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Biology of *Dendroctonus murrayanae* (Coleoptera: Curculionidae: Scolytinae) in Idaho and Montana and Comparative Taxonomic Notes

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ABSTRACT We studied the biology of *Dendroctonus murrayanae* Hopkins (Coleoptera: Curculionidae: Scolytinae) in lodgepole pine, *Pinus contorta* Douglas, in Idaho and Montana. The beetle was not a primary agent of tree mortality. Susceptible host trees were physically damaged, had thin foliage, or were otherwise predisposed to infestation. Beetles attacked individual trees, not in groups, near ground level and at low density. Life stages and their behavior are described. Egg galleries were constructed upward and usually had short spurs. Mating occurred in the egg gallery. Eggs were laid in an elongated group, not in niches, in a shallow excavation along only one side of the egg gallery. Larvae aggregated in a communal chamber, feeding side by side, but separated before pupation. *D. murrayanae* has four instars. One annual generation is indicated, overwintering as larvae. *D. murrayanae* occurred in some trees with *Pseudips* (=*Ips*) *mexicanus* (Hopkins), *Ips pini* (Say), and *Hylurgops porosus* (LeConte) but seldom with the mountain pine beetle, *Dendroctonus ponderosae* Hopkins. No natural enemy or commensal insect was observed in brood chambers. A new character on the frons is described and the relationship of *D. murrayanae* and the spruce beetle, *Dendroctonus rufipennis* (Kirby), is discussed.

KEY WORDS Scolytinae, *Dendroctonus murrayanae*, lodgepole pine

The lodgepole pine beetle, *Dendroctonus murrayanae* Hopkins (Coleoptera: Curculionidae: Scolytinae), was described from specimens collected at Keystone, WY (Hopkins 1909). The beetle infests lodgepole pine, *Pinus contorta* Douglas (Pinales: Pinaceae), in the Rocky Mountains from Utah and Colorado to British Columbia and Alberta, Canada; and jack pine, *Pinus banksiana* Lamb., from the Northwest Territories to Ontario, Canada, and Minnesota and Michigan (Bright 1976, Wood 1982, Furniss and Johnson 2002). *D. murrayanae* has received little study. Some information concerning its biology is in an obscure survey report of an infestation in the upper Wind River drainage, WY, by Evenden (1924); field observations in Utah during 1960 (Wood 1963); and a study of the diversity of bark beetles in thinned versus unmanaged (not thinned) mature lodgepole pine in southeastern British Columbia (Safranyik et al. 2004). This beetle has escaped attention because of its extreme rarity relative to other *Dendroctonus* species and because it has not caused economic damage. Adults of destructive (primary) species such as the mountain pine beetle, *Dendroctonus ponderosae* Hopkins, overcome host defenses by mass attack and introduction of tree-pathogenic fungi. *D. murrayanae*, however, does not aggregate in the adult stage; as few as a single pair may invade a tree successfully. Their larval offspring survive by aggregating in a communal chamber like the boreal spruce beetle, *Dendroctonus punctatus* LeConte (Furniss 1995). We describe the biology of *D. murrayanae* in lodgepole pine as determined from field observations and laboratory rearing. Reported are the first collection record from Northwest Territories, Canada; a new host record (*Pinus albicaulis* Engelmann); and presence of a longitudinal, subcarinate line on the frons of a majority of specimens that does not appear in the species descriptions. Results of the study and the taxonomic relationship of *D. murrayanae* and the spruce beetle, *Dendroctonus rufipennis* (Kirby), are discussed.

Methods and Materials

Field. We collected *D. murrayanae* in Montana and in Idaho at the following locations and dates: MONTANA. Jefferson Co. Beaverhead Deer Lodge N.F. Homestake Pass. 7 August 2007; Meagher Co., Jumping Creek campground. 14 June 1989: Park Co., W. Fork Boulder Cr. campground. 24 July 1988; Beaverhead Co., Elkhorn Hot Springs. 9 September 1978; IDAHO. Lemhi Co. Eight km SW of Bannock Pass. 9 August 2006; Clearwater Co., Wind Lake. 17 July 1986; Custer Co. 3 km W of Pass Cr. Summit. 19 July1985; Lemhi Co. 5 km SW of Bannock Pass. 18–19 July 1984. We also collected the beetle in the Northwest Territories (new locality record) and British Columbia,

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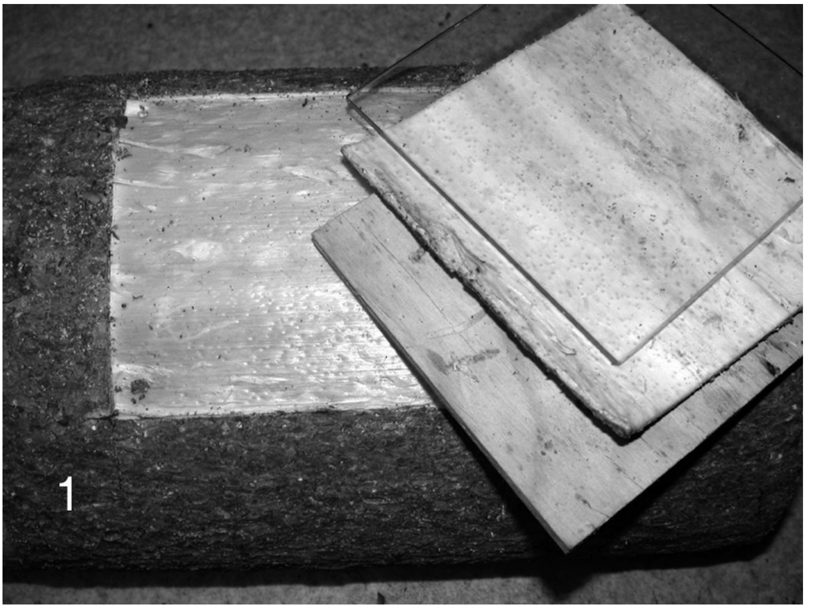

Fig. 1. Preparation of a phloem plate for rearing and observation of *D. murrayanae* in the laboratory. A piece of bark, removed from a freshly felled lodgepole pine, is shown sandwiched between plywood backing and plate glass. After inserting a stage of the beetle, the sandwich will be held together with masking tape.

Canada, in 1982 during study of another scolytid, *D. punctatus* (Furniss 1995).

Infested trees were located symptomatically by the condition of their foliage (thin or reddened), the presence of mechanical injury (e.g., porcupine, lightning, or root suffocation), and pitch masses extruded from gallery entrances near ground level. Data were taken on the density and height of *D. murrayanae* attacks, gallery characteristics (e.g., length, orientation, and egg deposition), and number and stages of broods. We also sought and recorded insects associated with *D. murrayanae* galleries or elsewhere in the stem. Live larvae were obtained for rearing at Moscow from Lemhi County, ID, on 9 August 2006 and Jefferson County, MT, on 7 August 2007.

Laboratory. Broods were propagated at room temperature in lodgepole pine phloem plates consisting of pieces of bark 15 by 15 cm compressed between plate glass (Fig. 1) as used for *D. punctatus* (Furniss 1995). A cell to contain a female, eggs, or larvae was cut in the phloem face before being compressed under glass with masking tape. Plates were confined in plastic bags to inhibit drying. Phloem plates permitted periodic observation and photography of behavior and development of *D. murrayanae* without disturbing them. The number of larval instars was determined by observation of molting of larvae in phloem plates and confirmed by measuring headwidths of a few larvae taken from one plate when they molted.

Specimens Examined. Females: 105, males: 98 as follows: Hopkins collection, Smithsonian Institution, National Museum of Natural History, Washington, DC (NMNH), 11 female, 9 male. Colorado University, Boulder, (UCMC), 7 female, 9 male (vouchers for Kelley and Farrell, 1998). Canadian National Collection, Ottawa (CNC), 38 female, 25 male. Forest Service, Fort Collins, CO (including the only record from *Pinus albicaulis*[3]), 16 female, 10 male. Forest Service Region 1, Missoula, MT, 6 female, 5 male. W. F. Barr Entomological Museum, University of Idaho, Moscow (WFBM), 34 female, 33 male, and immature stages (senior author's collections including the first record from the Northwest Territories[4]). Representative adult and immature specimens from this study are designated for deposit in the W. F. Barr Entomological Museum, University of Idaho, Moscow, ID.

Results

Description of Life Stages

Egg. The egg is satiny white, oblong in shape, and 1.2 mm average length (range, 1.1–1.3 mm) by 0.7 mm average width (range, 0.5–0.8 mm) ($n = 30$).

Larva. The ultimate (fourth) instar larva was illustrated by Hopkins (1909) (plate VIII, fig. 1) and described by Thomas (1965). It is distinguished from *D. rufipennis* [=*obesus* (Mannerheim)] by the abdomen having amber dorsopleural lobes and the dorsal plates on segments 8 and 9 being rugose and with a strongly elevated tubercle laterally on each plate. *D. rufipennis*

[3] Among specimens loaned from USDA Forest Service, Fort Collins, CO, are 13 labeled: Dubois Wyoming; *Pinus albicaulis* 7-24-36; J. A. Beal Colr.; Hopk. U.S. 17700-M-1.

[4] CANADA Northwest Territories; Trout Lake River campground (100 km SE of Fort Simpson); VI-15-1992 *Pinus banksiana* Lamb; M. M. Furniss Collector.

Table 1. Headwidths of *D. murrayanae* larvae

Instar	*n*	Headwidth, mm	
		Avg.	Range
I	17	0.56	0.51–0.60
II	9	0.74	0.61–0.85
III	10	0.92	0.87–1.02
IV	44	1.16	1.05–1.28

larvae lack pigmentation of the dorsopleural lobes, and the dorsal plates on segments 8 and 9 are less rugose and lack tubercles (Thomas 1965). The gastric caeca are elongate and arranged in a band of 55–85 caeca encircling the midgut (Thomas 1967). The larva has four instars (Table 1).

Pupa. The pupa is whitish, exarate, with smooth elytra (rugose in *D. ponderosae*) and a pair of prominent pleural spines that are spiculate with sclerotized tips. The pupa is similar to that of *D. rufipennis* except that setae on the head are not as conspicuous and the metathoracic tubercles are strongly spiculate, whereas the corresponding setae in *D. rufipennis* are only slightly spiculate (Thomas 1965).

Adult. The sexually mature adult stage has a black body (described as dark brown in Wood 1963, 1982) with reddish brown elytra (becoming blackish with age) and varies in length from 5.0 to 7.3 mm (Wood 1982). Specimens that we examined varied in length from 4.5 to 6.9 mm ($n = 129$); mean length of females ($n = 68$) and of males ($n = 61$) was the same at 5.93 mm.

The frons is moderately flattened (impressed) from the epistoma to somewhat below the top of the eyes, forming a triangular area with its base at the epistoma. This flattened area causes the front of the head to seem to protrude slightly between the eyes in side profile. Ninety-three percent ($n = 182$) of specimens examined had a median longitudinal, subcarinate, line above the epistomal process (Fig. 2). This feature was not mentioned in the description of *D. murrayanae* by Hopkins (1909) or by Wood (1963, 1982). The subcarinate line varies in its prominence and length and occurs also on *D. rufipennis.*

The pronotum has a median longitudinal, impunctate, line extending half the distance from the base to the anterior edge. Elsewhere, the surface of the pronotum has deep punctures of fairly uniform density and that vary three-fold in diameter. Anterior punctures are generally larger and somewhat less uniform in density, whereas those located toward the base are smaller and somewhat more uniform in density. The caudal half of the proepisternal area is rather closely punctured and strongly roughened (in *D. rufipennis*, the caudal half of the proepisternal area is rather sparsely punctured and only feebly roughened; Swaine 1918).

The striae of the elytral disc have large, impressed, punctures that diminish greatly in size on the declivity. The declivity of females is convex, the striae are somewhat impressed, and the interstriae have a row of small granules. The declivity of males is flatter and shinier, the striae are less impressed, and the interstriae lack prominent granules.

The gastric caeca are elongate but differ from the larvae by being distributed about the circumference of the midgut rather than in a band on each side. They number "140–190 approx. total" (Thomas 1967).

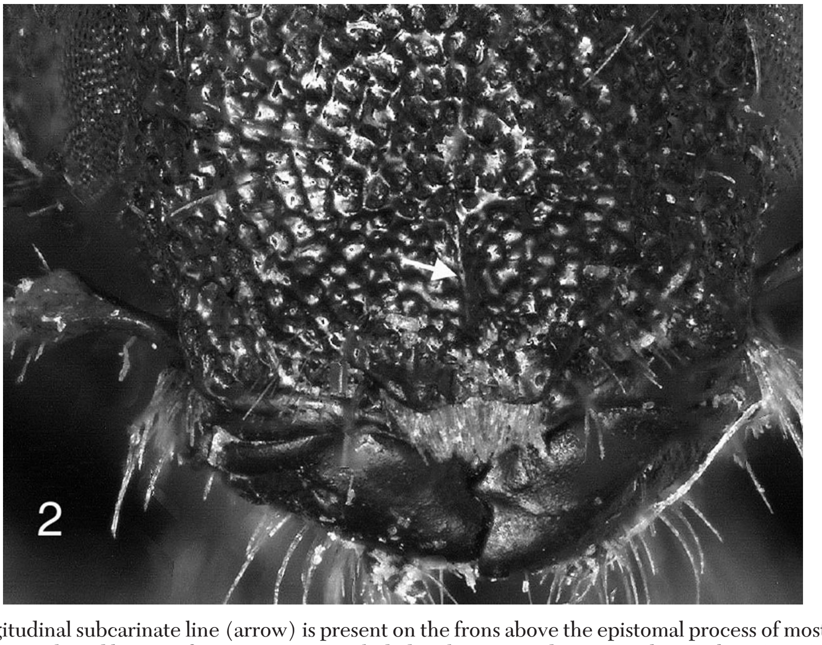

Fig. 2. A longitudinal subcarinate line (arrow) is present on the frons above the epistomal process of most *D. murrayanae* adults. This character, shared by *D. rufipennis*, was not included in the species description by Hopkins (1909) or Wood (1963, 1982).

Fig. 3. Eggs are laid in a strung-out mass at a widened place along one side of the egg gallery.

Seasonal History

In British Columbia, Canada, Safranyik et al. (2004) caught 116 *D. murrayanae* in barrier flight traps during 13 June–12 August of 1993–1998. Ninety-one percent were caught between 13 June and 13 July. The study sites were at elevations between 1,100 and 1,450 m (≈3,600–4,800 feet), much lower than our study sites in Idaho and Montana. Those authors also trapped 170 *D. murrayanae* (mean Julian date, 176 = 25 June) by caging lodgepole pine stumps.

In our study area, involving elevations >1,829 m (6,000 feet), samples of development indicate that one annual generation occurs, overwintering as larvae. For example, eggs were present at West Fork Boulder Creek, MT, on 24 July, and we observed eggs and first- and second-instar larvae on 9 August 2006 at Bannock Pass, Lemhi Co., ID. In Utah, first attacks occurred in the second week of July; eggs were present from 12 July to 9 September (Wood 1982). In northwest Wyoming, eggs and young larvae were present 5–7 August (Evenden 1924). At Jumping Creek, Meagher Co., MT, overwintered brood included pupae, and callow adults on 14 June 1989.

At constant room temperature, larvae were observed in phloem plates as they transformed eventually to pupae and adults. For example, three second-instar larvae, collected on 9 August 2006 at Bannock Pass (2,194 m [7,200 feet] elevation), had matured to adults between 5 and 15 September. Similarly, three second-instar larvae collected at Homestake Pass, Jefferson, County, MT (2,112 m [6,600 feet] elevation) on 7 August 2007 had matured to adults by 23–26 September. However, in Rocky Mountain locations such as these, transformation to adults before winter is unlikely to occur due to short summers there and where snow may occur in every month. Thus, broods seem to overwinter normally as larvae that mature to adults beginning in late spring. These adults fly to attack new hosts beginning in mid-June and lay eggs into August that hatch into larvae before winter.

Egg Gallery

The number of egg galleries varied from one to five per tree except in one (porcupine-girdled) tree, which had 17 galleries. Most attacks were <5 cm above

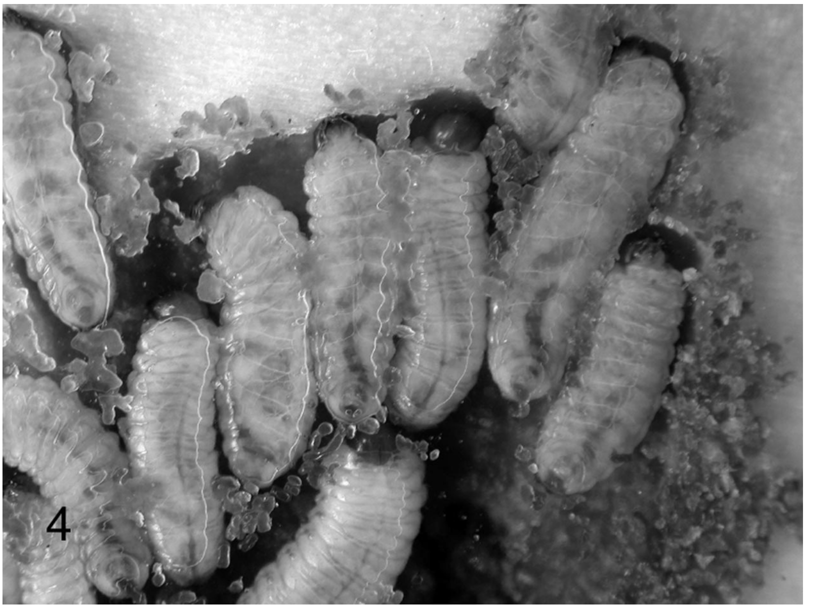

Fig. 4. After hatching, larvae of *D. murrayanae* congregate in the phloem and feed side-by-side, creating a brood chamber that extends from their parental egg gallery. These third-instar larvae were photographed in the laboratory through glass enclosing phloem into which they were inserted soon after hatching from eggs in the field.

ground; none occurred above 20 cm. Galleries were sealed by a relatively large pitch mass extruded from the entrance. The pitch crystallized in time, shedding bleached granules on the ground beneath the entrances, much like *D. punctatus* (Furniss 1995).

Of 39 complete galleries observed in the field, four were unsuccessful in establishing brood. Galleries tended to be irregularly linear in shape and directed upward; however, a few were aligned horizontally. Often, one or two short spurs led from the gallery, perhaps used to turn around. Representative complete egg galleries in the field ranged between 13 and 23 cm in length, with a mean of 18 cm (n = 7). Those observed by Evenden in Wyoming (1924) were "10–14 inches (25–36 cm) in length," whereas Wood (1963)) noted that in Utah they averaged "≈12 cm in length; the longest ones were 20 cm." The numbers of galleries observed by them were not given.

Eggs were laid in an elongated group (Fig. 3), not in niches, in a shallow excavation along only one side of the egg gallery. Wood (1963, fig. 59) shows brood chambers on each side of the gallery, one going up and one down. We saw only one egg clutch, or one brood chamber, per gallery and it was always on the more downward side or inward-curved side. At the times of our field collections, we obtained counts of three complete egg clutches: 55 at Jumping Creek and 55 and 58 at Bannock Pass. Wood (1963) reported that the eggs are deposited in the expanded area in "groups of 20–50 or more." Upon hatching, larvae aggregated along a feeding front (Fig. 4), forming a chamber that expanded as the larvae grew in size. However, each larva created a separate mine in preparation for pupating.

Infestation Characteristics

Trees infested by *D. murrayanae* displayed various symptoms, including physical damage such by lightning or porcupine girdling, suffocation of roots by road-fill, or crowns with thin foliage or reddened foliage. Infested trees were never aggregated. Trees with reddened foliage also were infested by other scolytids: *Pseudips* (=*Ips*) *mexicanus* (Hopkins), *Ips pini* (Say), and *Hylurgops porosus* (LeConte), but rarely by the mountain pine beetle. We are uncertain as to whether or not *D. murrayanae* infested the trees before these other scolytids. In Montana and Idaho, the infested trees occurred above 1,829-m (6,000-feet) elevation, toward the upper elevation limit of lodgepole pine in this region.

Associated Organisms

Broods of *D. murrayanae* were free of parasitic or predacious insects and no commensal insect was observed in egg galleries or brood chambers. However, three scolytids (*H. porosus, P. mexicanus,* and *I. pini*), infested adjacent areas of the stem in several dying trees. The mountain pine beetle was present in two trees containing *D. murrayanae* but was not closely associated with galleries of the latter. In recent years, we began to observe the red turpentine beetle, *Dendroctonus valens* LeConte, infesting the bases of lodgepole pine (e.g., Bannock Pass, ID, in 2006), but we have not yet found it in any tree infested with *D. murrayanae.* The pitch masses at *D. valens* gallery entrances, and its egg galleries, were indistinguishable from those of *D. murrayanae.*

Discussion

Our study has defined or clarified several aspects of the seasonal history and biology of *D. murrayanae.* One annual generation was indicated in the study area, overwintering as larvae. Only one egg clutch occurred per gallery rather than two as reported in Wood (1963, 1982). Also, a subcarinate, line was present on the frons of most adults, a feature not described previously. This beetle was not a primary tree-killer in any instance observed in the field, occurring at low density and only in damaged or dying trees. Furthermore, *D. murrayanae* was found seldom in trees with the common primary tree-killer *D. ponderosae*, the reason for which has not been investigated.

Grissell (1983) listed *D. murrayanae* as a host of *Rhopalicus pulchipennis* (Crawford) (Hymenoptera: Pteromalidae). Throughout our study, however, parasitoids, predators, and commensals were absent in galleries of *D. murrayanae.* The reason for this may relate to blockage of the gallery entrance by an extruded pitch mass and the robust movements of the aggregated larvae. These characteristics would prevent direct entry of insects such as *R. pulchipennis* and would foil a parasite such as *Coeloides dendroctoni* Cushman (Hymenoptera: Braconidae), which oviposits through the bark onto solitary (confined) larvae of *D. ponderosae.*

During recent fieldwork, at Bannock Pass, ID, we observed several lodgepole pine that were infested in their bases with *D. valens.* The pitch tubes and gallery system characteristics were indistinguishable from those of *D. murrayanae.* The causal insect could be identified only by examining the parent adults in the galleries or the dorsal plates on abdominal segments eight and nine of the larvae (Thomas 1965). *D. valens* has been collected rarely from lodgepole pine in the northern Rocky Mountains, and we had not noted it previously in areas where *D. murrayanae* occurs. The reason for this seemingly new behavior is unclear, but it may be an indication of climate change or it may be due to our having searched more intensively as the study neared closure.

Hopkins revised the genus *Dendroctonus* (Hopkins 1909) based on anatomical features of the adults and immatures and on biological features as they were known then. He placed *D. murrayanae* in a group with *D. punctatus* and *D. micans.* Wood (1963) added *D. rufipennis* [=*obesus* (Mannerheim)] to the group primarily on the basis of similarity of adult anatomical features. Thomas' work with larvae and pupae (Thomas 1965) supported Woods' revision. Lanier (1981) determined the karotypes of 14 of the 18 *Dendroctonus* species recognized at the time (*D. micans* was not included; *D. murrayanae* was represented by seven specimens from "Canada: Alberta, 20 miles west of Banff"). His findings supported the validity of the grouping of *D. murrayanae* by Wood and Thomas. Kelley and Farrell (1998) reported a molecular phylogeny of 19 *Dendroctonus* species that generally supports previous groupings but with *D. murrayanae* and *D. rufipennis* on one branch and *D. valens* and *D. terebrans* on another. Our discovery of the subcarinate line on the frons further supports the close relationship of *D. murrayanae* and *D. rufipennis* proposed by Kelley and Farrell.

Acknowledgments

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