

# STRIKING GOLD IN SOUTHERN CALIFORNIA: DISCOVERY OF THE GOLDSPOTTED OAK BORER AND ITS CENTRAL ROLE IN OAK MORTALITY

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Since 2002, aerial survey data have revealed extensive oak mortality on Federal, State, tribal, and private lands in San Diego County, California. About 17,000 coast live oaks (*Quercus agrifolia*), California black oaks (*Q. kelloggii*), and canyon live oaks (*Q. chrysolepis*) have died in a 1,200 km<sup>2</sup> area centered on the Descanso Ranger District of Cleveland National Forest, and Cuyamaca Rancho State Park. Drought was considered the principal cause of this tree mortality for many years, and various pathogens have been suspected but never confirmed. In June 2008, the goldspotted oak borer, *Agrilus coxalis* Waterhouse (Coleoptera: Buprestidae), was identified as the primary cause of this oak mortality. An investigation of the collection history of *A. coxalis* (58 specimens or records from 25 collections) revealed that it was first recorded in the 1880s in Guatemala and southern Mexico, and then later in the early 1900s in southeastern Arizona (Table 1), suggesting that *A. coxalis* is native to Central and North America. It was first collected in southern California in 2004 through Department of Food and Agriculture survey traps. We hypothesize that *A. coxalis* arrived in southern California during the last 10-15 years as a consequence of either a continuous range expansion from adjacent Arizona or Mexico, or an introduction on oak firewood. The latter hypothesis is highly likely because firewood has been imported into southern San Diego County from Mexico for the last 20 years and the oak forests of southeastern Arizona are a relatively short auto trip from the southern California zone of mortality. Because the zone of mortality is isolated by desert to the east and by a band of healthy host type to the south and southeast, we conclude that the hypothesis of continuous range expansion is unlikely.

Ground surveys in 2008 established that the distribution of *A. coxalis* in southern California is contiguous with the zone of tree mortality. Observations documented through these surveys provide the first record of larval habits, host association, damage, and mortality associated with *A. coxalis* (Coleman and Seybold, 2008a, b), and firmly establish that the recent oak mortality in southern California, known colloquially as “oak croak,” can be explained logically and entirely by the feeding activity of this aggressive buprestid beetle. Early symptoms of infestation are dark-colored stains on the bark surface, D-shaped adult exit holes, and thinning crowns. Bark removed by foraging woodpeckers is also a common sign on *Q. agrifolia*. *Agrilus coxalis* attacks oaks aggressively along the main stem and largest branches. No additional insect species are associated with early *A. coxalis* injury. Larval galleries of *A. coxalis* are abundant on the wood surface, patches of cambium are killed, branches die back, and eventually trees die after several years of continuous infestation.

Our preliminary observations in CA suggest that *A. coxalis* tends to prefer *Q. agrifolia* and *Q. kelloggii* (both “red” oaks, subgenus *Erythrobalanus*) more than *Q. chrysolepis* (an intermediate oak species, i.e., neither a red nor a white oak, subgenus *Lepidobalanus*). There have been no observations of injury by *A. coxalis* to Engelmann oak, *Q. engelmannii*, a white oak species that occurs in San Diego Co. During a detection survey in the Huachuca and Santa Rita Mountains of southeastern Arizona (Cochise, Pima, and Santa Cruz Counties), we observed D-shaped exit holes, meandering dark-colored larval galleries on the sapwood, and pupal cells in the outer bark of silverleaf oak, *Q. hypoleucoides* (a thick-barked red oak). Similar

injury symptoms were noted and mature *Agrilus* sp. larvae were collected from the outer bark of a dying Emory oak, *Q. emoryi* (another red oak), at a location in the Santa Rita Mountains (Pima County). We suspect that these two native Arizona *Quercus* spp. are hosts of *A. coxalis*, whereas we found no evidence that the two native Arizona white oaks, Arizona white oak, *Q. arizonica*, and Gray oak, *Q. grisea*, had injury symptoms from *A. coxalis* or any woodboring Buprestidae. We hypothesize that phloem thickness, bark structure, and host chemistry may influence susceptibility to *A. coxalis*. White oaks commonly have fibrous, furrowed bark and thin phloem, whereas red oaks have thick phloem. Additional observations and host susceptibility tests are needed to test this hypothesis. Trapping studies were initiated in 2008 in two stands of *Q. agrifolia* in California to assess trap efficacy and flight periodicity of *A. coxalis*. Lindgren funnel traps (hung at 1.5 m), window traps (1.5 m), and purple prism flight-intercept sticky panel traps (3 m) were assessed for trap efficacy. Traps were baited with a high release rate ethanol attractant. Four traps were assessed for each trap type at each site and monitored weekly. Trap catches were 0 for funnel traps,  $1 \pm 0.4$  for window traps, and  $50.4 \pm 12.4$  for purple prism traps (mean  $\pm$  SE/trap/6 mo). Purple prism traps were significantly more effective at attracting *A. coxalis* than both other trap types ( $F_{2,21}=15.1, P<0.001$ ).

Long-term plots were established in 2008 in stands of *Q. agrifolia* and *Q. kelloggii*/Jeffrey pine (*Pinus jeffreyi*) in California to assess oak susceptibility, forest stand mortality, regeneration, and to gather additional insect life history information. On these plots, 76 percent of the trees were *Quercus* spp., and 67 percent of these *Quercus* spp. had evidence of injury from *A. coxalis*, but no trees <15 cm at breast height had this injury. Oak mortality attributed to *A. coxalis* currently represents 13 percent of the total density of these stands.

The native distributions of the three California hosts of *A. coxalis* extend north through most of the state along the coastal foothills and along the Sierra Nevada Mountains (Fig. 1). The buprestid is currently injuring and killing *Quercus* spp. between 380 to 1830 m in southern California (Fig. 2). Previous collection records in its native region extend to 2,195 m (Table 1). Thus, this new pest to oaks has the potential to impact more northern regions in California. Firewood movement represents a significant pathway for introducing this species into these regions. Future studies will attempt to more clearly define the distribution of *A. coxalis* in southern California with prism flight-intercept sticky panel traps. Additional projects will investigate the potential for oak-specific kairomonal attractants and assess the efficacy of purple and lime-green prism traps at three heights and with three baits. Emergence and management of *A. coxalis* from oak firewood will also be examined.

#### Literature Cited

- Coleman, T.W.; Seybold, S.J. 2008a. **New pest in California: The goldspotted oak borer, *Agrilus coxalis* Waterhouse. Pest Alert R5-RP-022.** Vallejo, CA: U.S. Department of Agriculture, Forest Service, Region 5. 4 p.
- Coleman, T.W.; Seybold, S.J. 2008b. **Previously unrecorded damage to oak, *Quercus* spp., in southern California by the goldspotted oak borer, *Agrilus coxalis* Waterhouse (Coleoptera: Buprestidae).** Pan-Pacific Entomologist. 84: 288–300.

**Table 1. Historical collection records for the goldspotted oak borer, *Agrilus coxalis* Waterhouse (Coleoptera: Buprestidae)**

Date	Locality	Collection	Site Description	Notes/Comments
undated	Juquila, Mexico	BMNH		From Waterhouse (1889); Hespenheide (1979), lectotype
undated	Cordova, Mexico	BMNH		From Waterhouse (1889); Hespenheide (1979), paratype
undated	Capetillo, Guatemala	BMNH		From Waterhouse (1889); Hespenheide (1979), paratype
undated	S. Geronimo, Guatemala	BMNH		
undated	AZ	HESP	Miller Canyon, Huachuca Mts.	From Waterhouse (1889); Hespenheide (1979), paratype
undated	AZ	FMNH	Huachuca Mts.	From Hespenheide
				From J.N. Knull personal collection†; 2 specimens,
				Chas. Schaeffer co-types
VI-16	Cochise Co., AZ	FMNH	Palmerlee, Huachuca Mts.	From J.N. Knull personal collection†, determined by C. Schaeffer
VII-26	AZ	CAS	Santa Rita Mts.	From Chamberlain personal collection†; Also in Fisher (1928)
VII-26	Cochise Co., AZ	CAS	Palmerly	From Chamberlain personal collection†; catalog #231, paratype
VIII-4	Cochise Co., AZ		Rams (Ramsey) Cn., Huachuca Mts.	From Fisher (1928); C. Schaeffer personal collection
VIII-15	Cochise Co., AZ		Palmerlee, Miller Cn., Huachuca Mts.	From Fisher (1928); C. Schaeffer personal collection
IX-14	AZ	FMNH	Chiricahua Mts.	From J.N. Knull personal collection†
VIII-2-1905	AZ	AMNH	Huachuca Mts.	“R.C.”
VIII-4-1905	Cochise Co., AZ	USNM	Palmerlee, Miller Cn., Huachuca Mts.	From C. Schaeffer personal collection, 3 specimens, including 1 cotype†; Also in Schaeffer (1905), beating black oak branches <sup>s</sup>
VIII-10-1908	AZ	CAS	Chiricahua Mts.	From Van Dyke personal collection†
III-21-1939	Tamaulipas, Mexico	FMNH	Santa Engracia	From J.N. Knull personal collection†
VIII-15-1940	Pima Co., AZ	CAS	Madera Cn. Foothills, Santa Rita Mts.	Donated 1962†
VII-12-1950	AZ	FMNH	Huachuca Mts.	From J.N. Knull personal collection†, 3 specimens, including 1 collected on VII-19-1950
VII-15-1953	AZ	FMNH	Chiricahua Mts.	From J.N. Knull personal collection†, 2 specimens
VII-5-1956	Chiapas, Mexico	EMEC	5 mi SE San Cristobal de las Casas	From GHNC
VII-5-1956	Chiapas, Mexico	FSCA	5 mi SE San Cristobal de las Casas	From Hespenheide
VII-17-1957	AZ	FMNH	Chiricahua Mts.	From J.N. Knull personal collection†, 4 specimens
VI-17-1963	Santa Cruz Co., AZ	CIDA	Santa Rita Mountains, Madera Canyon, 1706 m	†
VII-24-1965	Pima Co., AZ	UAIC	Upper Bear Canyon, Santa Catalina Mts.	
VII-13-1965	Chiapas, Mexico	GHNC	2 mi NW Pueblo Nuevo, LLU Bio. Station	
V-11-12-1969	Chiapas, Mexico	CMNC	10 mi E Teopisca	From Hespenheide
V-11-12-1969	Chiapas, Mexico	HESP	10 mi E Teopisca	From Hespenheide
V-14-1969	Chiapas, Mexico	CMNC	16 mi E Teopisca	From Hespenheide
V-17-1969	Chiapas, Mexico	CMNC	8 mi NE San Cristobal de las Casas	From Hespenheide
V-26-1969	Chiapas, Mexico	CNCI	4 mi SE San Cristobal	From Hespenheide
VI-8-1969	Chiapas, Mexico	CNCI	3 mi NE San Cristobal	From Hespenheide
V-30-1969	Chiapas, Mexico	CNCI	Laguna Montebello Parq. Nat., 1524 m elev.	From Hespenheide
VI-5-1974	Chiapas, Mexico	CLBC	7 mi SE Teopisca	From Hespenheide
VIII-30-31-1977	Baja California Sur,	RLWE	Sa. Victoria, Sierra de La Laguna, trail W of La Laguna, 1830 m elev.	Beating <i>Quercus</i> sp.; Also in Westcott (2005)

VII-19-1981	Veracruz, Mexico	EMEC	Jalapa, Veracruz	
V-25-1987	Chiapas, Mexico	CLBC	11 km NE San Cristobal d. I. Casas	From Hespenheide
IX-28-1989	Chiapas, Mexico	CSCA	10 km E San Cristobal de las Casas	From Hespenheide
IX-1-1990	Chiapas, Mexico	HESP	16 km SO Ocosingo	From Hespenheide
VI-20-1990	Chiapas, Mexico	RHTC	30 km W Comitán	From Hespenheide
VII-25-30-1990	Chiapas, Mexico	TAMU	Municipio San Cristobal San Felipe, 2194 m elev.	Malaise Trap, From Hespenheide
VI-21-1990	Chiapas, Mexico	FSCA	Laguna Montebello Parq. Nat., 1524 m elev.	From Hespenheide
V-24-1991	Baja Vera Paz, Guatemala	CMNC	7.8 km W Chilasco, 1700 m elev.	From Hespenheide
V-10-1994	Tamaulipas, Mexico	USNM	10 m E Tula, 1189 m elev.	Oak Forest; J.E. Wappes
VII-5-2001	Oaxaca, Mexico	RLWE	10 km E Mitla, 1890 m elev.	Beating oak
VII-16-30-2004	San Diego Co., CA	CSCA	Paco Picacho Campground, Cuyamaca State Park	Also in Westcott (2005), 2 specimens
VI-18-2004	San Diego Co., CA	CSCA	Chamber Park, Cuyamaca State Park	Also in Westcott (2005)
VII-24-2006	San Diego Co., CA	CSCA	Julian, 4945 Heist Park Road	Funnel trap catch with exotic Ips lure
VI-27-2008	San Diego Co., CA	CAS	Noble Canyon Trailhead, Cleveland NF	Purple flight intercept traps near <i>Quercus agrifolia</i>
	No holdings	BPBM		Surveyed March 2009
	No holdings	BYU		Surveyed March 2009
	No holdings	LACM		Surveyed Dec. 2008
	No holdings	SBNM		Surveyed Jan. 2009
	No holdings	SDMC		Surveyed Dec. 2008
	No holdings	UCDC		Surveyed Nov. 2008
	No holdings	UCR		Surveyed Dec. 2008

#### Museum acronyms (all in the United States unless otherwise indicated)

AMNH—American Museum of Natural History, New York, NY  
 BMNH—The Natural History Museum, London, UK  
 BPBM—Bernice P. Bishop Museum, Honolulu, HI  
 BYU—Provo, Brigham Young Univ., Monte Bean Life Science Museum, Provo, UT  
 CAS—California Academy of Sciences, San Francisco, CA  
 CIDA—College of Idaho, Orma J. Smith Museum of Natural History, Caldwell, ID  
 CLBC—Charles L. Bellamy—affiliated with CSCA  
 CMNC—Canadian Museum of Nature, Ottawa, Ontario, Canada  
 CNCI=CNC—Canadian National Collection of Insects, Ottawa, Ontario, Canada  
 CSCA—California State Collection of Arthropods, Sacramento, CA  
 EMEC—University of California, Essig Museum of Entomology, Berkeley, CA  
 FMNH—Field Museum of Natural History, Chicago, IL  
 FSCA—Florida State Collection of Arthropods, Gainesville, FL  
 HESP—Henry A. Hespenheide, personal collection, Los Angeles, CA  
 LACM—Los Angeles County Museum of Natural History, Los Angeles, CA  
 MCZ—Museum of Comparative Zoology, Harvard University, Cambridge, MA  
 RHTC—Robert H. Turnbow, personal collection  
 RLWE—Richard L. Westcott, personal collection  
 SBNM—Santa Barbara Museum of Natural History, Santa Barbara, CA  
 SDMC—San Diego Natural History Museum, San Diego, CA  
 TAMU—Texas A & M University, College Station, TX  
 UAIC—University of Arizona Insect Collection, Tucson, AZ  
 UCDC—University of California, The Bohart Museum of Entomology, Davis, CA  
 UCR—University of California Riverside, Riverside, CA  
 USNM—National Museum of Natural History, Washington, DC

†These specimens were accessioned under the previous synonym, *Agrilus auroguttatus*. §Another specimen from this series is accessioned in the MCZ.

#### References

- Fisher, W.S. 1928. **A revision of the North American species of buprestid beetles belonging to the genus *Agrilus***. Bulletin 145. Washington, DC: Smithsonian Institution, United States National Museum. 347 p
- Hespenheide, H.A. 1979. **Nomenclature notes on the *Agritinae* (Buprestidae)** IV. Coleopterists Bulletin. 33:105–120.
- Schaeffer, C. 1905. **Some additional new genera and species of Coleoptera found within the limit of the United States**. Museum of the Brooklyn Institute of Arts and Sciences Science Bulletin. 1(7): 141–179.
- Waterhouse, C.O. 1889. **Insecta. Coleoptera. Serricornia. 62. *Agrilus coxalis*** Biologia Centrali-Americana. Vol. III, Pt. 1: 89.
- Westcott, R.L. 2005. **A new species of *Chrysobothris eschscholtz* from Oregon and Washington, with notes on other Buprestidae (Coleoptera) occurring in the United States and Canada**. Zootaxa. 1044: 1–15.



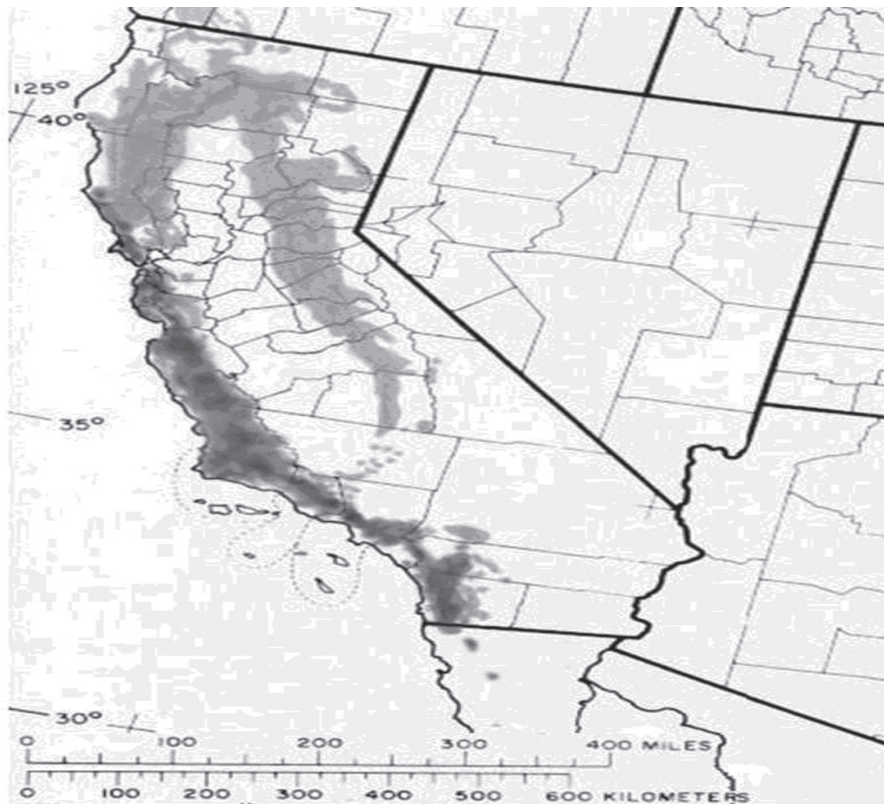


Figure 1. Native distribution of coast live oak (*Quercus agrifolia*) (dark grey) and California black oak (*Q. kelloggii*) (light grey) in California, both are confirmed hosts of the goldspotted oak borer (*Agrilus coxalis*).

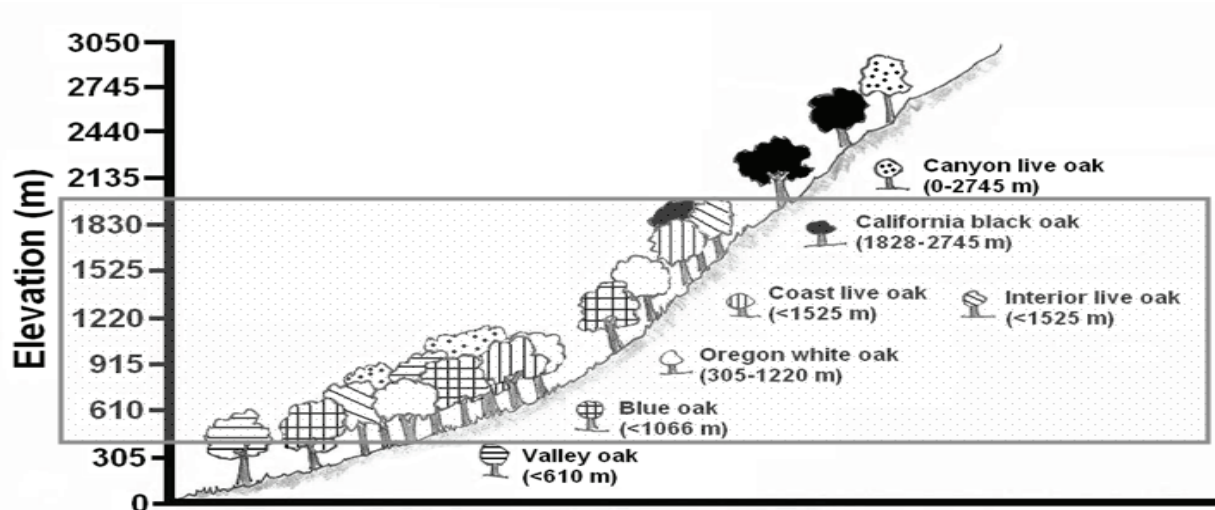


Figure 2. Elevational range of native oaks (*Quercus* spp.) and current distribution of goldspotted oak borer (*Agrilus coxalis*)—caused mortality observed in California (shaded area).