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A STUDY OF WOOD BORING BEETLES IN THE KERALA PART OF NILGIRI BIOSPHERE RESERVE

George Mathew

Kerala Forest Research Institute
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George Mathew
Entomology
Forest Protection Programme Division

Kerala Forest Research Institute
Peechi – 680 653

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Abstract

In the survey on the timber beetles in the Kerala part of Nilgiri Biosphere Reserve, 57 species of beetles belonging to 8 families were recorded. Maximum number of insects was recorded from Silent Valley (24 spp.) followed by New Amarambalam (17 spp.) and Wynad (11 spp.). Of the various groups recorded, Platypodidae and Scolytidae contained maximum number of species, which mostly preferred fresh logs or unhealthy standing trees. In the case of older logs, infestation by the secondary borers like Bostrychidae, Passalidae and Blattidae (woodroaches) have been noticed in addition to termites and scavengers like millipedes, earthworms and wood louse.

With regard to the various factors leading to borer infestation, wind, damage by wild animals, mechanical injury to trees due to lopping of branches for fodder and firewood, were the most important. *Tectona grandis*, *Kydia calycina* and *Terminalia alata* were highly susceptible to damage by wild animals, especially the elephants. Wind damage was noticed with large trees having dense crown such as *Mesua ferrea, Dysoxylum beddomei, Myristica malabarica* and *Palaquium ellipticum*. With regard to relative susceptibility to borer attack, *Palaquium ellipticum, Dysoxylum beddomei, Cullenia exarillata, Bischofia javanica, Cinnamomum* spp., *Myristica dactyloides* and *Mesua ferrea* among evergreen species and *Schleichera oleosa* and *Macaranga peltata* among deciduous species were the most susceptible.

The faunal elements showed high degree of endemism and also contained species having affinities with Australasian, African and Malaysian forms. Most of the beetles recorded on various evergreen tree species such as the cerambycids *Chloridolum alemene* Thoms. (attacking *Palaquium ellipticum)* and *Xylotrechus subscutellatus* Chev. (attacking *Callicarpa tomentose*); the scolytid *Diamerus curvipes* Wlk. (attacking *Myristica malabarica*); the platypodid *Crossotarsus minax* Wlk. (attacking P*alaquium ellipticum)*; the curculionid *Trachodes* sp. nr. a*cutangulus* Hell. (attacking *Myristica malabarica*); the brenthid *Cyphagogus westwoodi* Parry (attacking *Bischofia javanica*) and the passalid *Leptaulax dentatus* Fb. were mostly restricted to the evergreen forests. Because of their role in the decomposition of dead wood, these beetles have more ecological significance. Since they are restricted to evergreen forest habitats, their chances of assuming pest status in other timber species outside their habitat are rather limited.

1. INTRODUCTION

The term ‘Biosphere’ refers to that zone of earth where life exists. It includes three strata *viz.*, the lithosphere, hydrosphere and atmosphere. The lithosphere, which varies in thickness from 15-40 kms, forms the outer crust of earth. The outer most layer of this crust is rocky in nature and it disintegrates to form the soil. Atmosphere is the layer of air surrounding the earth and extending to a height of 600 kms. The hydrosphere includes all the water bodies.

1. 1. Biosphere Reserves and Biodiversity Conservation

All biodiversity that we find on earth are the products of several million years of evolution. Creation and extinction are two phases of life. The interaction of living organisms among themselves and with the environment has led to an increase in biodiversity over the years. In addition to this, there are also various evolutionary pathways, which produce a vast array of species and ecosystems. On the contrary, various catastrophes like drastic changes in climate brought about by continental drift, massive volcanic eruptions or asteroid impacts have caused mass extinction of life on various parts of the globe. Equally or even more important is the change brought about by human interference. Ever since the appearance of man on the earth's surface, there has been considerable disturbance to natural ecosystems due to exploitation of the natural resources, for both short term and long term requirements. With industrialization and stress on productivity, the pressure on biosphere has increased tremendously leading to pollution of air and water. One third of world’s forests, major part of fresh water lakes, rivers, seas and most of the grass lands have been either destroyed or altered affecting all life existing in these habitats. Loss of biodiversity has tremendous implications on the survival of mankind in this universe. Therefore, it has long been felt that man should mend his ways to bring a halt to this degradation. It was with this concern

abundant water availability because of the rivers Krishna, Godavari, Cauvery and their tributaries Bhima, Thungabhadra, Kabani and Bhavani.

The plateaus and the adjoining hills of Wynad, Mysore, Sigur and Talaimalai with elevation ranging from 700 to 1000m form the boundaries of this Reserve in the north. In the south are the plateau and the hills of Attappadi, Siruvani and Bolampatti with altitudes ranging from 150m to 1800m. In the west are the slopes of Nilambur, New Amarambalam and Silent Valley, which descend to 250 m in Calicut plains. In the east are the mountains of Nilgiris, which slopes down to 250m in the Coimbatore plains. The wildlife sanctuaries of Wynad, Nagarhole, Bandipur, Mudumalai and the Silent Valley National Park belong to this Reserve.

1.1.1. a. Forests types

An array of habitats and vegetation types ranging from dry scrub jungle, dry and moist deciduous forests, semi evergreen, evergreen and wet evergreen forests, sholas, grass lands and swamps are found in this area. The most important forest types are described below.

Tropical wet evergreen forests

The wet evergreen forests, which are dense and multi storied, occur along the western slopes up to an altitude of 1500m where the annual rainfall is over 2000mm. This type of forests, having large trees attaining over 50m in height is characteristically found in Silent Valley and in parts of New Amarambalam and Attapadi areas of Kerala State. *Dipterocarpus indicus, Mesua ferrea, Palaquim ellipticum, Artocarpus hirsuta, Bischofia javanica, Garcinia indica, Hopea parviflora, Hopea wightiana, Pterospermum reticulatum, Syzygium gardneri, Diospyros* spp. and *Cinnamomumum zeylanicum* are the dominant trees. Association of *Dipterocarpus – Mesua - Palaquim* is very prominent. Lichens, mosses, epiphytes and climbers are fairly common. Due to the closed canopy, the ground is usually devoid of grasses.

Tropical montane evergreen shola-grassland

In the Nilgiri Biosphere Reserve, sholas are found along the upper Nilgiris plateau and on the higher reaches of Siruvani hills in Tamil Nadu State above an altitude of 1800m. Shola vegetation is very specialised on account of typical temperate conditions. Trees are stunted and are usually restricted to the valleys and the slopes are covered with grasses. The important tree species in the sholas are *Cinnamomumum wightii, Elaeocarpus* spp., *Gordonia obtusa, Meliosoma* spp., *Liqustrum roxburghi, Litsea* spp., *Symplocos* sp. and *Syzygium arnottianum*. The ground flora consists of Rubiaceae and Acanthaceae of which *Strobilanthus* spp. are quite abundant. The grasslands contain species from the genera *Cymbopogon, Themeda, Ergrostis* and *Tripogon*.

Tropical semi evergreen forests

This type of forests, which is a transition between the evergreen and the moist deciduous types, is found along the lower reaches of western slopes and below the montane shola vegetation along the northern and eastern slopes. It contains several elements of the evergreen forests like *Vitex altissima, Persea macrantha, Holigarna arnottiana* and moist deciduous species such as *Bombax ceiba, Trewia nudiflora, Lagerstroemia lanceolata, Schleichera oleosa* and *Caryota urens*. The ground is usually devoid of grasses. The Wynad plateau is the typical site having good representation of moist deciduous trees such as *Lagerstroemia lanceolata, Terminalia tomentosa, Dalbergia latifolia, Schleichera oleosa, Xylia xylocarpa, Kydia calycina* and *Tectona grandis*. Large clumps of Arundinaceae are often found in the lower storey. The ground may have a good growth of tall grasses such as *Themeda* spp. and *Cymbopogon* spp.

Tropical dry deciduous forests

The dry deciduous scrub thicket characterised by the presence of short grasses and thorny shrubs (*Acacia* spp. and *Lantana camara*), is dominantly found in the Mysore plateau, Talamalai plateau and a large portion of the rain shadow slopes of the Nilgiris. Because of the frequent fires, fire hardy species like *Anogeissus*

that UNESCO evolved the concept of 'Biosphere Reserve' in 1971 under its Man and Biosphere (MAB) programme.

Biosphere Reserves have been constituted in sensitive environments since these are the areas prone to serious destruction. It is actually a region set aside for careful scientific management and for developing basic knowledge on conservation of natural ecosystems and biological diversity and to link conservation with sustainable development. Therefore, the objective of setting up Biosphere Reserves is not only protection of wild species but also for promoting international cooperation, people-environment interaction, etc., in its management. The ecosystem must be large enough to ensure self-perpetuation and unhindered evolution of the entire organisms.

The first Biosphere Reserve was designated in 1976 and since then there has been a rapid increase in their numbers and currently there are 243 Biosphere Reserves spread over 65 countries.

1. 1. 1. The Nilgiri Biosphere Reserve

Consistent with the concept of conserving biodiversity in its totality, the Nilgiri Biosphere Reserve (NBR) was constituted on 1st September 1986 around the Nilgiri Mountains and adjoining hills of the Western Ghats region. It includes two of the biogeographical provinces *viz.*, the Malabar rain forest and the Deccan thorn forest. With the formation of this Biosphere Reserve, the biological and cultural heritage of these two regions would be conserved.

This Reserve, spread over contiguous areas of Kerala, Karnataka and Tamil Nadu, is 5520.4 sq km in extent. Of this, 1455.5 sq km is in Kerala, 1527.4 sq km in Karanataka, and 2537.6 sq km. in Tamil Nadu. The Nilgiri, Nilambur and Siruvani hills form the major mountain ranges in this area. The average annual rainfall ranges from 500 mm to 7000 mm. Temperature also shows wide fluctuations and may reach up to 40°C in the rain shadow areas. There is

latifolia, Tectona grandis, Terminalia tomentosa, T. chebula, Albizzia odoratissima, Grewia tiliifolia, Pterocarpus marsupium, Chloroxylon swietenia and *Adina cordifolia* are quite abundant in this type of habitat. The bamboo *Dendrocalamus strictus* is very common. The ground layer shows a good grass cover of *Tehemeda, Cymbopgon, Imperata* and *Heteropogon*.

Tropical dry thorn forests

The relatively dry regions contain this type of forests where *Acacia leucophloea, Albizia amara, Hardwickia pinnata, Zizyphus xylopyrus, Dicrostachys cinerea, Xeromphis spinosa, Erythroxylum monogynum* and *Capparis sepiaria* are the common plant species. Short grasses occur on the ground layer. This vegetation type has largely disappeared from the Deccan plateau where it was once extensive and at present the Moyar valley has the best representation of this type of forests.

1.1.1. b. Fauna

More than 100 species of mammals, 550 of birds, 30 of reptiles and several species of invertebrates such as insects and arachnids have been recorded from this area. The area is also important on account of the occurrence of the largest known population of Nilgiri Tahr and Lion Tailed Macaque, Elephants, Tiger, Gaur, Sambar and Cheetal. Of these, the former two species *viz.*, the Nilgiri Tahr and Lion Tailed Macaque are endangered. Fresh water fishes of the genera *Horabagrus, Bhavania* and *Travancorica* are also seen. The tribal population includes the Cholanaikans of Nilgiris, the only surviving hunter-gatherer community of the Indian subcontinent. With regard to invertebrates, a few studies have been made mainly on the insect fauna of Silent Valley, Wynad and New Amarambalam reporting 135 species from Wynad, 704 species from Silent Valley and 41 species from New Amarambalam (Mathew, 2004).

1. 1. 2. Zones of Nilgiri Biosphere Reserve

Based on broad management principles, various zones have been recognized within the Biosphere Reserve. This includes the core zone, manipulation zone and the restoration zone. For management purposes the Reserve has been divided into a core area of 1240 sq km and a buffer zone of about 4280 sq km. In the core zone, forestry operations, collection of minor forest produce, tourism, construction of dams, etc. are not allowed. The manipulation zone is an area identified for minimum activities involving forestry, agriculture and tourism. It has the largest area (3238.7 sq km) in the Reserve. For tourism, an area covering 335 sq km has been set apart in the Nagerhole Wildlife Sanctuary, Bandipur National Park and Mudumalai Wildlife Sanctuary. All the cultivated areas within the Biosphere Reserve belong to the agricultural zone. Highly degraded areas adjacent to the Biosphere Reserve belong to the restoration zone.

1. 2. Timber beetles

The insect order Coleoptera to which belong the beetles, contain nearly one quarter of a million known species, which is equivalent to about 40% of the insect fauna of the world, and form the largest group in the animal kingdom. The habits of the many different forms of beetles are so diversified that representatives of this order may be found in every main type of environment suitable for the existence of insects.

Timber inhabiting beetles constitute one of the important groups of the order Coleoptera that are of tremendous forestry importance. In many temperate countries, they are a major problem in forest plantations. For instance, the pine beetle *Dendroctonus* spp. (Scolytidae) that appears in regular epidemics is a serious pest of pine plantations. *Ips longifolia*, another widely distributed pest, is a serious problem throughout pine forests in several continents (Pesson and Chararas, 1969). Similarly, *Euwallacea fornicatus* is a serious pest of several crops particularly pomegranate, coffee and tea in India (Mote and Tambe, 2000).

The palm beetles *Oryctus rhinoceros* (Scaraboidea) and *Rhynchophorus ferrugineus* (Curculionoidea) cause mortality of palms. The furniture beetles *Anobium punctatum* (Anobiidae), *Lyctus africanus* (Lyctidae) and *Sinoxylon anale* (Bostrychidae); the mango borer *Batocera rufomaculata* and cashew borer *Plocaederus ferrugineus* are examples of certain wood inhabiting beetles of economic importance.

Pioneering studies on the timber beetles found in the Indian subcontinent were made by Stebbing (1914) during the turn of this century. He gave a detailed account of the morphology, taxonomy, biology and bionomics of various species attacking important timbers. Later, Beeson (1941) summarised subsequent works on timber beetles. Recent works include studies by Beaver and Browne (1975, 1978), Schedl (1959, 1960, 1962, 1965, 1971 a, b, c), Chandra (1981), Chandra and Ahmad (1985), Roonwal (1971) and Rai (1971) on Scolytidae and Duffy (1963, 1968) on Cerambycidae. A detailed account of beetles and their classification is given in the CAB Identification Guide on Coleoptera (Booth *et al.*, 1990). Gnanaharan *et al.* (1985) and Mathew (1982) studied timber beetles associated with commercially important stored timber in Kerala and their control.

Timber beetles are of diverse habits and based on the nature of attack, they can be broadly classified into four major functional groups *viz*., primary borers, secondary borers, scavengers and predators. The primary borers attack standing trees that are either weak or mechanically damaged, freshly cut timber with intact bark, debarked timber, sawn logs, converted timber or various finished products. Sometimes even saplings or seedlings are also affected (Meshram *et al.*, 1993). The families Cerambycidae, Buprestidae, Bostrychidae, Curculionidae, Brenthidae, Anthribidae, Scolytidae and Platypodidae contain important primary borers. The secondary borers are those attacking dead wood lying on the forest floor that have already been attacked by the primary borers or infested by fungal pathogens. The families Passalidae and Lucanidae contain important secondary borers. The scavenger beetles live inside the borer tunnels feeding on debris or on fungal spores. The families Tenebrionidae, Alleculidae, Mycetophagidae and

Colydidae contain saprophytic forms. The predatory beetles live within the borer holes of primary or secondary borers feeding either on the larvae or beetles. The families Colydidae, Cucujidae, Trogositidae, Histeridae and Cleridae contain important predatory beetles. Brief accounts of various families of the timber beetles are given below.

1. 2. 1. Primary borers

Cerambycidae

This is a very large family comprising of about 35,000 species belonging to some 4,000 genera classified under eleven subfami1ies. They are elongate, with long antennae because of which, they are also known as longhorn beetles. Antennae are usually 11-segmented, often much longer than body, being held backwards over the body or held spread out in front. Head often with strongly projecting mandibles; eyes usually strongly incised by antennal insertions, being often divided into two parts joined by narrow line. Pronotum flattened with distinct side margins or elongate, cylindrical often with spines or tubercles. Elytra almost always elongate or strongly attenuated apically, leaving hind wings and part of abdomen exposed. Legs, with tarsi pseudotetramerous. They generally attack unhealthy standing trees, freshly cut logs and sometimes finished products. The grubs, which are large, elongated and enlarged with prominent segmentation anteriorly, feed on the inner layers of bark and timber, making elongate galleries as they grow (Pl. VI, Fig.1). Most species have an annual life cycle with a long larval period.

Buprestidae

This is a large family comprising of about 400 genera and 15,000 species. They are usually brilliant metallic in colouration and hence the common name jewel beetles. Body size ranges from 1.5 to 60 cm. Antennae are 11 segmented, short and serrate. Head hypognathous and deeply sunk in prothorax. Legs relatively short with pentamerous tarsi. Adults feed on foliage and the larvae subsist on

wood under bark of living or dead trees or shrubs. The grubs are elongated resembling the cerambycid larvae but have a subapical constriction anteriorly.

Bostrychidae

This is a moderate-sized family of about 80 genera and 650 species. The beetles are parallel sided, usually cylindrical, and have hypognathous head which is hidden from above by the hood-shaped pronotum. The latter, without distinct lateral margins. Antennae short with 3 or rarely 4-segmented club of variable shape, sometimes lamellate. Eyes round or oval, prominent, posteriorly fitting against the pronotum. Scutellum visible. Elytra parallel sided, with strong apical declivity, bearing tubercles, spines, or ridges. Abdomen with 5 visible sternites, basal sternite subequal to second. Tarsi simple, 5-segmented. The beetles generally bore in converted timber and finished products. The female beetle tunnels into the sapwood, parallel to the circumferance of the log. The eggs are laid in small niches on the walls of this tunnel. The newly hatched larvae make longitudinal tunnels. The grubs are cream coloured, soft and curved with 3 pairs of thoracic legs. They are broad anteriorly and become narrow posteriorly. Pupae are whitish with a hood-like prothorax. In heavy infestations, the tunnel may follow an irregular course (Pl. V, Fig.3). Pupation takes place at the end of the tunnel. The length of life cycle may take about two months in some cases and under favourable conditions the generations are continuous.

Scolytidae

This is a large family comprising of about 180 genera. Majority of them tunnel into the bark, cambium or wood of their hosts and hence the popular name of bark or ambrosia beetles. They are small in size measuring 0.5-13.0 mm in body length. In shape, they vary from cylindrical to hemispherical. Colour is usually yellow, brown, or black, sometimes shining and glabrous, densely pubescent or covered with scales. Antennae geniculate, with abrupt, compact, 3-segmented club. Head, which is not prolonged into distinct rostrum, may be visible from above or at least partly concealed in dorsal view. Eyes flat, very rarely rounded,

usually elongate, sometimes notched. Pronotum, either weakly or strongly declivous distally. Elytra entire, concealing pygidium. Tarsal segment 1 not longer than 2 or 3, either pseudotetramerous or distinctly 5-segmented. They generally bore in the bark and sapwood of standing trees of freshly cut logs. They have the habit of cultivating fungi in their tunnels, which cause staining to the wood. They may also play a role in the transfer of pathogenic organisms causing diseases. The grubs are small, soft, white or cream coloured. They are usually convex dorsally and flat ventrally in most bark feeding species and more or less flat in species that bore in solid wood. They are devoid of legs and crinkled. The gallery consists of an entrance tunnel leading from bark to a main circular gallery above and the larval cells originate latero-ventrally on either side (Pl. IV, Figs.1-4; Pl.V, Fig.1).

Platypodidae

This is a moderate sized family of 24 genera containing about 700 species. They are commonly known as pinhole borers. The beetles are usually brown or black, elongate and cylindrical in shape. Antennae geniculate, scape large ending in an unsegmented club. Head not covered by the pronotum, which is elongate and truncate anteriorly. Elytra punctate-striate. Tarsi pentamerous. They generally attack fresh logs with intact bark. The tunnels penetrate deep into the wood. Like Scolytidae, they too have the habit of cultivating fungi in their tunnels, which cause staining to the wood, which is a serious drawback for timber meant for peeling. The female lays eggs inside tunnels made in the wood. At first, the tunnel runs radially into the sapwood and then turns to a side. In timbers without heartwood, the full depth of several inches is bored in a sinuous course. From the main tunnel, secondary tunnels branch off and run for variable distances (Pl.V, Fig.2).

Curculionidae

This family comprising of approximately 41,000 species belonging to 3600 genera, is considered to be the largest among the wood boring beetles. They vary

much in shape, sculpture and vestiture. The important characteristic of this family is the rostrum, which is variable in shape, and size as well as the 11-segmented, geniculate antennae bearing a 3-segmented densely pubescent club. Elytra variable, short to elongate, sometimes truncate leaving the pygidium exposed. Legs usually short and stout. Tarsi usually pseudotetramerous. They may bore in standing trees or in logs, both fresh and old. The grubs are soft, whitish and devoid of thoracic legs. Grubs make rambling tunnels in the wood, which are packed with wood dust (Pl.V, Fig.4).

Brenthidae

This family comprising of 2300 species belonging to 325 genera, is mostly restricted to the tropics. The beetles have a rostrum, which is usually brown or black, glabrous, characteristically parallel sided. Antennae 11 segmented, moniliform or filiform, rarely geniculate, and ending in 3-segmented club. Antennae are inserted at the base or middle of the rostrum either laterally or dorsally at base or middle of the rostrum. Sexual dimorphism is evident from the size of the rostrum. In males, the rostrum is shorter, broad and with larger mandibles. The grubs are curved, cylindrical, abruptly expanded at the metathorax and from then tapers to the small head. Posterior end expanded. Larval tunnels are radial. They generally bore in the sapwood of freshly cut logs. They occur in groups.

1. 2. 2. Secondary borers

Passalidae

This is a small family of 44 genera and about 500 species of relatively large beetles ranging from 10-70 mm in size. They are black, shining and longitudinally striate, flattened beetles, subparallel in form. Antenna 10-segmented, the apical 3 to 6 segments forming loose, rather hairy, lamellate club. Head prognathous, mandibles short and stout. Abdomen with 5 visible sternites. Tarsi pentamerous. Most passalids are tropical with relatively few species in Africa or in temperate countries.

Passalids are reported to be subsocial in habits with adults and young ones staying together. The beetle excavates chambers inside the wood of rotting logs of fallen trees that are moist. Eggs are laid in the cavity and the adult beetle remains in the cavity until the eggs hatch and sometimes remains with the larvae (Pl.VI, Fig.2). Larvae with the hind legs reduced to a 2-segmented scale-like structure, the distal tip of which when scraped on the outer surface of the middle coxae, produce a stridulatory sound. The larvae are thus able to communicae with the mother beetles, which also stridulate by scraping a part of the ventral surface of their membranous hind wings on the dorsal surface of their abdomen. The mother passalids also watch over their clutch of eggs and over the young larvae, feeding them with a regurgitated gruel of wood particles and keep them close to her through an exchange of stridulatory sound signals (Grasse,).

Lucanidae

This is a moderate sized family of about 100 genera and 1200 species, commonly called stag beetles on account of the enlarged, antler-like mandibles of the males. They are black or brown, sometimes with yellow markings. Body length 4-7 cm. Antennae are geniculate and 10-segmented, first segment being as long as the rest of antenna. The last 3 segments are either lamellate or developed asymmetrically, not capable of closed to form a compact club. Head prognathous and mandibles stout which in males is often very strongly developed. Tarsi pentamerous. The larvae feed on rotting wood and live in or beneath bark of rotting timber. Adults feed on plant exudates.

1. 2. 3. Scavengers

Trogositidae

This is a moderate family of 60 genera and 600 species. Size range from 1 to 50 mm. They are elongate, cylindrical beetles characterised by their short, clubbed antennae and tetramerous tarsi. They usually live beneath bark in the tunnels of wood boring insects feeding in fungal fruiting bodies. Larvae may be predaceous

on other insects or feed on fungi. Buprestidae, Cerambycidae, Bostrychidae and Scolytidae are the families generally attacked.

Silvanidae

A small family of 350 species and 48 genera of varying shape mostly elongate and parallel sided, with size ranging from 1.7-6.5 mm. Antennae 11-segmented with quadrate to weakly transverse segments forming weak club. Tarsi pentamerous. The family is closely related to Cucujidae. They occur under bark of dead tress probably feeding on moulds or fungal spores although some may be predators of immature stages of wood boring beetles. Some like *Oryzaephilus* are economically important pests of stored products.

Mycetophagidae

A small family of small, oval beetles comprising of 18 genera and 200 species. Length varies from 1-7 mm. Antennae 11-segmented usually with a 3-segmented club and rarely with 2-segmented club. Tarsal formula 3-4-4 in male and 4-4-4 in females. Most species live under bark of decaying wood feeding on fungal material.

1. 2. 4. Predatory beetles

A number of families are associated with wood boring beetles as predators an account of which has been given by Beeson (1941) and Mathew (1985). Brief accounts of important predatory families are given below.

Cleridae

These beetles are elongate in form measuring 10-12 mm in size often known as checkered beetles on account of their striking colour patterns. The larvae are more or less hairy, cylindrical with strongly sclerotised pronotum and a hard plate bearing hooks on the 9^{th} abdominal segment. They are important predators of small wood boring beetles belonging to Bostrychidae, Anobiidae, Scolytidae and

Platypodidae, feeding on the eggs, larvae and adults. *Tillus notatus, Cylidrus cyaneus* and *Tarsostenus univittatus* are the important predatory beetles.

Colydidae

A moderate sized family of 150 genera and 1100 species, which are variable in shape being elongate and cylindrical to broadly oval and flattened, having elytral declivity characteristic of Brenthidae and Platypodidae. Antennae either 10 or 11 segmented with 1, 2 or 3-segmented club. Legs relatively short with tarsal formula of 4-4-4. These beetles are not entirely carnivorous and are able to subsist on decaying bark and sapwood. They have been reported on Cerambycidae, Bostrychidae, Scolytidae, Platypodidae and Curculionidae.

Cucujidae

They are elongate and flattened forms, the smaller forms being confused with *Lyctus* beetles. They may be predaceous or scavergers. They have been reported from the borer holes of Cerambycidae, Bostrychidae, Scolytidae, Platypodidae and Curculionidae.

Histeridae

They are usually black, characterised by their hard, polished and striate integument. Cerambycidae, Bostrychidae, Lyctidae, Scolytidae, Platypodidae, Antribidae and Curculionidae are generally attacked.

2. MATERIALS AND METHODS

2. 1. Study area: Kerala part of Nilgiri Biosphere Reserve

As has been stated earlier, 1455.5 sq km area falls in the Kerala part of this Biosphere. Wynad Wildlife Division, Silent Valley National Park, Mannarkkad, Palghat, Nilambur south and Nilambur (north) Divisions are included in the Kerala part of NBR (Fig.1). Of this, 239.5 sq km belong to the core area, 870 sq km to the forestry zone, and 100 sq km to the tourist zone. Details regarding the various Divisions of the Kerala part of the Biosphere are given below:

2.1.1. Wynad Biosphere Division

The forests of the Wynad Biosphere Division are located on the northwestern part of the Nilgiri plateau, and is spread over three States of Karnataka, Kerala and Tamil Nadu. The Kerala portion of the forest can be divided into two parts, the North and South Wynad. The Northern Wynad consists of Begur, Karthikulam, and Edakode reserve forests. Southern Wynad consists of Mavinhalla, Rampur, Kurchiyat, Kuppady, Edathara, Kallur, Alathur, Neminad and Nulpuzha reserve forests. The topograhy is hilly and undulating with fertile valleys, and the elevation varies from 600 to 1100 m. Rainfall varies from 1500 to 1800 mm. July and August receive maximum rainfall. Large areas are under teak and eucalyptus. *Artocarpus hirsuta, Mangifera indica, Holigarna arnottiana, Machilus macrantha, Vateria indica, Hopea parviflora, Polyalthia fragrans, Tetrameles nudiflora, Evodia* spp., *Cedrela toona, Vitex altissima, Elaeocarpus serratus, Cinnamomum zeylanicum, Actinodaphne hookeri, Olea dioica* and *Diospyros* sp. are the common tree species in natural forests. In addition to these, various species of bamboos are also found in the area.

2.1.2. Nilambur Biosphere Division

The Nilambur Forest Division is situated between 11° 26' and 11° 9' N 1attitude and 75° 48' and 76° 33'E longitude. New Amarambalam, Karimpuzha and Nellikutha are main forest patches. The area is drained by the river Chaliyar and its tributaries. Large areas are under teak, most of which are along the riverbanks.

The temperature varies from 17° and 37°C. The average rainfall is over 2600 mm on the hills, it may even go up to 4000 mm. A large portion of the deciduous forests has been converted to teak plantations. The New Amarambalam forests contain mostly evergreen forests. *Calophyllum elatum, Dipterocarpus indicus, Palaquium ellipticum, Mesua ferrea,* and *Hopea parviflora* are the most common evergreen trees in this area. Bamboos and reeds are also present.

2.1.3. Palghat Biosphere Division

This Forest Division is situated south of Nilgiri District. Silent Valley and Attappady are the main areas belonging to this Division. Ghat forests like Silent Valley receive more than 7500 mm while scrub forests in the plains receive less than 1200 mm. The average rainfall in the Attappadi valley is about 2500 mm. Temperature also varies between the different localities. Maximum temperature goes to more than 40° C in the plains whereas the same in the ghats remain below 32°C. The minimum temperature in the ghat region is about 10°C and about 20°C in the plains.

Silent Valley region contains evergreen forests and grass lands. Common tree species are *Cullenia exarillata, Machilus macrantha, Elaeocarpus tuberculatus, Palaquium elipticum, Mesua ferea, Calophyllum elatum, Canarium strictum, Artocarpus heterophyllus, Cinnamomumum zeylanicum, Holigarna arnottiana* and *Hopea glabra*. The major plant associations in this area are *Cullenia-Palaquium* association (Kunthipuzha basin), *Palaquium-Mesua* association (Poochapara and adjoining areas), *Poeciloneuron-Palaquium* association (north part along upstream of Kunthipuzha) and *Mesua-Calophyllum* association (east of Kunthipuzha to north of Walakkad). Moist deciduous forests occur in the Attappady Valley, particularly portions of block I to V teak plantations, but where teak has failed bamboo has grown well. On the rain shadow region the main vegetation type is dry deciduous forests, and this merges with the degraded areas in places where population pressure is high with severe problems of grazing and fire.

2. 2. Sampling of Insects

Sampling of insects was done within each Forest Range belonging to the various Forest Divisions in the study area. Each Range contained human settlements, natural forests and plantations. Since the proportion of dead and fallen timber was less in the plantations due to firewood collection by settlers, sampling was done in the natural forests by walking along diagonal transects and extracting the insects from infested logs lying on the forest floor using a field knife or a chisel. Natural forest patches in each of the forest Divisions in the study area were visited once. The signs of borer infestation are evident from the dust coming out of the borer holes. The insects collected were preserved in methylated spirit and data on their habits and habitats recorded. The intensity of damage was rated based on qualitative estimation of damage into low (up to 15% damage); moderate (up to 50% damage) and high (above 50% damage). The insects collected were later sorted out, pinned and labelled and stored in insect storage boxes and identity worked out by reference to literature, reference insect collections or by consulting experts.

3. RESULTS

3.1. Predisposing factors leading to borer infestation

The primary causes of tree mortality could be due to various reasons such as attack by wild animals like elephants, bison, boar, deer, etc.; human induced damage following cutting of trees for fodder and firewood; tree fall due to wind; incidence of fire or attack by pathogenic organisms especially by wound pathogens that attack trees subject to mechanical damage. A summary of observations on the causes of tree mortality due to these causes is given in Table 1 and in Appendix III - V.

Table 1. Data on the primary causes of tree mortality in the study area

Study area	**Causes of tree mortality**						
	Wild animals	Incidence of fire	Human activity	Pathological	Soil erosion	Windfall	Total
Nilambur	29		7	6	2	73	117
Palghat	6	3	13	1	120	427	570
Wynad	130	7	1	2	6	1	147
Total	165	10	21	9	128	501	834

Data presented in Table 1 shows that windfall, attack by wild animals and incidence of pathogens following mechanical injury were the most important causes of tree mortality observed **(**Pl. III, Fig. 1-3). Of these, windfall was the most important cause of tree mortality at Palghat Biosphere Division. Due to strong wind especially during rains, the trees were uprooted partially or completely, which was very pronounced in several locations in this Division. Usually large trees of *Mesua ferrea, Dysoxylum beddomei, Myristica malabarica, Palaquium ellipticum, Persea macrantha, Agrostistachys borneensis* and

Bischofia javanica having dense crown were prone to damage during wind or rain. Damage caused by wild animals was another major cause for tree mortality. In the Wynad Biosphere Division where the density of wild animals particularly the elephants is high, considerable damage to trees has been noticed. Here, the barks of several tree species were either peeled off or trees pulled out by elephants. Trees like Teak, *Terminalia alata* and *Kydia calycina* were the most preferred species for elephants (Appendix III- V). Mechanical injury involving lopping of trees for fodder, extraction of bark, incidence of fire etc., was also observed. Such mechanicaly damaged, as well as dead or partially dead trees and logs were found to be infested by various beetle borers especially of the families Platypodidae, Scolytidae and Cerambycidae as well as by wound pathogens. In Nahan Forest Division, Himachal Pradesh, Thapa *et al.* (1990) reported that fire affected chir pine trees were easily infested by various timber beetles such as *Sphenoptera aterrima* (Buprestidae), *Polygraphus* sp. (Scolytidae) and *Platypus biformis* (Platypodidae). Similarly, attack by woodboring beetles may become a predisposing factor for secondary infestation by pathogenic fungi leading to tree mortality. Sreedharan *et al*. (1991) have reported mortality of Silver Oak trees planted for shade in tea planations due to borer attack. Similarly, Balasundaran and Sankaran (1991) reported mortality of teak trees due to *Fusarium solani*.

3.2. Incidence pattern of wood borers in the study area

A major portion of dead wood observed in the study area showed signs of varying intensity of borer attack. Data gathered on the incidence pattern of various wood inhabiting organisms indicated higher incidence of timber beetles in dead wood compared to live tree (Table 2). Of the various groups of timber beetles, the Platypodidae were more abundant (29.2%) compared to Cerambycidae (27.82%), Scolytidae (14.94) and Bostrychidae (12.69). In addition to these, a large number of secondary borers and scavenger organisms belonging to diverse groups such as millipedes, centipedes, earthworms, wood louse, etc., were also recorded in dead wood that have been lying on the forest

floor for a long period (Table 3). The occurrence of predatory beetle groups like Cleridae and Histeridae was noticed in timber infested by the cerambycids.

Table 2. Data on the incidence pattern of timber inhabiting organisms in live and dead trees.

Groups of timber inhabiting organisms	**Timber inhabiting organisms recorded**		
	In live tree	In dead tree	Total
Primary Borers			
Cerambycidae	8	234	242
Scolytidae	7	123	130
Platypodidae	12	242	254
Bostrychidae	5	105	110
Curculionidae	0	34	34
Brenthidae	1	7	8
Secondary borers			
Elateridae	0	4	4
Passalidae	1	39	40
Tenebrionidae	0	9	9
Unidentified	2	86	88
Woodroaches	1	17	18
Scavengers			
Termites	-	10	10
Millipedes	0	11	11
Earthworms	0	5	5
Wood louse	0	3	3
Centipedes	0	3	3
Predatory beetles	2	35	37

As far as the infestation intensity of affected logs was concerned, majority of the logs (62.35%) showed only mild infestation although a small proportion (5.88%) was with medium or high (4.56%) infestation intensity (Table 3). The logs that

Table 3. Incidence and intensity of borer attack recorded at different locations in the study area

Locality	**Biosphere Division**	**Intensity of infestation**			
		Heavy	**Medium**	**Mild**	**No attack**
Mancheri	Nilambur	-	-	26	20
Meenmutti	Nilambur	-	9	15	1
New Amarambalam	Nilambur	-	-	46	-
Ambalappara & Neelikkal	Palghat	-	1	9	8
Aruvampara	Palghat	1	-	12	6
Chembotti junction	Palghat	2	-	6	6
Kattimuddi	Palghat	-	2	93	5
Kummatanthode	Palghat	-	-	8	8
Neelikkal	Palghat	7	6	29	14
Panthanthode	Palghat	1		11	6
Parathode	Palghat	6	9	14	10
Pathrakadavu	Palghat		1	8	5
Podumaram area	Palghat	3	5	20	18
Ponkuzhy	Palghat	1	1	7	7
Poochappara	Palghat	2	2	44	8
Pulipara	Palghat	-	-	2	-
Punnamala	Palghat	7	6	32	18
Syrandri	Palghat	5	7	45	36
Begur	Wynad	-	-	9	1
Maragadha	Wynad	3	-	29	37
Muthumalai road	Wynad	-	-	7	7
Muthenga	Wynad	-	-	12	-
Thirunelli	Wynad	-	-	9	-
Trijunction	Wynad	-	-	27	6
Total		38	49	520	227

- No observation

were found to be free of infestation by borers (27.2%) were either relatively fresh or belonged to durabile timber species. However, the logs on getting infested by borers become easily susceptible to further infestation by different groups of borers, saprophytes and pathogens. The rate of progression of wood decomposition due to these organisms is worth exploring.

With regard to economic importance, the cerambycids, because of the larger size of their larvae and the extensive galleries that they tunnel in the wood, are considered to be very important in wood degradation. The scolytids and platypodids, although smaller in size, penetrate deep into the wood. Moreover, since these organisms cultivate fungi in the larval tunnels, the wood gets stained which is a serious drawback to timber meant for peeling veneers.

With regard to the occurrence of these groups of insects in the different study areas, Nilambur and Palghat Biosphere Divisions showed high proportion of platypodid and cerambycid infestation while in the Wynad Biosphere Division, scolytid infestation was the highest followed by cerambycid and platypodid attack (Fig.2).

Fig. 2. Proportion of different groups of borers in the study area

In the Palghat Biosphere Division where wind fallen trees were present in large numbers, the trees showed infestation by Platypodidae, Scolytidae and Cerambycidae. Of the three Biosphere Divisions, Palghat Division (Silent Valley area) was the richest in the diversity of infesting species followed by Nilambur Division (New Amarambalam area) and Wynad Division (Table 4).

Table 4. Timber beetles recorded from various locations

Insect family	**Study Area**			
	Silent Valley	**Wynad**	**Nilambur**	**Total No. of species recorded**
Cerambycidae	1	2	2	5
Bostrychidae	-	1	-	1
Scolytidae	16	4	-	18
Platypodidae	9	2	7	16
Curculionidae	3	1	3	6
Brenthidae	3	2	3	7
Passalidae	-	1	-	1
Staphylinidae	1	-	-	1
Histeridae	1	1	1	1
Blattidae	1	1	1	1
Total	**35**	**15**	**17**	**47**

3.3. Relative susceptibility of various timber species to borer infestation

Borer infestation recorded in various timber species is listed in Appendix II. *Palaquium ellipticum*, *Dysoxylum beddomei*, *Cullenia exarillata*, *Bischofia javanica*, *Cinnamomum* spp., *Myristica dactyloides* and *Mesua ferrea* among evergreen species and *Schleichera oleosa* and *Macaranga peltata* among deciduous species were the most susceptible ones. Attack by the primary borers

belonging to Platypodidae, Scoytidae and Cerambycidae, was the most common type of damage. In older logs, infestation by the secondary borers like Bostrychidae, Passalidae and Blattidae (woodroaches) has been noticed, in addition to termites and scavengers like millipedes, earthworms and wood louse. These organisms preferred mostly rotting timber that was present in relatively undisturbed forest floor where the logs remained moist. In disturbed forests with open forest canopy where the required microclimatic conditions were not available, the occurrence of these organisms was found to be restricted. It seems that a certain degree of microclimatic conditions are required for the survival of these insects. The ecological preferences of these organisms are worth exploring since these organisms will be useful as biotic indicators for monitoring forest degradation.

3.4. Timber beetle fauna of Kerala part of Nilgiri Biosphere Reserve

Altogether, 57 species of timber beetles belonging to 9 families have been recorded from about 65 timber species as listed in Appendix 1 & II. A brief description of the beetle, its host timber and the nature of damage are given below under their respective families:

3.4.1. Primary borers

A. *Cerambycidae*

In this study, 5 species have been collected which were found to attack *Palaquium ellipticum*, *Diospyros* sp., *Callicarpa tomentosa* and *Ficus glomerata*. Brief descriptions of various species recorded in this study are given below.

***a. Chloridolum alcmene* Thoms. (Pl. I, Fig. 1)**

Recorded from relatively fresh logs of *Palaquium ellipticum* at Poochapara (Silent Valley). Intensity of infestation was heavy with several larvae infesting the log. Mature larva measures 50 mm in length and 9 mm in breadth, Head with frons strongly sinuate medially; a pair of pits situated alongside frontal sutures.

Mouth frame pale, feebly sclerotised. Mandible with basal half testaceous, apical half ferrugineous. Maxilla with segment 3 of palp distinctly shorter than segment 2. Abdomen with dorsal and ventral ampullae bearing numerous large moniliform tubercles. Legs well developed, 3- segmented, about as long as maxillary palp. Spiracles with peritreme broadly oval, without marginal chambers. Widely distributed in Andaman Islands, Myanmar, India, and Thailand in the Oriental region where it is reported to tunnel in *Citrus aurantium*, *C. medica*, and *C. reticulata*.

b. Coptops **sp. (Pl. I, Fig. 2)**

This dark brown beetle measuring 16 mm in length was recorded from *Diospyros* sp., and *Terminalia alata* in New Amarambalam. Larva was found to bore in the sapwood causing minor damage. Elytra with two prominent lateral, irregular black marks, the anterior one being the largest. The samples were taken from moderately older fallen wood.

c. Glenea **sp. (Pl. I, Fig. 3)**

This beetle was recorded from relatively fresh logs of *Palaquium ellipticum* at New Amarambalam. Several larvae were observed boring in the sapwood. Damage was minor. The beetle is chocolate brown measuring 15mm in length. Antenna black in colour. Head with a transverse oval spot. Elytra with distinct shoulders bearing a distinct black spot. Another spot at about the middle with two black U- shaped black marks. Elytra distally narrowed ending in a transverse distal margin. Body prominent with black lateral spots. Earlier, *Glenea indiana* Thoms. and *G. homonospils* Thoms. have been recorded as borers of *Zanthoxylum rhetsa* from stacks of freshly cut timber at Vazhachal (Trichur Division) (Mathew, 1982).

d. Myagrus hynesi **Paseoe (Pl. I, Fig. 4)**

This beetle was recorded from *Ficus glomerata* at Tirunelly (Wynad). Relatively fresh samples with green bark were found attacked causing minor damage to

sapwood. In the Oriental Region, it has been reported from India, Java, and Sumatra breeding in *Ficus racemosa*, *Ficus* sp. and *Grewia* sp. The beetle is light brown in colour bearing, irregular white patch laterally on the pronotum, which extends to the sternum and head. Pronotum with medium light brown patches anteriorly. Small white spots are also present at the anterior, middle and the posterior parts of the elytra. Pale stripes present on the legs.

Mature larva is very slender with very strongly depressed head; antennal foramen closed posteriorly. Ocelli very indistinct owing to sclerotization of gena. Prothorax with posterior area of pronotum micro-spiculate, interspersed with numerous glabrous spots. Eusternum dull, micro-granulate laterally. Abdomen with ampulla not tuberculate, finely crenulate. Pleural tubercles without sclerotized pit but bearing numerous setae. Spiracles with peritreme pale, broadly oval. Length upto 34 mm; maximum breadth 5 mm. Emergence occurs from May to August.

***e. Xylotrechus subscutellatus* Chev. (Pl. I, Fig. 5)**

Recorded from *Callicarpa tomentosa* at Tirunelly (Wynad). Both fresh and relatively older logs were affected with larvae boring deep into the heartwood with longitudinal galleries in the sapwood causing minor damage. Dark brown beetle measuring about 18 mm in length, having triangular head**.** Eyes large and round. Pronotum globular. This insect is distributed in Sri Lanka and India, infests logs as well as standing and dying trees. The larval galleries may deeply penetrate into the heartwood. The reported host plants of this insect include *Coffea arabica, Dalbergia latifolia, Pterocarpus marsupium, Tectona grandis, Vitex altissima, V. pinnata, Codiaeum maculata, Kydia calycina, Polyalthia coffeoides* and *Olea dioica.* The life cycle is usually annual but may overlap to the next year. Pupation takes place near the surface. Emergence occurs throughout the year but mainly in April, July and August. Infestation to Polyalthia logs felled in all months of the year, except in May and June has been reported (Beeson, 1941). Infestation was heavy for logs felled from September to

February, particularly to logs stored in the open, and low in other months. A related species *X. buqueti* Lap. *et* Gory, has been reported to bore in the sapwood of teak in Nilambur (Mathew, 1982).

B. Bostrychidae

Only one species has been recorded, viz., *Sinoxylon atratum* Lesne.

***a. Sinoxylon atratum* Lesne (Pl. I, Fig. 7)**

Recorded from *Acacia* sp. from Thirunelly, where the beetles were found to cause severe damage to the sapwood. It is a dark brown beetle measuring 3-4 mm. Head is puncturate and finely rugose. Prothorax is transversely ridged, with the anterior part rugose bearing rasp-like structures. Laterally, 4 teeth-like processes are present of which the innermost three are the longest.

Distributed in Peninsular India, and throughout the Oriental region to Australia. The larva tunnels irregularly in the dead and dying sapwood reducing the wood to a fine powder. Reported host plants include *Artocarpus hirsutus, Bombax ceiba, Casuarina equisetifolia, Emblica officianalis, Hopea parviflora, Lagerstroemia microcarpa, Mallotus philippensis, Paraserianthes falcataria, Pongamia pinnata, Terminalia paniculata* and *Santalum album* (Beeson, 1941; Mathew, 1982).

C. Scolytidae

Ten species of Scolytidae belonging to 6 genera have been recorded in this study as discussed below.

***a. Cryphalus* sp.**

Collected from the sapwood of unidentified timber. Only the superficial layers of sapwood was attacked. Measures 1.5 mm in length. Elytra puncturate, beset with short, flat scales arranged linearly in the posterior 1/3. Beetles belonging to this genus are widely distributed in the Siwaliks, Dehra Dun, North India, North-West Himalaya where they are reported to breed in *Erythrina suberosa* and *Quercus*

incana. Earlier, Mathew (1982) has reported a related species *Cryphalus carpophagus* (Horning) from *Hevea brasiliensis* (at Peechi) and an unidentified species of *Cryphalus* from *Mesua ferrea* (at Vazhachal).

***b. Diamerus curvipes* Wlk. (Pl. I, Fig. 8)**

Collected from *Myristica beddomia* at Neelikkal in Silent Valley causing minor damage to sapwood. The beetle is brownish in colour measuring 4.5 mm in length. Head with frontal tuft of hairs. Pronotum narrowed anteriorly, smooth. Elytra strongly striate having parallel rows of raised ridges bearing conical tubercles, which are prominent at the distal 1/3.

***c. Euwallacea (=Xyleborus) fornicatus* Eichh. (Pl. I, Fig. 9)**

Collected from an unidentified timber at Syrandhri in Silent Valley. The gallery was confined to the bark and sapwood. This insect, which is widely distributed in the Oriental region occurs in India, Fiji, Malaysia, Sri Lanka, Bangla Desh and Papua New Guinea. Although, most frequently this insect breeds in cut, drying, or temporarily unhealthy, small stems and branches of numerous dicotyledonous trees, it is a well known pest in plantations of castor, tea, *Paraserianthes falcataria* and *Grevillea robusta* (in Sri Lanka), *Gmelina arborea* (in Malaysia) and *Schleichera oleosa* (in Java) (Beeson, 1941). It has also been reported from various localities in Kerala (Mathew, 1982). The gallery is formed in the transverse plane of the wood, in which the larvae live together and pupate.

The life cycle takes five to six weeks for completion and breeding is continuous, with overlapping generations, so that the species is active at all times and in all stages of development. It is polygamous, and the males, which are few, short-lived and incapable of flight, normally do not leave the parent nest. In Sri Lanka and southern India it is the most important pest of tea, and it has considerable potential as a pest of newly formed plantations.

***d. Xyleborus assamensis* Eggers (Pl. I, Fig. 12)**

Collected from *Cinnamomum* sp. at Syrandri in Silent Valley. Gallery confined to the sapwood. The beetle measures 2-2.5 mm in length. Pronotum roughly cylindrical with a median conical prominence and having anterior and lateral warts. Elytra elongate with parallel rows of worts.

***e. Xyleborus burmanicus* Beeson**

Collected from *Palaquium ellipticum* at Syrandri in Silent Valley. Gallery confined to the sapwood. Beetle measures 3 mm in length. Light brown in colour, beset with short stiff sparse hairs. Pronotum with a median raised point and with reticulate markings. Elytra with linear raised spots. Posterior end dark.

***f. Xyleborus butamali* Beeson (Pl. I, Fig. 13)**

Collected from *Terminalia* sp. at Poochapara in Silent Valley. Gallery confined to the sapwood. Dark brown, stout beetle measuring 6 mm in length and 3 mm in width. Head hemispherical with several teeth-like processes anteriorly. Body covered with long stiff hairs and puncturate.

***g. Xyleborus cognatus* Bldfd.**

Collected from *Palaquium ellipticum* at Syrandri in Silent Valley. Gallery confined to the sapwood. Brown beetle, measuring 2.5 to 3 mm in length. Antenna with a round club, which is pale. Pronotum elongate, anterior half hemispherical, puncturate and having sparse hairs. Punctures arranged in hemi-circular rows. Elytra elongate with puctures arranged linearly and bearing sparse hairs. Elytral declivity shallow.

***h. Xyleborus perforans* Wollaston (Pl. I, Fig. 14)**

It was collected from Neelikkal in Silent Valley in *Myristica beddomia*. Beetles were breeding profusely in the bark and outer sapwood. Beetles measure 2 mm in length. Pronotum cylindrical with a conical prominence at about 2/3 distance

from the apex. Rows of tiny worts in the anterior half. Elytra with parallel dark brown streaks, slightly pitted.

This insect is sub-cosmopolitan in distribution, being recorded in the tropics from Australia, Barbados, Ceylon, Fiji, Ghana, Grenada, Guyana, Jamaica, Kenya, India, Fiji, Malaysia, Mauritius, New Britain, Nigeria, Pakistan, Papua, St. Vincent, Samoa, Sarawak, Seychelles, the Solomon Islands, and Trinidad. It is unselective in its choice of host, being recorded as breeding in the wood of more than 100 tree species. Usually it breeds in newly cut logs, felling slash, dead trees, temporarily unhealthy or injured trees or in tapped panels of *Hevea brasiliensis* (in Sri Lanka and Guyana). It has also been reported as a minor pest of sugarcane and coconut.

The gallery consists of irregular branched tunnels, without communal chambers, lying in the transverse plane of the wood, or sometimes there may be two or more such systems connected by longitudinal shafts. The beetles are polygamous and the males, which are few, short-lived, and incapable of flight, normally do not leave the parent nest, in which they fertilize members of the same brood.

***i. Xyleborus morstatti* Hagedorn**

It was collected from *Myristica beddomia* at Neelikkal in Silent Valley. Gallery confined to the sapwood. Measures 1.5 to 2 mm in length. Black in colour. Body puncturate. Pronotum broadened posteriorly. Elytral tip hemi-circular having parallel striae and short hairs.

***j. Xylosandrus* sp. (Pl. I, Fig. 15)**

It was collected from Neelikkal in Silent Valley from *Myristica beddomia*. Beetles, which measure 1.5 mm in length, were found breeding in the sapwood. Adults are dark brownish in colour. Pronotum puncturate. Elytra having raised ridges bearing warts and short scales.

D. Platypodidae

Sixteen species belonging to 3 genera have been recorded as detailed below.

***a. Crossotarsus lunatus* Bees.**

Collected from *Schleichera oleosa* at Poochapara in Silent Valley. Gallery penetrate deep in the wood. The beetle was damaged and hence description of the species was not possible.

***b. Crossotarsus minax* Wlk. (Pl. I, Fig. 17)**

Collected from *Palaquium ellipticum, Terminalia bellerica, Mallotus philippensis* at Meenmutti in New Amarambalam (Nilambur Division) and Poochapara (Silent Valley). Gallery penetrate deep in the wood. Beetle measures 6-6.5 mm. The main tunnel runs horizontally across the log. The branch tunnels run vertically. Beeson (1941) reports that emergence of adults takes place for 5 months from November to March. Larva has been described by Gardner (1932).

***c. Crossotarsus saundersi* Chap.**

Recorded from *Palaquium ellipticum* at Syrandri (Silent Valley). Gallery penetrate deep in the wood. The beetle was damaged and hence description of the species was not possible.

***d. Crossotarsus* sp. nr. *saundersi* Chap.**

Recorded from an unidentified timber species at Tirunelly (Wynad Division). Brown beetle measuring 3-4 mm in length. *Crossotarsus saundersi* Chap. has been reported from Baliyapattam (Kannur) from *Vateria indica*. It is a widely distributed species throughout the Oriental, Australasian and African regions, attacking a wide range of species (Beeson, 1941).

***e. Crossotarsus squamulatus* Chap.**

Recorded from unidentified timber species at Neelikkal, Syrandri, Poochapara (Silent Valley) and Meenmutti (New Amarambalam). Beetle dark brown measuring 5.5-5.8 mm. Elytra with prominent striae with the declivity having sharp, conspicuous teeth. The main gallery is horizontal with vertical branch tunnels that split into terminal subsidiary branches.

***f. Diapus* sp.nr. *assamensis* (Pl. I, Fig. 18)**

Recorded from *Melia dubia* at Mancheri (Nilambur). Galleries reach as far as the centre of the log. Members of this genus are generally associated with dipterocarps. Head having a median carina. Pronotum with the postero-lateral margin expanded into a flap. Elytra with parallel striae that are raised or bold, narrowed distally and having a median notch / depression. Posteriorly, drawn out into a blunt process.

***g. Diapus impressus* Janson (Pl. I, Fig. 19)**

Recorded from *Xylia xylocarpa* at Meenmutti (New Amarambalam). Galleries reach as far as the centre of the log. Beetle measures 3.5 mm and appears more or less similar to *D. assamensis.* It has been reported in *Alnus nepalensis, Quercus incana* and *Q. semicarpifolia* in the Himalayas (Beeson, 1941).

***h. Diapus quinquespinatus* Chapuis**

Recorded from *Persea macrantha* at Neelikkal (Silent Valley). Galleries reach as far as the centre of the log. Brown beetle measuring 3.5 mm in length. Head round with median and 2 lateral ridges. Pronotum with a subapical black line, which is rhomboidal in the centre. Elytra broadened posteriorly with a series of projecting ridges that extend outwards. Declivity flat, disc-shaped with 2 prominent processes and one narrow inner set.

This is a very widely distributed species in the old world tropics from West Africa to the Pacific being recorded from Ghana, Zambia and Papua. In the

Oriental region, it is recorded from India, Sri Lanka, Fiji, Malaysia, Sabah, Samoa, Sarawak, the Solomon Islands and Queensland.

This small ambrosia beetle shows little selectivity in its choice of hosts. It normally breeds in the wood of a variety of decaying or fallen trees. Sometimes it also occurs as a wound parasite. It has been found to infest trees of *Dyera costulata* that have been injured and weakened by tapping, usually in association with the longicorn *Batocera rufomaculata*. Infestation leads to degradation of timber due to borer holes and stains that develop in infested timber.

It is monogamous, and the tunneling of the nest is initiated by the male, but continued by the female. A fully developed nest penetrates rather deeply into the host and comprises of a system of branched galleries, lying mainly in the transverse plane of the wood, and pupal cells grouped above and below short tertiary tunnels. In tropical conditions, the generations are continuous leading to occurrence of broods all through the year.

***i. Platypus amarensis* Bees.**

Collected from an unidentified species of timber in Meenmutty (New Amarambalam). Galleries reach deep into the wood. Beetle with head spherical having a black median line. Pronotum with the postero-lateral edges expanded into flap-like processes. Elytra smooth having longitudinal dark brown lines. Posterior end flat and darker in shade.

***j. Platypus biformis* Chap. (Pl. I, Fig. 20)**

Recorded from *Myristica beddomia* at Neelikkal (Silent Valley). Galleries confined to the sapwood. The beetle measures 5-7.5 mm. and has been recorded as a borer of felled *Pinus longifolia.* The gallery system consists of an entrance tunnel which runs into the wood and turns into the main circumferential gallery. The gallery system appears in a single transverse plane, but it may descend or ascend in other planes so that the canals criss-cross (Beeson, 1941).

***k. Platypus cupulatus* Chap.**

Recorded from *Bischofia javanica* at Silent Valley. Beetle measures 5-6 mm in length. Elytra with a notch at the distal part and having the edges drawn out and flap-like. Elytra broadened posteriorly with a distinct swollen border. Striae more pronounced posteriorly. Distal end of elytra projecting into a ridge with the inner edge drawn out into a blunt process. Posterior end has a septum having two distinct dark brown patches. Declivity with a distinct cavity or notch bordered in black.

It is widely distributed in the Oriental region being recorded from the Andaman Islands, Sri Lanka, New Guyana, South India, Malaysia and Sarawak. It normally breeds in newly cut logs, and branch wood of numerous dicotyledonous trees, but also occurs as a secondary borer of injured or weakened trees. It is abundant in Malaysia, where, it commonly infests injured or sickly *Hevea brasiliensis.* Repored as a borer in *Wendlandia tinctoria* in upper Myanmar. It attacks a number of host plants, which include *Bombax malabaricum, Dipterocarpus pilosus, Shorea robusta, Tectona grandis* and *Terminalia bellerica*. The life cycle takes about 4 weeks for completion (Beeson, 1941).

The species is monogamous, and the formation of nest is initiated by the male, continued, after mating, by the female, and completed by the older larvae. The galleries are branched lying mainly in the transverse plane of the wood, with pupal cells grouped above and below short territory tunnels. The life cycle is completed in 5 to 6 weeks and breeding is continuous all through the year so that the generations are overlapping with the result, all stages are present at all times., but the emergence of the young adults from the nest tend to be irregular. The species has little or no potential as plantation pests.

***l. Platypus cupulifer* Wich.**

Measures 3.5 mm in length. Similar to *Platypus uncinatus* Blandford in appearance, but with darker texture of the elytra and the more conspicuous elytral

process. Recorded from *Ficus* sp., at Poochapara (Silent Valley). Recorded host plants include *Bombax malabaricum, Dipterocarpus pilosus, Mesua ferrea, Shorea robusta* and *Tetrameles nudiflora*.

***m. Platypus cylindrus* Fb. (Pl. II, Fig. 1)**

Recorded from *Palaquium ellipticum* at Poochapara (Silent Valley). The material was damaged and hence description of the species was not possible.

***n. Platypus* sp. nr. *obtusipennis* Schedl. (Pl. II, Fig. 2)**

Recorded from *Myristica beddomia* and an unidentified species from Meenmutti (New Amarambalam). The material was damaged and hence description of the species was not possible.

***o. Platypus uncinatus* Bldfd. (Pl. II, Fig. 3)**

Recorded from an unidentified timber species at Tirunelly (Wynad). Beetle measures about 3 mm in length. Dorsum of head has a median, black line. Pronotal margin with a notch at about the middle. Elytra smooth and shining and of darker shade posteriorly with a blunt, pointed lobe. Declivity with a conspicuous U-shaped cavity. This insect, which is widely distributed throughout the Indian, Sri Lankan, Myanmar and Malaysian region, is known to attack a variety of species like *Albizia lebbeck, Anogeissus latifolia, Bombax malabaricum, Dipterocarpus pilosus, Ficus glomerata, Gmelina arborea, Shorea robusta* and *Terminalia bellerica* (Beeson, 1941).

***p. Platypus* sp.**

Recorded from *Terminalia bellerica* from New Amarambalam. The material was damaged and hence description of the species was not possible.

E. Curculionidae

Seven species belonging to 4 subfamilies under 6 genera have been recorded.

Cryptorhynchinae

***a. Cryptorhynchus rufescens* Roel. (Pl. II, Fig. 6)**

Recorded from *Ficus* sp., and *Canarium strictum* from Poochapara and Neelikkal in Silent Valley. Dark brown weevil measuring 7 mm in length. Rostrum long, tubular and curved. This species is distributed in central and eastern Asia, from Kashmir through northern India, Pakistan, and Myanmar to Japan. Body covered with flat scales. Pronotum wedge-shaped. Elytra with parallel striae bearing rows of scales.

In India and Pakistan, this weevil is a secondary pest of *Pinus khasya* and *P. roxburghii*, often associated with infection by *Cronartium himalayense*. There are several generations during the year, adults appearing in April, June and July to September, and the species may over-winter in any stage of development. The larva, which has been described by Gardner (1934), makes irregular tunnels in diseased trees or those subjected to severe fire injury. Infestation of saplings in plantations has also been recorded.

***b. Camptorrhinus* sp. (Pl. II, Fig. 8)**

Recorded from *Callicarpa* sp. at New Amarambalam. The borer holes were mostly confined to the sapwood and the damage was mild. The beetles are dark brown, having patches of cream-coloured scales and measuring 6 mm in length. Rostrum smooth, shining, beak-like and slightly curved in the middle. Pronotum rectangular, broad at the base. Elytra boat-shaped, conical and narrow distally and pitted. Members of this genus are known to be borers in various timber species: *C. albiziae* boring in *Albizia lucida*; *C. dorsalis* boring in L*annea grandis* and *C. scrobicollis* boring in *Vateria indica, Erythrina suberosa, Hardwickia binata* and *Shorea robusta* (Beeson, 1941).

c. *Camptorrhinus* sp. nr. *mangiferae* Mschl. (Pl. II, Fig. 7)

Recorded from *Dalbergia latifolia* at Tirunelly (Wynad Division). *C. mangiferae* has been reported to bore in *Mangifera indica*. Beetle emergence occurs during the end of monsoon from July to August. The material collected in this study was damaged and hence description of the species was not possible.

***d. Mecistocerus simplex* Fst. (Pl. II, Fig. 9)**

Recorded on *Callicarpa* sp. from New Amarambalam. The borer holes were few and the damage was rated as mild. Dark brown beetle measuring about 10 mm in length. Rostrum tubular, beak-shaped, curved and with 2 teeth at the tip. Body covered with brown scales and having pits arranged in rows. Pronotum with a median ridge. Femora with a distinct subapical notch. Recorded on *Callicarpa* sp. at New Amarambalam.

Species belonging to this genus are known to be borers in dead wood. Of the various species reported, *M. fluctiger* is the most polyphagous species attacking a variety of timber species. Mathew (1982) has recorded *M. mollis* Fst. as a borer in *Erythrina* logs at Vazhachal (Trichur Division).

Cossoninae

***e. Cossonus* sp.nr. *canarensis* Fst. (Pl. II, Fig. 5)**

Recorded from *Myristica beddomia* at Neelikkal (Silent valley). Rostrum short and broad, subapically narrowed, antennae arising ventrally. Club densely pubescent. Pronotum puncturate, rectangular, slightly narrowed apically with a median furrow in the posterior half. Elytra elongate, cylindrical, puncturate, with the punctures arranged in linear rows. It has already been reported as a borer in the wood of *Ficus bengalensis* (Beeson, 1941). A related species *C. divisus* Mischl. has been reported from *Artocarpus heterophyllus* at Kuppady (Wynad Division) (Mathew, 1982).

Trachodinae

***f. Trachodes* sp.nr. *acutangulus* Hell. (Pl. II, Fig. 10)**

Beetle recorded to bore in *Myristica malabarica* at Neelikkal in Silent Valley. The damage caused was minor. Beetle with body covered with tufts of raised scales and tubercles. Snout long and tubular. Eyes golden and shining. Pronotum with the apical half narrow. Elytra with parallel striae.

F. Brenthidae

Saeven species belonging to 3 genera under two sub families have been recorded as detailed below.

Arrhenodinae

***a. Agriorrhynchus* sp. (Pl. II, Fig. 13)**

Recorded from *Lannea coromandelica* at New Amarambalam. Borer holes were confined to the sapwood and the damage was minor. Stout, dark brownish beetle measuring 15 mm in length. Elytra mottled with light brown specks. Rostrum long with a constriction and two lateral bulging giving the appearance of a crocodile's head. Antennae arise sub-apically at about 1/4 length of the rostrum. Antennae moniliform, apical segment about double the size of the usual segments. Apical end broad with a curved notch having two stout spines, basally broad and apically pointed, bearing denticles on the inner side. Eyes projecting laterally at about 3/4 length from the apex. A median longitudinal notch extending as far as the eyes. Elytra with longitudinal striae. First femora flattened basally and swollen apically, of moderate length and with pointed processes on the ventral margin. Median and hind femora basally narrowed.

Brachyderinae

***b. Blosyrus* Schonk**

Dark brown beetle, measuring 6mm. Rostrum short and stout. Antennae slender with an elongate club. Two dorsal carina extending from the elytra to the tip of the rostrum. Pronotum short and ring-shaped. Body covered with scales. Elytra with parallel striae and with a median raised ridge along the elytral declivity. Several conical prominences on the declivity, of which four are prominent.

***c. Caladromus nellyi* Guer. (Pl. II, Fig. 14)**

Recorded from *Dysoxylum beddomei* at New Amarambalam. Damage caused was minor. Slender beetle measuring 10-12 mm in length, brownish in colour. Rostrum comparatively shorter with a median cup-like notch. Antennae moniliform. Pronotum dome-shaped with the apex drawn out. First femora short, stout with the base swollen and apically narrowed. Hind femora elongate with the basal half narrow and distal half broad. Tibia with a stout beak-like spine and another short spine-like process at the base.

***d. Cyphagogus buccatus* Kl.**

Collected from Neelikkal (Silent Valley) in unidentified wood. Moderate sized beetle having spatulate rostral tip with the antennae arising subapically. Antennal segments moniliform with a prominent conical apical segment. Pronotum apically compressed and posteriorly swollen. Elytra with parallel striae. Hind femora elongate, its basal half narrow and distal half swollen.

***e. Cyphagogus* sp.nr. *obconiceps* Senna (Pl. II, Fig. 15)**

Collected from Tirunelly (Wynad) infesting *Terminalia bellerica*. Measures 6 mm in length. Rostrum rectangular, apically spatulate with a median notch. Antennae moniliform with a conical apical segment. The last three segments appear different from the rest. Pronotum apically narrowed with a median carina. Elytra puncturate, with punctures appearing in longitudinal striae. First and 3rd

femora with the apical half narrow and distal half swollen. Tarsal segments round and distinct.

***f. Cyphagogus planifrons* Kirsch.**

Collected from *Bischofia javanica* at New Amarambalam. The material was damaged and hence description of the species was not possible.

***g. Cyphagogus westwoodi* Parry (Pl. II, Fig. 17)**

Collected from *Bischofia javanica* at Silent Valley. Dark brown beetle of slender build, measuring 11 to 13 mm in length. Rostrum of moderate length, apical part broad with antennae arising subapically. Antennae moniliform with the segments becoming broader from base towards apex. Pronotum with a subapical constriction and having a butt-like process. Elytra with parallel striae and sparsely hairy. Front femora basally narrowed and curved. Hind femora narrow for 3/4 length and then swollen.

***h. Cyphagogus* sp. (Pl. II, Fig. 16)**

Collected from Poochapara and Neelikkal (Silent Valley) and from Tirunelly (Wynad). The host timbers were *Syzygium mundagam*, *Myristica beddomia* and *Agrostistachys* sp. Beetle slender, dark brown and measures 8 mm in length. Rostrum spatulate. Head bulged out in the middle bearing eyes laterally. Pronotum narrowed at the apex and bulged in the middle. Elytra with longitudinal striae bearing linear tubercles, sparsely hairy. Front femora narrow basally and broadened distally. Hind femora with slender, narrow basal half and broad distal half.

3.4.2. Secondary borers

A. Passalidae

***a. Leptaulax dentatus* Fb. (Pl. II, Fig. 19)**

This beetle was found breeding in an unidentified decaying wood at Tirunelly in Wynad Forest Division.

3.4.3. Predatory beetles

A. Histeridae

***a. Platysoma atratum* (Pl. II, Fig. 18)**

Beetle collected from borer holes of Cerambycidae in *Terminalia* sp., and *Ficus* sp. at Tirunelly (Wynad Division); Neelikkal and Poochapara (Silent Valley) and New Amarambalam (Nilambur Division).

3.4.4. Scavenger beetles

A. Staphylinidae

***a. Pinophiolus javanus* (Pl. II, Fig. 19)**

Recorded from highly degraded logs of *Myristica beddomia* at Neelikkal (Silent Valley).

4. DISCUSSION

4.1. Faunal elements

Information generated on timber beetles of the Nilgiri Biosphere Reserve indicates survival of a rich and diversified fauna in this region. The fauna contained Australasian, African and Malaysian elements. The platypodids *Crossotarsus saundersi* (Australasian and African regions), *Diapus quinquespinatus* (Ghana, Zambia, Papua New Guinea, Malysia, Queensland, Solomon Island and Fiji), *Platypus cupulatus* (New Guyana and Malysia), *Platypus uncinatus* (Malaysia); the curculionid *Cryptorhynchus rufescens* (Myanmar to Japan) and the cerambycid *Chloridolum alcmene* (Myanmar and Thailand) are some of the species distributed in other geographical regions. Because of their isolation from their counterparts surviving elsewhere in totally different environmental conditions, the chances of such species slowly evolving into characteristic 'species-groups' is very high. Occurrence of such 'species-groups' have been revealed in a study of the moth fauna of Silent Valley in Kerala and Kinabalu in Malaysia. On the otherhand, certain species such as *Serixia* sp., *Acalolepta rusticatrix* (Cerambycidae); *Xylothrips flavipes* (Bostrychidae); *Crossotarsus nilgiricus* (Platypodidae); *Sphaerotrypes coimbatorensis* (Scolytidae); *Mecopus* sp., *Pagiophloeus longclavis* and *Myocalandra exarata* (Curculionidae); *Crossotarsus squamulatus*, *C. minax*, *Diapus impressus*, *Platypus cupulifer*, *P. biformis* (Platypodidae); *Xyleborus butamali*, *Xyleborus morstatti* (Scolytidae) as well as *Cyphagogus buccatus*, *C. planifrons* and *Caladromus mellyi* (Brenthidae) show high degree of endemism since they are restricted to the evergreen forest habitats of NBR or south Western Ghats.

4.2. Host specificity

Most of the beetles recorded in this study, excepting a few like the bostrychid *Sinoxylon atratum* and the scolytid *Euwallacea fornicatus*, showed a high degree

of specificity to selected timber species. Borers infesting evergreen tree species in tropical rain forests tend to be highly host specific, specialized and have narrow distribution compared to species associated with deciduous species which, being polyphagous can survive in a variety of host timbers. At present, large quantities of timber are being imported to India from various countries particularly from Africa and South East Asia. Recently, Krishnasamy *et al.* (1991) have intercepted as many as 24 species of beetles from imported timber at Madras port. The chances of timber beetles getting introduced through these imports need to be examined closely. Information on the timber beetles of specific forest areas, their distribution, host range and nature of damage is essential in order to assess the threat to indigenous timber species from exotic borers.

4.3. Intensity and nature of infestation

Dead wood present on the forest floor were both fresh as well as old. In forests, usually large trees get uprooted in heavy rain and wind. Mortality of trees due to other reasons such as damage by wild animals, incidence of fire, pests and pathogens has also been noticed. A succession of beetles ranging from primary borers, secondary borers and scavengers infest these logs, as a result of which the wood get disintegrated to humus. Usually, the borers initially damage the outer sapwood portion of durable timbers. In the case of soft and moderately hard species (perishable timbers), the borers may penetrate deep in the wood and cause severe damage to the entire wood. Platypodid and scolytid borers are the common borers associated with such timber. Since these beetles have the habit of cultivating fungi within the tunnels, the wood is also likely to be tainted. Presence of borer holes and stain are serious problems to logs meant for peeling. Rajput *et al.* (1990) reported reduction in strength in wood afftected by scolytid beetles. *Myristica beddomia, Cinnamomum* sp., *Palaquium ellipticum, Bischofia javanica, Melia dubia, Persea macrantha, Mallotus philippensis, Dysoxylum beddomei, Canarium strictum, Schleichera oleosa, Terminalia bellerica, Lannea*

coromandelica, Ficus sp., and *Acacia* sp. were the most susceptible species. Rotting logs of evergreen species contained the passalid beetle *Leptaulax dentatus* (Plate III, Fig. 3) in all the three areas. The beetles were seen in aggregation and all stages were present inside the tunnels. In addition to this, the woodroach *Dicellonotus* sp. (Plate II, Fig.20) was also observed to make large tunnels in the wood. It was interesting to note that both the above species of insects were confined to large rotting logs present in interior forests and not in the disturbed areas. The usefulness of these organisms as indicators of forest degradation is worth exploring. A large number of scavenger organisms such as ground beetles, termites, millipedes and earthworms were also present in rotting timber, which have an important role in nutrient cycling.

4.4. Significance of timber beetles recorded from the Kerala part of NBR

As has been elucidated earlier, most of the timber beetles recorded from NBR formed part of an undisturbed ecosystem where their primary role seemed to be one of recycling of dead organic matter lying on the forest floor. None of these beetles have the potential to survive outside their natural habitat and even if infested logs are transported outside the forest, the beetles have only limited chance to survive and hence do not pose any threat to timber industry. Thus, these beetles have more of an ecological significance rather than of much economic importance.

The timber beetles recorded from the Kerala part of NBR showed strong affinity with elements present in the Indo-Malayan region. However, the insects occurring in this are are known to be quite unique and distinct from their counterparts in the Indo-Malayan region both in the morphological and bio ecological traits. This must be due to their evolution over years in specialised habitats characteristic to NBR. Almost all of the beetles recorded in this study were collected from specific evergreen timber species in interior forests. Many of them, particularly of the families Scolytidae and Platypodidae still remain to be

identified and it is quite likely that many of these might turn out to be new species. Investigations on their range of distribution and habitat associations in the Oriental Region will provide useful clues on the patterns of speciation taking place in isolated habitats in the range of a species.

5. CONCLUSIONS

The primary causes of tree mortality in the Nilgiri Biosphere Reserve are mechanical injury to standing trees by wild animals, tree fall due to wind and rain, human induced damage due to fire, cutting of trees for fodder and firewood or attack by pathogenic organisms. Of these, windfall was the most important cause of tree mortality at Wynad and Palghat Biosphere Divisions. Usually large trees of *Mesua ferrea, Dysoxylum beddomei, Myristica malabarica, Palaquium ellipticum, Persea macrantha, Agrostistachys borneensis* and *Bischofia javanica* having dense crown are prone to damage during wind or rain. In the Wynad Biosphere Division where the density of wild animals, particularly the elephants is high, considerable damage to trees has been noticed. Elephants peeled off the bark of several tree species such as Teak, *Terminalia alata* and *Kydia calycina*. Such mechanicaly damaged as well as dead or partially dead trees were infested by various beetle borers especially of the families Platypodidae, Scolytidae and Cerambycidae. The former were more abundant compared to the other families.

Of the three Biosphere Divisions, Palghat Division (Silent Valley area) was the richest in species diversity, followed by Nilambur (New Amarambalam area) and Wynad Divisions. The faunal elements showed strong affinity with Malaysian forms with a high degree of endemism especially in Platypodidae and Scolytidae. Since the fauna in these forests has been evolving in isolation over a long period, there is great interest with respect to their zoo-geographical affinities. The passalid *Leptaulax dentatus* and the woodroach *Dicellonotus* sp., which were recorded from large logs of rotting wood in the interior forests, have potential as biotic indicators of environmental quality.

Almost all of the beetles recorded in this study were collected from interior forests and their host timber were typical evergreen species. None of these beetles appeared to have the potential to survive outside their natural habitat and hence

they are not likely to assume pest status on other commercial timber species outside their habitat. Even if infested logs are transported outside the forest, the beetles have only limited chances to survive and hence do not pose any threat to wood industry. The beetles recorded in this study actually formed part of an undisturbed ecosystem where their primary function seemed to be one of recycling dead organic matter lying on the forest floor. The study revealed the significance of the timber beetles in sustaining the pristine forest ecosystem in the Nilgiri Biosphere Reserve.

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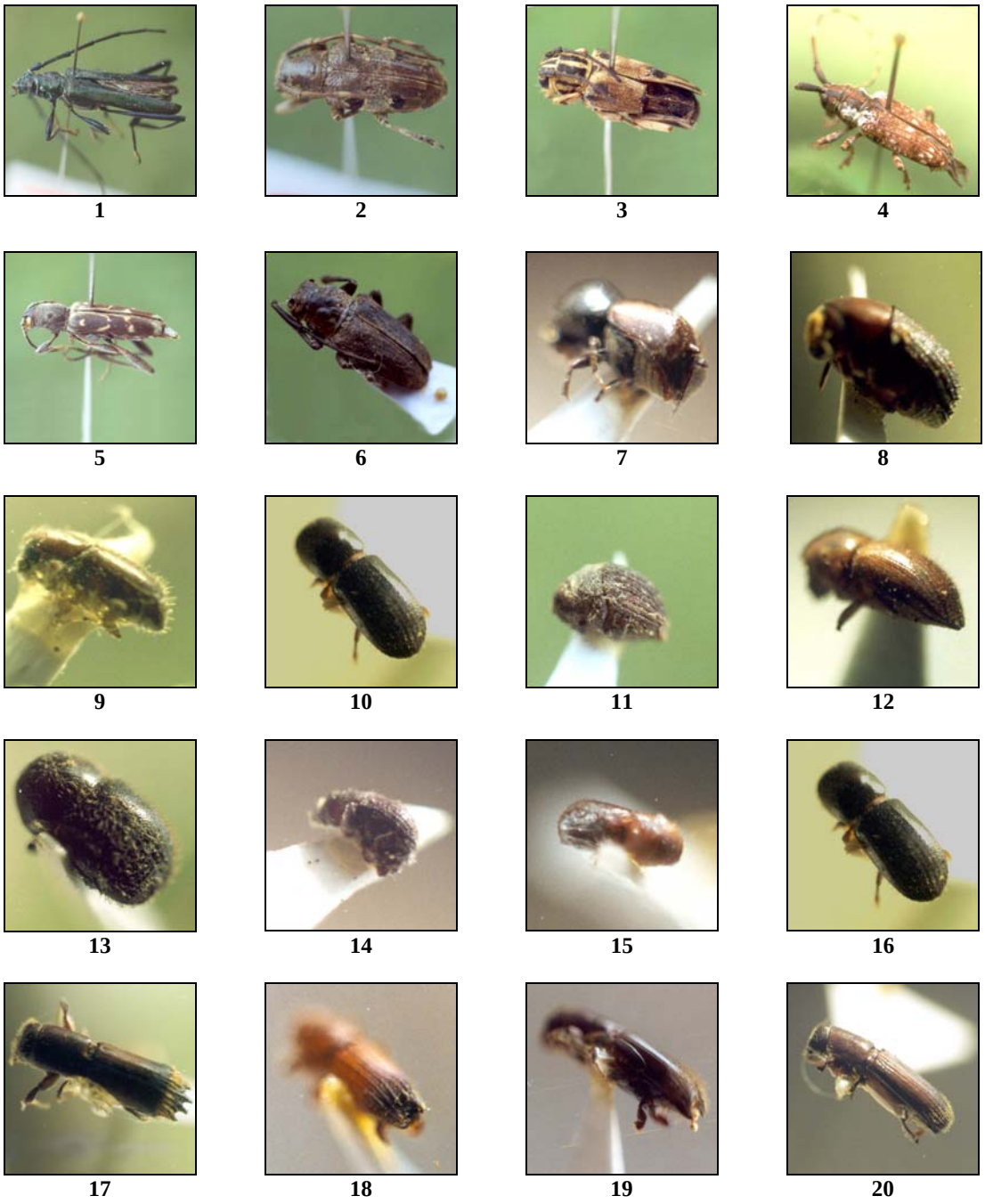
PLATE I



Figs. 1-20: Cerambycidae: *Chloridolum alcmene* Thoms. 1, *Coptops* sp. 2, *Glenea* sp. 3, *Myagrus hynesi* Pascoe 4, *Xylotrechus subscutellatus* Chev. 5, *Unidentified* sp. 6, **Bostrychidae:** *Sinoxylon atratum* Les. 7; **Scolytidae:** *Diamerus curvipes* Wlk. 8, *Euwallacea fornicatus* 9, *Euwallacea* sp. 10, *Sphaerotrypes coimbatorensis* 11, *Xyloborus assamensis* Eggers 12, *Xyleborus butamali* Beeson 13, *Xyleborus perforans* Wallaston 14, *Xylosandrus* sp. 15, *Xylosandrus* sp. 16; **Platypodidae:** *Crossotarsus minax* Wlk. 17, *Diapus* sp. nr. *assamensis* 18, *Diapus impressus* Janson 19, *Platypus biformis* Chap. 20.

PLATE II

Figs. 1-20: Platypodidae: *Platypus cylindrus* Fb. 1, *Platypus* sp. nr. *obtusipennis* Schedl 2, *Platypus uncinatus* Bldfd. 3, *Platypus* sp. 4; **Curculionidae:** *Cossonus* sp. nr. *canarensis* Fst. 5, *Cryptorrhynchus rufescens* Roel. 6, *Cryptorrhynchus mangiferae* Mschl. 7, *Camptorrhinus* sp. 8, *Mecistocerus simplex* Fst. 9, *Trachodes* sp. nr. *acutangulus* Hell. 10, *Hylobius angustatus* Faust. 11, *Mecopus* sp. 12; **Brenthidae:** *Agriorrhynchus* sp. 13, *Caladromus nellyi* Guer. 14, *Cyphagogus* sp. nr. *obconiceps* Senna 15, *Cyphagogus* sp. 16, *Cyphagogus westwoodi* Parry 17; **Histeridae:** *Platysoma atratum*, 18; **Staphylinidae:** *Pinophiolus javanus*, 19; **Passalidae:** *Leptaulax dentatus* Fb. 20;

PLATE III

1

2

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4

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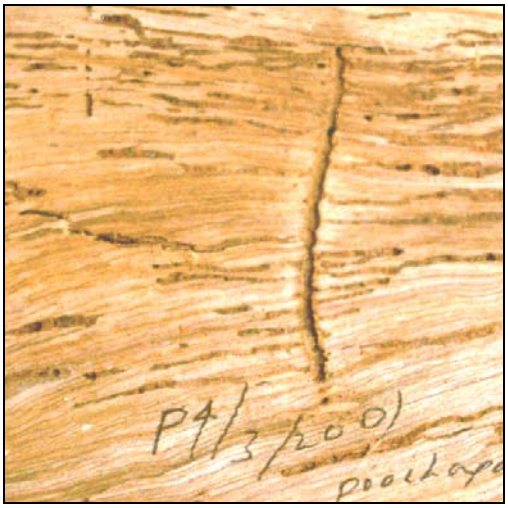
6

Figs. 1-6: Unidentified Elateridae 1; Unidentified Elateridae 2; *Dicellonotus* sp. (Blattidae) 3; Mortality of standing trees in Silent Valley due to cerambycid infestation 4-5; Mechanical injuries to a standing trees caused by wild animals 6.

Plate IV



1

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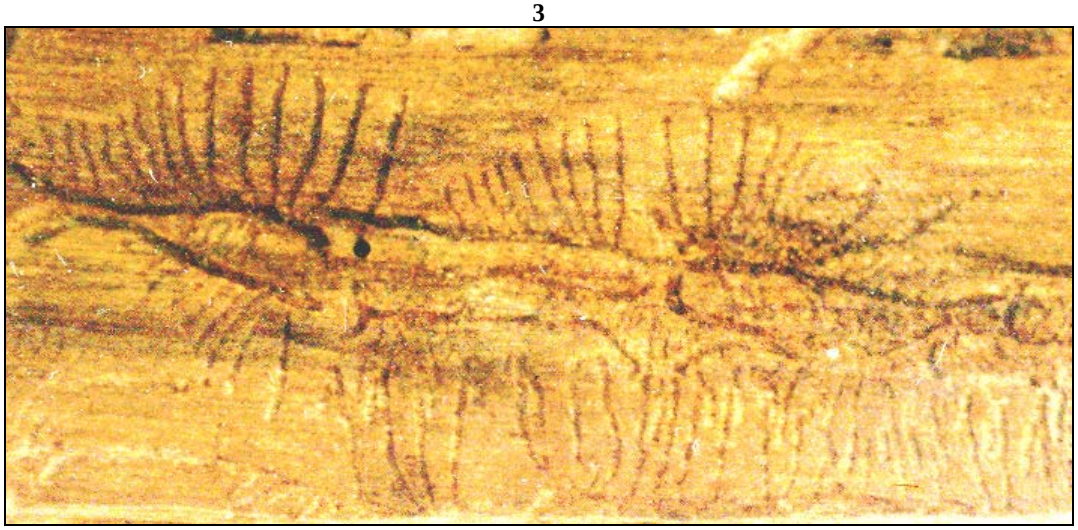
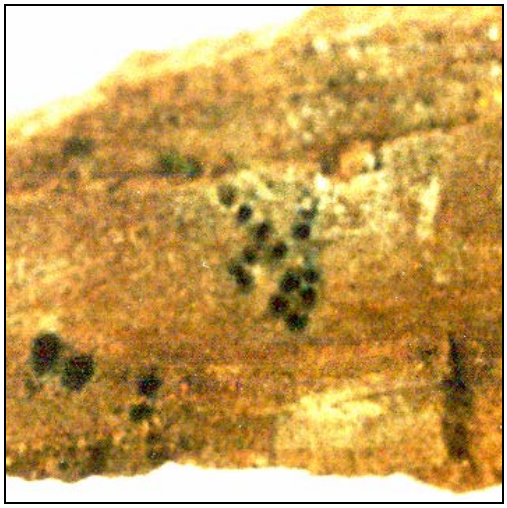


4

Figs. 1-4: Samples of wood/bark showing infestation by scolytid beetles

Plate V

1



2

3

4

Figs. 1-4: *Euwallacea fornicatus* Eichh. gallery on bark of *Myristica malabarica* 1; *Platypus cylendrus* Fb. gallery on wood of *Palaquium ellipticum* 2; Infestation by *Sinoxylon* sp. in rubber wood 3; *Cryptorrhynchus rufescens* Roel. on *Ficus* sp. 4.

Plate VI

1

Plate VI, Fig. 1. Infestation of *Xylotrechus* sp. (Cerambycidae) in teak wood.

Appendix 1. List of timber beetles collected from the Kerala part of NBR

Insect family / species	Host timber	Locality	Remarks
Family: Cerambycidae			
Chloridolum alcmene Thoms.	*Palaquium ellipticum*	Poochapara	High infestation with tunnels reaching as far as the heartwood.
Coptops sp.	*Diospyros* sp.; *Terminalia alata*	New Amarambalam	Gallery reaches as far as the centre of the log. Minor damage.
Glenea sp.	*Palaquium ellipticum*	New Amarambalam	"
Myagrus hynesi Pascoe	*Ficus glomerata*	Thirunelli	Low infestation Damage minor.
Xylotrechus subscutellatus Chev.	*Callicarpa tomentosa*	Thirunelli	Bores into the heartwood.
Family: Bostrychidae			
Sinoxylon atratum Les.	*Acacia* sp.	Thirunelly	Infestation high. Cause serious damage to sapwood.
Scolytidae *Ambrosiodmus* sp.	*Persea macrantha*	Neelikkal	Low infestation confined to the outer sapwood.
Cryphalus sp.	Unidentified timber	Wynad	"
Diamerus curvipes Wlk.	*Myristica malabarica*	Neelikkal	"
Euwallacea andamanensis (Blandford)	*Cinnamomum* sp., *Terminalia* sp.	Syrandri, Poochapara	"
Euwallacea fornicatus Eich.	Unidentified timber species.	Syrandri	"
Euwallacea sp.	Unidentified timber species	Silent Valley	"
Ficicis despectus Walker	*Ficus* sp.	Poochapara	"

Microperus alpha (Sampson)	*Myristica dactyloides, Agrostistachys meeboldii*	Neelikkal	High infestation restricted to bark.
Sphaerotrypes coimbatorensis (Pl. I, Fig.11)	*Ficus* sp.	Poochapara	Infests live trees. Minor infestation.
Xyleborus andrewesi (Blandford)	*Grevillea robusta, Terminalia bellerica*	Tirunelly	Infests live trees. Gallery reaches as far as the centre of the log.
Xyleborus perf'orans Wollaston	*Myristica malabarica, Schleichera oleosa*	Neelikkal, Poochapara, Syrendri	High infestation causing extensive damage to the bark and outer sapwood.
Xyleborus assamensis Eggers	*Cinnamomum* sp.	Syrandri	Minor attack confined to the outer sapwood.
Xyleborus butamali Beeson (Pl. I, Fig. 13)	*Terminalia* sp.	Poochapara	"
Xyleborus cognatus Bldfd.	*Palaquium ellipticum*	Syrandri	"
Xyleborus morstatti Eggers	*Myristica malabarica*	Neelikkal	"
Xyleborus burmanicus Beeson	*Palaquium ellipticum*	Syrandri	"
Xylosandrus crassiusculus (Motschulsky)	*Grevillea robusta*	Tirunelly	Gallery reaches as far as the centre of the log.
Xylosandrus terminatus (Eggers)	*Bischofia javanica*	Silent Valley, Muthanga	Low infestation. Attack confined to the sapwood.
Xylosandrus sp. (Pl. I, Fig. 15)	*Myristica malabarica*	Neelikkal	"
Platypodidae			
Crossotarsus saundersi Chap.	*Palaquium ellipticum*	Syrandri	Gallery reaches as far as the

			centre of the log.
Crossotarsus lunatus Bees.	*Schelichera oleosa*	Poochapara	"
Crossotarsus minax Wlk.	*Palaquium ellipticum*, *Terminalia bellerica*, *Mallotus philippensis*	Meenmutti, New Amarambalam, Poochapara	"
Crossotarsus squamulatus Chap.	*Terminalia* sp.	Neelikkal, Syrandri, Meenmutti, Poochapara	Minor attack confined to the outer sapwood.
Crossotarsus sp. nr. s*aundersi* Chap.	*Grevillea robusta*	Thirunelly	Minor attack. The galleries penetrate deep into the wood.
Diapus sp. nr. *assamensis*	*Melia dubia*	Mancheri	"
Diapus impressus Janson.	*Xylia xylocarpa*	Meenmutti	Infestation found in patches over the logs, each having 5-8 borer holes.
Diapus quinquespinatus	*Persea macrantha*	Neelikkal	Galleries reach deep in to the centre of the log.
Platypus amarensis Bees.	Unidentified species	Meenmutti	Minor attack confined to the outer sapwood
Platypus biformis	*Bischofia javanica*	Silent Valley	"
Platypus cupulatus Chap.	*Bischofia javanica*	Silent Valley	"
Platypus cupulifer Wich.	*Ficus sp.*	Poochapara	"
Platypus cylindrus Fb.	*Palaquium ellipticum*	Poochapara	Gallery reaches as far as the centre of the log.
Platypus sp. nr. *obtusipennis* Schedl.	*Myristica malabarica*, Un-identified tree	Meenmutti	Minor attack confined to the outer sapwood.

Platypus uncinatus Bldfd.	Unidentified tree	Thirunelly	"
Platypus sp. (Pl. II, Fig. 4)	*Terminalia bellerica*	New Amarambalam	"
Family: Brenthidae			
Sub family: Arrhenodinae			
Agriorrhynchus sp.	*Lannea coromandelica*	New Amarambalam	Minor attack.
Brachyderinae			
Caladromus mellyi Guer.	*Dysoxylum beddomei*	New Amarambalam	"
Cyphagogus buccatus Kl.	Unidentified timber species	Neelikkal	"
Cyphagogus sp.nr. *obconiceps* Senna	*Terminalia bellerica*	Thirunelly	"
Cyphagogus planifrons Kirsch.	*Bischofia javanica*	New Amarambalam	"
Cyphagogus westwoodi Parry	*Bischofia javanica*	Silent valley	"
Cyphagogus sp.	*Syzygium mundagam*, *Myristica malabarica*, *Agrostistachys* sp.	Poochapara, Neelikkal, Thirunelly	"
Family: Curculionidae			
Subfamily Curculioninae			
Hylobius angustatus Fst. (Pl. II, Fig. 11)	Unidentified timber	Silent Valley	Minor damage to outer sapwood.
Subfamily: Zygopinae			
Mecopus sp. (Pl. II, Fig. 12)	Unidentified wood	New Amarambalam	Infestation low causing mild damage.

Subfamily: Cossoninae			
Cossonus Clairw. (sp. nr. *canareasis* Fst.)	*Myristica malabarica*	Neelikkal	Infestation low causing mild damage.
Subfamily: Cryptorrhynchinae			
Camptorrhinus sp.	*Callicarpa* sp.	New Amarambalam	Mild damage.
Camptorrhinus Schr. (sp.? *mangiferae* Mschl.)	*Dalbergia latifolia*	Thirunelly	Bores deep into the wood, with galleries reaching as far as the heartwood.
Mecistocerus simplex Fst. (Pl. II, Fig. 9)	*Callicarpa* sp.	New Amarambalam	Mild damage.
Cryptorrhynchus rufescens Roel.	*Ficus* sp., *Canarium strictum*	Poochapara, Neelikkal	"
Subfamily: Trachodinae			
Trachodes sp. nr. *acutangulus* Hell.	*Myristica malabarica*	Neelikkal	Mild damage.
Family: Passalidae			
Leptaulax dentatus Fb.	Unidentified decaying wood	Thirunelly, Neelikkal, New Amarambalam	Bores in rotting wood, making large cavities.
Family: Histeridae			
Platysoma atratum	*Terminalia* sp., *Ficus* sp.	Thirunelly, Neelikkal, New Amarambalam, Poochapara	Beetle collected from cerambycid borer tunnels; probably predating on larvae.

Family: Staphylinidae **Subfamily: Paederinae**			
Pinophiolus javanus	*Myristica malabarica*	Neelikkal	Found within highly degraded wood.
Order Dictyoptera **Family: Blattidae**			
Dicellonotus sp. (Pl. III, Fig. 3)	*Palaquium ellipticum*	Silent Valley, Wynad, New Amarambalam	Bores deep in the rotting wood making large excavations.

Appendix II. Summary of borer infestation to different tree species in the study area

Tree species	Cearmbycidae	Scolytidae	Platypodidae	Bostrychidae	Curculionidae	Brenthidae	Elateridae	Passalidae	Unidentified	Tenebrionidae	Termite	Woodroache	Millipede	Earthworm	Wood louse	Centipede	Pill Millipede
Agrostistachys borneensis	12	-	2	1	-	-	-	-	-	-	-	-	-	-	-	-	-
Ailanthus triphysa	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Artocarpus heterophyllus	2	1	3	-	-	-	-	-	2	-	-	-	-	-	-	-	-
Bischofia javanica	8	6	6	4	2	-	-	1	5	-	5	-	2	2	-	-	-
Butea monosperma	1	1	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-
Callicarpa tomentosa	1	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-
Canarium strictum	-	2	4	3	2	-	-	-	-	-	-	-	-	-	-	-	-
Cassia fistula	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cinnamomum sp.	5	3	15	6	-	1	1	1	4	-	3	-	-	-	-	-	-
Cullenia exarillata	19	6	14	4	-	-	-	13	12	-	9	4	6	2	-	1	1
Dalbergia latifolia	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-
Dimocarpus longan	2	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Diospyros sp.	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dysoxylum beddomei	6	1	8	2	3	1	-	4	8	-	8	2	-	-	-	-	-
Elaeocarpus	1	-	1	-	1	-	-	1	-	-	-	-	-	-	-	-	-

munroii																	
Eucalyptus sp.	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-
Ficus sp.	2	4	11	1	6	-	-	1	-	1	1	-	-	-	-	-	-
Flacourtia jangomas	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Garcinia indica	4	1	4	-	-	-	-	-	1	-	-	-	-	-	-	-	-
Gmelina arborea	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Grevillea robusta	-	1	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-
Grewia nervosa	1	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-
Holigarna beddomei	3	-	1	2	-	-	-	-	-	-	2	-	-	-	-	-	-
Holigarna nigra	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-
Hopea parviflora	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Knema attenuata	2	2	3	-	-	-	-	1	-	-	-	-	-	-	-	-	-
Kydia calycina	3	5	2	6	-	-	-	-	1	-	2	-	-	-	-	-	-
Lagerstroemia microcarpa	1	1	-	-	-	-	-	-	1	-	3	-	-	-	-	-	-
Macaranga peltata	10	3	15	7	1	-	-	1	4	2	8	-	-	-	-	-	-
Mangifera indica	3	3	3	2	1	-	-	-	-	1	2	-	-	-	-	-	-
Melia dubia	1	-	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mesua ferrea	14	1	10	2	-	-	-	5	8	1	11	4	-	1	1	2	-
Myristica malabarica	3	21	17	5	-	3	1	1	3	-	6	1	-	-	-	-	-
Neolamarckia cadamba	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Palaquium ellipticum	32	15	29	4	2	1	-	6	15	1	7	3	1	-	1	-	-
Persea macrantha	9	7	5	4	1	-	1	1	7	-	4	-	-	-	-	-	-
Phyllanthus emblica	1	1	1	-	-	-	-	-	-	-	1	-	-	-	-	-	-
Schleichera oleosa	11	3	11	2	-	-	-	-	-	-	-	1	-	-	-	-	-
Shorea roxburghii	5	-	3	1	-	-	-	-	-	-	2	-	-	-	-	-	-
Stereospermum chelonoides	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Syzygium sp.	4	1	3	2	-	-	-	1	1	-	2	-	-	-	-	-	-
Tectona grandis	6	7	6	11	-	-	-	-	5	-	21	-	-	-	-	-	-
Terminalia alata	4	5	2	2	1	-	1	-	1	-	-	-	-	-	-	-	-
Terminalia bellerica	-	1	2	2	-	-	-	-	-	-	-	-	-	-	-	-	-
Terminalia chebula	-	2	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-
Terminalia paniculata	1	1	1	-	1	-	-	-	-	-	2	-	-	-	-	-	-
Terminalia sp.	3	2	4	3	3	-	-	-	1	2	-	-	-	-	-	-	-
Vitex altissima	1	1	1	1	-	-	-	-	-	-	1	-	-	-	-	-	-
Xylia xylocarpa	1	1	2	1	-	-	-	-	-	-	-	-	-	-	-	-	-
Xylosoma latifolium	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified sp. (Kattu vaka*)	1	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	-	-	2	1	-	-	-	-	-	-	-	-	-	-	-	-	-

Unidentified sp. (Adhar*)																	
Unidentified sp. (Edaneer *)	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified sp. (Goddha*)	1	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified sp. (Peechal*)	1	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified sp. (Velgir*)	4	3	6	3	-	-	-	-	1	-	-	-	-	-	-	-	-
Unidentified sp. (Chuvanna chadachi)	-	1	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-
Unidentified sp. (Kalkanjiram*)	-	2	4	4	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified sp. (Vayal*)	-	1	2	2	-	-	-	-	1	-	-	-	-	-	-	-	-
Unidentified sp.	2	1	3	1	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified sp.	19	2	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified sp.	22	10	30	13	10	2	-	3	6	1	13	3	2	-	1	-	-
Grand Total	242	130	254	110	34	8	4	40	88	9	118	18	11	5	3	3	1

- No infestation

* Vernacular name

Appendix III- Observations on tree mortality due to reasons other than borer attack in Nilambur Biosphere Division

Tree species	Elephant	Fire	Human activity	Pathologic	Wind	Total
Agrostistachys borneensis	-	-	-	-	1	1
Bischofia javanica	-	-	-	-	2	2
Callicarpa tomentosa	-	-	-	-	1	1
Canarium strictum	-	-	-	-	1	1
Cinnamomumum sp.	-	-	1	1	1	3
Diospyros sp.	1	-	-	-	1	2
Dysoxylum beddomei	-	-	-	-	1	1
Ficus sp.	-	-	-	-	4	4
Lagerstroemia microcarpa	-	2	-	-	2	4
Melia dubia	-	-	-	-	1	1
Myristica malabarica	-	-	-	-	7	7
Palaquium ellipticum	-	-	-	-	7	7
Persea macrantha	-	-	-	-	1	1
Tectona grandis	27	1	-	-	-	28
Terminalia bellerica	-	-	-	-	1	1
Terminalia paniculata	-	2	1	-	3	6
Terminalia sp.	-	-	-	-	3	3
Vitex altissima	-	-	1	1	-	2
Xylia xylocarpa	1	2	2	-	2	7
Unidentified sp. (Adhar*)	-	-	-	-	1	1
Unidentified sp. (Goddha*)	-	-	-	-	1	1
Unidentified sp. (Peechal*)	-	-	-	-	1	1
Other Unidentified trees	-	-	1	-	31	32
Grand Total	29	7	6	2	73	117

* Vernacular name

Appendix IV - Observations on tree mortality due to reasons other than borer attack in Palghat Biosphere Division

Tree species	Elephant damage	Errosion	Fire	Human activity	Pathogenic infestation	Wind	Total
Agrostistachys borneensis	-	-	-	-	-	16	16
Ailanthus triphysa	-	-	-	-	-	1	1
Artocarpus heterophyllus	-	-	1	-	6	1	8
Bischofia javanica	-	1	1	-	6	11	19
Callicarpa tomentosa	-	-	-	-	-	2	2
Canarium strictum	-	-	-	-	1	5	6
Cinnamomumum sp.	-	-	-	-	1	21	22
Cullenia exarillata	-	-	-	-	18	29	47
Dimocarpus longan	-	-	-	-	-	4	4
Diospyros sp.	-	-	-	-	-	1	1
Dysoxylum beddomei	-	-	-	-	4	24	28
Elaeocarpus munroii	-	-	-	-	1	1	2
Ficus sp.	-	-	-	-	-	5	5
Flacourtia jangomas	-	-	-	-	-	1	1
Garcinia indica	-	-	-	-	-	9	9
Grewia nervosa	-	-	-	-	-	1	1
Holigarna beddomei	-	-	-	-	2	6	8
Holigarna nigra	-	-	-	-	-	1	1
Hopea parviflora	-	-	-	-	-	2	2
Knema attenuata	-	-	-	-	-	5	5
Lagerstroemia microcarpa	-	-	-	-	-	1	1
Macaranga peltata	-	1	-	-	8	31	40
Melia dubia	-	-	-	-	-	3	3
Mesua ferrea	-	-	9	1	31	31	72
Myristica malabarica	-	1	-	-	4	16	21
Neolamarckia cadamba	-	-	-	-	-	3	3
Palaquium ellipticum	-	-	1	-	15	62	78

Persea macrantha	-	-	-	-	4	14	18
Schleichera oleosa	-	-	1	-	1	21	23
Shorea roxburghii	-	-	-	-	-	1	1
Syzygium sp.	-	-	-	-	-	7	7
Tectona grandis	-	-	-	-	-	6	11
Terminalia alata	1	-	-	-	-	1	2
Terminalia sp.	-	-	-	-	-	4	4
Unidentified sp. (Kattu vaka*)	-	-	-	-	-	3	3
Unidentified sp. (Adhar*)	-	-	-	-	-	1	1
Unidentified sp. (Edaneer *)	-	-	-	-	-	1	1
Unidentified sp. (Goddha*)	-	-	-	-	-	1	1
Unidentified sp. (Velgir*)	-	-	-	-	1	8	9
Unidentified sp. (Kalkanjiram*)	-	-	-	-	-	1	1
Unidentified sp. (Vayal*)	-	-	-	-	1	3	4
Unidentified sp.	-	-	-	-	-	3	3
Unidentified sp.	-	-	-	-	-	24	24
Other Unidentified trees	-	-	-	-	16	32	48
Grand Total	6	3	13	1	120	427	570

* Vernacular name

Appendix V- Observations on tree mortality due to reasons other than borer attack in Wynad Biosphere Division

Tree species	Elephant	Errosion	Fire	Human activity	Pathologic	Total
Bischofia javanica	3	-	-	-	-	3
Butea monosperma	1	-	-	-	-	1
Cassia fistula	3	-	-	-	-	3
Dalbergia latifolia	2	-	-	-	-	2
Eucalyptus sp.	4	-	-	-	-	4
Ficus sp.	1	-	-	-	-	1
Gmelina arborea	4	-	-	-	-	4
Grevillea robusta	1	-	-	-	-	1
Kydia calycina Roxb.	19	-	-	-	-	20
Macaranga peltata	2	-	-	-	-	2
Mangifera indica	2	2	-	-	1	5
Myristica malabarica	7	-	-	-	-	7
Palaquium ellipticum	1	-	-	-	-	1
Persea macrantha	1	2	-	-	-	3
Phyllanthus emblica	7	-	-	1	1	9
Schleichera oleosa	2	-	-	-	-	2
Shorea roxburghii	6	1	1	-	-	8
Stereospermum chelonoides	2	1	-	-	-	3
Syzygium sp.	0	1	-	1	-	2
Tectona grandis	19	-	-	-	1	20
Terminalia alata	17	-	-	-	-	17
Terminalia bellerica	2	-	-	-	-	2
Terminalia chebula	2	-	-	-	-	2
Terminalia sp.	2	-	-	-	-	2
Xylosma latifolium	1	-	-	-	-	1
Unidentified sp1.	1	-	-	-	-	1
Unidentified sp. (Chuvanna chadachi*)	4	-	-	-	-	4

Unidentified (Kalkanjiram*)	9	-	-	-	1	10
Other Unidentified trees	6	-	-	-	1	7
Grand Total	131	7	1	2	6	147

* Vernacular name

Appendix 1. List of timber beetles collected from the Kerala part of NBR

Insect family / species	Host timber	Locality	Remarks
Family: Cerambycidae			
Chloridolum alcmene Thoms.	*Palaquium ellipticum*	Poochapara	High infestation with tunnels reaching as far as the heartwood.
Coptops sp.	*Diospyros* sp.; *Terminalia alata*	New Amarambalam	Gallery reaches as far as the centre of the log. Minor damage.
Glenea sp.	*Palaquium ellipticum*	New Amarambalam	"
Myagrus hynesi Pascoe	*Ficus glomerata*	Thirunelli	Low infestation Damage minor.
Xylotrechus subscutellatus Chev.	*Callicarpa tomentosa*	Thirunelli	Bores into the heartwood.
Family: Bostrychidae			
Sinoxylon atratum Les.	*Acacia* sp.	Thirunelly	Infestation high. Cause serious damage to sapwood.
Scolytidae *Ambrosiodmus* sp.	*Persea macrantha*	Neelikkal	Low infestation confined to the outer sapwood.
Cryphalus sp.	Unidentified timber	Wynad	"
Diamerus curvipes Wlk.	*Myristica malabarica*	Neelikkal	"
Euwallacea andamanensis (Blandford)	*Cinnamomum* sp., *Terminalia* sp.	Syrandri, Poochapara	"
Euwallacea fornicatus Eich.	Unidentified timber species.	Syrandri	"
Euwallacea sp.	Unidentified timber species	Silent Valley	"
Ficicis despectus Walker	*Ficus* sp.	Poochapara	"

Microperus alpha (Sampson)	*Myristica dactyloides, Agrostistachys meeboldii*	Neelikkal	High infestation restricted to bark.
Sphaerotrypes coimbatorensis (Pl. I, Fig.11)	*Ficus* sp.	Poochapara	Infests live trees. Minor infestation.
Xyleborus andrewesi (Blandford)	*Grevillea robusta, Terminalia bellerica*	Tirunelly	Infests live trees. Gallery reaches as far as the centre of the log.
Xyleborus perf'orans Wollaston	*Myristica malabarica, Schleichera oleosa*	Neelikkal, Poochapara, Syrendri	High infestation causing extensive damage to the bark and outer sapwood.
Xyleborus assamensis Eggers	*Cinnamomum* sp.	Syrandri	Minor attack confined to the outer sapwood.
Xyleborus butamali Beeson (Pl. I, Fig. 13)	*Terminalia* sp.	Poochapara	"
Xyleborus cognatus Bldfd.	*Palaquium ellipticum*	Syrandri	"
Xyleborus morstatti Eggers	*Myristica malabarica*	Neelikkal	"
Xyleborus burmanicus Beeson	*Palaquium ellipticum*	Syrandri	"
Xylosandrus crassiusculus (Motschulsky)	*Grevillea robusta*	Tirunelly	Gallery reaches as far as the centre of the log.
Xylosandrus terminatus (Eggers)	*Bischofia javanica*	Silent Valley, Muthanga	Low infestation. Attack confined to the sapwood.
Xylosandrus sp. (Pl. I, Fig. 15)	*Myristica malabarica*	Neelikkal	"
Platypodidae			
Crossotarsus saundersi Chap.	*Palaquium ellipticum*	Syrandri	Gallery reaches as far as the

			centre of the log.
Crossotarsus lunatus Bees.	*Schelichera oleosa*	Poochapara	"
Crossotarsus minax Wlk.	*Palaquium ellipticum*, *Terminalia bellerica*, *Mallotus philippensis*	Meenmutti, New Amarambalam, Poochapara	"
Crossotarsus squamulatus Chap.	*Terminalia* sp.	Neelikkal, Syrandri, Meenmutti, Poochapara	Minor attack confined to the outer sapwood.
Crossotarsus sp. nr. s*aundersi* Chap.	*Grevillea robusta*	Thirunelly	Minor attack. The galleries penetrate deep into the wood.
Diapus sp. nr. *assamensis*	*Melia dubia*	Mancheri	"
Diapus impressus Janson.	*Xylia xylocarpa*	Meenmutti	Infestation found in patches over the logs, each having 5-8 borer holes.
Diapus quinquespinatus	*Persea macrantha*	Neelikkal	Galleries reach deep in to the centre of the log.
Platypus amarensis Bees.	Unidentified species	Meenmutti	Minor attack confined to the outer sapwood
Platypus biformis	*Bischofia javanica*	Silent Valley	"
Platypus cupulatus Chap.	*Bischofia javanica*	Silent Valley	"
Platypus cupulifer Wich.	*Ficus sp.*	Poochapara	"
Platypus cylindrus Fb.	*Palaquium ellipticum*	Poochapara	Gallery reaches as far as the centre of the log.
Platypus sp. nr. *obtusipennis* Schedl.	*Myristica malabarica*, Un-identified tree	Meenmutti	Minor attack confined to the outer sapwood.

Platypus uncinatus Bldfd.	Unidentified tree	Thirunelly	"
Platypus sp. (Pl. II, Fig. 4)	*Terminalia bellerica*	New Amarambalam	"
Family: Brenthidae			
Sub family: Arrhenodinae			
Agriorrhynchus sp.	*Lannea coromandelica*	New Amarambalam	Minor attack.
Brachyderinae			
Caladromus mellyi Guer.	*Dysoxylum beddomei*	New Amarambalam	"
Cyphagogus buccatus Kl.	Unidentified timber species	Neelikkal	"
Cyphagogus sp.nr. *obconiceps* Senna	*Terminalia bellerica*	Thirunelly	"
Cyphagogus planifrons Kirsch.	*Bischofia javanica*	New Amarambalam	"
Cyphagogus westwoodi Parry	*Bischofia javanica*	Silent valley	"
Cyphagogus sp.	*Syzygium mundagam*, *Myristica malabarica*, *Agrostistachys* sp.	Poochapara, Neelikkal, Thirunelly	"
Family: Curculionidae			
Subfamily Curculioninae			
Hylobius angustatus Fst. (Pl. II, Fig. 11)	Unidentified timber	Silent Valley	Minor damage to outer sapwood.
Subfamily: Zygopinae			
Mecopus sp. (Pl. II, Fig. 12)	Unidentified wood	New Amarambalam	Infestation low causing mild damage.

Subfamily: Cossoninae			
Cossonus Clairw. (sp. nr. *canareasis* Fst.)	*Myristica malabarica*	Neelikkal	Infestation low causing mild damage.
Subfamily: Cryptorrhynchinae			
Camptorrhinus sp.	*Callicarpa* sp.	New Amarambalam	Mild damage.
Camptorrhinus Schr. (sp.? *mangiferae* Mschl.)	*Dalbergia latifolia*	Thirunelly	Bores deep into the wood, with galleries reaching as far as the heartwood.
Mecistocerus simplex Fst. (Pl. II, Fig. 9)	*Callicarpa* sp.	New Amarambalam	Mild damage.
Cryptorrhynchus rufescens Roel.	*Ficus* sp., *Canarium strictum*	Poochapara, Neelikkal	"
Subfamily: Trachodinae			
Trachodes sp. nr. *acutangulus* Hell.	*Myristica malabarica*	Neelikkal	Mild damage.
Family: Passalidae			
Leptaulax dentatus Fb.	Unidentified decaying wood	Thirunelly, Neelikkal, New Amarambalam	Bores in rotting wood, making large cavities.
Family: Histeridae			
Platysoma atratum	*Terminalia* sp., *Ficus* sp.	Thirunelly, Neelikkal, New Amarambalam, Poochapara	Beetle collected from cerambycid borer tunnels; probably predating on larvae.

Family: Staphylinidae **Subfamily: Paederinae**			
Pinophiolus javanus	*Myristica malabarica*	Neelikkal	Found within highly degraded wood.
Order Dictyoptera **Family: Blattidae**			
Dicellonotus sp. (Pl. III, Fig. 3)	*Palaquium ellipticum*	Silent Valley, Wynad, New Amarambalam	Bores deep in the rotting wood making large excavations.

Appendix II. Summary of borer infestation to different tree species in the study area

Tree species	Cearmbycidae	Scolytidae	Platypodidae	Bostrychidae	Curculionidae	Brenthidae	Elateridae	Passalidae	Unidentified	Tenebrionidae	Termite	Woodroache	Millipede	Earthworm	Wood louse	Centipede	Pill Millipede
Agrostistachys borneensis	12	-	2	1	-	-	-	-	-	-	-	-	-	-	-	-	-
Ailanthus triphysa	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Artocarpus heterophyllus	2	1	3	-	-	-	-	-	2	-	-	-	-	-	-	-	-
Bischofia javanica	8	6	6	4	2	-	-	1	5	-	5	-	2	2	-	-	-
Butea monosperma	1	1	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-
Callicarpa tomentosa	1	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-
Canarium strictum	-	2	4	3	2	-	-	-	-	-	-	-	-	-	-	-	-
Cassia fistula	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cinnamomum sp.	5	3	15	6	-	1	1	1	4	-	3	-	-	-	-	-	-
Cullenia exarillata	19	6	14	4	-	-	-	13	12	-	9	4	6	2	-	1	1
Dalbergia latifolia	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-
Dimocarpus longan	2	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Diospyros sp.	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dysoxylum beddomei	6	1	8	2	3	1	-	4	8	-	8	2	-	-	-	-	-
Elaeocarpus	1	-	1	-	1	-	-	1	-	-	-	-	-	-	-	-	-

munroii																	
Eucalyptus sp.	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-
Ficus sp.	2	4	11	1	6	-	-	1	-	1	1	-	-	-	-	-	-
Flacourtia jangomas	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Garcinia indica	4	1	4	-	-	-	-	-	1	-	-	-	-	-	-	-	-
Gmelina arborea	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Grevillea robusta	-	1	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-
Grewia nervosa	1	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-
Holigarna beddomei	3	-	1	2	-	-	-	-	-	-	2	-	-	-	-	-	-
Holigarna nigra	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-
Hopea parviflora	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Knema attenuata	2	2	3	-	-	-	-	1	-	-	-	-	-	-	-	-	-
Kydia calycina	3	5	2	6	-	-	-	-	1	-	2	-	-	-	-	-	-
Lagerstroemia microcarpa	1	1	-	-	-	-	-	-	1	-	3	-	-	-	-	-	-
Macaranga peltata	10	3	15	7	1	-	-	1	4	2	8	-	-	-	-	-	-
Mangifera indica	3	3	3	2	1	-	-	-	-	1	2	-	-	-	-	-	-
Melia dubia	1	-	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mesua ferrea	14	1	10	2	-	-	-	5	8	1	11	4	-	1	1	2	-
Myristica malabarica	3	21	17	5	-	3	1	1	3	-	6	1	-	-	-	-	-
Neolamarckia cadamba	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Palaquium ellipticum	32	15	29	4	2	1	-	6	15	1	7	3	1	-	1	-	-
Persea macrantha	9	7	5	4	1	-	1	1	7	-	4	-	-	-	-	-	-
Phyllanthus emblica	1	1	1	-	-	-	-	-	-	-	1	-	-	-	-	-	-
Schleichera oleosa	11	3	11	2	-	-	-	-	-	-	-	1	-	-	-	-	-
Shorea roxburghii	5	-	3	1	-	-	-	-	-	-	2	-	-	-	-	-	-
Stereospermum chelonoides	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Syzygium sp.	4	1	3	2	-	-	-	1	1	-	2	-	-	-	-	-	-
Tectona grandis	6	7	6	11	-	-	-	-	5	-	21	-	-	-	-	-	-
Terminalia alata	4	5	2	2	1	-	1	-	1	-	-	-	-	-	-	-	-
Terminalia bellerica	-	1	2	2	-	-	-	-	-	-	-	-	-	-	-	-	-
Terminalia chebula	-	2	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-
Terminalia paniculata	1	1	1	-	1	-	-	-	-	-	2	-	-	-	-	-	-
Terminalia sp.	3	2	4	3	3	-	-	-	1	2	-	-	-	-	-	-	-
Vitex altissima	1	1	1	1	-	-	-	-	-	-	1	-	-	-	-	-	-
Xylia xylocarpa	1	1	2	1	-	-	-	-	-	-	-	-	-	-	-	-	-
Xylosoma latifolium	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified sp. (Kattu vaka*)	1	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	-	-	2	1	-	-	-	-	-	-	-	-	-	-	-	-	-

Unidentified sp. (Adhar*)																	
Unidentified sp. (Edaneer *)	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified sp. (Goddha*)	1	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified sp. (Peechal*)	1	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified sp. (Velgir*)	4	3	6	3	-	-	-	-	1	-	-	-	-	-	-	-	-
Unidentified sp. (Chuvanna chadachi)	-	1	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-
Unidentified sp. (Kalkanjiram*)	-	2	4	4	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified sp. (Vayal*)	-	1	2	2	-	-	-	-	1	-	-	-	-	-	-	-	-
Unidentified sp.	2	1	3	1	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified sp.	19	2	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified sp.	22	10	30	13	10	2	-	3	6	1	13	3	2	-	1	-	-
Grand Total	242	130	254	110	34	8	4	40	88	9	118	18	11	5	3	3	1

- No infestation

* Vernacular name

Appendix III- Observations on tree mortality due to reasons other than borer attack in Nilambur Biosphere Division

Tree species	Elephant	Fire	Human activity	Pathologic	Wind	Total
Agrostistachys borneensis	-	-	-	-	1	1
Bischofia javanica	-	-	-	-	2	2
Callicarpa tomentosa	-	-	-	-	1	1
Canarium strictum	-	-	-	-	1	1
Cinnamomumum sp.	-	-	1	1	1	3
Diospyros sp.	1	-	-	-	1	2
Dysoxylum beddomei	-	-	-	-	1	1
Ficus sp.	-	-	-	-	4	4
Lagerstroemia microcarpa	-	2	-	-	2	4
Melia dubia	-	-	-	-	1	1
Myristica malabarica	-	-	-	-	7	7
Palaquium ellipticum	-	-	-	-	7	7
Persea macrantha	-	-	-	-	1	1
Tectona grandis	27	1	-	-	-	28
Terminalia bellerica	-	-	-	-	1	1
Terminalia paniculata	-	2	1	-	3	6
Terminalia sp.	-	-	-	-	3	3
Vitex altissima	-	-	1	1	-	2
Xylia xylocarpa	1	2	2	-	2	7
Unidentified sp. (Adhar*)	-	-	-	-	1	1
Unidentified sp. (Goddha*)	-	-	-	-	1	1
Unidentified sp. (Peechal*)	-	-	-	-	1	1
Other Unidentified trees	-	-	1	-	31	32
Grand Total	29	7	6	2	73	117

* Vernacular name

Appendix IV - Observations on tree mortality due to reasons other than borer attack in Palghat Biosphere Division

Tree species	Elephant damage	Errosion	Fire	Human activity	Pathogenic infestation	Wind	Total
Agrostistachys borneensis	-	-	-	-	-	16	16
Ailanthus triphysa	-	-	-	-	-	1	1
Artocarpus heterophyllus	-	-	1	-	6	1	8
Bischofia javanica	-	1	1	-	6	11	19
Callicarpa tomentosa	-	-	-	-	-	2	2
Canarium strictum	-	-	-	-	1	5	6
Cinnamomumum sp.	-	-	-	-	1	21	22
Cullenia exarillata	-	-	-	-	18	29	47
Dimocarpus longan	-	-	-	-	-	4	4
Diospyros sp.	-	-	-	-	-	1	1
Dysoxylum beddomei	-	-	-	-	4	24	28
Elaeocarpus munroii	-	-	-	-	1	1	2
Ficus sp.	-	-	-	-	-	5	5
Flacourtia jangomas	-	-	-	-	-	1	1
Garcinia indica	-	-	-	-	-	9	9
Grewia nervosa	-	-	-	-	-	1	1
Holigarna beddomei	-	-	-	-	2	6	8
Holigarna nigra	-	-	-	-	-	1	1
Hopea parviflora	-	-	-	-	-	2	2
Knema attenuata	-	-	-	-	-	5	5
Lagerstroemia microcarpa	-	-	-	-	-	1	1
Macaranga peltata	-	1	-	-	8	31	40
Melia dubia	-	-	-	-	-	3	3
Mesua ferrea	-	-	9	1	31	31	72
Myristica malabarica	-	1	-	-	4	16	21
Neolamarckia cadamba	-	-	-	-	-	3	3
Palaquium ellipticum	-	-	1	-	15	62	78

Persea macrantha	-	-	-	-	4	14	18
Schleichera oleosa	-	-	1	-	1	21	23
Shorea roxburghii	-	-	-	-	-	1	1
Syzygium sp.	-	-	-	-	-	7	7
Tectona grandis	-	-	-	-	-	6	11
Terminalia alata	1	-	-	-	-	1	2
Terminalia sp.	-	-	-	-	-	4	4
Unidentified sp. (Kattu vaka*)	-	-	-	-	-	3	3
Unidentified sp. (Adhar*)	-	-	-	-	-	1	1
Unidentified sp. (Edaneer *)	-	-	-	-	-	1	1
Unidentified sp. (Goddha*)	-	-	-	-	-	1	1
Unidentified sp. (Velgir*)	-	-	-	-	1	8	9
Unidentified sp. (Kalkanjiram*)	-	-	-	-	-	1	1
Unidentified sp. (Vayal*)	-	-	-	-	1	3	4
Unidentified sp.	-	-	-	-	-	3	3
Unidentified sp.	-	-	-	-	-	24	24
Other Unidentified trees	-	-	-	-	16	32	48
Grand Total	6	3	13	1	120	427	570

* Vernacular name

Appendix V- Observations on tree mortality due to reasons other than borer attack in Wynad Biosphere Division

Tree species	Elephant	Errosion	Fire	Human activity	Pathologic	Total
Bischofia javanica	3	-	-	-	-	3
Butea monosperma	1	-	-	-	-	1
Cassia fistula	3	-	-	-	-	3
Dalbergia latifolia	2	-	-	-	-	2
Eucalyptus sp.	4	-	-	-	-	4
Ficus sp.	1	-	-	-	-	1
Gmelina arborea	4	-	-	-	-	4
Grevillea robusta	1	-	-	-	-	1
Kydia calycina Roxb.	19	-	-	-	-	20
Macaranga peltata	2	-	-	-	-	2
Mangifera indica	2	2	-	-	1	5
Myristica malabarica	7	-	-	-	-	7
Palaquium ellipticum	1	-	-	-	-	1
Persea macrantha	1	2	-	-	-	3
Phyllanthus emblica	7	-	-	1	1	9
Schleichera oleosa	2	-	-	-	-	2
Shorea roxburghii	6	1	1	-	-	8
Stereospermum chelonoides	2	1	-	-	-	3
Syzygium sp.	0	1	-	1	-	2
Tectona grandis	19	-	-	-	1	20
Terminalia alata	17	-	-	-	-	17
Terminalia bellerica	2	-	-	-	-	2
Terminalia chebula	2	-	-	-	-	2
Terminalia sp.	2	-	-	-	-	2
Xylosma latifolium	1	-	-	-	-	1
Unidentified sp1.	1	-	-	-	-	1
Unidentified sp. (Chuvanna chadachi*)	4	-	-	-	-	4

Unidentified (Kalkanjiram*)	9	-	-	-	1	10
Other Unidentified trees	6	-	-	-	1	7
Grand Total	131	7	1	2	6	147

* Vernacular name