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Chapter 2

Psittacanthus in Mexico

The *Psittacanthus*, parrot-flower, is the only genus of the family Loranthaceae that is significant to conifer forestry in North America. These mistletoes do not occur in Canada or the United States; and in Mexico, they are only important in central and southern portions. *Psittacanthus* also occurs in Central America (rarely on conifers) and other regions of the tropical New World where these mistletoes achieve their greatest diversity and abundance on numerous hardwoods. Plants are showy (fig. 2-1), become quite large, and are locally abundant. They are damaging to conifers, but they also provide special resource values. Because there are few studies for *Psittacanthus* on conifers (for example, Vázquez 1993a) and the taxonomy is confused, information on these mistletoes is sparse and difficult to interpret. This chapter reviews *Psittacanthus* on conifers with regard to life cycle, description, damage, importance, and management.

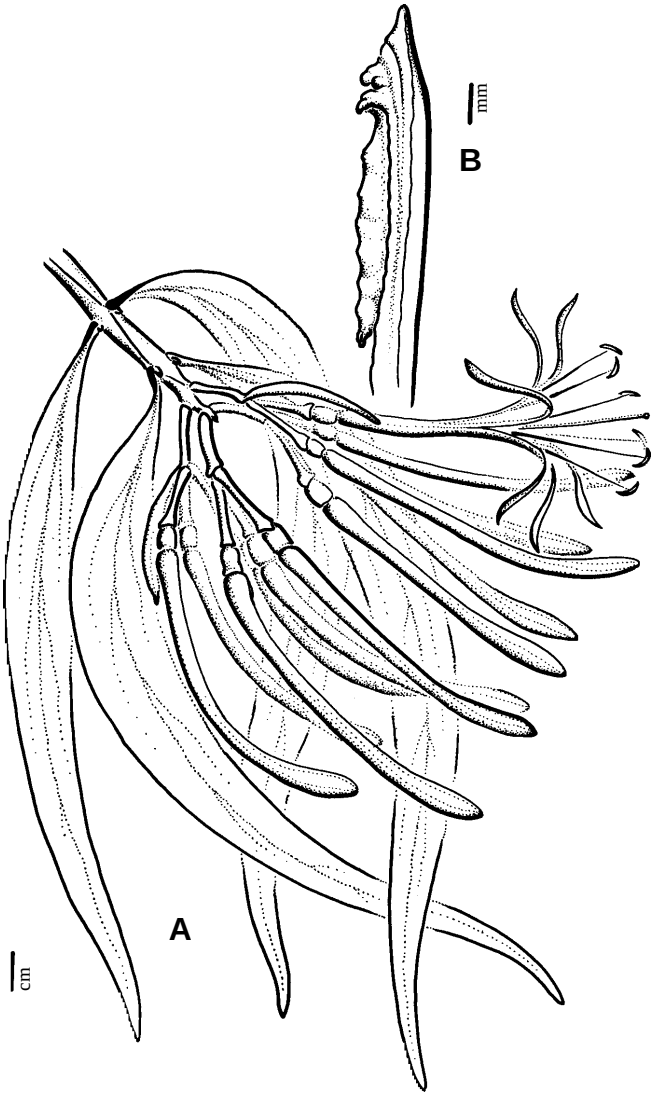

Figure 2-1—*Psittacanthus angustifolius*, **A** habit, leaves and flowers and **B** tip of petal. Illustration courtesy of Job Kuijt, edited from figure 10 in Annals Missouri Botanical Garden. 74:524.

General Life Cycle

The life cycle of *Psittacanthus* is divided into the fundamental processes of dispersal and development separated by inoculation and germination. Although some seeds are dispersed to the lower branches of an infested host by gravity, *Psittacanthus* is typically dispersed by birds feeding on fruits and defecating on branches. Incubation and production of the first flowers require several years. Once established, however, the infection is perennial, and the mistletoe produces a large haustorium with many long branches. Although *Psittacanthus* does photosynthesize, it is a parasite, and when it becomes large, it seriously interferes with host growth and reproduction.

Some of the *Psittacanthus* features that enhance bird-dispersal are time and duration of maturation, fruit size and attractiveness, adaptations for passage through the digestive tract, adhesion, and rapid germination after being voided (see Kuijt 1969a). Watson (2001) reviews the literature on coevolution of mistletoes and associates. Salas (1988) reports a study of *Psittacanthus* dispersal by birds at three sites in Michoacán (table 2-1). He observes that only eight out of 162 captured birds (4.9 percent, two crescent-chested warblers, a single Audubon's warbler, and two Bullock's orioles) carried mistletoe seeds in their feathers. Typical dispersal of *Psittacanthus* is for a passerine bird to feed on the fruit, fly to another tree, and void the seed to a suitable branch for infection. As with other mistletoes, those factors that influence bird abundance, distribution, and feeding behavior also affect the mistletoe's dispersal, population dynamics, host relations, and evolution (Lopez and Ornelas 1999).

Vázquez (1989) summarizes a 5-year study of *Psittacanthus calyculatus* on *Pinus douglasiana* in Michoacán. Additional data from that study are reported here (fig. 2-2) with observations of annual phenology (table 2-2). Bello (1984) provides photographs of an establishing seed, young plant, developing haustorium, and severely infested tree. *Psittacanthus* fruits are large (2.0 by 2.5 cm), and seeds have a sticky (viscous) layer that easily adheres them to a branch. When the basal portion of a mature seed makes contact, the seed germinates, opens its large cotyledons, and establishes an infection. Then 5 months later, the first true leaves are produced. Vegetative growth with more leaves and branches continues throughout the first year. Although shoot growth is determinate, the plant branches dichotomously expand its total length over the first 3 years at a rate of 30 cm per year. In May of the fourth year, shoot terminals begin producing flower buds. Full flowering is reached in 6 months; pollination occurs in November and December. The usual pollinators for most species are thought to be hummingbirds; but Freeman and others (1985) suggest passerine birds are the principal pollinators of *P. calyculatus* in Sinaloa. Senescing flowers are shed from November through March of the fourth year. Fruit maturation requires about 1 year and occurs from November to February of the fifth year. A generation therefore requires on average about 5 years to complete. Mature plants continue to flower and grow each year with an annual phenology that varies by host and elevation. On *Pinus douglasiana* at 1,700 m above sea level, full flowering occurs in November; on *P. pseudostrobus* at 2,400 m, flowering is delayed 3 months. Although an infection begins as a small plant growing *on* a host branch, it can

Table 2-1—Dispersal of *Psittacanthus calyculatus* at three sites in Michoacán, Mexico, for three guilds of bird species.

Guild	Species	Site		
		Canoa alta	Capácuaro	Cicapien
Insectivore				
	a Flycatcher	X	-	-
	Audubon's warbler	X	X	X
	Hermit warbler	-	-	X
	Common yellowthroat	X	-	-
	Black and white warbler	-	X	-
	Painted redstart	X	-	X
	Gray-sided chickadee	-	-	X
	Olive warbler	-	X	X
	Bushtit	-	X	X
	White-breasted nuthatch	-	-	X
	Warbling vireo	X	-	-
	Hutton's vireo	-	-	X
	Crescent-chested warbler	X	-	X
	Wilson's warbler	-	-	X
Omnivore				
	Bullock's oriole	X	X	X
	Gray silky-flycatcher	X	-	X
	American robin	-	X	X
Granivore				
	Rufous-capped brush-finch	-	X	X
	Black-headed grosbeak	-	X	X

Source: Salas (1988).

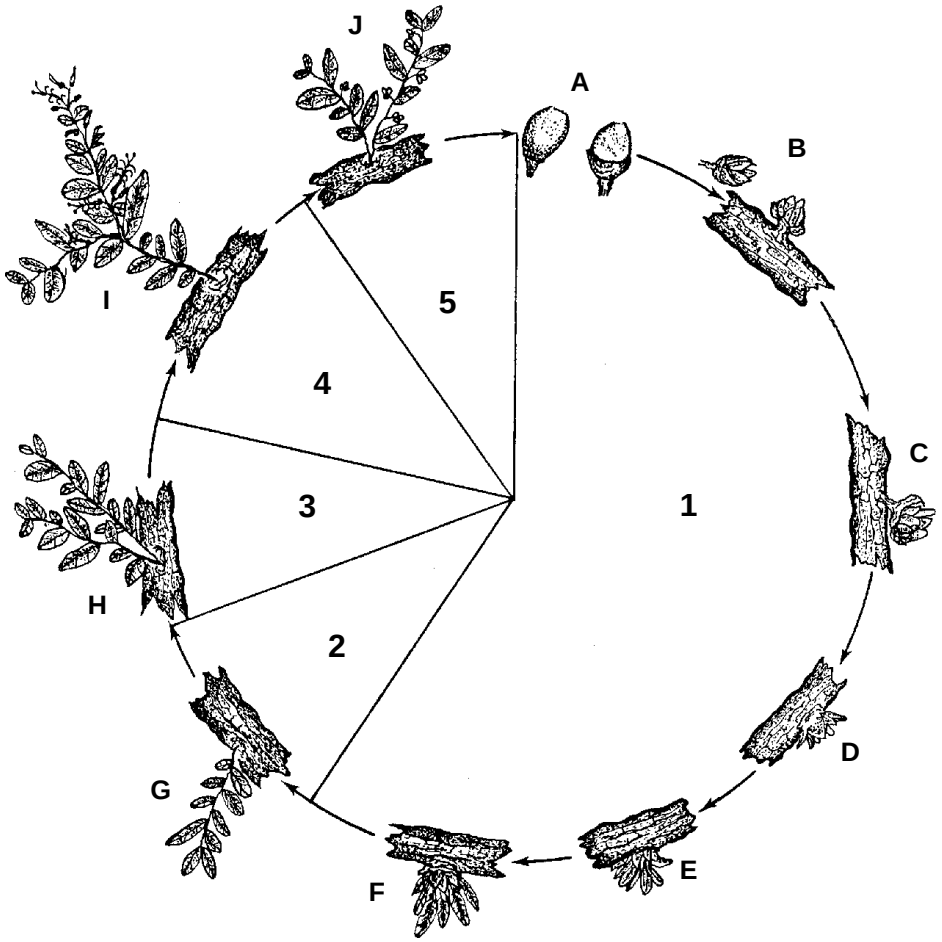

Figure 2-2—Life cycle of *Psittacanthus calyculatus*, from observations by Vázquez (1989) over a 5-year period. Year 1: A October, fruit matures; B November, infection; C November, cotyledons appear, D April, leaf buds appear; E October, leaves sprout; F October, leaves develop. Year 2: G continued vegetative growth. Year 3: H additional shoots develop. Year 4: I November, flowering. Year 5: J November, fruits mature.

Table 2-2—Phenology of *Psittacanthus calyculatus* on *Pinus douglasiana.*

Stage [b]	Month [a]											
	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
V1	X	X	-	-	-	-	-	-	-	-	-	-
V2	X	X	X	-	-	-	-	-	-	-	-	-
V3	X	X	X	X	X	X	X	X	X	-	-	-
FL1	X	X	X	X	X	X	X	X	-	-	-	-
FL2	X	X	-	-	-	-	-	-	-	-	-	-
FL3	X	X	-	-	-	-	-	-	-	-	-	-
FR1	X	X	X	X	-	-	-	-	-	-	-	-
FR2	X	X	X	X	X	X	X	X	X	X	X	X
FR3	X	X	X	X	-	-	-	-	-	-	-	-

[a] Month during which stages of life cycle are evident.
[b] V1 = early vegetative, V2 = full vegetative, V3 = final vegetative, FL1 = early flowering, FL2 = full flowering, FL3 = final flowering, FR1 = early fruiting, FR2 = full fruiting, FR3 = final fruiting.

ultimately *replace* the entire terminal portion of the host branch. With the vegetative growth of a single plant and sexual reproduction generating new plants, an infestation can eventually take over most of a tree's crown. Vázquez (1986) suggests a four-class system for rating infestation severity.

Kuijt (1967, 1970) describes the interesting anatomy and morphology of seedlings, seedling establishment, and the haustorium of *Psittacanthus*. Seedlings and the haustorium have several particular features that help construct a phylogeny for the genus (Kuijt 1983). The haustorium in *Psittacanthus* becomes quite large and is even harvested as a specialty product (see below).

Description of Genus

Psittacanthus
Mistletoe, parrot-flower, muérdago verdadero

Shrubby parasites of trees and other woody plants; stems brittle, erect, cylindrical or square, frequently ridged; epicortical root absent, primary haustorium often large; phyllotaxy opposite or whorled, leaves large (maximum 1 m in length), leathery or fleshy, green, persistent, opposite; leaf blade cordate, obovate, oval or lanceolate; leaf apex pointed; floral bracts short and stout; flower bisexual, six-partite, with a tubular perianth, 3 to 8 cm long, yellow, red, or orange, smooth; stamens dimorphic, as numerous as perianth lobes; anthers rarely more than 6 mm; ovary inferior, one-chambered; fruit berry, elliptical, green initially, developing into black or dark brown seed; endosperm lacking or apparently so (Standley 1920 but see Kuijt 1983).

Psittacanthus is endemic to the New World and ranges from Mexico to Argentina (Cházaro and Oliva 1988b). According to Reséndiz and others (1989), *Psittacanthus* is found in 25 Mexican States, absent only from Aguascalientes, Coahuila, Chihuahua, Hidalgo, Nuevo León, Tamaulipas, and Distrito Federal. Although *Psittacanthus* is distributed throughout Mexico, it is most common in the Central and Southern regions. Most species of *Psittacanthus* have broad host ranges on numerous woody hardwoods; some include conifers among their hosts. On conifers, *Psittacanthus* is limited to the cool temperate forests where conifers occur. The elevational distribution in Mexico ranges from 800 m on *Pinus oocarpa* to 3,300 m on *P. rudis*.

The taxonomy of *Psittacanthus* is quite confused; a comprehensive, monographic treatment would greatly benefit our understanding of the genus. Because of misidentification or subsequent taxonomic revision, numerous reports and publications refer to mistletoes using names that do not properly apply; sufficient information to identify the subject mistletoe is seldom given. These taxonomic difficulties are being overcome with projects such as Flora Mesoamericana (2002). Managers and researchers can reduce the confusion in the future by filing voucher specimens with a recognized herbarium for identification and future reference.

Standley (1920) initially describes only seven species of *Psittacanthus* for Mexico; Reséndiz and others (1989) later recognize 14 species for the country. Host data are frequently absent or sparse (genus only) on herbarium labels, but Reséndiz and others (1989) compile available data for Mexico from numerous collections. They report as hosts of *Psittacanthus* more than 50 genera of angiosperms and conifers, including trees, shrubs, and cactus. The primary angiosperm hosts are *Quercus*, *Acacia*, *Juglans*, *Ficus*, *Populus*, *Salix*, *Prunus*, *Prosopis*, *Annona*, *Bursera*, *Citrus*, *Nerium*, *Olea*, *Crataegus*, *Bacharis*, *Fraxinus*, *Eucaliptus*, *Persea*, *Cassuarina*, *Pseudosmondingium*,

Arbutus, *Ulmus*, *Liquidambar*, *Psidium*, *Spondia*, *Phitecellobium*, *Amphipterigium*, *Pyrus*, *Mimosa*, and *Cydonia*. No monocots are known to be parasitized. *Psittacanthus* throughout its range is reported for conifers mostly on pine (table 2-3). In Mexico, the most common *Psittacanthus* species on conifers are *P. calyculatus* and *P. macrantherus* (Bello and Gutierrez 1985). Mathiasen and others (2000c) first report *P. angustifolius* on pine in Southern Mexico; this and other species (for example, *P. pinicola*) may be more widely distributed than apparent from the literature.

Description of Species

Only several species of *Psittacanthus* are reported as parasites of conifers in Mexico. Because of taxonomic uncertainty and the recent discovery of a new species for Mexico, we include in addition to frequently reported mistletoes several other species known or suspected to infect conifers in Mexico.

1. *Psittacanthus americanus*

Psittacanthus americanus (Mart.), Flora 13:108, 1830. =*Loranthus americanus* L

Description. Shrub 1 m tall; shoots erect and spreading, square or more or less angular, smooth; leaves fleshy, ovate, elliptical, rounded, 6 to 10.5 cm long by 3 to 6.5 cm wide, apex very obtuse; petiole short; perianth 6 cm long, bright red or orange; fruit berry, 0.8 by 1.0 cm, green initially, developing into reddish brown (Bello and Gutierrez 1985, Standley 1920).

Discussion. Vázquez and others (1986) refer to *Psittacanthus americanus* as abundant on *Pinus leiophylla*, *P. teocote*, and *P. montezumae* at sites in Michoacán. Standley (1920) adds Guerrero, and Bello and Gutierrez (1985) add Chiapas and Veracruz to the distribution. Reséndiz and others (1989) describe the species as having the smallest elevational range of the Mexican species. Kuijt (personal communication), however, reserves the name *Psittacanthus americanus* for a mistletoe of the Lesser Antilles that is not found in North or Central America. The collections of *Psittacanthus americanus* from Mexico should be re-examined.

2. *Psittacanthus angustifolius*

Psittacanthus angustifolius Kuijt, Ann. Missouri Bot. Gard. 74:523–525, 1987.

Description. Stems sharply angular; leaves paired, narrow, thin, 17 by 2.5 cm, base acute, apex attenuate; petiole to 5 mm long; inflorescences terminal, of four to six triads (groups of three); triad peduncles about 1 cm long, lowest with bracts to 2 cm long; bud stout, straight or somewhat curved; petals orange, 7.5 to 8 cm long, petal apices 4 mm wide, blunt, each with a

Table 2-3—Conifer hosts of *Psittacanthus* as reported in examined literature.

Host species	Reference
Abies religiosa	Bello (1984), Bello and Gutierrez (1985)
Cupressus sp.	MartÌnez 1983
Pinus caribaea var. *hondurensis*	Kuijt (1987), Mathiasen and Howell (2002)
Pinus douglasiana	Bello (1984), Bello and Gutierrez (1985), Vázquez (1989)
Pinus lawsonii	Bello (1984)
Pinus leiophylla	Bello (1984), Bello and Gutierrez (1985), Gibson (1978), Vázquez (1989), Vázquez and Pérez (1989), Vázquez and others (1982, 1985, 1986)
Pinus maximinoi	Mathiasen and others (2000b)
Pinus michoacana	Bello (1984), Bello and Gutierrez (1985)
Pinus montezumae	Vázquez (1989), Vázquez and Pérez (1989), Vázquez and others (1982, 1985, 1986)
Pinus oocarpa	Mathiasen and others (2000b)
Pinus oocarpa var. *ochoterenia*	Mathiasen and others (2000c)
Pinus pseudostrobus	Bello (1984), Gibson (1978)
Pinus tecunumanii	Melgar and others (2001)
Pinus teocote	Bello (1984), Bello and Gutierrez (1985), Vázquez and Pérez (1989), Vázquez and others (1982, 1985, 1986)

fleshy ligule-like median crest extending inwards (see fig. 2-1); anthers 6 mm long (Kuijt 1987).

Discussion. Kuijt (1987) only reports the host as pine, but the reported host range now includes *Pinus caribaea* var. *hondurensis*, *P. oocarpa*, *P. oocarpa* var. *ochoterenia*, *P maximinoi*, *P. tecunumanii*, and *Psidium guineese* (Mathiasen and Howell 2002, Mathiasen and others 2000b, Mathiasen and others 2000c, Melgar and others 2001). The mistletoe is known from Nicaragua, Belize, Honduras, Guatemala, and Mexico (Chiapas). Although the mistletoe appears to be more common and damaging in Central America (Mathiasen and others 2000c), it has only recently been described, and new populations are being discovered. With its wide host range, it may be more common in southern Mexico than presently reported.

3. *Psittacanthus calyculatus* (*sensu lato*)

Psittacanthus calyculatus (DC.) G. Don, Gen. Syst. 3:415, 1834.

Psittacanthus rhynchanthus (Bentham) Kuijt, Ann. Missouri Bot. Gard. 74:529, 1987

=*P. chrismarii*

Description. Shrub 1.0 by 1.5 m tall, herbaceous initially but becoming woody; stems green, quadrangular or ridged when young; leaves dark green, 5 to 14 cm long by 1.4 by 6 cm wide, leathery, lanceolate or elliptical to ovate, smooth; leaf blade asymmetric, margin undulating, with long attenuate apex and cuneate base, venation pinnate and prominent; inflorescence terminating the shoot; flower buds strongly incurved, 4 cm long, tip acute, base dilated, on peduncles up to 2 cm long, bracts fused to cup-like structure, in triads, perianth 3 to 5 cm long, red to orange, smooth; stamens as numerous as perianth lobes; fruit berry, 2.5 cm long by 2 cm wide, glabrous, with flaring calyculus (Bello and Gutierrez 1985, Hernandez 1991). Bello (1984) and Cházaro and Oliva (1988a) provide brief descriptions and illustrations.

Kuijt (1987) recognizes two similar taxa of *Psittacanthus* initially described as *Loranthus calyculatus* and *L. rhynchanthus*. He applies the name *P. calyculatus* to the Mexican species (Puebla and Morelia) in which the mature, unopened bud is nearly straight with a blunt tip, and the name *P. rhynchanthus* to a lowland, Mesoamerican (to Venezuela) species in which the bud is distinctively curved and beaked. He describes a number of additional characteristics that distinguish the two, such as symmetrical leaves 8 by 4 cm for *P. calyculatus* and asymmetrically curved, larger leaves 12 by 4 cm for *P. rhynchanthus*. Kuijt (1987) does not mention any host preference differences, but given the southern and lowland distribution of *P. rhynchanthus*, we suspect the more common parasite of conifers in Mexico is *P. calyculatus*. These differences, however, can only be resolved by examination of voucher specimens in light of Kuijt's interpretation of the type material.

Discussion. Bello (1984) lists the conifer hosts of *Psittacanthus calyculatus* as *Abies religiosa*, *Pinus douglasiana*, *P. lawsonii*, *P. leiophylla*, *P. michoacana*, *P. pseudostrobus*, and *P. teocote*. Vázquez here adds *Pinus montezumae*, *P. herrerai*, *P. pringlei*, and *P. rudis* and describes this as the species with the most number of conifer hosts, largest distribution, and most importance. Bello and Gonzales (1985) locate the mistletoe (without host distinction) as from Tamaulipas to Jalisco, Chiapas, Yucatan, Oaxaca, Valley of Mexico, Guanajuato, Morelia, and Michoacán. Freeman and others (1985) add Sinaloa, and Hernandez (1991) adds Tlaxcala. The mistletoe in Michoacán is widespread, mostly found in the subhumid temperate zones, from 1,300 to 2,750 m (Bello and Gonzales 1985). In natural stands of *P. leiophylla* and *P. pseudostrobus* in Michoacán, Gibson (1978) observes the mistletoe has a patchy distribution and some sites are severely infested. Vázquez (1989) describes the life cycle and phenology of this mistletoe. Vázquez (1994b) and Vázquez and others (1986) discuss control.

4. *Psittacanthus macrantherus*

Psittacanthus macrantherus Eichl., Mart. Flora Brasilense. 5(2):26, 1868.

Description. Shrub 1.0 m tall; shoots stiff, brown, cylindrical, glabrous; leaves 6 to 7.5 cm long, fleshy, elliptical, obovate, margin entire, apex obtuse, base attenuate; perianth 5.5 to 6.5 cm long, yellow or orange, large; anthers 18 mm long, as numerous as perianth lobes; fruit berry, green, glabrous (Bello and Gutierrez 1985, Standley 1920).

Discussion. Bello and Gutierrez (1985) only identify the hosts as pine and fir; but Vázquez (here) describes the pine hosts as *Pinus engelmannii*, *P. herrerai*, *P. lawsonii*, *P. lumholtzii*, *P. oocarpa*, and *P. pseudostrobus*. The mistletoe occurs locally in the Sierra de San Pedro Nolasco, Jalisco (Cházaro 1989b), Oaxaca and Michoacán (Bello and Gutierrez 1985), and Sinaloa (Gentry 1946). It ranges in elevation from 1,300 to 2,200 m. It is the second most important *Psittacanthus* on conifers in Mexico.

5. *Psittacanthus pinicola*

Psittacanthus pinicola Kuijt, Ann. Missouri Bot. Gard. 74:525–529, 1987.

Description. Stems terete, becoming fissured and black with age; leaves symmetrical, in irregular whorls of three 11 by 2.5 cm, elliptical to lanceolate; apex rounded, base tapered; inflorescences lateral, axillary, often on older leafless stems, an umbel of two or three dyads (groups of two); petals 4 cm long, red with yellow-green tip, orange in middle, ligulate at base; buds inflated at ovary to 5 mm, tapering to slender,

curved tip at 1.5 mm; anther 3 to 4 mm long (Kuijt 1987, includes two illustrations).

Discussion. This attractive mistletoe is distinguished by the combination of parasitism on pine (*Pinus caribaea*) and inflorescences composed of pairs of flowers. The species is known from Central America at elevations below 650 m; it appears not to cause serious damage (Mathiasen and Howell 2002). Although we are aware of no collections from Mexico, other mistletoes (namely *Arceuthobium hondurense*) have recently been found to have widely disjunct distributions from Honduras to Mexico.

6. *Psittacanthus schiedeanus*

Psittacanthus schiedeanus (Schltdl. & Cham.) Blume, Sys. Veg. 7(2):1730, 1830.

Description. Shrub large, to 50 cm; stems, sharply quadrangular and four-winged until large lenticels develop; nodes flattened; haustorium very large; leaves bluish-green, 20 cm long by 8 cm wide; leaf blade asymmetric, ovate 6 to 16 by 1.4 by 4.5 cm; apex attenuate; petiole distinct and stout; venation pinnate; inflorescence terminal, leafless, forked; flowers 6.5 to 8 cm long in bud, on peduncles 1.5 to 2 cm long, perianth orange, 3 to 5 cm long, segments linear, separated to base, recurved; stamens dimorphic, very slender; fruit berry, 1.5 cm long by 1 cm wide (Bello and Gonzales 1985, Standley 1920). Bello (1984), Cházaro and Oliva (1988a), and Hernandez (1991) provide illustrations. Kuijt (1967) describes seedling structure and development in great and illustrated detail.

Discussion: The hosts most commonly reported for *Psittacanthus schiedeanus* are oaks and other hardwoods (Bello 1984, Lopez and Ornelas 1999). Vázquez and others (1982) name *Pinus leiophylla*, *P. montezumae*, and *P. teocote* as important, damaged hosts in Michoacán. Collections from Honduras (EAP) extend the hosts to include *P. oocarpa*. Standley (1920) reports this mistletoe as occurring in Central America and Mexico from Veracruz to Michoacán and Oaxaca. Hernandez (1991) describes its distribution in Tlaxcala, and it is collected from Chiapas (Flora Mesoamericana 2002).

Damage and Effects on Host

Damages produced by *Psittacanthus* to pine hosts include reductions of diameter increment, cone production, and seed viability. Vázquez and others (1982, 1985) report a series of studies from Michoacán to determine the effects of *Psittacanthus* to *Pinus leiophylla, P. montezumae,* and *Pinus teocote.*

Vázquez and others (1982, 1985) observe that the reduction in diameter increment for trees infected by *Psittacanthus* varies by host species and size class. The diameter increment of infected *Pinus leiophylla* trees is only 10 percent of uninfected trees (0.7:7.0 mm per year). The diameter increments of infected *P. montezumae* and *P. teocote* are both 47 percent of uninfected trees of the species, although the two species grow at different absolute rates (0.2:5.3 mm and 0.7:1.5 mm per year, respectively). Increment losses are greatest in the 20-cm diameter class for *P. leiophylla* and *P. montezumae* and in the 40-cm class for *P. teocote.* Reduction in diameter increment can also be expressed as loss in productivity or volume. Reduced volume production by infected *P. leiophylla* corresponds to half the annual productivity of 127 trees per ha or 0.0186 m^3 per tree per year. Infected *P. montezumae* lose the equivalent of 0.0843 m^3 per tree per year; infected *P. teocote* lose 0.0150 m^3 per tree per year. In terms of growth, *P. montezumae* is the species most severely impacted.

Vázquez (1986) uses a four-class rating system (table 2-4) to stratify *Psittacanthus*-infected trees by disease severity and to assess the effects on reproductive potential (Vázquez and Pérez 1989). They observe that severely infected trees of *Pinus montezumae* and *P. teocote* fail to produce cones, and *P. leiophylla* produces 23.8 percent fewer cones. Moderately infected trees of *P. montezumae* produce 37.5 percent fewer cones, and moderately infected *P. teocote* produce 19.4 percent fewer cones. No reduction in cone production is noted for moderately infected *P. leiophylla* or lightly infected trees of any species. They also note an effect on seed germination. Seeds from severely infected *P. leiophylla* exhibit only a 67 percent germination rate. Seed germination from moderately infected trees is reduced 25 percent for *P. montezumae* and 5 percent for *P. teocote*. In terms of reproductive loss, *P. montezumae* is the species most severely impacted.

Economic and Ecological Importance

Although *Psittacanthus* is established as a widespread and damaging parasite of conifers in Mexico, it is also important for medicine, crafts, and wildlife

Table 2-4—Four-class rating system for evaluating severity of diseases caused by *Psittacanthus.*

Disease index	Infection class	Percent of crown infected
0	uninfected	0
1	light	1–30
2	moderate	31–60
3	severe	61–100

(Cházaro and others 1992). Vázquez and others (1982, 1985) and Vázquez and Pérez (1989) document the impacts of *Psittacanthus* on conifer growth and reproduction. Martinez (1983) reports that 3,396 ha of *Pinus lumholtzii*, *P. montezumae*, *P. leiophylla*, *Cupressus*, *Quercus*, and *Alnus* in Jalisco, Mexico, and Michoacán are infested by *Psittacanthus*. Over most of its extensive range, however, *Psittacanthus* appears to occur as small patches of a few infected trees. Traditional medicines are produced from the mistletoe; Browner (1985) identifies some of these uses in Oaxaca. The large haustorium of an old *Psittacanthus* infection causes distorted growth of the host branch into an interesting form resembling a rose or similar flower after the mistletoe tissue is removed. Artisans use these woodroses to produce lamp stands and other decorative, craft items (Cházaro and others 1992). These mistletoes are also used and are important to numerous birds for nectar and fruit (Freeman and others 1985, Lopez and Ornelas 1999, Salas 1988).

Management Strategies

The *Psittacanthus* mistletoes are easily detected, obligate parasites, with long life cycles, and slow rates of spread and intensification. Because of these attributes, economic control is generally feasible. Chemical and silvicultural methods are used for mistletoe control; some biological control occurs naturally but has not been developed as management tool (Cházaro and others 1992, Hernandez 1991).

Biological Control

The principal insects that feed on *Psittacanthus* belong to the order Homoptera, including scale insects *Coccus*, *Saccharicoccus*, *Gascardia*, and *Aenidomytilus*, and the aphid *Macrosiphum* (Vázquez and others 1986). These homopterans feed exclusively on plant sap, infesting leaves, branches, flowers, and fruits. A heavy infestation weakens and may eventually kill a host mistletoe plant. *Macrosiphum* has the best potential as a biological control agent because aphids are excellent vectors of viruses (Horst 2002), which are themselves agents of biological control.

Vázquez and others (1986) report isolating the fungi *Alternaria*, *Ceratocystis*, and *Fumago* from *Psittacanthus*. The disease caused by *Alternaria* (see García 1977, Horst 2002) in *Psittacanthus* produces leaf spot of older leaves and blight of young branches. The fungus spreads quickly during wet periods and induces concentric dark lesions, which lead to extensive necrosis of mistletoe leaves and shoots. Because *Ceratocystis* causes much damage and is readily cultured, it has a good potential as a biological control agent. *Fumago* causes blights and sooty molds; these fungi are very common in tropical and subtropical agriculture around the world. The development of *Fumago* is promoted by the secretions of some Homopterans (aphids and scales). The resulting disease and infestation can produce reactions in the host plant similar to symptoms caused by mistletoe itself; severe leaf infestations reduce photosynthesis and therefore growth (García 1977, Horst 2002).

Chemical Control

Few studies for chemical control of *Psittacanthus* on conifers are published (for example, Vázquez 1994b). Vázquez and others (1986) describe an experiment in Michoacán on *Psittacanthus calyculatus* and *P. americanus* infecting *Pinus leiophylla*. They report 1-month and 6-month evaluations of commercial application of four herbicides: two 2,4-D derivatives (Esterón and Fitoamina), one pyridine (Gramoxone), and one urea derivative (Karmex). At neither observation time did Karmex appear to damage the mistletoe. At 1 month, Gramoxone appears to provide excellent control with high mortality rate (80 percent) of fruits, leaves, and branches and slight transient phytotoxicity in the pine. At 6 months, however, the mistletoe treated with Gramoxone recovers and produces new vigorous buds, flowers, and fruits. Therefore, Gramoxone only causes a temporary delay in mistletoe development. At 1 month, Fitoamina causes severe damage, 40 percent defoliation, to mistletoe leaves and tender buds but has less effect on the mistletoe fruits. At 6 months, Fitoamina affects 80 percent of the mistletoe with defoliation, leaf spotting, and fruit deformity. At 6 months, Esterón causes complete defoliation of the mistletoe and failure to set fruit. The 2,4-D derivative herbicides are the more effective chemical control agents, but their use must be consistent with local regulations.

Silviculture

Several silvicultural practices are useful for controlling *Psittacanthus* in severely infested stands. The appropriateness of a given method depends on numerous factors, including stand type and location, infection intensity, management objectives, and constraints. Sanitation, intermediate thinning, shelterwood, and clearfelling are available techniques. Sanitation consists of removing severely infected trees and leaving light and moderately infected trees. Periodic examinations are made to monitor disease intensification; trees are removed as they become heavily infected. Sanitation is usually conducted at the time of intermediate thinnings, but if intensification is rapid relative to the thinning cycle, early removal may be considered. During shelterwood regeneration cuts,

mistletoe-infected trees are generally removed and not used as seed trees. Lightly infected, genetically superior trees are occasionally retained to provide seed and then removed after 5 years. Where more than 75 percent of trees are infected and most are severely infested, clearfelling is usually employed for stand regeneration. Replacement with species less damaged or resistant to mistletoe infection can be considered.

As with all mistletoes, the first decision on control is whether it is appropriate given the management objectives of the stand, values produced in the stand, and available options for treatment.