Review Article

Dwarf mistletoe (*Arceuthobium oxycedri*) and damage caused by dwarf mistletoe to family Cupressaceae

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Abstract

Mistletoe is an angiospermic plant famous for its shoot hemi-parasitizes activity of higher plant species. It parasitize thousands of vascular plant species and depend almost entirely on their tree hosts for water and nutrients. Their damaging effects are growth reduction, branch distortions, and decreased longevity. All mistletoes take water and nutrients by tapping the host xylem but differ in their dependence on the host for carbon. Dwarf mistletoes (*Arceuthobium* spp.) are considered to be mainly heterotrophic, tapping the host phloem for carbon compounds. It is an obligate parasite with an endophytic 'root' system that infects trees and shrubs of the family Cupressaceae. The aim of this review is to cover the basic concepts of dwarf mistletoes and its host range for family Cupressaceae.

Key words: Angiospermic parasite; Cupressaceae; dwarf mistletoe

Mistletoes

Parasitic plants are common in many natural and seminatural ecosystems from tropical rain forests to the high Arctic [1]. It has been estimated that 1% of all angiosperm species are parasitic [2,3] and about 40% of plant parasites are shoot parasites, parasitizing the above ground parts of their host plants, while the other 60% are root parasites [4]. Angiosperm parasites are confined to dicot subclasses Magnoliidae, Rosidae and Asteridae and represents approximately 22 families, 265 genera and 4000 species [5].

Mistletoes are angiosperm shoot hemiparasites of higher plant species [2, 6] parasitize thousands of vascular plant species and depend almost entirely on their tree hosts for water and nutrients [7]. They are considered to be pathogens of trees because of their damaging effects, particularly growth reduction, branch distortions, and decreased longevity [8]. All mistletoes take water and nutrients by tapping the host xylem but differ in their dependence on the host for carbon [9]. These plants have also complex associations with animals that pollinate their flowers and disperse their seeds [2, 10].

Mistletoes as polyphyletic group parasites includes species in the Loranthaceae, Viscaceae, Eremolepidaceae, Misodendraceae and Santalaceae [11, 12]. Among these families two major families, are Loranthaceae and Viscaceae. The Loranthaceae is the largest family within the mistletoes with 950 species [13] while the Viscaceae contains 365 species [12].

Dwarf Mistletoes

Dwarf mistletoes (*Arceuthobium* spp.) are one the important genus of the Viscaceae. They are considered to be mainly heterotrophic, tapping the host phloem for carbon compounds [14, 15] other mistletoes are usually considered as autotrophic, depending on their host for water and inorganic nutrients only [12]. The chromosomes number of all species of *Arceuthobium* examined are $n=14$ [16]. No natural hybridization or polyploidy is present in the genus. The absence of hybridization and polyploidy has apparently resulted in relatively clear, dendritic lines of evolution and well-defined species [17].

Dwarf mistletoes can attack on all ages and sizes of trees. Mostly the larger trees are usually infested, while lesser proportions of the younger trees are infested [18]. Dwarf mistletoes spread by way of pressure-released seeds, with spread occurring both from tree to tree and within the crowns of individual trees [19]. Plants tend to build up initially in the lower portion of the crown and gradually spread upward. Tree growth and vigor usually decline only when more than half the crown is parasitized. Most infected trees can survive for several decades; generally the smaller trees decline and die more quickly than the larger ones [20]. Infection centers tend to expand at a rate of 1 to 2 feet per year [21].

Description of Dwarf mistletoes

Dwarf mistletoes are herbs or shrubs from 0.5 cm to approximately 70 cm high

parasitic on Pinaceae and Cupressaceae. Plants glabrous, variously colored from greenish yellow to orange, reddish or black, dioecious. Stems with variant (anomalous) patterns of secondary growth. Branches dichotomous or verticillate, stem internodes terete. Leaves reduced to scales, decussate, in 4 ranks, connate. Flowers axillary or terminal on branchlets, decussate or whorled, peduncle absent, pedicel short to nearly absent. Male flower subglobose or ovoid in mature bud, perianth lobes 3 or 4, $\pm$ rotate. Anthers sessile, inserted on perianth lobes, circular, 1-loculed, dehiscence transverse, central nectary present. Pollen grains subprolate, 3-lobed to circular in polar section. Female flower ovoid to ellipsoid in mature bud, epigynous; perianth tube short, 2-lobed, adnate to ovary, persistent. Placentation free, central. Style short; stigma obtuse. Berry ovoid or ellipsoid, apex different in texture from base, exocarp smooth, explosively dehiscent at maturity. Seeds without true integuments, usually 3 to 5 mm long, ovate-lanceolate, containing one (rarely two) distal, cylindrical embryo, with copious endosperm [17].

Dwarf mistletoe life cycle

The dwarf mistletoe life cycle (Fig. 1) begins with the seed. Fruit normally contains a single seed with one embryo, but fruits may rarely contain two seeds or a single seed with two embryos [22]. Dwarf mistletoes possess one of the most effective hydrostatically controlled, explosive mechanisms of seed dispersal known in flowering plants [23, 24]. Local dispersal occurs when seeds are shot from mistletoe plants at velocities as high as 100 kph. Seed dispersal range is usually 6 to 11 m, but some seeds may travel as far as 15 m. Long distance dispersal occurs through birds or rodents to initiate new infection centers.

Seeds have a viscous coating (viscin) that easily adheres to any object they strike,

especially conifer needles [25, 26]. Intercepted seeds usually remain on the needles until the first fall rain wets the hygroscopic viscin. Gravity then pulls the well-lubricated seed to the base of an upright needle. As the viscin dries, the seed is cemented to the shoot surface. Seeds intercepted by downward-pointing needles generally fall to lower branches or to the ground [27]. To achieve infection, seeds must lodge on shoot segments usually less than 5 years old, only this portion of the host can be considered a "safe-site," i.e., a place where a seed can germinate and establish an infection. Seeds are not deposited at safe-sites, and a high proportion of those that do arrive at safe-sites are lost to disease, predation, or removal by rain. Seed interception rates, however, are highly variable and depend on stand structure and composition, position of the dwarf mistletoe on the host, and needle characteristics of the host tree [28].

The first visible symptom of dwarf mistletoe is swelling of host tissue at the site of infection. The radicle produced by the seed grows until it reaches a suitable bark crevice, bud, or needle base. A holdfast forms that completes the infection process by wedging into the host tissues and producing an extensive haustorial absorptive system. These "sinkers" penetrate the xylem of the host and are sub-sequently embedded by additional growth of xylem tracheids to which they are connected [29]. The expanding network of sinkers eventually breaks through the surface to form new aerial shoots, buds, flowers, and seeds. Aerial shoots typically range in height from 2 to 10 cm, and the branching pattern may be whorled or fanlike. Aerial shoots do not emerge until the second or third year. Shoots emerges about two years after infection. Within another two to three years, the plants flower and fruits develop [15].

All mistletoes are dioecious, and female plants have flowers that produce seed while male plants have small inconspicuous flowers that produce pollen. Aerial shoots are only a few inches long. Several clumps may appear on one branch, and witches' broom and dieback may develop in older infections [30]. Male flowers have three or four "petals" that open to expose the pollen sacs, but female flowers are inconspicuous and remain closed. Most flowers are pollinated by insects. Fourteen to 18 months after pollination, the fruit, or fleshy berry, matures, with each berry containing a single seed. From infection to seed production takes 4 to 5 years. Spread is from tree to tree, and infection centers in young stands typically develop around larger and older infected residual trees [15].

Arceuthobium oxycedri

Genus *Arceuthobium* have 42 recognized species [31]. Among these species *Arceuthobium oxycedri* is an obligate parasite with an endophytic 'root' system. *Arceuthobium oxycedri* infects trees and shrubs of the family Cupressaceae and distinguished from other species primarily by its deep green colour, higher frequency of whorled branching. elongated internodes (especially in staminate plants) which are of approximately equal width from the base to near the apex. The younger portions of plants including the fruit are glaucous in live plants, but glaucousness tends to disappear on drying.

Shoots mostly 5-10 cm high, but can grow up to 20 cm high, green, verticillate branching common basal shoots 1-4 mm across. Third internode 5-9mm long. shoots terete, internodes markedly wider at the top than at the base. Staminate flowers 1.5-2.5 mm, perianth mostly 3- merous occasionally 4-merous rarely 2-merous [15]. pollen polar diameter 17-19µm, equatorial diameter 19-

Fig.1. Generalized Life Cycle of Dwarf Mistletoe. This illustration show a complete life cycle of a Dwarf Mistletoe on host plant.

22um. The mature fruit is about 3.0 mm long and 1.5 - 2.0 mm wide.

Cupressaceae as host of *Arceuthobium oxycedri*

Arceuthobium oxycedri infects trees and shrubs of the family Cupressaceae. 17 *Juniperus* taxa two taxa of *Chamaecyparis*, five *Cupressus*, one *Thuja* and one *Platyclusus* are known hosts of *A. oxycedri*.

Damage cause by *Arceuthobium oxycedri*

There are many reports about the occurrence of *A. oxycedri* throughout the world but only few reports of damage or impacts caused by this parasite are available [32]. Those few reports indicate that dwarf mistletoe (*A. oxycedri*) can cause potentially serious damage to host plants throughout its range.

Table 1: Hosts and distribution of *Arceuthobium oxycedri*

S.No	Name	Country of report with reference
<i>Juniperus</i>		
<u>1</u>	<i>J. communis</i> (Common juniper)	Portugal [15], Spain [32], France [33], Italy [34], Slovenia [35] Croatia [36], Bulgaria [15]
<u>2</u>	<i>J. convallium</i>	China (Tibet) [37]
<u>3</u>	<i>J. drupacea</i> (Syrian juniper)	Greece [36], Ukraine [38], Turkey[15], Lebanon [39]
<u>4</u>	<i>J. excels</i> (Grecian juniper)	Ukraine [40], Turkey [15], Pakistan [41], India [42]
<u>5</u>	<i>J. polycarpus</i>	Azerbaijan [43], Ukraine [40], Uzbekistan [44],Tajikistan [45] India [42]
<u>6</u>	<i>J. foetidissima</i> (Stinking juniper)	Ukraine [38],Turkey [15]
<u>7</u>	<i>J. oblonga</i>	Azerbaijan [46]
<u>8</u>	<i>J. oxycedrus</i> (Prickly juniper)	Morocco [47], Algeria [48], Spain [49], France [50], Italy [34] Croatia [15], Bulgaria [51], Lebanon [39], Iraq [52], Turke [15], Syria [39], Ukraine [40], Greece [15]
<u>9</u>	<i>J. phoenicea</i> (Phoenician juniper)	Morocco [47], Spain [49], France [33]
<u>10</u>	<i>J. pseudosabina</i> (Xinjiang juniper)	Tajikistan [45]
<u>11</u>	<i>J. Sabina</i> (Savin Juniper)	Spain [49], Ukraine [40], , Iran [53], Croatia [50]
	<i>J. semiglobosa</i> (Russian juniper)	Ukraine [54], Uzbekistan [44], Tajikistan [45]
<u>13</u>	<i>J. squamata</i>	China [55]
<u>14</u>	<i>J. tibetica</i> (Tibet juniper)	China [55]
<u>15</u>	<i>J. thurifera</i> (Spanish juniper)	Spain [54], Ukraine [40]
<u>16</u>	<i>J. virginiana</i> (Eastern red-cedar)	Ukraine [40]
<u>17</u>	<i>17. J. wallichiana</i> (Wallich juniper)	China [55]
<i>Chamaecyparis</i>		
<u>18</u>	<i>Chamaecyparis funebris</i> (Chinese weeping cypress)	Ukraine [38]
<u>19</u>	<i>Chamaecyparis thyoides</i> (Atlantic white-cedar)	Central Europe [55], germany [56], Croatia [35]
<i>Cupressus</i>		
<u>20</u>	<i>Cupressus arizonica</i> (Arizona cypress)	Spain [54] Ukraine [40]

<u>21</u>	<i>Cupressus lusitanica</i>	Ukraine [40]
<u>22</u>	<i>Cupressus benthamii</i>	Ukraine [40]
<u>23</u>	<i>Cupressus macnabiana</i> (MacNab cypress)	Ukraine [40]
<u>24</u>	<i>Cupressus macrocarpa</i> (Monterey cypress)	Ukraine [40]
Thuja		
<u>25</u>	<i>Thuja orientalis</i> (Northern Whitecedar)	Ukraine [40] Spain [54]
Platycladus		
<u>26</u>	<i>Platycladus orientalis</i> (Oriental arbor-vitae)	Central Europe [56] Ukraine [40]

Lararev and Grigorov [38], repotted *A. oxycedri* on the Crimean Peninsula of the Ukraine especially along the Peninsula's southern shore in 1908. They indicated an infection rate of 10-20% at elevations of 500-600 m and in a single 0.25 ha study plot 238 of 262 trees (90.8%) were infected and 135 (51.5%) of the trees had been killed.

An early report by Brandis, [59] indicates that *A. oxycedri* kills *Juniperus excelsa* at elevations of 9000-11000 ft (ca 2700-3350 m) in the Upper Chenab River Basin of northern Himachal Pradesh, India. Further Bhattacharyya and Uniyal, [42] reported that Heavily infected trees die after a few years. Rios-Insua, [32] repotted *A. oxycedri* in natural forests of *Juniperus* near Madrid in central Spain and tested applications of the herbicides 2-4D and 2-4-5T applied to infected portions of trees and found no adverse effects of the herbicides on the host trees.

According to Fataliev, [46] report *A. oxycedri*, caused decreased growth of affected trees, deformity and high levels of mortality in Azerbaijan.

Mo-Mei Chen [37] reported *A. oxycedri* in southwestern China, Xizang Province (Tibet) and near the Bhutan border, 30 km southwest of Lhozhag (Luozha), where 34% of 126 trees were infected.

Ciesla et al., [60] reported *A. oxycedri* in Ziarat Juniper (*Juniperus excelsa*) forest in Balochistan Province of Pakistan. They indicated that *A. oxycedri* surrounded

approximately 3,500 ha, or about 4% of the total forest area. In the infested portions of the Chasnak Valley, an estimated 31.76% of the host trees are infected with a mean area dwarf mistletoe rating (DMR) of 1.53 and an estimated 2.03% annual mortality rate. In the Sasnamana Valley 22% of the trees are infested with a mean area DMR of 0.52.

Sarangzai et al., [41] also reported *A. oxycedri* damage to Ziarat Juniper in Salam valley, Ziarat valley and Salik Sakhobi. They estimated that in Salam valley, 15 plots (119 trees) of the 25 sample plots were infected with dwarf mistletoe (33.6%), having an area mean Dwarf Mistletoe Rating (DMR) of 0.63. In Ziarat Valley, 10 plots (77 trees) of the 15 sample plots were infected (23.2%), with a mean DMR of 0.46. In Salik Sakhobi, 6 plots (82 trees) out of 10 sample plots were infected (18.2%), with a mean area DMR of 0.73.

Gajsek et al., [58] reported *A. oxycedri* damage in Slovenia. According to them *A. oxycedri* was present on six of 11 inventoried plots; most infected plots were located in the wider area of the Dragonja Valley. Of all examined *J. oxycedrus* specimens, 76.56% were infected.

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