Diagnostic protocol for the identification and detection of *Dendroctonus valens* LeConte (Red Turpentine Beetle)

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This version of the National Diagnostic Protocol (NDP) for *Dendroctonus valens* LeConte (Red Turpentine Beetle) is current as at the date contained in the version control box on the front of this document.

NDPs are updated every 5 years or before this time if required (i.e. when new techniques become available).

The most current version of this document is available from the National Plant Biosecurity Diagnostic Network (NPBDN) website: http://plantbiosecuritydiagnostics.net.au/resource-hub/priority-pest-diagnostic-resources/

Cover photograph: J. Bartlett, QPIF DEEDI

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1 INTRODUCTION

Dendroctonus valens LeConte (Coleoptera: Curculionidae: Scolytinae), the red turpentine beetle (RTB) is a bark beetle. Adults and larvae tunnel and feed gregariously in the inner bark and phloem of the host trees. Bark beetles carry fungal spores which germinate in the host. The fungus causes timber staining and tree decline and/or death (Owen *et. al.* 2005).

The genus *Dendroctonus* Erichson includes 19 described species, most of which are native to North and Central America, with two species in Europe and Asia (Wood 1982). All species infest coniferous hosts. In North and Central America *Dendroctonus* beetles are considered to be the most destructive and economically damaging beetles in natural pine forests (Bright 1976; Wood 1963, 1982 and multiple authors). *Dendroctonus valens* is the largest of the 19 described species in the genus.

Dendroctonus valens was introduced into China during the 1980s in green, bark-on logs which were imported from the USA west coast for mine construction (Cognato *et. al.* 2005; Yan *et. al.* 2005). RTB became established in *Pinus tabuliformis,* Chinese pine, in native stands and in plantations, readily adapting to a new host. The first major pest outbreak was reported in 1999. *Dendroctonus valens* is usually a secondary pest in its native area, but in China it is a primary tree killer.

1.1 Appearance

Dendroctonus valens males and females are similar in appearance. Adults are 5.4 mm to 9 mm long, stoutly built and reddish brown in colour (Figure 1). The head is visible from above (Figures 1 and 12d), antennae are geniculate, with a 5 segmented funicle and 3 segmented, expanded club (Figure 12b). The pronotum is rounded, with punctation and without asperites (Figure 12d). Elytra (Figure 12c) have distinct raised striae, and are punctuate-granulate. Pubescence on the head and body is yellowish brown, long, soft and semi-erect. Larvae are C-shaped, legless and mainly white, with a distinct, dark head capsule, small dark patch at the tip of the abdomen and, in older larvae, a line of small darker tubercles laterally on the body.

Figure 1. Dendroctonus valens (Source: http://www.bugwood.org).

1.2 Native Host Range

Dendroctonus valens, unlike most *Dendroctonus* species, has a wide host range. Kelly and Farrell (1998) list more than 30 recorded hosts or potential hosts in the genus *Pinus*, including *Pinus radiata* and *P. taeda*, both grown in Australia. Randall (2006) reports at least 40 hosts in America, in both native and exotic conifers, with *P. ponderosae, P. contorta, P. radiata* and *P. coulteri* the primary hosts in North America. RTB has also been recorded occasionally infesting *Larix*, *Abies*, *Picea* and *Pseudotsuga* species (Pajares and Lanier 1990).

Figure 2*. Dendroctonus valens* damage to *Pinus tabuliformis*, China (Photograph: Donald Owen, California Department of Forestry and Fire Protection, Bugwood.org).

1.3 Effect on host

In North and Central America RTB is considered to be a secondary pest, weakening but not killing trees. The beetles usually infest sick, fire scarred and damaged trees or trees which have been attacked and weakened by primary pests (Smith 1971). *Dendroctonus valens* also infests stumps and fallen logs. RTB has been reported as a primary pest in rare instances, for example killing healthy trees (Bright 1976) and ponderosa pine in plantations in California (Yan *et. al.* 2005). *Dendroctonus valens* is usually found in relatively small numbers in the host, as compared to the mass attacks of *Dendroctonus brevicomis* LeConte (Wood 1963) for example. Once inside the tree, both adults and larvae tunnel in the inner bark and phloem, interfering with the flow of nutrients. Additionally, the beetles introduce various species of fungi which weaken the host trees and interfere with defensive reactions (Randall 2006).

In China RTB is a primary pest and infests and kills healthy trees. The first outbreak occurred in 1999; to date more than 500,000 ha have been infested and 10 million trees killed (Yan *et. al.* 2005; Cognato *et. al.* 2005; Cai *et. al.* 2008).

1.4 Relationship with other organisms

Other beetles*: Dendroctonus valens* is often found colonising the same tree as more aggressive and damaging *Dendroctonus* species, and other bark beetle species (Wood 1982; Owen *et. al.* 2005). In California, *D. valens* is often found infesting the same trees as *Ips paraconfusus* Lanier (Coleoptera: Scolytidae) California fivespined ips, and *D. brevicomis* (Smith 1971; Fettig *et. al.* 2005). *Dendroctonus valens* does not usually kill ponderosa pine, but *D. valens* infestation can predispose the host to attacks by *Dendroctonus ponderosae* Hopkins,

which result in tree death (Owen *et. al.* 2005; Wood 1963). *Dendroctonus ponderosae* (mountain pine beetle) are characterised by the development of solitary larvae that feed extensively in the phloem, leading to eventual death of the tree. In comparison, *D. valens* larvae feed gregariously in the phloem of the base of living trees or in the roots. Symptoms and sampling methodology of *D. ponderosae* is similar to *D. valens* (Figure 3 and 4).

Figure 3. Lodgepole pine (*Pinus contorta*) forest with *D. ponderosae* damage. Area was salvage logged, young trees dying (Photograph J. King, Merritt, British Columbia).

Figure 4. Dying lodgepole pine tree (*Pinus contorta*) with brown crown caused by *Dendroctonus ponderosae* (Photograph J. King, Merritt, British Columbia).

Fungi: Bark beetles carry and transmit symbiotic fungi which change the host's physiology, weakening and/or killing the host and reducing host resistance to beetle attack (Paine *et. al.* 1997). One of the blue stain fungi carried by *D. valens* is *Leptographium terebrantis* Barras and Perry which contributes to the decline of the host and is associated with black stain root disease in ponderosa pine in California (Owen *et. al.* 2005).

2 TAXONOMY

Note: In this report the genus *Dendroctonus* is included in the Scolytinae, a subfamily of Curculionidae, following Lawrence and Britton (1991), Rabaglia (2002) and Alonso-Zaragaza and Lyall (2009). Wood (1963, 1982) and Wood and Bright (1992) regard this taxon as Family Scolytidae which can cause confusion.

Kingdom	Animalia
Phylum	Arthropoda
Class	Insecta
Order	Coleoptera
Superfamily	Curculionoidea
Family	Curculonidae
Subfamily	Scolytinae Tomicini Shuckard, 1840
Genus	*Dendroctonus* Erichson 1836
Species	*Dendroctonus valens* LeConte 1860, 59.

Synonyms

Scolytus terebrans: Harris 1826, 169.

Hylurgus terebrans Harris 1841, 72.

Dendroctonus beckeri Thatcher, 1954

Dendroctonus rhizophagus Thomas and Bright, 1970

3 BIOLOGY

Based on Wood (1963, 1982); Smith (1971); Randall (2006), *Dendroctonus valens* is a bark beetle. Bark beetles in the genus *Dendroctonus* tunnel in the inner bark and phloem/cambium region and feed in the phloem of the host (Wood 1963, 1982).

Dendroctonus valens usually colonises the lower trunk at the root collar and often enters large exposed roots, but infestations can go up to about 2-3 m above ground level (Pajares and Lanier 1990; Randall 2006). Unhealthy and otherwise stressed trees, individually or in groups, fresh stumps and fresh logs are attacked most frequently. Trees of pole size (20+cm DBH) or greater are most susceptible. Occasionally large populations may develop in stumps and trash at logging sites and move into apparently healthy trees. Rappaport et al (2001) report that a combination of thinning and subsoiling was associated with *D. valens* attack.

Dendroctonus valens does not usually initiate attack in large numbers, unlike many other species of *Dendroctonus*.

3.1 Life Cycle

Dendroctonus valens has a wide distribution (see previous information) and its activity patterns and development times vary with climate. In northern, colder parts of its range in the northern hemisphere, generation time is one and sometimes two years. The winter is spent mostly as adults, occasionally as larvae, but very rarely as eggs or pupae. In warmer

southern parts of the northern hemisphere there can be up to three generations per year, with beetles active all year and with overlap of generations.

In the higher latitudes of the northern hemisphere beetles fly from May to October at temperatures around 19-23^{o}C. With increasing temperatures in spring new adults chew out exit holes and emerge to disperse and search for hosts Several adults may emerge through the same exit hole. In the southern areas of the northern hemisphere, in the warmest part of the beetle's range, adults may emerge throughout the year.

Females initiate boring in a suitable host, and are then joined by males. There is usually one pair of adults per gallery but there can be more. Initially the gallery is horizontal but then turns vertically down. A fully developed gallery can be 1 cm to more than 3 cm wide and up to 1m or more in length. Galleries are vertical in the trunk, and the beetles will tunnel down into large upper roots. The tunnelling cuts through resin vessels, and resin and frass are pushed out of the galleries by the beetles, or ooze onto the bark, forming pitch tubes surrounding the entrance hole (Figures 5 and 6), often with frass and pitch pellets on the ground. Pitch tubes of RTB can be up to 50mm in diameter on pines, much larger than the pitch tubes of any other *Dendroctonus* species. After egg laying adults bore out through the bark to reinfest, or die in the gallery.

Eggs are laid in groups along the sides of the galleries, with the areas marked off by 'partitions' of frass and pitch borings (Figure 7). Eggs are ovoid, white and about 1mm long. There can be a few to more than one hundred in the egg mass, which extends up the gallery as a single long patch, or in several groups. Eggs hatch in 1-3 weeks.

Figure 5. Pitch tubes evident on a tree infested with *Dendroctonus valens* (Photograph: Bob Oakes, USDA Forest Service, http://www.bugwood.org).

Figure 6. *Dendroctonus valens* entrance hole on bark and developing pitch tube (Photograph J. King, Queensland Primary Industries and Fisheries, Department of Employment, Economic Development and Innovation, QPIF DEEDI).

Figure 7. *Dendroctonus valens* egg mass in gallery (Photograph Kenneth E. Gibson, USDA Forest Service, http://www.bugwood.org).

Figure 8. *Dendroctonus terebrans* larvae. Almost identical to *D. valens* larvae, note lateral tubercles (Photograph: Gerald J. Lenhard, Louisiana State Univ, http://www.bugwood.org).

Larvae[1] are legless, white and C-shaped with a brown, sclerotised head capsule and a small dark area at the hind end (Figure 8). Later instars develop a row of small dark tubercles laterally on the body. Unlike many other Scolytinae larvae, some *Dendroctonus* larvae

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Note there are limited photographs of *D. valens* larvae available. Some images of specimens labelled as *D. valens* larvae appear to be available on http://www.forestryimages.org, http://www.invasive.org and http://www.ipmimages.org).[1]

possess species-specific features. Among them, *D. valens* has a fused, sclerotized dorsal plate armed with seven sharp projections located on the 8th and 9th abdominal segments (Thomas, 1957).

Larvae feed gregariously in the galleries generally moving in the same direction as the gallery and increasing the length and width of the gallery apex, to a fan-like shape (Figures 9 and 10). Patches of cambium up to 25 cm across are killed by their feeding. There are four larval instars. Larval development time is 6-8 weeks, depending on temperature, and mature larvae are up to 12 mm long.

Pupae Pupation takes place in the galleries. Larvae pupate individually in pupal cells scooped out at the side of the gallery or in fresh inner bark towards the leading edge of the gallery. Pupal development is about 1 week.

Adults emerge from pupa as pale tenerals. After about a week they are mature, with a red-brown integument, and they will then over-winter in the galleries for several months, or, in warm temperatures, emerge from the host after several days and disperse.

Figure 9. Old pitch tubes on bark (left) and formation of galleries, frass and adults (right) (Photograph J. King, QLD Primary Industries and Fisheries, Department of Employment, Economic Development and Innovation, QPIF DEEDI).

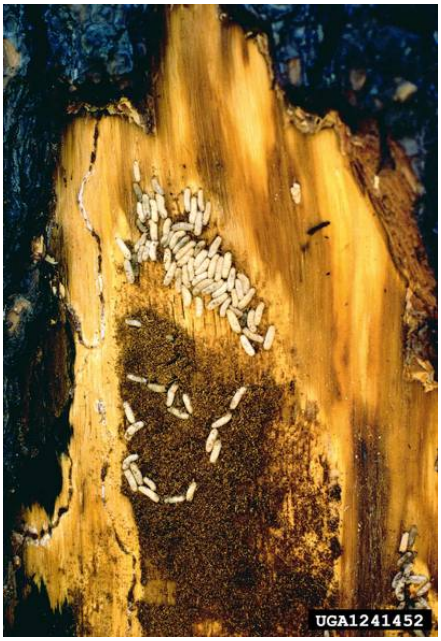


Figure 10. *D. valens* larvae feeding (Photograph Ladd Livingston, Idaho Department of Lands, http://www.bugwood.org

4 MISIDENTIFICATION OF SIMILAR PESTS IN AUSTRALIA

World-wide, there is a large number of woodborer species belonging to Scolytinae and Platypodinae which attack a wide range of pine species. There are a very limited number of woodborers attacking pine species in Australia, however. There is no comprehensive identification key to the world's Scolytinae species so when it is suspected that the damage could be attributed to an exotic species the identifier has to consult a broad range of references. Some of the recommended references are: Cline *et al.* 2009, Freude *et al.,* 1981, Mercado, 2010, Nearns, 2010, Pfeffer, 1995 and Wood, 1982 and 2007. Unfortunately the Australian Scolytinae have not been reviewed recently. The two fairly recent references (Peters *et al.* 1996, and Elliot *et al.,* 1998) deal with the pest species only and neither of them are taxonomic revisions.

The major bark and ambrosia beetles associated with *Pinus* species in Australia (DAFF 2004; Elliott *et. al.* 1998) and their differences to *Dendroctonus valens* are described in Table 1.

Table 1. Bark and ambrosia beetles associated with *Pinus* species in Australia and differences to *Dendroctonus valens.*

Species	**Differences compared to *Dendroctonus valens* mature adults**
Platypus subgranosus Schedl (Platypodinae)	Body shape long, narrow; elytral declivity ornamented; basi tarsus longer than next 3 segments
Amasa truncatus Wood & Bright; several *Xyleborus* species (Scolytinae)	Head not exposed when viewed from above; basal margins of elytra straight, unarmed; significantly smaller
Hylastes ater (Paykull) (Scolytinae)	Antennal funicle 7-segmented; grey to black; length to 5 mm
Hylurgus ligniperda (Fabricius) (Scolytinae)	Black with reddish hair; antennal funicle 6-segmented, club conical; length to 6 mm
Ips grandicollis (Eichoff) (Scolytinae)	Reddish brown; elytral declivity ornamented with spines
Ernobius mollis (Linneus), *Anobium punctatum* (De Geer) (Anobiidae)	Brown; antennae filamentous, without compact club; tarsi with segment 4 clearly visible, not reduced and concealed

Note: All species listed are generally smaller than *D. valens,* which is up to 9 mm long.

5 DETECTION

5.1 Plants, plant products or other articles capable of harbouring the pest

Dendroctonus valens has been recorded from more than 40 *Pinus* spp., including *P. radiata* and *P. taeda,* which are grown in plantations in Australia, and occasionally from *Larix* spp., *Picea* spp. and *Pseudotsuga* spp*.* (Kelley and Farrell 1998; Randall 2006). Kelley and Farrell (1998) suggest RTB is capable of infesting more *Pinus* species than those recorded to date.

5.2 Symptoms on plant hosts

On standing trees:

Pitch tubes form on the lower 2-3 m of the trunk (Figures 5 and 6). Pitch tubes are a mixture of resin exuded by the host in reaction to beetle tunneling and frass produced by the beetles. The mixture is kicked out by the beetle and congeals on the surface of the tree or falls to the ground as pellets. The resin is white to yellow, the frass is reddish-brown with the pitch tube being initially white/to pale pinkish which darkens with age. The length of the pitch tubes can vary with the amount of resin produced by the host, but can reach 50mm. There will also be frass on the bark and pellets of borings (frass and resin mixed) on the ground beneath the tree (Smith 1971; Wood 1982; Randall 2006).

None of the softwood-associated Scolytinae in Australia cause the formation of pitch tubes on the host.

- Yellowing and browning of the tree crowns: this is more likely to be primarily due to environmental factors or other pest beetles rather than *D. valens*.
- Small emergence holes, depending on the age of the infestation.

Under bark:

- Galleries will be present under the bark (Figures 7,9,10), they are relatively wide (20-50mm or more) compared to other bark beetles (Appendix 1) and partially filled with reddish brown frass and borings. Galleries are generally vertical in the tree and range from about 10cm to 1m or more in length, (see life history for further information)
- Beetles, life stage(s) depending on season and location.
- Fungus-caused blue stain, although this can be caused by other species of bark and ambrosia beetles and their associated fungi.

5.3 Articles capable of harbouring the pest.

Softwood timber with bark intact, particularly *Pinus* sp. from infested areas:- any untreated material including: logs, flitches, sawn timber, packaging or dunnage with bark attached. Also decorative items made from softwood with bark attached.

5.4 Association with the host, climatic conditions and seasonality

Dendroctonus valens is most likely found in trees of diameter breast height greater than 20 cm (pole size) to mature to senescent and fallen logs and stumps (Smith 1971; Randall 2006; Lee *et al.* 2008). In warmer climates, with up to 3 generations a year, all life stages may be present. In colder climates, with a 1 or 2 year life cycle, all life stages may be present in the spring/summer while adults or larvae are present in winter.

In northern China beetles tunnel extensively and over-winter in the root system. Yan *et al.* (2005) suggest this offers greater protection from the extreme winter cold, while the tunneling, and the fungi introduced into the roots by the beetles may partly explain the high death rate of trees. In its native range the beetles only tunnel in large upper roots.

5.5 Methods for discovering the pest in the commodity

- Visual: in the field: hand lens, axe, chisel, possibly chain saw; spade etc. for root infestation.
  in the lab: Maggy Lamp, dissecting microscope, chisel/knife for separating bark
- X-ray as used by AQIS
- Mechanical: as above.

5.5.1 Methods for extracting, recovering, and collecting the pest

Insects
Lift bark, examine underside of bark and exposed sapwood for frass, galleries and insects. Lift insects carefully and place in 70% or 100% ethyl alcohol (depending on identification method) in a glass container with appropriate labels. Store securely for identification.

Host
Depending on size, keep the whole item or remove samples; seek advice from AQIS on appropriate fumigation/destruction. Treat samples to disinfest and store labelled samples for reference.

5.5.2 Criteria for the determination of a positive result

Positive result:

Presence of some or all of the following:

- beetles/pupae/larvae
- frass under the bark
- pitch tubes and/or frass on the outer surface of bark (Figures 5 and 6)
- characteristic galleries in lower trunk and/or large upper roots (Figures 7,9,10).

6 IDENTIFICATION

Adult *Dendroctonus valens* can be identified morphologically. There are no complete keys available for the identification of all the known genera and species contained within the subfamily Scolytinae. This protocol is also limited to the accurate separation of *Dendroctonus valens* from the limited insect pests of pines within Australia with which it may be confused.

Proven methods for the reliable identification of RTB using molecular diagnostic tests were not available at the time of writing.

6.1 Morphological Identification

All specimens for identification should be prepared by a person with curatorial experience for entomological specimens as diagnostic characters can be easily damaged.

Materials and Equipment

- Good quality binocular microscope, at least 40x magnification, and microscope light.
- Size 3 entomological pins, entomological forceps, soft crane bill forceps, fine paint brush.
- Card labels, either laser printed or handwritten permanent ink; to include place and date of collection, origin of specimen if intercepted, collector's name, host if known; determination labels.

Adults: card triangles (points) and water soluble glue for mounting.

- Micropins should not be used as they may damage the specimen. Dead, dry specimens should be relaxed before mounting so that all required characters can be displayed; alternatively glass vials and 70% ethyl alcohol.

Immature stages: small glassvials, 70% and 100% ethyl alcohol.

- A pictorial guide to adult identification is provided in Figures 13 - 15.

Method

Adults

Prepare the point by putting it on a pin. Bend the apex of the point down slightly. Place a spot of glue on the tip and mount the beetle so that, viewed dorsally, the tip of the point and glue are between the right fore and mid coxae. Place the label on the pin. After identification place a determination label on the pin. Store the specimens in an entomological storage cabinet or equivalent. Specimens for molecular identification should be placed in 100% ethyl alcohol and preferably stored in a freezer, ideally at – 20^{o}C.
It may be necessary to clean the specimen to allow characters to be clearly seen. Adults can be cleaned with a fine sable brush dipped in 70% ethyl alcohol and allowed to dry before mounting on a point.

Immature stages

Identification of immature stages is extremely difficult. Specimens should be sent to a specialist, preferably for molecular diagnosis.

Specimens of all immature stages for morphological identification and reference should be placed in 70% ethyl alcohol in glass vials, and labelled as for adults.

Adult and immature specimens for molecular identification should be stored in glass vials in 100% ethyl alcohol with appropriate labels.
PaDIL Plant Biosecurity Tool Box - *Dendroctonus frontalis* - includes some characters to identify scolytine larvae to tribe but for more specific information use Thomas, 1957.

Bark and damage samples should be wrapped in plastic film and placed in a deep freeze for 48 hrs, or fumigated. Frozen samples should be allowed to thaw slowly in their wrapping. Samples can then be permanently labelled and stored for reference.

Determined specimens of adult *Dendroctonus valens* are held in the entomology collections of the following organisations:

Queensland Primary Industries and Fisheries, DEEDI, Indooroopilly, Brisbane, QLD

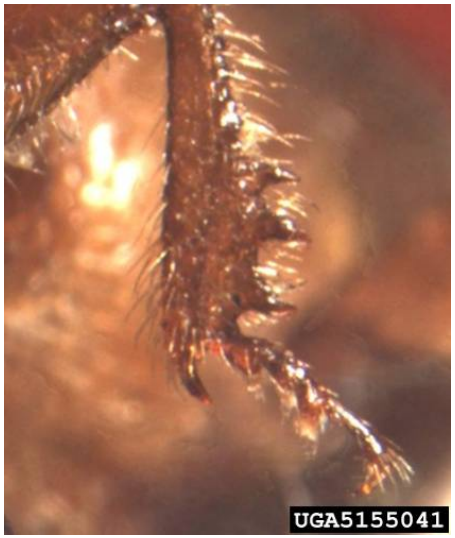
AQIS, Eagle Farm, Brisbane, QLD

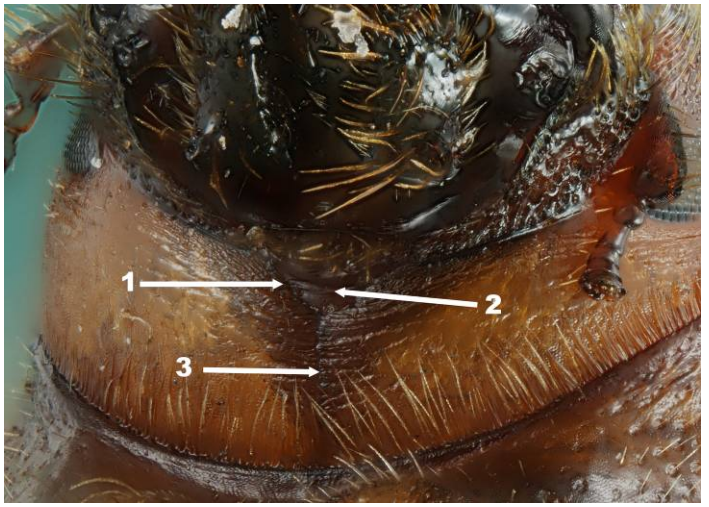
AQIS, Cairns Airport, Cairns, QLD.

Museum of Victoria, Melbourne, Vic.

Photographs of galleries are included in this report.

For a complete list of *Dendroctonus* spp. reference specimens held at Queensland Primary Industries and Fisheries Entomology collection, Brisbane, see Appendix 2.



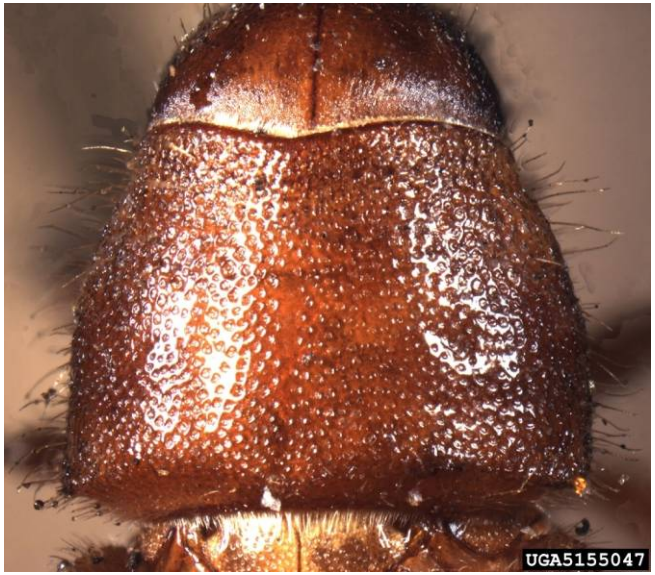


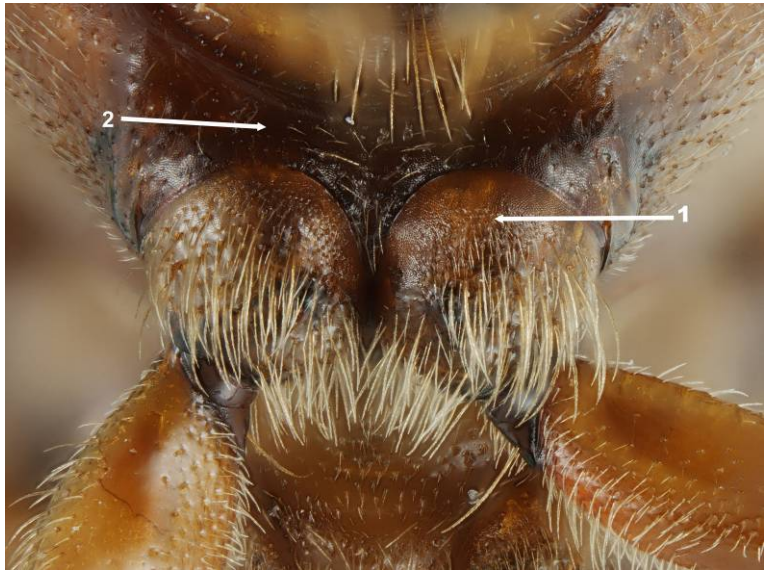
a) Antennae geniculate with compact 3 segmented club 1. 5-segmented funicle 2. Procurved sutures in club *D. valens* antenna, Photograph: Justin Bartlett, QPIF-DEEDI.	**b) Tarsal segmentation** 5-5-5 Tarsomere 4 very reduced, partly concealed by tarsomere 3. Basal tarsomere **not** longer than 2-4 combined. *D. terebrans* tibia and tarsus. Photograph: J.R. Baker & S.B. Bambara, North Carolina State University, http://www.bugwood.org	**c) Rostrum** very short Pregular sutures present on underside of head. 1. Pregular suture 2. Pregular sclerite 3. Gular suture *D. valens* head, ventral Photograph: Justin Bartlett, QPIF-DEEDI.

Figure 11. Characters for recognising subfamily Scolytinae, bark beetles; (a) antennae, (b) tarsal segmentation and (c) rostrum.
(For alternative keys to subfamily and genus see Pest and Disease Image Library (PaDIL): Security Tool Box: *Dendroctonus frontalis*).

a) Head , *D. valens* visible from above; frons with or without median groove (here without median groove); 1) epistomal process well developed. Eyes elongate, not divided, (Photograph: Justin Bartlett, QPIF DEEDI).	**b) Antennae** antennal club symmetrical, 3-segmented flattened; 1). 5-segmented funicle 2). sutures extending across club and obvious, slightly procurved. *D. valens* antenna, (Photograph J. Bartlett, QPIF DEEDI).	**c) Elytra** Basal margin procurved, armed with series of crenulations; basal margin not extended anteriorly; with medial scutellar notch and scutellum visible. *D. valens* elytra (Photograph J.R. Baker & S.B. Bambara, North Carolina State University, http://www.bugwood.org)

Figure 12. Morphological characteristics used for identification of adults of *Dendroctonus* species; (a) head, (b) antennae, (c) elytra and (d) protonum.





d) Pronotum: Rounded, not grooved; anteriorly emarginate; narrower behind anterior margin than basally; with punctures, without asperites or roughening *D. valens* pronotum (Photograph: J.R. Baker & S.B. Bambara, North Carolina State University, http://www.bugwood.org)	**e)** Forecoxae (1) contiguous or very close together Precoxal area (2) of prosternum short, without lateral prosternal ridge *D. valens* procoxae (Photograph J. Bartlett, QPIF DEEDI).
* All tibiae with several small teeth on apical and lateral margins (Figure 11b). Vestiture entirely hairlike, without scales.	

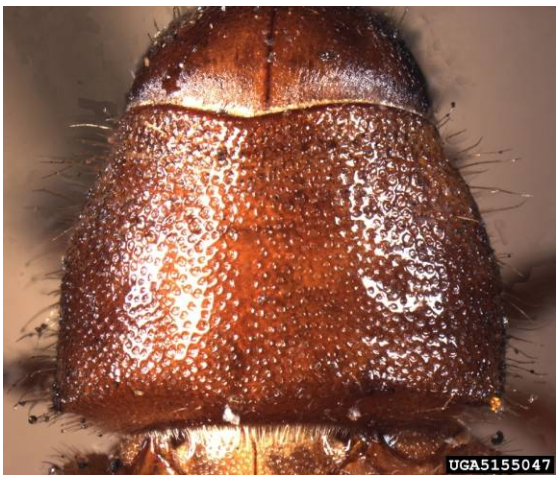
Figure 12 (continued). Morphological characteristics used for identification of adults of *Dendroctonus* species.

a) Large species

Average length 8mm.
Mature adults reddish-brown,
vestiture gold-brown to reddish brown.

b) Frons feebly convex, without a median groove or impression below the upper margin of the eye.

c) Epistomal process (1) prominent, convex medially, lateral margins strongly raised.



d) Elytral declivity with surface shining, interstriae slightly and evenly elevated, with setiferous punctures granulate

e) Pronotum with evenly sized punctures

Figure 13. *Dendroctonus valens* characteristics for identification; (a) insect, (b) frons, (c) epistomal process, (d) elytral declivity and (e) pronotum (Photographs: (a) http://www.bugwood.org; (b,c) J. Bartlett, QPIF DEED and (d,e) J.R. Baker & S.B. Bambara, North Carolina State University, http://www.bugwood.org).

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7.1 Resources

http://www.barkbeetles.org/browse/subject.cfm?SUB=33

Links to images and information leaflets on *Dendroctonus valens* and other *Dendroctonus* species.

http://www.forestpests.org/northeast/southernpinebeetle.html

A field guide to diseases and insect pests of northern and central Rocky Mountain conifers. USDA Forest Service.

http://www.ipm.ucdavis.edu/PMG/PESTNOTES/pn7421.html

General information on bark beetles, notes on *Dendroctonus* species including *D. valens*.

http://www.padil.gov.au/pests-and-diseases/Pest/Main/135644

Images and in formation, useful references and links.

http://www.cabicompendium.org/NamesLists/FC/Full/DENCVA.htm

Forestry Compendium, taxonomy and information.

8 CONTACT POINTS FOR FURTHER INFORMATION

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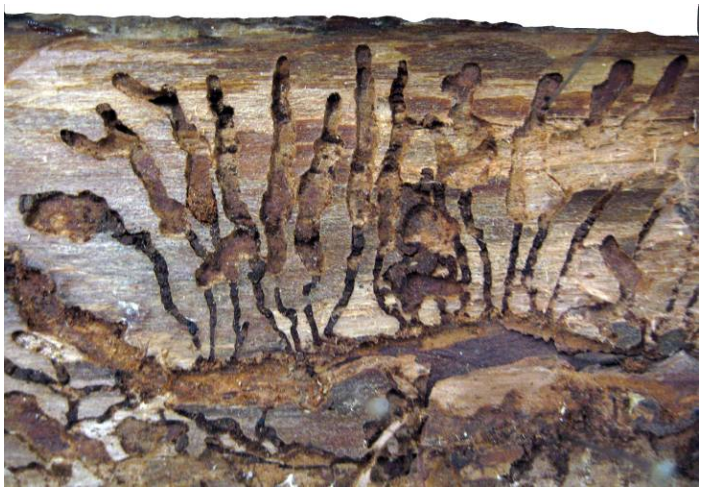
This protocol was peer reviewed and verified by Peter R. Davis on behalf of Davis Consultants.

10 APPENDIX

Figure 14. Comparison of *Dendroctonus* species damage, from samples in the Pacific Forestry Collection (Photographs J. King, Queensland Primary Industries and Fisheries, Department of Employment, Economic Development and Innovation, QPIF DEEDI).

Dendroctonus pseudotsugae

Dendroctonus murrayanae



Dendroctonus simplex

Dendroctonus simplex

Dendroctonus valens

Dendroctonus valens

Dendroctonus punctatus

Dendroctonus ponderosae, a) Inner bark/phloem with extensive galleries and blue stain. Note: galleries differ to *D. valens* which have vertical galleries (sample collected by JK at Merritt, BC).

Figure 15. *Dendroctonus ponderosae* damage in lodge pole pine at Merritt, British Columbia. Picture shows adults and galleries packed with frass (Photographs J. King).

Table 2. Exotic Coleoptera reference specimens added to the Queensland Primary Industries and Fisheries Entomology Collection from the Michigan State University collection and the Pacific Forestry Centre collection.

Species	Number	Source
Cerambycidae		
Xylotrechus longitarsus Casey	3	CFS – Dr Leland Humble
Rhagium inquisitor (L.)	2	CFS
Evodinus monticola (Randall)	2	CFS
Acmaeops proteus (Kirby)	2	CFS
Curculionidae - Scolytinae		
Dendroctonus valens LeConte	8	MSU (6) Dr Anthony Cognato
		CFS (2)
Dendroctonus murrayanae Hopkins	2	CFS
Dendroctonus punctatus LeConte	2	CFS
Dendroctonus ponderosae Hopkins	26	Collected from tree by J. King
Dendroctonus simplex LeConte	2	CFS
Hylastes porculus Erichson	4	MSU
Hylastes nigrinus (Mannerheim)	4	CFS
Ips pini (Say)	6	MSU
Pseudips mexicanus (Hopkins)	2	CFS
Tomicus piniperda (L.)	3	MSU
Dryocoetes autographus (Ratzeburg)	4	MSU
Euwallacea validus Eichhoff	1	MSU
Gnathotrichus materiarus (Fitch)	3	MSU
Gnathotrichus sulcatus (LeConte)	2	CFS
Pityophthorus sp.	2	MSU
Trypodendron domesticum (L.)	2	CFS
Trypodendron lineatum (Olivier)	2	CFS
Xyleborinus alni (Niisima)	2	CFS
Xyleborinus saxeseni (Ratzeburg)	2	CFS
Xyleborus dispar (F.)	2	CFS
Xyleborus pfeilii (Ratzeburg)	2	CFS
Xylosandrus germanus Blandford	3	CFS (2) MSU (1)
Xyloterinus politus (Say)	2	CFS

CFS = Canadian Forest Service; MSU = Michigan State University.

Table 3. *Dendroctonus* species held in QPIF collection, Brisbane, Australia.

Dendroctonus brevicomis LeConte	*Dendroctonus pseudotsugae* (Hopkins)
Dendroctonus frontalis Zimmerman	*Dendroctonus rufipennis* Kirby
Dendroctonus murrayanae Hopkins	*Dendroctonus simplex* LeConte
Dendroctonus ponderosae Hopkins	*Dendroctonus terebrans* (Olivier)
Dendroctonus punctatus LeConte	*Dendroctonus valens* LeConte