A CRITICAL REVIEW ON THE BIOLOGY AND CONTROL OF LORANTHACEAE WITH A PARTICULAR REFERENCE TO BANGLADESH

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Loranthaceae includes semiparasitic plants which are known as mistletoes. In Bangladesh mistletoes attack a large number of hosts, viz., Gamar, Teak, Sal, Mango, Jackfruit and many ornamental plants. In the country 15 species under 7 genera of Loranthaceae have been recorded and their distribution have been discussed. The important hosts of mistletoes have been listed. A critical review on the biology and control of mistletoes has been presented. Attention has been drawn to generate adequate studies for appropriate control of the parasites in our context.

INTRODUCTION

Loranthaceae includes semiparasitic plants which are commonly known as mistletoes. All over the world they cause more economic loss than any other angiospermic parasites. They mostly attack dicotyledons and gymnosperms which include horticultural plants as well as forest trees. The effects of parasites on the hosts are manifold, such as, reduction of vigour and growth rates, poor fruit and seed production, formation of burrs on the trunk or branches, reduction in foliage, drying of top, predisposition to insect and other disease attacks ultimately causing premature death. In tropical and sub-tropical forests, mistletoe infection sometimes causes heavy damages to many forest trees.

In Bangladesh Gamar (*Gmelina arborea* Roxb.) is severely attacked by *Scurrula parasitica* Linn, in the forests of Chittagong and Chittagong Hill Tracts. Gamar plantations of 15 years or older are seriously damaged and consequently raising of pure plantation of Gamar in Bangladesh has been abandoned (Anon. 1974). Many other important forest trees like Sal (*Shorea robusta* Gaertn. f.), Teak (*Tectona grandis* Linn.), etc. and several important fruit trees like Mango (*Mangifera indica* Linn.), Jack fruit (*Artocarpus heterophyllus* Lamk.) are also attacked by misletoes.

Mistletoes are of two types : dwarf mistletoes (members of sub-family Viscoideae) and broad leaved mistletoes

(members of sub-family Loranthoideae). There are a number of publications on the biology, ecology, control measure and various other aspects of the American dwarf mistletoes *Arceuthobium*. Literature on the tropical broad leaved mistletoes is rather scattered. Only the tropical species *Dendrophthoe falcata* (Linn. f.) Etting to some extent has been studied in detail (Singh 1962, Johri and Bhatnagar 1972).

No studies on the biology or control of mistletoes in Bangladesh have yet been done. Recently the taxonomy of the family from Bangladesh has been prepared (Alam 1983).

Considering the heavy damage caused by the members of the family to many important forest and horticultural trees, a critical review on the biology and control of the group has been discussed in this paper with a view to facilitating further studies for appropriate control of the parasite. Members of Loranthaceae recorded from Bangladesh and their distribution have been given.

The following is a list of the species with synonyms of Loranthaceae recorded from Bangladesh :

Genera	Species	Synonyms
Dendrophthoe	1. *D. falcata* (Linn. f.) Etting.	*Loranthus longiflorus* Desr.
	2. *D. pentandra* (Linn.) Miq.	*L. pentandrus* Linn.
Helixanthera	3. *H. cylindrica* (Jack.ex Roxb.) Dans.	*L. heteranthus* DC.
	4. *H. ligustrina* (Wall. ex Roxb.)Dans	*L. ligustrinus* Wall. ex. Roxb.
	5. *H. parasitica* Lour.	*L. pentapetalous* Roxb.
Macrosolen	6. *M. cochinchinensis* (Lour.) Van Teigh.	*L. ampullaceus* Roxb. *L. globosus* Roxb.
Scurrula	7. *S. gracilifolia* (Roxb. ex Schult.) Dans.	*L. scurrula* Linn. Var. *graciliforus* Kurz
	8. *S. parasitica* Linn.	*L. scurrula* Linn.
	9. *S. pulverulenta* (Wall. ex. Roxb.) G. Don.	*L. pulverulentus* Wall. ex Roxb.
Taxillus	10. *T. thelocarpa* (Hook. f.) Alam.	*L. thelocarpus* Hook. f.
	11. *T. umbellifer* (Schult.) Dans.	*L. umbellifer* Schult.
Tolypanthus	12. *T. involucratus* (Roxb.) *Van Tiegh*	*L. involucratus* Roxb.
Viscum	13. *V. articulatum* Burm.	
	14. *V. monoicum* Roxb. ex DC.	
	15. *V. orientale* Willd.	

DISTRIBUTION

Members of Loranthaceae are mostly tropical. They occur in the whole of Southern Hemisphere, and in southern parts of the Northern Hemisphere of the globe.

Out of 15 species occurring in Bangladesh the most common species are *D. falcata, M. cochinchinensis, S. parasitica, S. gracilifolia* and *V. monoicum*. These are widely distributed in all the districts of Bangladesh. *S. pulverulenta* is distributed in northern districts mainly Rajshahi and Dinajpur, *T. thelocarpa* in Chittagong and *T. umbellifer* in Sylhet. Species of *Helixanthera* are distributed in the forests of Sylhet and Chittagong.

Occurrence of mistletoes are prevalent in the forests of Sylhet and Chittagong. *D. falcata* and *V. monoicum* are two common species of the Sunderban forests.

There is hardly any tree or shrub which is immune to the attack of mistletoes (Johri and Bhatnagar 1972). Records about the hosts of the members of Loranthaceae are found in many literature among which the worth mentioning are Brandis (1906), Fischer (1907, 1926), Rao (1923) Kanjilal *et. al* (1940), Sinclair (1955), Singh (1962), Gill and Hawksworth (1961), Singh and Basu Choudhury (1972), Greenham and Hawksworth (1964), Johri and Bhatnagar (1972).

The following is a list of important hosts and their parasites in Bangladesh :

Gamar (*Gmelina arborea*)
- *D. falcata*
- *S. gracilifolia*
- *S. parasitica*

Teak (*Tectona grandis*)
- *D. falcata*
- *M. cochinchinensis*
- *S. pulverulenta*

Sal (*Shorea robusta*)
- *D. falcata*
- *H. parasitica*
- *M. cochinchinensis*
- *S. pulverulenta*

Mango (*Mangifera indica*)
- *D. falcata*
- *D. pentandra*
- *H. ligustrina*
- *M. cochinchinensis*
- *S. pulverulenta*
- *V. monoicum*
- *V. orientale*

Jack fruit (*Artocarpus heteorophyllus*)
- *D. falcata*
- *M. cochinchinensis*
- *V. monoicum*

Kul, Boroi (*Ziziphus mauritiana* Lam.)
- *D. falcata*
- *M. cochinchinensis*
- *V. articulatum*
- *V. monoicum*

Tea (*Camellia sinensis* O. Ktze.)
- *M. cochinchinensis*

BIOLOGY OF THE MISTLETOES

Members of the family are semiparasitic, typically stem parasites. As their leaves contain chlorophyll, they are able to manufacture carbohydrates but for water, mineral salts and other soluble materials, they are dependent on the host plants (King 1966). Lamont and Southall (1982) stated

that concentration of Cu, Zn, Mg and K are higher in the mistletoe *Amyema preissii* than in the host. The concentration of Ca and N shows no variation while the concentration of Fe is consistently higher in the host than in the parasite. They confirmed that mistletoes extract significant amount of minerals from the host. But Nicoloff (1923) stated that the parasites contain 2 to 6 times the amount of nitrogen present in the host plant. Trees infected by *D. falcata* contain more starch and less ethanol-soluble carbohydrate than the healthy trees. The parasites contribute 25 – 30% of its carbon needs through photosynthetic fixation of CO_2, the balance being presumably derived from the host (Misra 1970).

Schaffer *et al* (1983) stated that stubstance like cytokinin might be related to the formation of witchers broom caused by dwarf mistletoes (*Arceuthobium* Spp.).

The mistletoe flowers are either hermaphrodite or unisexual (monoecious or dioecious). The general belief is that the pollination in the group is accomplished by birds. In the showy flowered Loranthoideae,birds, particularly the sunbirds (Necteriniidae) and the mistletoe birds or flower peckers (Dicaeidae) are undoubtedly the principal pollinating agents (Ali 1932). Ali (1931) states that the life history of *L. longiflorus* (*D. falcata*) "—is so inextricably linked up with the existence of sunbirds and flower peckers that it would soon die out altogether without the intervention of the birds." The structure of the mature flower bud is such that they do not open and wither unless some external pressure is applied to them. This is done by the bills of the birds that visit the flowers for necters. While doing so anthers burst against their forehead and are carried to another flower. Sands (1924) observed that honey suckers visited *Loranthus* flowers early in the morning. Singh (1962) reported that in western India (Konkan), the sun-birds (*Leptocoma lotenia, L. asiatica* and *L. zeylanica*) are mainly responsible for fertilizing the *Dendrophthoe* flowers. The fact that birds are indispensable for fertilization was confirmed by Ali who covered a bunch of buds with wire gauge which were later found to wither without setting any fruit (Singh 1962). Loranthoideae have bird pollinated flowers and Viscoideae have insect pollinated flowers (Van Leeuwen 1954). The floral morphology of small flowered dioecious Loranthoideae and Viscoideae favour entomophily (Gill and Hawksworth 1961). Although birds play an important role in pollination, selfing is a rule, otherwise there would have been more evidence of hybridization among many Australian species which come to flower at the same time (Johri and Bhatnagar 1972). The time of pollination varies with the species without particular reference to climatic range (Gill and Hawksworth 1961).

There is no detailed study on fertilization. Johri and Bhatnagar (1972) state that the pollen grain germinate on the stigma and the pollen tube emerges from one of the three germ pores and traverses intercellularly through the stylar tissue and comes to lie at the tip of the embryo sac. The pollen tube may be swollen, and occasionally shows a tendency towards branching.

The seeds of mistletoes are surrounded by a persistent and very adhesive pulp,

the viscin layer. The viscin surrounding the seeds plays an important role in attaching the seeds to some object. It also absorbs water from rain, mist or dew and thus prevents the seed from perishing (Sands 1924). Also it provides water during germination (Johri and Bhatnagar 1972). Studies with dwarf mistletoes (*Arceuthobium* Spp.) revealed that viability of freshly collected seeds was inconsistently high which decreased with the storage (Schrapf 1970).

Birds play an important part in dissemination of seeds in mistletoes. The berries are eaten by certain birds and are disseminated by them. When the birds eat the fruit, the adhesive pulp sticks to their feet and beak. The seeds are thus carried away and lodged in the twigs and branches of the trees (King 1966, Gill and Hawksworth 1961, Johri and Bhatnagar 1972, Zilka and Tinnin, 1976). The seeds are also spread in the excrement of birds. When ripe, the berries may fall to lower branches and germinate under favourable conditions (King 1966).

Germination takes place under favourable condition. The radicle growing to the cortex of the host tree, enlarges and forms an attachment disc, the hold fast. A peculiar root-like structure, the haustorium, develops from the undersurface of this disc and grows from the cortex to the cambium of the host. The penetration is usually effected through some weak areas like lenticels or cracks. From there, further root-like outgrowths, known as sinkers, penetrate into the water carrying tissue (xylem) of the host during the first year, and it is not until the second year, the first pair of green leaves develop from the bud on the attachment disc (Weber 1938).

Singh (1962) states that the haustorium is morphologically a stem. He confirmed his statement by culturing of the embryosae of *D. falcata*. The seeds of several Loranthaceae do not require any special stimulant from the substrate, and germinate on any living or dead object. Germination occurs under suitable conditions of moisture and temperature and light is absolutely necessary for germination. Culture studies had confirmed this fact for *D. falcata* (Johri and Bajaj 1963). Rate of germination in darkness is less. It is generally agreed that both chemical and mechanical forces take part in the process of penetration of the haustoria. The host tissue reacts to the entry of the haustorium by swelling and forming a "burr" (Johri and Bhatnagar 1972).

The species of *Phoradendron* (an American genus) develop on the host tree into globose masses of considerable size (30–60 cm across) on the host tree. They live, on average, for about 10 years, usually being killed because of excessive shade or mechanical breakage. Some species have frequently been reported to attain an age of 20 years (Weber 1938). In Bangladesh species of *Dendrophthoe* take the shape of both erect and hanging bush upto 2 m long. *M. cochinchinensis* develops runner like roots and finally becoming bushy and sometimes becoming hanging. The species of *Viscum* become pendant, *Scrurrula* species attain the shape of considerable bush of 30–50 cm across having runner like roots at early age. When mature, point of attachment to the host become swollen. In Gamar, the parasites sometimes occupy the whole crown of the host tree. In Bangladesh, the longevity of the parasites has not been estimated. But it has been

noticed that they can thrive for a considerable period, sometimes 10 years or more.

Hyperparasitism : Some members of Loranthaceae attack the other members of the family. Many examples of hyperparasitism have been cited (Singh 1962, Pundir 1979). In our country *V. articulatum* attacks *D. falcata*. It has been noted that *M. cochinchinensis* is parasitic on *D. falcata*. Cases of cannibalism are also reported in *D. falcata* (Singh 1962) and in *S. pulverulenta* (Pundir and Adhin 1982.) Cannibalism has been seen in *M. cochinchinensis* in our country..

Host relationship : Works on host relationship of broad leaved mistletoes are very scanty. Dwarf mistletoe parasitism is a dynamic process, and some variation is to be expected. Hawksworth and Wines (1972) expressed that the length of time required for the parasite to kill a tree varies considerably and depends on many factors : the species of host and mistletoe involved ; the amount of infection in a tree ; the vigour of the tree ; the ecological and climatic situation under which the tree is growing ; and activity of secondary pests particularly bark beetles which attack and kill the infected trees.

CONTROL MEASURES

Control of mistletoes has been advocated and frequently practised throughout the world where the parasites damage trees or shrubs of economic value. Gill and Hawksworth (1961) pointed out that the direct control measures include two methods : (i) Physical removal of infected trees or their parts by pruning, poisoning or burning. This was also pointed out by Koppikar (1948), Mathur (1949) and Sarma (1952) (ii) Use of chemicals which kill the endophytic system without causing any damage to the host. King (1966) stated that in case of physical removal it is desirable to remove the mistletoe from the infected trees. The infected branches may be cut out. The removal should be made at least 50 cm below the point of attachment of the mistletoe to the host to ensure the removal of the penetrating endophytic system that extend up and down the branch. Spread and intensification of dwarf mistletoes (*Arceuthobium* sp.) is accomplished primarily by explosive fruits rather than by animal vectors. So, once the parasite is eradicated or materially removed in an area, there remains practically no chance for reinfection from outside (Gill and Hawksworth 1961). Amputation of infected branch should be done before the mistletoes fruit and in a manner to avoid the spread of the disease (Greenham and Hawksworth 1964). Gill and Hawksworth (1961) added that an inadvertent introduction of mistletoes could also be checked with the help of quarantine measures. The control of either of vectors or pollinators has been suggested but never practised (Ali 1931). Singh (1962) stated that such a step would result in disturbing the biology of the forest.

In addition to pruning, complete removal of seriously affected trees have been recommended as silvicultural practice. Removal of infected Teak trees has been recommended by Koppikar (1948). Homfray (1936) stated that regular heavy thinning keeping only large and vigorous crowns is very effective in reducing the severity of the attacks of mistletoes on Gamar. He recommended the thinning of heavy "D"

grade. Annual thinnings between 3 and 10 years and thinning at intervals of 5 years between 10 and 20 years of age have been recommended. Selective and clear cutting operations are also recommended as part of logging practices of the species affected by dwarf mistletoes. But it has been observed that a single Gamar tree in an open space has been heavily infested. Hawksworth *et al* (1977) stated that strict sanitation of infected trees of *Pinus controta* Dougl. ex Loud by 3.05 m x 3.05 m thinning reduced the infestation.

Isolation strips have been recommended in some instances. Those should be 0.4 km wide for control of leafy mistletoes on *T. grandis* in the West Indies. Strips of 18.24 m wide have been recommended for the control of dwarf mistletoes on conifers in U. S. A. (Greenham and Hawksworth 1964).

Chemical control is becoming more feasible as herbicides are more selective. In India Kadambi (1954) reported that *Scurrula pulverulenta* on *Dalbergia sissoo* Roxb. was eliminated when $CuSo_4$ and feronoxone were injected into the host. Singh (1955) pointed out that sprays of chemicals, viz., ammonium sulphate, ammonium thiocyanate, copper sulphate, potassium dichromate and sodium dinitro-orthocresylate did not affect the parasite (*D. falcata*) appreciably but their effect on hosts were variable. He further stated that sprays of 2,4–D, sodium salt of 2,4–D, feronoxone, and potassium salt of 2,4–T affect the parasite in most cases, but their reaction on different hosts is variable. Lemon, Mango and Guava were seriously affected. Similar results were obtained by Seth (1958) who stated that spraying with ammonium sulphate, $K_2Cr_2O_7$, 2,4–D (Sodium salt), 2,4,5–T (Potassium-salt) were either ineffective or caused damage to the host. George (1966) reported that sprays with 1 : 1 dimethyl 4 : 4–bipyridylium showed effective control of mistletoe on Teak. The critical time of spray was reported to be the early summer when the Teak tree is devoid of its foliage. No residual toxicity of the chemical was observed. Gill and Hawksworth (1961) mentioned that MCPB (4–chloro-2 methylphenoxbutyric acid) had given promising results on the hosts (*Eucalyptus* Spp.) subject to injury from 2,4–D. Recently Delabraze and Lanier (1972) published results on chemical control of *V. album* var *abietis* on Silver Fir. Foliar sprays of 2,4–D (amine), 2,4–MCBP (Na salt). 2,4,5–T (ester) and injection or putting of MCBP, 2, 4, 5–T (ethrel) or $CuSO_4$ in cuts made at the base of infested branches showed effective results. Among the chemicals used, MCBP was mentioned as the most effective but with some phytotoxicity and $CuSO_4$ was the least effective. Ghosh and Balasundaran (1980) in India have demonstrated an injection technique using water soluble rhodamine B dye to check the parasite *D. falcata* on Teak.

Chemical methods for the control of mistletoes have been satisfactorily practised in Australia. Sprays and injectons of various chemicals, particularly formulations of 2, 4–D, have successfully killed *Amyema* Spp. and related genera on *Eucalyptus* (Gill and Hawksworth 1961). Greenham and Brown (1957) summarised the following conclusions :

(i) Injections of triethanolamine salt of 2, 4–D resulted in the

extermination of 70 to 100% mistletoes particularly of *Amyema pendula*, on several species of *Eucalyptus*. There was partial defoliation and nearly 5%of the hosts perished.

(ii) A second spraying was recommended to kill the odd mistletoes surviving after the first treatment.

Singh (1962) recommended the sprays of refined diesel oil (powerine) emulsion (prepared by dissolving 15–20 g of ordinary washing soap in about 500 ml of boiling water, adding tap water to make up one gallon followed by addition of desired concentration of oil, mixture churned briskly until powerine emulsifies producing a milky fluid) to control *D. falcata*. During summer, on sunny days, 40% powerine emulsion sprays killed the parasite on many hosts. However, in winter, the concentration needed to be raised to 50%. This spray has the advantage that it has very little or no effect on the hosts. The concentration of powerine emulsion spray is inversely proportional to the temperature in respect of its effectiveness.

A certain amount of natural control exists in some areas where particular insects and fungi lessen the infestation of the mistletoes (Greenham & Hawksworth 1964). Hawksworth (1971) gave a brief account of the insects and fungi as biological control agents for dwarf mistletoes (*Arceuthobium* Spp.). Mistletoe canker caused by different species of *Nectria* seemed to reduce the mistletoe incidence (Funk *et al* 1973, Smith and Funk 1980). Mark *et al* (1976) stated that resin disease of mistletoe (*Arceuthobium americanum* Nutt. ex Engel) caused by *Aureobasidium pullalans* and *Alternaria alternata* is promising to control dwarf mistletoe without causing any damage to the host.

There is no report from Bangladesh about the association of fungi in the control of mistletoes. Baloch and Ghani (1980) have reviewed the potentiality of biological control of angiospermic parasite by fungi and insects in Pakistan.

Brief notes on the insect attack on dwarf mistletoes have been given by Gill and Hawksworth (1961) and Hawksworth (1971). Several species of butterflies including *Delias* and *Ogyris* (Lepidoptera) are destructive to shoots and leaves of Loranthoideae and Viscoideae in India (Mathur and Singh 1959, Mathur and Singh 1960, Gill and Hawksworth 1961). Graves and Graves (1980) noted that the larvae of *Citheronia regalis* (Lepidoptera) feed on the leaves of *Phoradendron flavescens* (Pursh) Nutt. and they pointed that it might be of some importance in biological control. In Bangladesh it has been noticed that the shoots of *M. cochinchinensis* are infected by some insects and leaves become curled. It has also been noted that the larvae of some insects feed on the leaves of *S. gracilifolia* on Gamar without causing any damage to the leaves of the host. Hyperparasities might have some effect as a means of biological control. Nath and Indira (1975) reported *Cuscuta reflexa* Roxb. as a rival of *D. falcata*. Ghosh *et al* (1984) stated that *viscum capitellatum*, a hyperparasite, could be a potential biological agent to control *D. falcata* on Teak.

Gill and Hawksworth (1961) mentioned that attempts to grow the mistletoes *in vitro* should be encouraged. This could provide detailed information on their physiology

which, in turn, should aid in solving practical problems in the control of mistletoes. Johri and Bhatnagar (1972) conducted *in vitro* studies and confirmed that the seeds of mistletoes can germinate in absence of any living object and the differentiation of haustoria is not dependent on contact with the living host. Chemical control of organ formation in *D. falcata* has been achieved. They expressed that if the chemical that inhibit the differentiation of haustoria in a number of mis letoes are identified, its application will help in preventing the spread of these parasites.

To overcome the mistletoe problem in Bangladesh, the biology, breeding system and physiology of the group should be studied in details. It is, therefore, desirable that a multidisciplinary study of the mistletoe of Bangladesh along with their control measures should be taken up.

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