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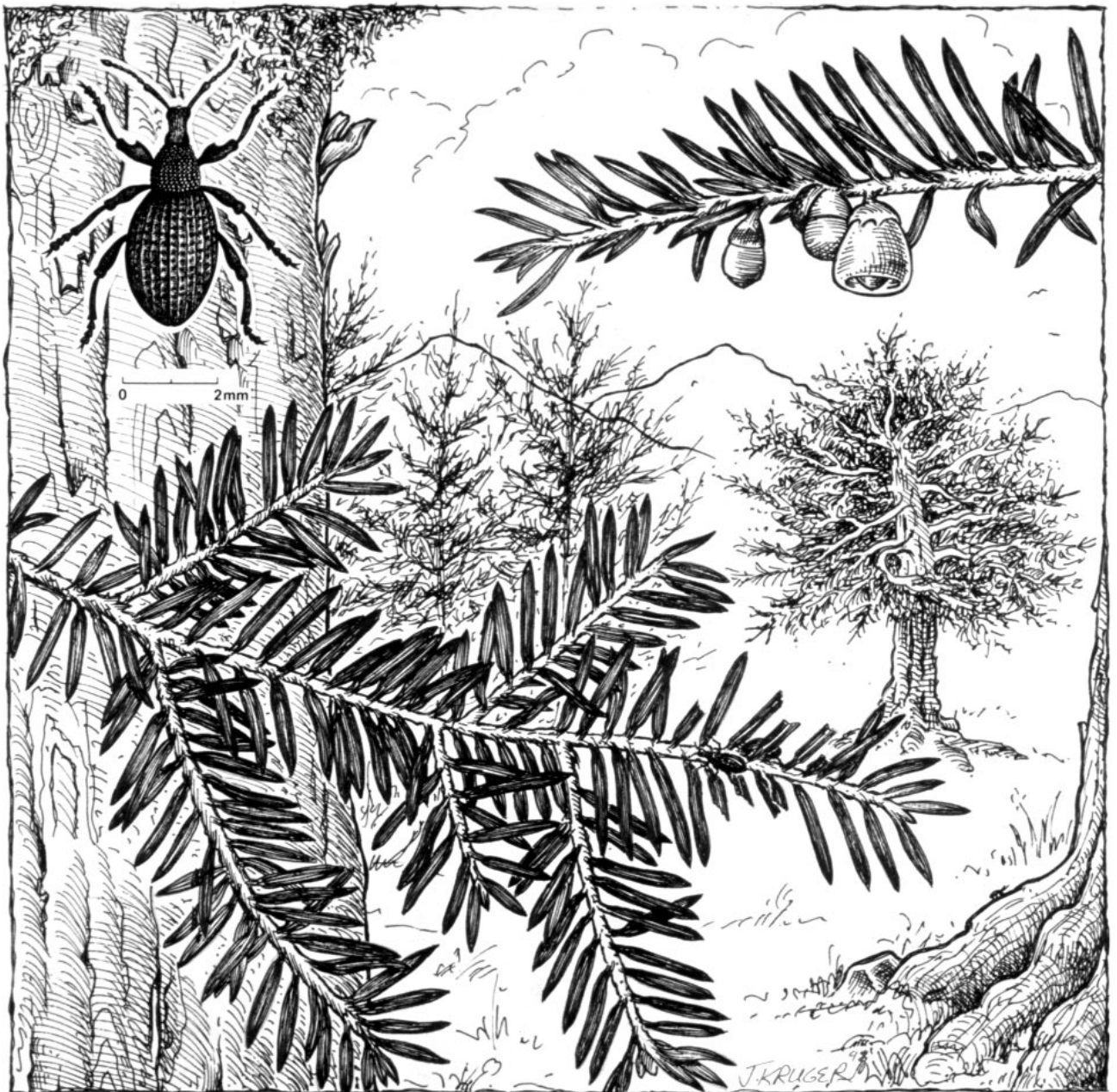
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A Review of the Insects and Mites Found on *Taxus* spp. With Emphasis on Western North America

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Abstract

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Forty-two species of insects and mites found on *Taxus* are discussed, including all those known to occur in North America, of which 27 occur in western North America. Thirty-eight species are phytophagous, and 28 of these have sucking, rather than chewing, mouth parts. It is suggested that some of the chemical compounds present in the foliage of different species *Taxus* select against chewing insects and favor fluid-feeding arthropods.

Keywords: *Taxus*, yew, insects, mites, host plant association, North America.

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Introduction

Experienced insect collectors, especially lepidopterists, have long known that species of *Taxus* have a depauperate insect fauna¹ compared to other trees, including other conifers. A systematic review of the literature supports this general impression. Southwood (1961) lists only a single species (a moth) occurring on *Taxus baccata* L. in Britain. Kennedy and Southwood (1984), in a reanalysis of the numbers of insects on British trees, revise the figure upwards to six species, including one mite. This contrasts with hazel (*Corylus avellana* L.) with 106 species, hawthorne (*Crataegus monogyna* Jacq.) with 209 species, and the two native oaks (*Quercus* spp.) with 423 species combined (Kennedy and Southwood 1984). We lack such detailed information on most of our native U.S. trees, especially western species, including information on associated insects and mites of even the horticultural species and varieties of yew in the west. Published information on arthropods on the Pacific yew (*Taxus brevifolia* Nutt.) is almost nonexistent (Bolsinger and Jaramillo 1990). Curiously enough, the earliest published record of an insect on Pacific yew was in 1915—in New Jersey! A scale insect was found “on *Taxus cuspidata brevifolia* growing in a nursery” (Weiss 1915). DeLeon (1952) observed that *T. brevifolia* Nutt. supported fewer species of insects than did the redwoods (*Sequoia sempervirens* (D. Don) Endl.), listing only a single species of a scale insect (*Aspidiotus hederæ* [Vallot]) and stating that it likely was introduced.²

As this study proceeded, and the list of species from different parts of the country and the world began to accumulate, the initial assumption of a small fauna on yew species was supported. Further, a distinct faunal pattern also emerged; most of the species were sucking rather than chewing arthropods. Large taxa of herbivores, most of which are chewing, were either completely absent or represented by only a few species; that is, Lepidoptera, Hymenoptera, most Coleoptera (weevils excepted), Hemiptera: Heteroptera, and even Diptera. Aside from a few Lepidoptera, several Coleoptera (one scarab beetle and a few weevils), and one gall-making fly, most species were found in the Homoptera (an aphid and three families of scale insects). Several mite species have been documented in the literature, and there are others known but not yet studied.³ Several phytophagous families of the true bugs (Hemiptera: Heteroptera) including the Miridae and Pentatomidae have not yet been documented from any species of *Taxus*. Many species of Miridae, in particular, are found on conifers, chiefly on those trees belonging to the family Pinaceae. The same is true of several large groups of Homoptera—Cicadellidae and Membracidae. Because so little collecting has been done from most native species of *Taxus*, other insects and mites surely await discovery, and some of the taxa mentioned above may yet be represented in the world fauna of *Taxus*. Thus far, only a few species are confined to *Taxus* and virtually all are polyphagous. This paper is part of a worldwide review now underway of insects and mites associated with all species of *Taxus*.

¹ Personal communication. 1990. Douglas Ferguson, Systematist, U.S. Department of Agriculture, Agricultural Research Service, Systematic Entomology Laboratory, Beltsville, MD 20705.

² *Aspidiotus hederæ* [Vallot] is now considered a synonym of *A. nerii* Bouch

³ Personal communication. 1993. G.W. Krantz, Professor of Entomology, Oregon State University, Corvallis, OR 97331.

Phytophagous Arthropods

The Mites: Acari

There is a distinct mite fauna associated with coniferous trees, a fauna that is still relatively unknown. As with the insect fauna, it appears that the mite fauna on *Taxus* is reduced in diversity compared to many tree species although it should be recognized that our knowledge is far from adequate. Thus far, two species of mites have been identified from yew in the west although others are known to occur but await study.^{4,5}

Representing the family Eriophyidae, *Cecidophyopsis psilaspis* (Nalepa), the yew bud mite, has been known from eastern North America for some time but only recently has been identified in the west from *Taxus brevifolia* in the Coast Range and Cascade Range of Oregon. These mites cause an expanded growth of plant tissues in the buds and ultimately bud abortion.⁶ The family Tenuipalpidae contains a species, *Pentamerismus taxi* (Haller), that is found at the base of yew needles, often in considerable numbers. Originally described from Switzerland (Pritchard and Baker 1958), it had been reported earlier from California (Pritchard and Baker 1951) as *P. morishitai* Pritchard and Baker and later synonymized with *P. taxi*. Species of *Pentamerismus* McGregor are found throughout the Holarctic Region on conifers excluding the Pinaceae. There is a reasonable possibility of finding additional species of this genus on other western conifers. Another species of mite, *Nalepella tsugifoliae* Keifer (Nalepellidae), the hemlock rust mite, is found on *Taxus* in eastern North America but has not yet been recorded from western North America (Johnson and Lyon 1991).

Insects: Insecta

The groups of insects known to occur on different species of yew are discussed below. The emphasis is on those found on *Taxus* spp. in western North America. General information on other insect taxa found in other parts of North America and other parts of the world are included when considered appropriate, as it seems quite likely that at least some representatives of these different groups will be found on yew in western North America.

Beetles (Coleoptera)--The weevils, or Curculionidae, are well represented in the fauna of *Taxus*, second only to the scale insects with six species (Johnson and Lyon 1991). As with the scales, most of the weevil species (four) are nonindigenous. The most important species is the black vine weevil (*Otiorhynchus sulcatus* (Fabricius)), a European species introduced into North America at least as early as 1831 (Warner and Negley 1976). Although flightless, it is now widely distributed in eastern and western North America. It is a parthenogenetic species--an ideal characteristic for an invading organism. A serious pest of many ornamental plants (over 140 hosts have been identified besides *Taxus* [Warner and Negley 1976]), it also has penetrated into the native landscape. We found this species as one of 56 nonindigenous species out of some 3,400 species of arthropods in an old-growth Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco) forest in western Oregon (Parsons and others 1991).

⁴ Personal communication. 1993. G.W. Krantz, Professor of Entomology, Oregon State University, Corvallis, OR 97331.

⁵ Unpublished data on file with the author.

⁶ Personal communication. 1993. G.W. Krantz, Professor of Entomology, Oregon State University, Corvallis, OR 97331.

Several other species of weevils cited below also were collected. The larvae of *O. sulcatus* feed underground on roots and the adults feed on the foliage, producing very characteristic damage (notching) to the needles. During summer 1992, in a 76-day period, a single female fed on 40 old needles and 510 new needles of *Taxus* spp. (*T. brevifolia* and *T. baccata*). It laid 181 eggs during 63 days, and most of these hatched (see footnote 5). Adult weevils live for several years. Nielsen and Dunlap (1981) discuss the reproductive potential of this species on different host plants. Three other species of *Otiorhynchus* are known to feed on *Taxus* spp.: *O. ovatus* (Linnaeus), the strawberry root weevil, another major insect pest; *O. rugifrons* (Gyllenhal); and *O. rugosostriatus* (Goeze), the rough strawberry weevil (Warner and Negley 1976, Wilcox and others 1934). All these species are nonindigenous and widespread, and only *O. rugifrons* is confined to northeastern North America (Newfoundland and Nova Scotia) (Warner and Negley 1976). The two remaining species, *Nemocestes incomptus* (Horn) (raspberry bud weevil or woods weevil) and *Sciopithes obscurus* Horn (obscure root weevil) are native to the Pacific Northwest. They, too, feed on a variety of different hosts (Johnson and Lyon 1991, Wilcox and others 1934). Some of the weevils discussed above are nocturnal feeders as adults and thus avoid detection. Even though most species are flightless, their expansion across the landscape has been impressive. Because of their broad host range, there is substantial literature on most of these species.

The Scarabaeidae beetle (*Maladera castanea* (Arrow)), known as the Asiatic garden beetle, was introduced into eastern North America in 1921 from the Orient (Drooz 1985). The adults feed on yew foliage and the larvae on the roots. It is not known to occur in western North America. The so-called rain beetles (Scarabaeidae: *Pleocomma* spp.) do occur in the Pacific Coast region, and a few of the species occur in mature, low-elevation coniferous forests where *T. brevifolia* is found. The life cycle is very long, with the larvae spending many years in the soil feeding on roots (Ritcher 1958). Although no records exist of *Pleocomma* feeding on yew, the beetles could be a potential pest species.

Flies (Diptera)--No species of Diptera has yet been found associated with yew in the west, but species of at least three different families are known elsewhere. The best known species is *Taxamyia taxi* Inchtaldl, a gall midge (Cecidomyiidae) well known in Europe where it makes galls on *Taxus baccata* (Mani 1964, Redfern 1975). Johnson and Lyon (1991) state that the species might occur in North America but has not yet been recognized, perhaps because the damage has been confused with that of the yew bud mite (*Cecidophyopsis psilaspis* (Nalepa)). A species of Drosophilidae (*Drosophila* sp.) was reared from the arils of *T. baccata* in Europe (Burla and Bachli 1991).

Aphids and scales (Homoptera)--At least one Aphididae is known to occur from *T. baccata* in India; but thus far, no species have been recovered in North America. Ghosh and others (1969) describe *Anocaudus taxus* from Khadralla, India. The specimens occurred on the roots. Hille Ris Lambers (1973) transferred *A. taxus* to the genus *Prociphilus* Koch when he considered *Anocaudus* Ghosh, Chakrabarti, Chowdhuri, and Raychaudhuri a synonym of *Prociphilus*.

Three species of the scale family Coccidae occur on *Taxus* spp. in North America. Specimens were determined tentatively as *Parthenolecanium corni* (Bouché) by M. Williams⁷ from *T. brevifolia* at two localities in western Oregon by the author. A second species (*P. fletcheri* (Cockerell)), known as the Fletcher scale, was reported from *T. media* var. *hicksi* in Rhode Island by Kerr (1951). Johnson and Lyon (1991) also record it from *Taxus* spp. and consider it a major pest of yew. The cottony taxus scale (*Pulvinaria floccifera* (Westwood)), also known as the cottony camelia scale, is widespread across North America, including the Pacific Coast (Drooz 1985). Crawlers settle on the needles and then move to the twigs, where they overwinter as second-stage nymphs (Johnson and Lyon 1991). This species was reported on *T. media* var. *hicksi* in Rhode Island (Kerr 1951).

The armored scales belonging to the family Diaspididae are well represented on *Taxus* spp. in North America. At least 15 species have been reported from the United States and Canada, and most are nonindigenous to North America (Dekle 1965; DeLeon 1952; Drooz 1985; Essig 1913; Johnson and Lyon 1991; McKenzie 1956; Rosen 1990a, 1990b). The species thus far found on *Taxus* spp. include *Aonidiella taxus* Lenonardi, *Aspidiotus nerii* Bouché, *A. spinosus* Comstock, *Chinoaspis pinifoliae* (Fitch), *Chrysomphalus dictyospermi* (Morgan), *C. ficus* Ashmead, *Dynaspidiotus britannicus* (Newstead), *Fiorinia externa* Ferris, *F. fiorinae* (Targioni-Tozzetti), *Hemiberlesia rapax* (Comstock), *Lepidosaphes beckii* (Newman), *L. maskelli* (Cockerell), *Pseudacaspis cockerelli* (Cooley), *Quadraspidotus perniciosus* (Comstock), and *Tsugaspidotus tsugae* (Marlatt). Reference to all these species may be found in the works cited above. Many of these species of scales feed on various hosts, including *Taxus*. Most are found in the United States on ornamental species and those grown in cultivated situations. Because most species have been introduced into North America from Asia and Europe, it is difficult to predict just what would happen to native species of *Taxus* growing under natural conditions. Because some scales do occur on native *Taxus*, the potential is there; only careful field work throughout the ranges of our native yews will keep us informed. Attention should be directed to areas surrounding urban and suburban localities. McClure (1980), and papers cited therein, provides very interesting information on the dynamics of exotic scale insects on conifers, including two species discussed here.

Six species of mealybugs (Homoptera:Pseudococcidae) are found on *Taxus* spp. in North America (Johnson and Lyon 1991, McKenzie 1967). These insects usually are found on the foliage and branches. The white, waxy secretions covering their bodies are characteristic and give them their common name. Taxonomically, this is a difficult group, and many name changes and misidentifications occur. Johnson and Lyon (1991) suggest that the host plant itself may influence the form of the insect.

⁷Personal communication. 1993. Professor of Entomology, Auburn University, Auburn University, AL 36849-5413.

The taxus mealybug (*Dysmicoccus wistariae* (Green)), known previously as *D. caspidatae* Rau, is the best known species on yew. Reported from Connecticut, Massachusetts, New Jersey, New York, Ohio, and Pennsylvania, it is the only one of the six mealybug species not known to occur in western North America, although it was included in the key to the species of *Dysmicoccus* for convenience by McKenzie (1967). The monograph of California mealybugs by McKenzie (1967) is an important reference for the western fauna. A second species, *Pseudococcus maritimus* (Ehrhorn), is a pest of *Taxus* in Ohio (Neiswander 1949) but is not yet known from yew in California, although the insect does occur there (McKenzie 1967). The species is more commonly known as the grape mealybug. *Pseudococcus comstocki* (Kuwana), introduced into eastern North America from Asia, is reported on *Taxus* (Johnson and Lyon 1991). This mealybug also was introduced into California and is reported by McKenzie (1967) from that State; he did not record the species at that time from *Taxus*.⁸

Three additional species of *Pseudococcus* are known from *Taxus* spp. in the west (McKenzie 1967). *Pseudococcus affinis* (Essig), the obscure mealybug, known previously as *P. obscurus* Essig, is commonly found on *Taxus* (Johnson and Lyon 1991). *Pseudococcus fragilis* Brain is reported from *T. baccata* in California where it was believed to have been introduced from Australia (McKenzie 1967). The final species, *P. longispinus* (Tarioni-Tozzetti), the long-tailed mealybug, is reported from Florida, Texas, and California (Johnson and Lyon 1991). McKenzie (1967) records it from California on *T. baccata* var. *washingtonii*.

Moths (Lepidoptera)--Although Lepidoptera are usually important foliage feeders in forested ecosystems, including conifers, it is remarkable that to date only three species have been reported from *Taxus* in North America (several other species are known from Europe). The Geometridae *Cladara limitaria* (Walker), the yellow-lined conifer looper (known for many years as *Nyctobia limitaria*), is found in eastern and western Canada and the Northern United States (Martineau 1984). As the name suggests, it feeds on other hosts besides *Taxus* (Butler and Kondo 1991; Evans 1983; Furniss and Carolin 1977; Hodges 1983; Prentice 1963; Rose and Lindquist 1977, 1980). Only Prentice (1963) reports the species from *Taxus* and without specific locality or species of yew. It is considered a summer feeding species (Rose and Lindquist 1977) and uncommon (Evans 1983). *Cladara limitaria* is found in British Columbia (Prentice 1963) and Oregon.⁹ Two additional species of Geometridae have been reported from Europe on yew: *Peribatodes rhomboidana* Schiff. and *Deileptenia ribeata* Cl. (Forster and Wohlfahrt 1981).

⁸ This citation is easily overlooked as it is found as an addendum on the unnumbered page of the monograph after p. 525.

⁹ Personal communication. 1993. Paul Hammond, Research Associate, Department of Entomology, Oregon State University, Corvallis, OR 97331.

The Pyralidae *Uresiphita reversalis* (Guenée), known as the genista caterpillar, is reported from California (Powell 1992). It feeds on various legumes, chiefly exotic species like broom and especially French broom (*Genista* [= *Cytisus*] *monspessulana* [L.]). Powell (1992) also records the caterpillars feeding on nonleguminous plants as well, including *Taxus* sp. and *Buddleia* sp. (Loganiaceae). Because of the lack of records before 1930, he suggests that *U. reversalis* is either an introduced or adventive exotic. According to Powell (1992), it may be native to the southeastern United States and Mexico, having been described originally as from "North America." Its first occurrence in the San Francisco Bay area was in 1966. He states that the species depends on introduced plants in California and thus may be an exotic or native non-indigenous species in that State.

The Tortricidae *Ditula angustiorana* (Haworth) is a species introduced from Europe (Clarke 1930, Freeman 1958, Keifer 1933). It too was long known under a different combination, *Batodes angustiorana* (Clarke 1930, Evans 1983, Prentice 1965). Known from several localities in eastern North America, it also was recovered from yew in British Columbia (Clarke 1930) and California (Keifer 1933). The species also was found feeding on holly in British Columbia. MacKay (1962) reports it from Washington. In Europe it is found on other hosts besides *Taxus*, including fruit trees (Bradley and others 1973). Apparently, it is not a common species in North America; Prentice (1965) considers it a solitary feeder.

The nun moth (*Lymantria monacha* L.) also has been reported from yew in Europe. Thus far, this species has not been reported from North America, although the nun moth is considered a major risk for introduction on raw logs from Siberia (USDA Forest Service 1991). Winter (1983) reports a species of Blastobasidae (*Blastobasis lignea* Walsingham) from yew in Britain.

Predaceous and Parasitic Arthropods

Beetles (Coleoptera)--Several species of the family Coccinellidae (ladybird beetles) have been reported feeding on the coccid, *Pseudococcus comstocki* (Kuwana), in Ohio by Sluss and Foote (1971). The species mentioned by these authors were *Adalia bipunctata* (L.) and *Coccinella transversoguttata richardsoni* Brown. With several scale insects found on yew species in the west, it is likely that some species of ladybird beetles will be found feeding on them.

Flies (Diptera)--Sluss and Foote (1971) report on the biology of *Leucopsis verticalis* Malloch, a fly of the family Chamaemyiidae whose larva was found to be a predator of *P. comstocki* (Kuwana) (Homoptera:Pseudococcidae) living on *T. cuspidata* Sieb. and Zucc. var. *hicksii* Rehd. in Ohio. The same paper contains references to other predators of the Homoptera.

Wasps (Hymenoptera)--A species of Encyrtidae (Hymenoptera:Chalcidoidea) belonging to the genus *Pseudleptomastix* Girault was reared from scale (*Pseudococcus comstocki* (Kuwana) (Homoptera:Pseudococcidae)) occurring on *T. cuspidata* var. *hicksii* in Ohio (Sluss and Foote 1971). It is quite likely that scale insects found on yew in western North America will be parasitized.

Discussion and Conclusions

Lacewings (Neuroptera)--Sluss and Foote (1971) report larvae of an unidentified genus and species of the Chrysopidae (lacewings) feeding on *P. comstocki* (Kuwana) that occurred on *T. cuspidata* var. *hicksi* in Ohio. Although members of the Neuroptera family Hemerobiidae are more likely to be found on conifers of all types in the west, Chrysopidae too are sometimes taken. In addition, we have several species of snakeflies in the west (Raphidioptera), a group not found in eastern North America. Two families occur here, Inocellidae and Raphidiidae; species of both families are predacious and potential predators of yew insects.

This brief overview includes information on 42 species of insects and mites: 27 occur in western North America, 38 are phytophagous, and 4 are parasitoids or predators. This is a preliminary review, based largely on the widely scattered literature, literature often tangential to *Taxus* but with references that include *Taxus* as one of many hosts for a given species. Compared to many other host plants, the information about its fauna is sparse, partly because the fauna is sparse and partly because the tree is, or rather has been, an obscure understory species.

Intensive field collecting on all the native *Taxus* species will certainly enlarge the known fauna. Most of the information we have is based on the literature of *Taxus* spp. grown as ornamentals rather than from native stands, with Europe excepted (*T. baccata*). But even there, the tree often is found in domesticated situations. The manner in which the arthropod records are presented often makes it difficult to know what species of *Taxus* is involved because only the generic name is used.

So many of the arthropod species found on *Taxus* spp. in North America are non-indigenous that it raises other questions about the nature of our native fauna. The papers by McClure (1977a, 1977b, 1977c, 1978) and McClure and Fergione (1977) provide a fascinating account of two introduced species of scale insects on hemlock in eastern North America. Both species, *Fiorinia externa* and *Tsugaspidotus tsugae*, also occur on *Taxus*.

Thirty-eight of the insects and mites associated with *Taxus* are phytophagous, and 28 of these (74 percent) are species with sucking mouth parts. Even though we know more about exotic species on *Taxus* in the United States, our fragmentary knowledge of native U.S. fauna seems to reflect the general taxonomic pattern shown by the nonindigenous species; that is, a preponderance of sucking rather than chewing species. Just why sucking taxa should be so well represented and chewing species so poorly represented is not known. The answer may be found in the chemicals found in the plant itself, especially in the foliage. Intensive investigations have been made into the chemical compounds found in all species of *Taxus* in an attempt to understand the frequency of the taxanes that are the sources of taxol, so important in the treatment of cancer. (Chang [1996] presents an interesting account of the general increased interest in yew in Taiwan.) The chemistry of *Taxus* is very well known. Contained within this vast literature on the chemical characteristics of the different species of *Taxus* are indications of the presence of other compounds, especially the phytoecdysteroids that interfere with the moulting of some insects (Pipa and others 1990). It is likely that the presence of these compounds in the foliage of the tree would interfere with development of immature chewing insects, such as caterpillars, sawflies, and leaf beetles. The few chewing insects that feed on yew foliage, the

scarab and especially the weevils, are adults and the larvae of weevils feed on the roots (Johnson and Lyon 1991). Thus it would seem that the sucking insects may bypass the defense mechanisms as they feed on the liquid portions of the leaves, twigs, and branches without macerating the tissues the way chewing insects do. Further investigations into the role of the chemical constituents of *Taxus* on the feeding activities of the insects and mites also will clarify the issue of feeding strategies.

As so often is the case, the results of one line of investigation (for example, reduced fauna found on *Taxus* spp.) leads to other investigations--the impact of plant compounds on the feeding habits of herbivores. The intensive work on yew because of its important medicinal qualities has provided interesting ancillary information of value in other areas of human activity--quite typical of many scientific efforts (Chang 1996).

Acknowledgments

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Forty-two species of insects and mites found on *Taxus* are discussed, including all those known to occur in North America, of which 27 occur in western North America. Thirty-eight species are phytophagous, and 28 of these have sucking, rather than chewing, mouth parts. It is suggested that some of the chemical compounds present in the foliage of different species *Taxus* select against chewing insects and favor fluid-feeding arthropods.

Keywords: *Taxus*, yew, insects, mites, host plant association, North America.

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