Management of Elm Bark Beetle, Scolytus Kashmirensis Schedl Infesting Elm Trees (Ulmus Species) in Kashmir

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Abstract

The present investigation revealed at the shot-hole borer (Scolytus kashmirensis) infested elm trees (Ulmus wallichiana and U. villosa) in Kashmir. A total of 650 elm trees were observed in 28 nurseries from the four districts of Kashmir Valley. Out of 650 trees, 136 were found infested with shot-hole borer, S. kashmirensis attack. According to the survey results, incidence of the borer was highest in Anantnag and Shopian districts i.e., 26.11% and 22.35%, respectively followed by Ganderbal and Baramulla i.e., 17.14% and 16.87%, respectively. The overall infestation recorded in these districts was 20.92%. Both the Ulmus spp. are susceptible to infestation but vary in degree. Ulmus wallichiana was found highly susceptible and low resistant as compared to U. villosa. The aforementioned borer exploited one or the other tissues of elm plants. The borer, S. kashmirensis mine the inner bark (the phloem-cambial region) on twigs, branches or trunks of elm trees and resulted in the stunted growth of infested host tree. The S. kashmirensis is of great economic importance as it attacks the living/healthy but weakened elms, lead them to ultimate death and also feed on the dead and dying plant tissues, so plays a significant role in the host plant physiology and/or economy.

KEYWORDS: Elm Bark Beetle, Elm Trees, Kashmir.

INTRODUCTION

Elms (Ulmus spp.) are among the famous dine and shade trees of Kashmir, which, besides lending charm and healthful fragrance to the atmosphere, are a great factor of revenue to the Valley. The elm is preferred over most other tree species for the use of fodder for cattle (sheep, goat, cow, buffalo, etc.). Villagers plant elms near the house for a sustained yield of fodder, which is being dried and kept for winter usage (Heybroek, 1965). These trees are predominant in Kashmir mostly found in the forests, nurseries, along the streets, in graveyards, convents, tombs of Sufi saints and college campuses. It produces a good quality timber, with many uses (Gamble, 1922, Pearson and Brown, 1932). Being important forest trees, they yield timber for a variety of products, including, houseboats and paddles, vehicle stock, furniture, athletic equipments, boxes and crates, ploughs, oil-presses, and musical instruments etc. In Kashmir, there are two species of elm – Ulmus wallichiana Planch. (Kashmiri elm) and U. villosa. Brandis eXGamble (Cherry-bark elm) belonging to members of temperate-coniferous forests (Heybroek, 1965).

Bark beetles (Coleoptera: Scolytidae), distributed worldwide are the most destructive insects of the forest trees. They are the most economically important forest insects with more than 6000 species have been described (Lieutier et al., 2004). Adult bark beetles bore through the outer bark to the inner cambial layer, where they channel out galleries to lay eggs. Larvae hatch in these galleries and may excavate additional channels as they feed. As bark beetles carve out galleries, they introduce blue-stain

fungi. These fungi grow in the wood, interfering with the tree‟s water transport system. Tree deterioration and eventually mortality result from tree girdling caused by the gallery excavation, and spread of blue-stain fungi (Brasier and Mehrotra, 1995).
Elm trees in poor physiological conditions are often attacked by species of the genus Scolytus (Coleoptera: Scolytidae) which, although they are secondary pests, are a major cause of trees decay (Felt, 1934; Rudinsky, 1962). Dutch Elm Disease (DED) (Gibbs and Brasier, 1973), caused by the fungus Ophiostoma ulmi (Schwarz) Nannfeltd [=Ceratocystis ulmi (Buisman) C. Moreau], is one of the most destructive plant diseases to affect elm trees (Brasier, 1991). The pathogen, by direct tyloses in water conducting vessels of infected wood, has caused the death of millions of elms in Western Europe and North America (Neumann and Minko, 1985). In the last few decades, the disease has also caused serious damage in Italy (Mittempergher and Ferrini, 1980; Mittempergher, 1982; Mittempergher et al., 1985; Mittempergher et al., 1996; 1998). The current and more devastating epidemics are instead due to the Ophiostoma nova-ulmi (Brasier, 1991). The Dutch elm disease pathogen present only in the Himalayas is O. himal-ulmi (Brasier and Mehrotra, 1995).

Although the disease may be transmitted in several ways (Schwarz, 1922; Westerdijk and Buisman, 1929; Smucker, 1935), insects are the best fungal vectors (Marchel, 1927; Jacot, 1934; 1936; Collins et al., 1936). In particular, the elm bark beetles belonging to the genus Scolytus Geoffroy (Coleoptera: Scolytidae) have been demonstrated to be the most efficient vector of the fungal spores (Fransen, 1931; Gibbs, 1974; Lanier, 1978; Beyer, 1979; Sengonca and Leisse, 1984; Webber and Brasier, 1984; Neumann and Minko, 1985; Webber, 1990; Basset et al., 1992; Favaro and Battisti, 1993; Battisti et al., 1994a; Faccoli and Battisti, 1997). Losses caused by the beetles are not confined to feeding activities alone but also intensifies by disseminating disease pathogens. Their population increases rapidly when there is abundance of decadent tree, wind fall and weakened tree due to water, diseases, nutrients or salt stresses (Wood, 1982).The distribution of bark beetles is largely determined by the distribution and abundance of their host tree species and climate (Lekander et al., 1977). The older, taller elms are preferred for feeding by the bark beetles and therefore much more likely to become diseased compared with younger trees (Sengonca and Leisse, 1984).
The trees infested by the bark beetles may be recognized at a distance by fading foliage of the tree, initially a light green then changing to a light straw color in a few weeks, and eventually to yellowish-brown. Close inspection may show a fine reddish-brown boring dust in bark cervices and at the base of the tree (Webber, 1990). Elsewhere in the world, various details of scolytid beetles have been worked out but no scientific information is available on various aspects of bark beetles except few reports of their occurrence in Kashmir and northern states of India (Stebbing, 1914; Beeson, 1941 and Schedl, 1957). Ulmus wallichiana is the host of elm bark beetle, Scolytus kashmirensis Schedl (Schedl, 1957). Scolytus kashmirensis is the common shot-hole borer on elm trees in Kashmir Valley. It acts as a vector of O. himal-ulmi, the Dutch elm disease pathogen only present in the Himalayas (Brasier and Mehrotra, 1995). By destroying thousands of elm trees, these bark beetles have greatly disturbed man's economic and social life. Keeping in view the fact that no work has been done on elm bark beetle, Scolytus kashmirensis Schedl (Coleoptera: Scolytidae) and the damage caused by it to the host tree, Ulmus spp., with the following objectives, it is proposed to undertake a thorough investigation on its management, so that a way may be paved for tackling the infestation effectively.

MATERIALS AND METHODS

The study "Management of elm bark beetle, Scolytu kashmirensi Schedl infesting elm trees (Ulmus spp.)" was carried out in Kashmir Valley of Jammu and Kashmir state both in the field as well as in the laboratory during 2009-2010.

1. Study Sites

Four Districts were selected from the Kashmir Valley and in each district two cites were marked (Table 1). The marked sites were:

Table 1. Study sites on the Kashmir Valley

S. No	District	Study Site
1.	Anantnag	Uttersoo
2.	Anantnag	Danter
3.	Shopian	Zainapora
4.	Shopian	Aglud
5.	Ganderbal	Nuner
6.	Ganderbal	Wayil
7.	Baramulla	Sangri
8.	Baramulla	Watrigam

2. Incidence and Distribution of Scolytus kashmirensis: To study the incidence and distribution of Scolytus kashmirensis of Ulmus spp. in Valley, monthly survey was conducted by fixed plot method. Frass indexing method was adopted to assess the borer infestation and rate of incidence of borers was calculated by the following formula:

$$\% \text{ infested} = \frac{\text{Total number of infested trees}}{\text{Total number of observed trees}} \times 100$$

Infestation of S. kashmirensis in Ulmus populations were observed on the basis of species specific symptoms. Shape and size of bore/ tunnel, outside through which faeces tunneling pattern, niche of the grubs, nature and distance between sub tunnels-bores/tunnels arising from the main feeding tunnel which open and chewed wood is expelled out and presence or absence of frass in main feeding tunnel are species specific and serve to characterize the infested plants.

Infestation rates were recorded separately for Ulmus spp. at the marked study site and analyzed statistically.

3. Collection and Preservation:

a) Immature stages:

The borer infested logs were cut and dissected to expose the grubs of different size and instars and pupae. Exposed grubs and pupae were killed in KAAD mixture or XA mixture and preserved in 70% ethyl alcohol. Direct preservation/killing in ethyl alcohol was avoided to prevent the darkening of specimens.

The standard method, as described by Borror and Delong (1973), was followed for the preparation of the killing agents and their composition was:

KAAD mixture	Kerosene Oil	10 ml
	Ethyl alcohol (95%)	70-100 ml
	Glacial acetic acid	20 ml
	Dioxane	10 ml
XA mixture	Xylene	50 ml
	Ethyl alcohol (95%)	50 ml

Immature stages killed in either of these mixtures were stored in the respective mixtures for ½ to 4 hours, depending upon the size, before the final preservation in 70% ethyl alcohol.

b) Adults:

The elm bark beetles, S. kashmirensis were manually collected and killed in temporary killing bottles using ethyl acetate as a killing agent, because it is least toxic to human beings. The specimens were relaxed by dipping them in Barbers fluid, which is used as a relaxing agent. The preparation of relaxing fluid (Barbers fluid) was as below:

Ethyl alcohol (95%)	50 ml
Distilled water	520 ml
Ethyl acetate	20 ml
Benzene	7 ml

4. Identification:

The elm logs infested with the shot-hole borer were cut into pieces of about 12 inches in length, sealed at both ends with melted paraffin wax to avoid the moisture loss and transported to the laboratory. These logs were put in jars covered with muslin cloth to let the grubs to emerge as adults. The adults were removed from the jars and identified with the help of literature. These adults were then used for biological studies. Few infested logs were also tied with the fresh logs to ensure the availability of the material amply in the rearing boxes.

5. Photography:

a) Digital Photography: Field photography was done with Sony Cyber Shot 10 megapixel digital camera.

b) Microphotography: Morphological characters were determined using scanning electron microscopy (SEM). Specimens were first placed in buffered glutaraldehyde (2.5%) for two hours fallowed by buffer washing for overnight. In the next step specimens were kept in α-amyl acetate for 10 minutes followed by Critical Point Drying for 25 minutes using CO_2. After two days of open drying the specimens were mounted on stubs and coated with gold using the Vacuum Evaporator. Electron micrographs were taken with S-3000H Scanning Electron Microscope. (HITACHI, Japan). The photographs were then developed on Kodak high quality photo paper.

6. Management of Shot-hole borer, Scolytus kashmirensis:

Cultural and Chemical measures were evaluated for the management of the shot-hole borer.

6.1. Cultural control:

Cultural control was executed by the following methods:

i) Pruning
ii) Sanitation
iii) Removal of brood trees

Pruning:

Spring and autumn pruning were made to investigate its impact on the infestation rate of the shot-hole borer among elm plants.

Sanitation:

It involved the prompt removal and disposal of dead and dying elms to reduce bark beetle breeding sites. The barked elm wood, leaves, twigs were completely disposed off along with their harboring beetles at two sites/locations during the present study in autumn, 2009. The infestation rate was compared with the control site in the following season.

Removal of brood trees:

It involved the removal of brood trees (unrecoverable-infested trees) followed by their destruction along with harboring grubs. A small proportion of infested trees were sacrificed during the present study in spring and autumn of 2009. Brood trees were removed in two elm nurseries at two sites/locations and the infestation rate was compared with the control plot/site in the next season.

6.2. Chemical control:

The chemical control is the quick, effective and most popular method of control for the borer. Following synthetic chemicals/ insecticides were screened against the borer, S. kashmirensis.

i) Dichlorvos
ii) Endosulfan
iii) Imidacloprid
iv) Benzene hexachloride (BHC)
v) Monocrotophos
vi) Monocrotophos + Carbendazim

Three different concentrations (0.05%, 0.1% and 1%) of the above chemicals were used against the elm borer and Pearson‟s square method was adapted for dilution of chemicals.

7. Data analysis:

The observations made during the current study were tabulated and graphically presented. The data was statistically analyzed by different methods. Arithmetic mean± SE (Standard error of mean) and Chi square (X^2) test were used to analyze the data.

RESULTS AND DISCUSSION

The bark beetles are distributed worldwide occupying a wide range of niches on woody and herbaceous plants. The species of genus Scolytus (Coleoptera: Scolytidae) attack elm trees (Ulmus sp.) in poor physiological condition and are a major cause of tree‟s decay (Felt, 1934; Rudinsky, 1967). Most species of the family are polyphagous causing wide spread mortality among host tree species (Craighead, 1950). There is no information available on Scolytus kashmirensis, a serious shot-hole borer of elm trees in Kashmir. In the present study, the S. kashmirensis was registered to attack elm trees in Kashmir and the observations related to its management are discussed under different subheadings as below:

Distribution:

The present observations revealed that the bark beetle, S. kashmirensis infested elm trees in Kashmir. Geographically it is distributed in the Himalayas (Brasier and Mehrotra, 1995). It is common shot-hole borer of elm trees in Kashmir (Schedl, 1957). The other species of the same genus, Scolytus has also been reported from India, China and Japan (Grune, 1979; Maslov, 1970). The distribution of bark beetles is largely determined by the distribution and abundance of the host tree species and climate (Lekander et al., 1977). The foregoing discussion revealed that the elm bark beetle, S. kashmirensis is restricted to the temperate regions of Himalayas. The incidence of the borer was highest in Anantnag and Shopian districts of Kashmir Valley i.e., 26.11% and 22.35% respectively followed by Ganderbal and Baramulla i.e., 17.14 % and 16.87% respectively. The present study is at par with the Webber (2004) who showed that changes in temperature, humidity, elevation and season influence the bark beetle infestation and disease incidence.

Biology:

Scolytus kashmirensis became active from second week of April up to the first week of September in Kashmir and larvae underwent into overwintering phase in the first week of September. It completed two generations (2nd partial one) in a year. These results are in agreement with the two generations of Scolytus Scolytus on elm (Beaver, 1967) and also of S. mali (Rudinsky et al.) under European conditions. However, Buhroo and Lakatos (2007) determined that S. nitidus completed three generations (3rd being partial) per year on apple trees in Kashmir. While as Scolytus amygaldi had four generations annually on fruit trees in Baluchistan (Janjua and Samuel, 1941). The pattern of the mother gallery of Scolytus kashmirensis was same as reported by Novak (1976) in case of Scolytus Scolytus and Scolytus multistriatus

Host selection, oviposition and infestation rate:

Host selection in Scolytids is very critical because the larvae are legless and incapable of moving between hosts. Sex pheromones, they produce aids elm bark beetle to locate their host tree (Svihra, 1982; Blight et al., 1983). The present observation is that elm bark beetle perceived the odour of host plants. The beetle under study, chewed the scars on twigs of both the plants (host and tentative non-host plants) supplied to them in cages, but laid eggs in only one of them (host plant). It was also demonstrated that both the species of elm (Ulmus wallichiana and U. villosa) were susceptible to the borer attack, however, U. villosa showed low susceptibility and high resistance as compared to U. wallichiana. Host plant selection by olfaction inScolytids is well documented (Vite and Baader, 1990; Borden, 2006; Drumont, 2009; Mendel, 2009). Ethylene, a plant hormone, has been reported as an attractant for the Olive bark beetle, Phloeotribus scarabaeoides Bern (Rodriguez et al, 2003). Monochamous sp. is attracted by pine terpenoids, monoterpenes and ethanol (Chenier and Philogene, 1989). Fransen (1939b) showed that Scolytus sp. can have distinct feeding preferences for particular elm species and these findings have been extended more recently (Colin, 2004; Sacchetti et al., 1990; Webber, 2000; Webber and Kirby, 1983). Certain trees appear to be highly attractive and act as “sinks” for large number of beetles which alight and then feed. Such trees may have high levels of chemical feeding stimulants in the bark, and a bark texture that also encourages feeding activity (Webber, 2004). Siberian elm is highly susceptible to the elm leaf beetle, as is the Japanese zelkova (Sinclair et al, 1987). This demonstrates that beetle preferences do operate in natural system

Management of Scolytus kashmirensis

1. Cultural control:

Seasonal pruning. Pruning of trees is a cultural operation, an economical tool employed in integrated pest management of perennial plants. The pruning cut for the removal of the branch should be made approximately 10′ behind the point at which healthy wood is first observed (Lanier, 1988). Wounding trees by pruning will attract the bark beetle vectors of Dutch elm disease (Byers et al., 1980).

The findings of the current study is at par with that of the Lanier (1988) who suggested that ideally, routine pruning should be done in the dormant season or should be restricted to the periods of beetle inactivity and of Donaldson and Seybold (1998), and Sanborn (1996) who recommended that elm trees should not be pruned from March to September. Spring and autumn pruning reduced infestation rate of the elm borer by 2.33% and 63.67% respectively.

Autumn pruning prevented the elm trees from the borer infestation by destroying the harboring grounds of overwintering larvae along with the pruned branches, thus restricting the infestation in the next season.

Spring pruning could not prevent the elm plants from the borer infestation as the twigs sprouted from the spring pruned plants are the preferred oviposition sites for elm shot-hole borer. Pruning in the management of S. kashmirensis, the shot-hole borer under study is appealing for several reasons viz., reduced the borer infestation rate significantly; no environmental hazard encountered; does not interfered in the economics of silvi ecosystems.

Sanitation. This is the most important element of management program for existing elms because it removes the elm bark beetles breeding habitat from the system. It consists of the immediate removal of any dead or wounded branches, and the debarking of branches stored for use as lumber and fuel. The present study is at par with the Schreiber and Peacock (1974); Van Sickle and Sterner (1976) who suggested that the most effective control measures against the elm bark beetles to date have been based on sanitation programs consisting of prompt removal of recently dead or dying trees, as well as the speedy destruction of all elm material infested by beetles. Lanier (1988) suggested that no borer infestation and thereof Dutch elm disease management program will be successful without good sanitation. Sanitation prevented elm trees from borer infestation as it destroyed the overwintering harboring grounds of the borer. It reduced the borer infestation rate by 61.02% in I elm plot and 63.49% in II elm plot as compared to control plot. Lanier (1988) suggested that sanitation including pruning combined with fungicides gives better disease management than sanitation, pruning or fungicides alone when dealing with a residual infection. Sanitation should be viewed as a community-wide management tactic.

Control by the removal of brood trees:

The control measure reported here is based on locating and subsequent removal of heavily infested trees (brood trees) that are unrecoverable which is an attempt to work out the control strategy against the shot-hole borer under study. Brood trees after removal were dissected and the harboring grubs were exposed and killed which in turn resulted in the failure of elm borer to regain pretreatment densities, thus infestation rate automatically reduced. Removal of heavily infested trees reduced elm borer, S.kashmirensis attack by 42.41% in two treatments.

Elm trees (Ulmus sp.) stressed by unfavorable environmental conditions, disease, defoilation, age, or poor tree care are most susceptible to bark beetle attack (Hagen, 1995). Heavy infestation of Lamiine species cause widespread mortality among host tree species (Yang et al, 1995; Ertain, 2003). Donley (1981) showed that the control of red oak borer, Enaphalodes rufulus by removal of infested trees reduced 50% and 90% borer population after treatments in first and second generations respectively.

The removal of heavily infested trees which are destined to death, does not disturb the economy of the silviculture industry.

2. Chemical control:

Chemicals for elm bark beetle control, the vectors of Dutch elm disease, have been researched since the 1940‟s (Zentmeyer et al., 1946 Diamond et al., 1949). Synthetic chemical treatment have been potentially useful for suppression of infestation of elm bark beetles (Davis and Dimon, 1952; Beckman, 1959; Smalley,1962). Faccoli (2001) used Carbendazim (8%), Monocrotophos (52%), Ometoato (50%), Methomil (35%), Acephate (42%) against the elm bark beetle, Scolytus multistriatus. Nishijima (1977) showed that Carbendazim is temporary very mobile within the tree, is quickly distributed to the foliage and it is lost as the leaves drop. Palaniswamy et al (1977) used Dieldrin. Carbaryl, BHC and DDT at 0.5% concentrate of each insecticide to control the red spotted longihorn beetle in Tamil Nadu. Malik (1965, 1966) used 50% DDT and 10% BHC against the Scolytus spp. in Kashmir orchards. Pajars (1989) used pyrethoid insecticides against the Scolytus multistriatus. Sharma and Tara (1985b, 1986) recommended the injection of kerosene oil and para-dichlorobenzene mixture; petrol, naphthalene and carbolic acid mixture; benzene; ethyl acetate; petrol and kerosene oil mixture; metasystox; ethylene dibromide and nuvan against insect pests of mulberry in Jammu. Lanier (1988) suggested that pruning combined with fungicide gives better Dutch elm disease management than pruning or fungicide alone when dealing with a residual infection. Nielson (1981) pointed out the limited vulnerability of borers to insecticides. This is partially true of species such as Scolytus kashmirensis that attack elm trees in Kashmir and spend much of their life cycle in the heartwood. The vulnerability of borers is positively correlated with its concentration (Cavalcaselle, 1972; Baksha, 1990; Smith, 1996).

The present observation revealed that the efficacy of the screened insecticides at different concentrations against S. kashmirensis varied significantly among themselves. 1.00% concentrate of all the screened chemicals were effective with Dichlorvos ranking first in efficacy against the borer under study. Dichlorvos was 92.70±3.3% efficient followed by a mixture of Monocrotophos and Carbendazim, BHC and Monocrotophos which killed 86.33±3.1%, 80.33±3.1% and 78.00±2.0% grubs respectively. However, Imidacloprid was least effective followed by Endosulfan. Technically 0.05% concentrate of these chemicals was ineffective whereas 0.1% solution controlled the pest population significantly. The results showed that the injection of 5ml of 1.00% solution of Dichlorvos or a mixture of Monocrotophos and Carbendazim per live bore could be used to control the infestation rate of S. kashmirensis effectively plants are subjected to incessant onslaught of insects. Bark beetles have been reported as potential or regular pests of forests in the Kashmir and are of great silvicultural importance. Preliminary investigators reported that elm plants are prone to the attack of insect pests which affect its economic product. The study entitled "Management of elm bark beetle, Scolytus kashmirensis Schedl infesting elm trees (Ulmus spp.) in Kashmir" was carried out during 2009-10 and the findings thereof are summarized as follows:

CONCLUSIONS AND RECOMMENDATIONS

The present investigation revealed that the shot-hole borer (Scolytus kashmirensis) infested elm trees (Ulmus wallichiana and U. villosa) in Kashmir. Both the Ulmus spp. are susceptible to infestation but vary in degree. Ulmus wallichiana was found highly susceptible and low resistant as compared to U. villosa. The aforementioned borer exploited one or the other tissues of elm plants. The borer, S. kashmirensis mine the inner bark (the phloem-cambial region) on twigs, branches or trunks of elm trees and resulted in the stunted growth of infested host tree. The S. kashmirensis is of great economic importance as it attacks the living/healthy but weakened elms, lead them to ultimate death and also feed on the dead and dying plant tissues, so plays a significant role in the host plant physiology and/or economy.

Biology. The shot-hole borer, Scolytus kashmirensis overwintered in the larval phase.

The larvae were seen to be active from 10th April and after few days they changed into pupae at the end of their larval galleries. The pupation period started from 15th April and the adult emerged from 1st May. The adults were seen to infest the new logs of elm trees and deposited eggs of the first generation. The first generation extended from 5th May upto 3rd July. The second generation eggs were laid from 12th July and this was a partial generation and the larvae entered into a overwintering phase. The overwintering phase extended from 6th September to 14th April of the next year. Scolytus kashmirensis completes one full generation and second partial generations per year in Kashmir.

Management strategies. Management practices which included cultural and chemical operations reduced the infestation rate significantly. Seasonal pruning reduced infestation of S. kashmirensis significantly; Spring and Autumn pruning reduced it by 2.33% and 63.67% respectively. Sanitation reduced the borer infestation rate by 61.02% and 63.49% in two treated elm plots. Removal of the brood trees reduced S. kashmirensis infestation rate by 42.41%. None of the two species of the genus Ulmus (U. wallichiana and U. villosa) offered complete resistance to the attack of the borer under study, however, U. villosa though prone to their attack showed slight resistance as compared to
the U. wallichiana screened in the region which are more or less equally susceptible to the borer. The synthetic chemicals viz., Dichlorvos, Endosulfan, Imidacloprid, BHC, Monocrotophos, and a mixture of Monocrotophos and Carbendazim screened against the elm shot-hole borer are effective, but their efficacy is proportional to their concentration.

Eventually, the present study generated the basic knowledge covering the Management of elm bark beetle, Scolytus kashmirensis infesting elm trees in Kashmir and this effort can be used as a foundation for much deeper understanding of the beetle if we are to manage this beetle and the Dutch elm disease more effectively and see a healthy return of the mature elm to our landscape.

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