botany Division (KFRI) has submitted the above work as a report (KFRI Research Report No. 139) to the Kerala Forest Department (Wildlife Wing).

Mammals studied in Idukki Wildlife Sanctuary

In a report (No.134) submitted to the Kerala Forest Department (Wildlife Wing) by Dr P.S. Easa from the Wildlife Division of KFRI, only twelve species of large sized mammals were recorded from the Idukki Wildlife Sanctuary. Elephants dominated in number as well as biomass. Ecological density of elephants was estimated to be 1.34 km^{-2}. Proportion of males in

the population was very low (2.75%) compared to adult females (91%). Low proportion of Juveniles (1.85%) and calves (0.92%) indicated a very unhealthy trend. There was no significant seasonal difference in the overall food availability in the Sanctuary. However, distribution of elephants showed significant differences between seasons with highest density during the post monsoon period.

It is interesting to note that 68 plant species belonging to 29 families were identified as food plants of elephants, grasses being the dominant ones.

A Status report on the Chinnar Wildlife Sanctuary

Chinnar Wildlife Sanctuary, the only dry deciduous scrub area in Kerala has become a wildlife sanctuary in 1984. This sanctuary is famous for the endangered grizzled giant squirrel, *Ratufa macroura*.

A team of scientists from KFRI, DrVijayakumaran Nair, Dr K.K. Ramachandran and Dr E.A.Jayson have prepared a status report of the Chinnar WLS, sponsored by the Wildlife Wing of the Kerala Forest Department. This has revealed 17 larger mammals and 143 species of birds. Based on transect data, the team has estimated 150 individuals of grizzled gaint squirrel. As a status report (KFRI Research Report No. 131), it can be expected that this would initiate more research work in this sanctuary, which is close to the Indira Gandhi Wildlife Sanctuary of Tamil Nadu.

A rich Flora amidst stress

A study on the flora of the Shenduruny Wildlife Sanctury, which lies along the Arienkavu-Kulathupuzha valley, in Kollam District of Kerala, revealed a commendably rich flora. Dr N. Sasidharan, scientist from the NWFP Division (KFRI) collected 951 angiosperm species from this sanctuary of which 309 species are Western Ghats endemics. Among them were 100 species belonging to threat categories including 10 species considered as possibly extinct. Two new species, *Polyalthia shendurunii and Ardisia stonei* were also described during the study.

An interesting aspect of this study was that severe biotic and abiotic pressures were noticed in this sanctuary. Presence of human settlements in and around the sanctuary and landslides due to heavy rains were common. It was noticed that members of Podostemaceae had been wiped out by flooding rivers. In spite of all this, nature lovers would be pleased to know that this sanctuary is the abode of such a rich flora. The above study has been reported (KFRI Research Report No.128) to the Kerala Forest Department (Wildlife Wing) who sponsored the study.

Participatory Management Suggested for NWFPs

It is well known that the Non-Wood Forest Products play an important role in the generation of income and employment. But the sustainable extraction of NWFPs without causing any damage to biodiversity is a challenge to researchers in this field. A team of scientists from KFRI, DrP.K. Muraleedharan, DrN. Sasidharan and DrK.K. Seethalakshmi carried out a detailed study on the NWFPs in the forest areas of Kerala, namely, Wayanad, Nilambur and Attappady. The Ford Foundation funded this project.

The team recorded 229 NWFPs from the study areas, of which less than 50 species were only commercially extracted. They found that more than 50 percent of the commercially extracted items were depleting due to overexploitation. An interesting observation was that vegetatively propagated NWFPs showed very good natural regeneration compared to species propagated by seeds. The report (KFRI Research Report No.133) presents a bleak picture on the socio-economic and institutional factors that have contributed to unsustainable extraction. The study team has concluded that most of the problems in NWFP collection have been caused due to the non-involvement of tribals in management decisions. Hence they have presented a participatory management action plan for the sustainable management of NWFPs in Kerala.

A fruting twig of gooseberry *(Phyllanthus emblica)*- a NWFP in great demand.

NEWS AND VIEWS

KFRI joins hands with CSIRO in eucalypt research

KFRI has signed a research agreement with Australia's Commonwealth Scientific and Industrial Research Organisation (CSIRO) for a joint research project on maximising productivity in eucalypt plantations. The possibility for such a collaboration had been indicated by Dr E.K.S. Nambiar, Chief Research Scientist from CSIRO, when he visited KFRI in 1996 (see Evergreen No.38). The collaboration has become operational since July 1997.

In India, which has the largest area of plantation eucalypts of any country in the world, growth rates in parts of the country are low due to the poor nutrient status of soils. Furthermore, sustainable production is problematic as indicated by decline in soil fertility and tree productivity. Interestingly, the problems are similar in Australia too. Hence nutrition of eucalypt plantations has been identified as a priority research area for maintenance of sustainable wood production.

The research will be based on the two eucalypt species planted in Kerala (*Eucalyptus tereticornis* and *E. grandis*) and will be conducted at four different locations, namely, Vadakkancherry, Punalur, Suryanelli and Vattavada. At each site, a series of six designed experiments will be initiated to investigate aspects of harvest residue management, nutrient application, use of legume undercrops to increase soil fertility and practical methods of water and soil conservation. The Australian component will use *E. globulus* and will also investigate methods of organic matter conservation through management of harvest residues, nutrient applications and incorporation of agricultural legumes as undercrops. Within this experimental framework, research will focus on four inter-linked sub-projects, investigating the impact of silvicultural options in eucalypt plantations on (i) nutrient status and nutrient cycling, (ii) tree physiology and water relations, (iii) tree growth and nutrient uptake, and (iv) soil process and tree growth modelling.

The results of this research will have wide applications. Apart from direct benefit India and Australia gain from this research, the results will be integrated into a general framework proposed by CIFOR. This way many other tropical countries can draw on the results.

Most of the funding for the above project will come from ACIAR (Autralian Council for International Agricultural Research). The Australian team of scientists will be led by DrA.M. O'Connell (CSIRO). The other members of the team are Dr Tim Grove, Mr. S.J. Rance Mr. J. Galbraith, Ms. Tuyen Pham (All CSIRO), Prof. R.J. Gilkes (University of Western Australia), Prof. P. Saffigna (Griffith University) and DrR. McMurtrie (University of New South Wales). The KFRI team will be led by DrK.V. Sankaran, with scientists from several Divisions taking part. They are Dr M. Balagopalan, Dr S. Sankar, Dr J. Kallarackal, Dr C.K.Somen, Dr J.K. Sharma, Mr. K.C. Chacko, Dr R.C. Pandalai, Dr M. Balasundaran and Dr C.N. Krishnankutty. The overall coordination in ACIAR will be done by Dr John Fryer. KFRI's execution

KFRI gains more soil analytic power

With the initiation of the KFRI-CSIRO collaborative project, funded by ACIAR, a number of research facilities have come to KFRI. The Atomic Absorption Spectrophotometer (AAS) is going to help in the multi-element analysis of soil and plant samples in the flame furnace. The new Auto Analyser, which works on the principle of colorimetry will help to estimate different forms of nitrogen and phosphorus. This has an automated block digester which can carry out 50 digestions simultaneously. The UV-Vis Spectrophotometer is also an advanced model. A number of other sample preparation equipment which include the hydraulic soil core extractor, sample diluter, mixer, shaker, dispenser, mulcher, electronic balances etc. are also available in the new laboratory set up for this project.

Besides the above analytical laboratory, the project will bring into KFRI a number of field equipments including two automated weather stations, a soil moisture measuring device working on time domain reflectometry (TDR) and sap flow gauges for measuring individual tree transpiration.

M. Balagopalan

Soil Science Division

of work in this project will be promoted by the Kerala Forest Department, Kerala Forest Development Corporation and Hindusthan News Print Limited. CSIRO will be directly helped by the University of Western Australia, University of New South Wales, Griffith University and Bunnings Treefarms. It is probably for the first time that so many experts from several institutions are assembled in a research project carried out at KFRI. Scientists from both the organisations are now looking forward to more collaborative research in other forestry areas also. The mutual visits and sharing of experience between the scientists of the two countries can be expected to improve the eucalypt productivity in both countries.

A butterfly house in KFRI

Nature lovers and entomologists will be pleased to visit the butterfly house being set up in KFRI. This venture has been funded by the Ministry of Environment and Forests, Government of India. The butterfly house is meant for captive breeding of a number of tropical butterflies. Besides, a butterfly garden will be landscaped around the butterfly house to attract butterflies like the Common Rose, Southern Bird Wing, Lemon Butterfly, Yellows, Blue Tiger, Common Crow etc. DrGeorge Mathew, who is the Principal Investigator in this project said that besides butterflies, Woodroaches, Passalids and other invertebrates will be also maintained in terraria for research and educational purpose.

IIBC Collaborates with KFRI for Mikania research

The Mikania weed which has become a big menace in several forest divisions and agricultural land in India, is reducing the land productivity tremendously. The International Institute of Biological Control is now collaborating with KFRI to explore the potential of finding a biological control for the weed. Since this could prove to be a long-term strategy, Dr K.V. Sankaran (Pathology Division) said that the team will be looking for some immediate solutions also to control this weed. The project is managed by the UK Natural Resources International and funded by the Department of International Development. *(see next page also)*

Slivering to ensure reed bamboo supply

Harvesting reed during rainy season has a major disadvantage : it affects the regeneration and also the emergence of new culms. If the forest department decides to implement a closure period to overcome this problem, mat weavers will be jobless during this period. Otherwise a reserve stock of reed should be available. This leads to problems connected with storage and protection against fungi and insects.

KFRI has come up with a simple solution to this problem : convert reed into slivers, treat in preservative chemicals, dry and store. This will ensure round the year supply of raw materials to weavers and reduce the wastage of reed.

Dr R. Gnanaharan (Wood Science Division, KFRI) who is the Principal Investigator in a project to study this, has proposed to import a slivering machine and conduct a techno-economic study to conclusively prove the advantages of upgrading technology in the traditional reed bamboo processing sector. The study will be conducted by KFRI and the Kerala State Bamboo Corporation as a collaborative project funded partially by the Kerala Forest Department. If successful, this technology will benefit the 200,000 workers depending on the reed for their sustenance.

Preservation of Sacred Groves recommended

In a workshop on Role of Sacred Groves in the Conservation and Management of Biodiversity organised by UNESCO, New Delhi and co-sponsored by the State Committee on Science, Technology and Environment, Government of Kerala the participants recommended the preservation of existing sacred groves as they are the genetic warehouses of natural forests. The workshop was held from 8-11 December 1997 at KFRI. Dr P.S. Ramakrishnan of the Jawaharlal Nehru University was the Technical Coordinator of the Workshop. The Workshop was attended by representatives of UNESCO, Paris, Director UNESCO, Delhi and over 40 scientists and managers from India and abroad.

The Workshop was inaugurated on 8 December by Prof. Moegiadi, Director, UNESCO, New Delhi by lighting the sacred lamp in the traditional style. During the inaugural session Prof. P.S. Ramakrishnan elaborated the Workshop goals and Dr Thomas Schaff, UNESCO, Paris delivered the

keynote address. Thirty papers were presented in four technical sessions which include 1. The concept: Socio-cultural, historical and socio-ecological aspects, 2. Sacred Groves around the world, 3. Sacred Groves in India-case studies and 4. Biodiversity Conservation, ecosystem functions of Sacred Groves and management aspects. The participants visited Iringole Kavu (a Sacred Grove) as a part of the Workshop study tour. Besides preservation, the Workshop also recommended to develop databases on Sacred Groves/sites detailing their-cultural, religious and ecological roles, to promote their conservation by linking them with the village level ecodevelopment, to evolve meaningful communication packages to make stakeholders aware of the multifaceted benefits from Sacred Grove conservation and sustainable management, to develop community based conservation programmes for Sacred Groves, and to strengthen anthropological studies in Sacred Groves.

Dr P.S. Ramakrishnan addressing the participants of the workshop on Sacred Groves. On the dias (from left) are Dr J.K. Sharma, Dr Sudha Mehndritta, Prof. Moegiadi and Dr Thomas Schaff.

The participants greatly benefited from the exposure they got to the Sacred Groves from different parts of the world.

Control of Mile-a-minute weed

Mikania micrantha is an aggressive and invasive plant climber with an extremely rapid growth rate (up to 9 cm/day), hence the common name, which is also shared with several other fast-growing species. It spreads by seed as well as stem fragments, and forms smothering mats. This perennial climber has been known since the 1950s as a problematic agricultural weed in both subtropical and tropical plantations and forestry crops throughout Asia and Oceania. However, it is only relatively recent that it has been reported as a threat to natural ecosystems.

If allowed to spread, *Mikania* weed has the potential to invade and degrade natural ecosystems, where it can outcompete slow-growing indigenous plants, ultimately altering not only the floral, but also the faunal composition. Reports from Northern India refer to the suppression of forest grasses by the weed, resulting in forage loss for the larger herbivores, particularly elephants. This habitat destruction is illustrated in forest systems in the Western Ghats of Southern India, where the weed climbs on the upper canopy. In the wet grasslands of the Nepalese Terai region, it smothers the unique vegetation. In Kerala, particularly badly affected trees include teak, eucalypt, bamboo, reeds, *Ailanthus* and *Acacia*. It is also a great threat to pineapple, banana and other agricultural crops.

In its neotropical native range (Brazil to Mexico), *Mikania micrantha* has a sporadic distribution and is typically restricted to riparian habitats, growing along the edges of water courses, particularly river banks and wetlands. It can be found on occasions in urban situations climbing over hedges and fences but is seldom invasive or aggressive. In these habitats, the plant is found intertwined with the natural vegetation, and rarely aggregates into mats. Within such an ecosystem, the plant is attacked by a variety of coevolved natural enemies, particularly arthropods and fungal pathogens; those which impact directly on the photosynthetic efficiency of the plant to reduce its vigour and competitive ability.

Herbicide control is not feasible where infestation is widespread, and environmentally undesirable in conservation areas. Cultural control is also uneconomic and potentially dangerous if not managed. Host-specific natural enemies of this weed have been identified in the neotropics, during surveys undertaken by the International Institute of Biological Control (IIBC), and these could offer the only sustainable, economically viable and ecologically benign solution to this problem.

K.V. Sankaran
Plant Pathology Division

Campus News

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K.M. Bhat 1998. Cambial activity and juvenile wood formation in teak.

KFRI Research Report No.138

M. Balagopalan, P. Rugmini and S. Chand Basha 1998. Soil nutrient management for teak plantations of Kerala

KFRI Research Report No. 139

M.S. Muktesh Kumar 1998. Studies on the epiphytic flora in the tropical forest ecosystem of Western Ghats with special reference to Nilgiri Biosphere Reserve.

New Research Projects

KFRI 280/97: Establishment of a semi-permanent field clonal propagation unit for *Eucalyptus*.

Investigators: Dr J.K. Sharma, Dr M. Balasundaran, Dr E.J. Maria Florence.

Objectives: i. To establish a semi-permanent field clonal propagation unit (FCPU) for clonal multiplication of eucalypts for experimental purpose. ii. To work out the economics of the production of ramets.

Funding source: ICFRE, Dehra Dun.

Duration: 3 years (July 1997 to June 2000)

KFRI 281/97 : Improving and maintaining productivity of eucalypt plantations in India and Australia.

Investigators : Dr K.V. Sankaran, Dr M. Balagopalan, Dr S. Sankar, Dr J. Kallarackal, Dr C.K. Somen, Dr J.K. Sharma, Mr. K.C. Chacko, Dr R.C. Pandalai, Dr M. Balasundaran, Mr. C.N. Krishnankutty.

Objectives : To identify and develop practices for manipulating soil organic matter, and soil and tree nutrient and water status as a basis for implementing silvicultural regimes which optimise conservation and use of site resources and which will allow sustainable wood production from eucalypt plantations.

Funding Source : Australian Centre for International Agricultural Research (ACIAR), Australia.

Duration : 5 years (July 1997 to June 2002)

KFRI 282/97: Testing and developing criteria and indicators for sustainable management of tropical plantation forests in India.

Investigator: Dr S. Sankar

Objectives: To test and develop criteria and indicators for sustainable management of forest plantations in India with special reference to long and short rotation teak and eucalypt plantations.

Funding source: Centre for International Research in Forestry, Indonesia.

Duration: August 1997 to December 1998.

KFRI 283/97 Integrated management of the alien invasive weed *Mikania micrantha* in the Western Ghats.

Investigators : Dr K.V. Sankaran, Dr E.J. Maria Florence, Dr P.K. Muraleedharan.

Objectives : i. To develop in the short-term chemical/biological methods for controlling *Mikania* in forest plantations and agroforestry systems. ii. To explore the potential of classical biological control as a long-term management strategy. iii. To develop and test an integrated pest management programme.

Funding Source : Department of International Development, U.K.

Duration : 3 years (August 1997 to March 1999).

KFRI 284/97: Employment, land use and intercultural ecoscope: Forest plantation transformation in the Kerala Highranges.

Investigator: Dr S. Sankar

Objectives: The central objective of the study is to find compatibility of employment generation and environmental sustainability in upstream Kerala. The objective breaks up in four parts.

i. Income generation by landless labour households through employment and access to natural resources. ii. Perceptions and decisions of planters and foresters pertaining to their cash crop cultivation and management of natural resources. iii. Natural resource transformations of forests into several types of plantations. iv. Effects of this transformation on soil, water,

plantations and natural ecosystems.

Funding source: Indian Council for Social Sciences Research, New Delhi.

Duration: 3 years (August 1997 to July 2000)

KFRI 285/98: Forest atlas of Kerala

Investigators: Dr A.R.R. Menon and Dr P. Vijayakumaran Nair.

Objectives: Preparation of range level forest maps.

Funding source: KFD Development Fund.

Duration: 3 months (January 1998 to March 1998)

KFRI 286/98 : Introducing mechanical slivering techniques in traditional reed indusrty : A techno economic study.

Investigators : Dr R Gnanaharan, Shri. Mammen Chundamannil, Shri. A.K. Kurien (Kerala State Bamboo Corporation).

Objectives : Technological evaluation of mechanical slivering process and treatment of slivers and their storage. ii. Socio-economic evaluation of using mechanically produced slivers vis-a-vis manually produced slivers in mat weaving.

Funding Source : KFD Development Fund

Duration : January - December 1998.

KFRI 287/98 : Maintanance of the permanent plots to demonstrate the effect of protecting teak plantations from teak defoliator.

Investigators : Mr. T.V.Sajeev, Dr R.V.Varma, Dr V.V.Sudheendra-kumar, Dr K.Mohandas.

Objectives : i. To maintain and continue the protection measures against the teak defoliator in the demonstration plot. ii. To demonstrate the need to adopt control measures against teak defoliator and to include it as part of intensive management practices.

Funding Source : KFD Development Fund

Duration : 3 years (January 1998 - December 2000)

KFRI 288/98 : Termite control in clonally propagated root trainer raised planting stock.

Investigator : Dr R.V.Varma.

Objectives : i. To study the nature and severity of termite damage in clonally propagated eucalypt plantation. ii. To standardise effective methods of treatment against termites attacking clonally propagated eucalypts.

Funding source : KFD Development Fund.

Duration : 3 years (January 1998 - December 2000).

KFRI 289/98 : Maintenance of seed stands and species trial plots of rattans.

Investigator : Dr C. Renuka

Objectives : To maintain the multilocational seed stands and trial plots of rattans in Kerala.

Funding Source : KFD Development Fund

Duration : 3 years (January 1998 - December 2000)

KFRI 290/98: Studies on clonal propagation of plus trees of teak (*Tectona grandis* L.f.) for identifying superior trees for plantation programme.

Investigators: Mr. T. Surendran and Silviculture Research Officer (KFD).

Objectives: i. To propagate plus trees of teak by rooting shoot cuttings. ii. To establish a clonal garden of plus trees of teak. iii. To monitor the growth of clonally propagated plants. iv. To identify superior trees for future clonal propagation programme.

Funding source: KFD Development Fund

Duration: 3 years (January 1998 to December 2000)

KFRI 291/98 : Maintenance and growth observations in multilocational provenance trial plots of eucalypts.

Investigators : Dr M. Balasundaram, Dr E.J. Maria Florence, Dr J.K. Sharma.

Objectives : i. Maintenance of provenance trial plots at Kottapppara, Punalur, Muthanga and Vallakadave by fire tending, weeding, proper labelling etc. ii. Recording growth measurements like GBH, height and disease resistance.

Funding Source : KFD Development Fund.

Period : 3 years

KFRI 292/98 : Pollination ecology of teak in Kerala.

Investigators : Dr K. Mohandas, Dr George Mathew, Mrs. E.P.Indira.

Objectives : i. To study the various aspects of pollination in teak in dry and moist zones in Kerala. ii. To study the rate of insect pollination. iii. To evaluate the effect of insect assisted pollination in boosting seed production.

Funding source : KFD Development Fund.

Duration : 3 years (January 1998 - Deccember 2000)

KFRI 293/98 : Revisionary studies on four genera of Indian bamboos

Investigator : Dr M.S. Muktesh Kumar

Objectives : Taxonomical revision of the four genera - *Dendrocalamus, Oxytenanthera (Pseudoxytenanthera), Schizostachyum* and *Sinarundinaria*.

Funding Source : Department of Science and Technology, Government of India.

Duration : 3 years (January 1998 to December 2000)

KFRI 294/98 : Conservation of invertebrates through captive breeding, with special reference to butterflies.

Investigator : Dr George Mathew

Objectives : i. To set up a butterfly house and garden to facilitate education of the public on the significance of nature conservation and to prepare a document on butterfly farming. ii. To standardise a methodology for mass rearing of butterflies in field cages. iii. To develop a centre to assist in the conservation of endangered species through mass rearing and reintroduction.

Funding Source : Ministry of Environment & Forests. Government of India.

Duration : 3 years (January 1998 - December 2000)

Participation in Seminars, Symposia and Workshops

Dr K. Balasubramanyam participated in the National Seminar on Natural Resources Management and Conservation held at Etawah, Uttar Pradesh from March 6-8, 1998 and contributed a paper on "Floral richness and diversity in the sacred groves of Kerala" by Balasubramanyam, K. and Induchoodan, N.C. He also participated in the National Symposium on the Recent Advances in Environmental Science organised by the Dept. of Botany, Guru Nanak Dev University, Amritsar from March 19-20, 1998 and presented a paper entitled "What sacred groves can contribute to biodiversity?" coauthored with N.C. Induchoodan.

Dr M. Balasundaran attended the International Seminar on sandal and its products held at Institute of Wood Science and Technology, Bangalore during December 18-20, 1997. He presented two papers entitled "Detection of phytoplasma in spiked sandal using DAPI stain", by Thomas, S. and Balasundaran, M. and "An effective method for clonal propagation of sandal".

Dr K.M. Bhat participated in XI World Forestry Congress at Antalya, Turkey during 12-22 October 1997 and presented a paper "Teak timber production in intensively managed plantations of the tropics" by Bhat, K.M. and Indira, E.P. He also convened a meeting of IUFRO 5.06.02 during the Congress.

Dr U.M. Chandrashekara attended the Regional Workshop on the Role of Sacred Groves in Management of Biological Diversity organised by UNESCO during 8-11 December 1997 at Kerala Forest Research Institute, Peechi. He presented a paper on "Conservation of Sacred Groves in Kerala : Issues and Strategies" (Chandrashekara, U.M. and Sankar, S.).

Mr. T.K. Dhamodaran attended an International Conference on Value Added Processing and Utilization of Less-Used Species at Kumasi, Ghana during 17-19 February 1998 and presented a paper "Effect of under-water storage in the utilization value of rubberwood" by Dhamodaran, T.K. and Gnanaharan, R.

Dr P.S. Easa attended a workshop on Biodiversity Monitoring in Eastern and Western Ghats organised by Indian Institute of Science, Bangalore and Ministry of Environement and Forests from 14-18 September 1997. He also attend-ed an International Conference on Medicinal Plants organised by Indian Institute of Science and FRLHT at National Institute of Advance Studies, from 16-19 February 1998 in the Indian Institute of Science, Bangalore. Dr R. Gnanaharan attended the International Seminar on Development of Indian Rubberwood Industry at Cochin during 12-14 February 1998 and presented an invited paper "Bureau of Indian Standards vis-a-vis rubberwood".

Dr E.A. Jayson, presented a paper entitled "Faunal diversity of the mangroves of Kerala" in the workshop on "Mangroves of Kerala" on 13 November 1997 at Trivandrum, organised by the STEC and CESS, Trivandrum.

Dr J. Kallarackal participated in National Seminar of Water and Nutrient Management in Spices held from 5-6 October 1997 at Madikeri, Coorg, Karnataka. He presented a paper on "Tree water consumption - an ecophysiological analysis" (Kallarackal, J. and Somen, C.K.). He also gave an invited special talk entitled "Eucalypt water consumption - facts and figures" at the Indian Science Congress held on 5-8 January, 1998 at Osmania University, Hyderabad. Dr Kallarackal also participated in the National Seminar on Oppurtunities and Challenges for Oil Palm Development held on 19-21 January 1998 in Vijayawada. He presented a paper entitled, "Ecophysiological parameters determining the performance of oil palm in peninsular India" by Kallarackal, J. and Jeyakumar, P.

Dr A.R.R. Menon attended the Workshop on Remote Sensing applications for Kerala held at Thiruvananthapuram on March 27-28 1998 and presented a paper entitled "Remote sensing applications in forestry" organised by the Institution of Engineers (India).

Dr C. Mohanan attended IUFRO Symposium on Innovations in Forest Tree Seed Science and Nursery Technology held at Pt. Ravishankar Shukla University, Raipur, M.P. during 22-25 November, 1997. He presented a paper on "Seed health problems in selected tropical recalcitrant and orthodox forest tree seeds and their impact on seedling production".

Dr Muktesh Kumar participated in the workshop on Mangroves of Kerala on 13 November 1997 and presented a paper on "Floral Diversity of Mangroves in Kerala". The workshop was organised by STEC, Govt of Kerala.

Dr P.K. Muraleedharan attended the International Conference on Medicinal Plants Conservation, Utilisation, Trade and Cultural Traditions, from February 15-19, 1998 in Bangalore.

Dr E.M. Muralidharan participated in the Tenth Kerala Science Congress held at Calicut from 2-4 January 1998.

Dr K.K.N. Nair attended the International Conference on Tropical Forests Restoration and Regional Strategies for Conservation organised by Society for Ecological Restoration and IUFRO at Miami, Florida, U.S., during 11-16 Novem-ber 1997, and presented two papers, "Biodiversity rehabilitation" and "Tropical Forests Restoration".

Shri. U.N. Nandakumar, Shri. K.C. Chacko and Dr A.R.R. Menon attended a Workshop on Preparing Guidelines for Site Specific Plans for forest officials organised by Kerala Forest Department at Trivandrum on 1 November 1997.

Dr K.V. Sankaran participated in the 23rd Annual meeting of Mycologi-cal Society of India and symposium on Fungi in Forest Ecosystem held at Kerala Forest Research Institute during 9-11

May 1997. A paper entitled "New hosts of *Myrothecium roridum* in Kerala" (Nawshad, K.I. and Sankaran, K.V.)was presented in the symposium. He also participated in a workshop entitled "Site Management and Productivity in Tropical Plantations - Impact on soils and options for management over successive rotations" convened by CIFOR in Pietermeritzburg, South Africa during 16-20 February 1998. He presented a paper entitled "Improving sustainable productivity of eucalypt plantations in Kerala, India".

Dr N. Sasidharan participated in the seminar on Medicinal Plants and their Conservation on 12 December 1997 in Wayanad, organised by M.S. Swaminathan Research Foundation Community Agro-biodiversity Centre and Development Agency for Rural Areas, Wayanad and gave a paper on the "Importance of conserving medicinal plants in non-forest areas".

Dr K.K Seethalakshmi participated in the IUFRO-Symposium on Innovations in Forest Tree Seed and Nursery Technology at Pt. Ravishankar Shukla University, Raipur from 22 to 25 November 1997 and presented a paper on "Seed handling practices for bamboos". She also participated in the seminar on Molecular techniques to crop improvement at C.M.S College, Kottayam from 29-31 December 1997 and presented a paper "Molecular techniques for bamboo systematics" by Seethalakshmi, K.K. and Madhavan, P. Dr Seethalakshmi attended the International Seminar on Medicinal Plants for Survival from 16-19 February at the National Centre for Advanced Studies, Bangalore.

Mrs. M.P. Sujatha participated in the Annual Convention and National Seminar of Indian Society of Soil Science during 18-21 October 1997 held at Science City Campus, Calcutta and presented a paper entitled "Soil fertility status and nutrient turnover in *Acacia auriculiformis* plantations in Kerala. She also participated in the Tenth Kerala Science Congress held at Regional Engineering College, Calicut during 2-4 January 1998 and presented a paper entitled "Site and soil characteristics of *Calamus* growing areas in Kerala".

Guest Lectures

Dr R. Gnanaharan gave a guest lecture on the "Scope of bamboo on habitat technology" to the graduate engineers and architechts undergoing a Master of Science in Habitat Technology Programme on 13 January 1998 at the Nirmithi National Institute of Habitat Management, Thiruvananthapuram.

Dr Jose Kallarackal gave a lecture on "Water relations and water stress in plants" on 9 February 1998 to the participants of a Refresher Course in Botany for college teachers at Govt. Victoria College, Palakkad.

Dr E.M. Muraleedharan gave lectures on "Micropropogation of forest trees" and "Low cost tissue culture" to participants of the Refresher Course for college teachers on 4th February 1998 held at Govt. Victoria College, Palakkad. He also gave a talk on "Applications of tissue culture" to the Botany Association of the NSS College, Nenmara on 12 February 1998.

Dr K.S.S. Nair gave a lecture on legal framework for bio-diversity conservation, to the Trivandrum Press Club on 29 March 1998.

Dr N. Sasidharan gave a lecture on Forests of Kerala on 20 January 1998 in the Biodiversity and Conservation Course for College and University teachers organised by the Academic Staff Colleg, University of Calicut. He also gave a lecture on field identification of forest trees on 24 January 1998 to the participants of Refresher Course in Botany for college teachers in Govt. Victoria College, Palakkad, Sponsored by Directorate of Collegiate Education, Govt. of Kerala.

Training imparted

Mr. K.C. Chacko, Dr R.C. Pandalai and Shri. U.N. Nandakumar, acted as Resource Persons for the workshop of Forest Officers of Social Forestry Circle, Ernakulam on "Degraded Forests" organised jointly by the Kerala Forest Department and KFRI on 23 September 1997 at KFRI, Peechi and took classes on the following topics: 1) Identification of degraded forests. 2) Causes of forest degradation. 3) Species selection for compensatory afforestation. 4) Strategies in afforestation of degraded areas.

Distinguished Visitors

Ms. Catherine Mackenzie, Technical Co-operation Officer, DFID, Foresrty Programme, Battaramulla, Sri Lanka, visited the Institute from 14-16 December 1998.

Dr Tim Grove, Principal Research Scientist, CSIRO Division of Forestry and Forest Products, Perth, Australia visited KFRI during January 1998.

Ph.D. Awarded

Mr. C.K. Somen was awarded Ph.D. Degree in Environmental Studies from Cochin University of Science and Technology, for his thesis entitled "Water relations, growth and gas exchange in *Acacia auriculiformis* under experimental and natural conditions". He was guided by Dr Jose Kallarackal, Plant Physiology Division.

KFRI Seminars

Dr V.M.G. Nair, University of Wisconsin, USA gave a seminar on Diseases of Trees on 13 Januray 1998 at KFRI.

Nominated

Dr P. S. Easa has been nominated by Ernakulam District Panchayat to the Advisory Council for People's Biodiversity Register of Ernakulam District and also to the Expert Group of Eastern and Western Ghats by the Ministry of Environment and Forests, Govt. of India. Dr K.S.S. Nair was nominated by the Govt. of India to the Salborer steering committee and attended a meeting at Jabalpur.

Workshop organised

KFRI organised a Regional Workshop on the Role of Sacred Groves in the Conservation and Management of Biodiversity from 8-11 December 1997.

Evergreen

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Sl. No.	Title of the Publiation	Unite Price US$	Ind.
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2.	Rattans of Western Ghats	10.00	100.00
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