

## The loneliest number: small sample sizes result in taxonomic changes in *Okanagana* (Hemiptera: Auchenorrhyncha: Cicadidae: Tibicininae)

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### Abstract

The genus *Okanagana* has several outstanding taxonomic issues which stem largely from the poor descriptions and small type series commonly used in the early 20<sup>th</sup> century. Here we address two known issues; relegating a former species to a junior subjective synonym and resurrecting a previously synonymized species. *Okanagana napa* Davis, 1919 was described from a single specimen but using morphology and other lines of evidence we identify it as conspecific with *O. arboraria* Wymore, 1934 **n. syn.** making the latter a junior subjective synonym. *Okanagana albibasalis* **stat. rev.** was improperly synonymized with *O. canescens* Van Duzee, 1915 and is revised to full species status based on their differing morphologies. We also provide corrections to the phylogenetic hypothesis in Cole *et al.* (2023) that result from these taxonomic acts.

**Key words:** Cicadas, Taxonomy, California

### Introduction

The genus *Okanagana* Distant, 1905 is the most speciose in North America, comprising 46 species with 33 described between 1900 and 1940 (Cole *et al.* 2023; Sanborn & Heath 2017; Smeds & Chatfield-Taylor 2025). Here we focus on two unresolved taxonomic issues: the improper synonymy by Bliven (1964) of *O. albibasalis* Wymore, 1934 as a junior synonym of *O. canescens* Van Duzee, 1915 and a proposed synonymy of *O. arboraria* Wymore, 1934 as a junior synonym of *O. napa* Davis, 1919. In both cases problems stem from one or more of the following issues: pigmentation variation, poor descriptions, and small type series (2 for *O. canescens* and 1 for *O. napa*) (Bliven 1964; Davis 1919; Sanborn & Heath 2017; Simons 1953; Van Duzee 1915).

*Okanagana napa* was described from a single strangely pigmented male specimen collected from California in “Napa County” (Davis 1919; Sanborn & Heath 2017). Davis later identified six specimens from Washington, Idaho and California, the last collected in 1931, none of which were collected near the type location (GBIF; Sanborn & Phillips 2013; Simons 1954). The lack of modern specimens and their irregular distribution (GBIF; Sanborn & Phillips 2013) calls into question whether the species is valid or is rather a pigment variation of another species as was *O. lurida* Davis, 1919, which is now a junior synonym of *O. occidentalis* (Walker in Lord, 1866) (Cole *et al.* 2023). In this paper we make *O. arboraria* **n. syn.** a junior subjective synonym of *O. napa*.

*O. albibasalis* was synonymized with *O. canescens* by Bliven in 1964 based on an argument regarding the color of the species’ basal wing membranes. In its description, white wing membranes diagnosed *O. albibasalis* from *O. canescens* with bright orange membranes (Wymore 1934). The original description of *O. canescens* does not mention the membrane color (Van Duzee 1915) but they are bright orange on both type specimens (WCT, *pers. obs.*). Davis’s 1919 revision introduced confusion as *O. canescens* keyed out using a white basal membrane (Davis 1919). The lack of the specific mention of an orange membrane in the original description of *O. canescens*, combined with the white membrane character state in Davis (1919), led Bliven to decide that this character of *O.*

*canescens* was misstated by Wymore and that *O. albibasalis* was a junior synonym of *O. canescens* (Bliven 1964; Davis 1919; Van Duzee 1915; Wymore 1934). This is in despite of a clear morphological diagnosis of the two species given by Wymore and Bliven providing no further evidence (Bliven 1964; Wymore 1934). Here we reverse this synonymy and reinstate *O. albibasalis* **stat. rev.** as a full species.

## Methods

Specimens were examined by the lead author from the CNC (Canadian National Insect Collection of Insects, Arachnids and Nematodes), SEMC (Snow Entomological Museum), the USNM (Smithsonian Institution), and from his personal collection. When direct examination of specimens wasn't possible, the available type specimens or paratypes were imaged for the use of the lead author. Unless otherwise noted all specimen imaging was done by the co-author at the CASC (California Academy of Science). Additional photos were examined from iNaturalist ([www. iNaturalist.org](http://www.iNaturalist.org)), those taken at SEMC by the lead author, and images of the holotype of *O. napa* taken by Joel Kits at the CNC. Morphological terminology is based on Moulds (2005) and the taxonomy from Cole *et al.* (2023). Record data were obtained in part from GBIF (GBIF.org accessed 31 October 2025, GBIF occurrence download at <https://doi.org/10.15468/dl.f9jygd>).

## Results

### New Synonymy

#### *Okanagana napa* Davis, 1919

*Okanagana napa* – Davis, 1919: 194.

*Okanagana arboraria* – Wymore, 1934: 166. **n. syn.**

**Type Locality:** Holotype: Napa County, California. Deposited at the USNM.

Type Locality of *Okanagana arboraria*: Holotype: Courtland, Sacramento County, California, USA. 5 September 1928. Deposited at CASC. (Sanborn & Heath 2017).

**Abbreviated Description of Holotype** (Fig. 1): *Head*: Postclypeus not pronounced with anterior border broadly orange, not distinctly sulcate. Epicranial suture yellow, incised. Vertex bilaterally marked with orange. Eyes protruding distinctly beyond width of head. Supra-antennal plates orange. Width of head less than anterior border of pronotum.

*Thorax*: Pronotum with apical pronotal margin orange, raised. Pronotal collar broad, distinctly raised and sinuate towards midline. Lateral margins strongly constricted apically. Pronotal margins yellow. Anterior angle of pronotum and lateral angles of pronotal collar rounded. Paramedian and lateral fissure broadly covered bilaterally with dull orange. Mesonotum shining black with orange markings as follows: broad, dull stripe at base of lateral margin; line along parapsidal suture terminates in broad, crescent-shaped marking; posterior-anterior line connects crescent-shaped marking to broadly triangular spots anterior to cruciform elevation; the connecting line radiates fine orange streaks; cruciform elevation and lateral depressions orange. Orange metanotum visible.

*Wings*: Hyaline with pale orange basal membrane. Forewings with 8 apical cells, hindwings with 6. Venation straw-colored. Basal cell of forewings clear. Fore and hind wing membrane orange.

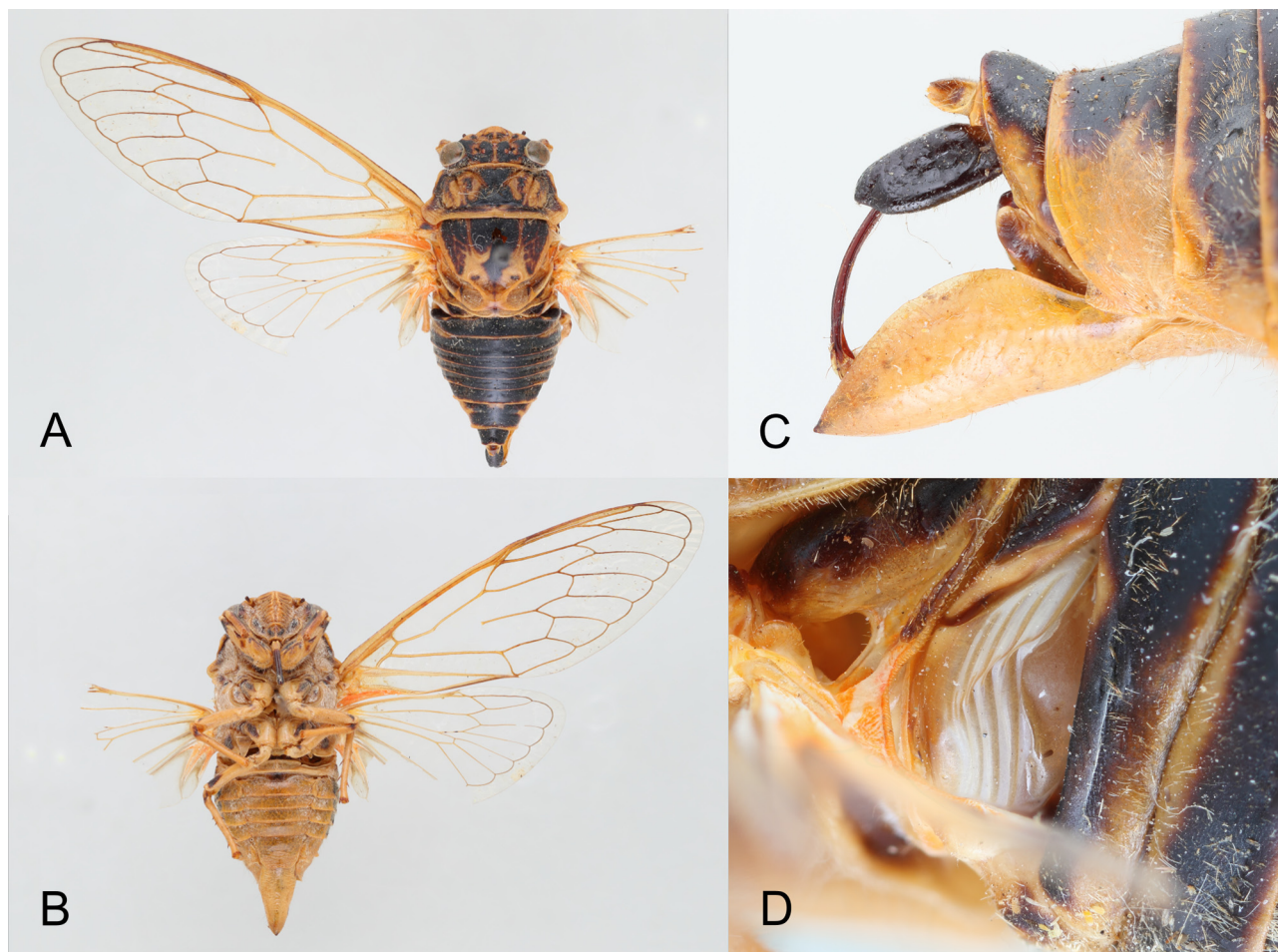
*Legs*: Largely orange. Base and apex of tibia and femur marked with black. Coxae orange marked with black. Metatibia with multiple spines.

*Abdomen*: Tergum shining black. Timbals with 5 long timbal ribs (Fig. 1D). Tergites narrowly bordered orange on posterior margin. Anterior and posterior lateral margin of t3 bordered orange forming broader stripe with t2. Abdominal segments t2 to t7 compact. Elongated t8 + pygofer forming tapered tip creating an overall spindle-shaped aspect to the abdomen (Fig. 1A). Sternites yellow, stVII concave at tip. Venter and tergites with only few short hairs.

*Male Terminalia*: Uncus with dorsal-ventral surfaces subparallel in the lateral aspect. Ventral surface with a slight apical curve forming a small tooth. Tip of the uncus with a distinct lobe in the dorsal aspect. Valve (stVIII)

length twice height measured from base. Dorsal surface with gradual curve. Uncus approximately  $\frac{1}{2}$  the length of valve (Fig. 1C).

*Size:* Length of body 24 mm; Width of head across eyes 7.5 mm; Expanse of fore wings 58 mm; Length of valve 4.5 mm (Davis 1919).



**FIGURE 1.** Holotype of *Okanagana napa*: A. dorsal habitus, B. ventral habitus, C. male genitalia, left lateral view, D. timbal.

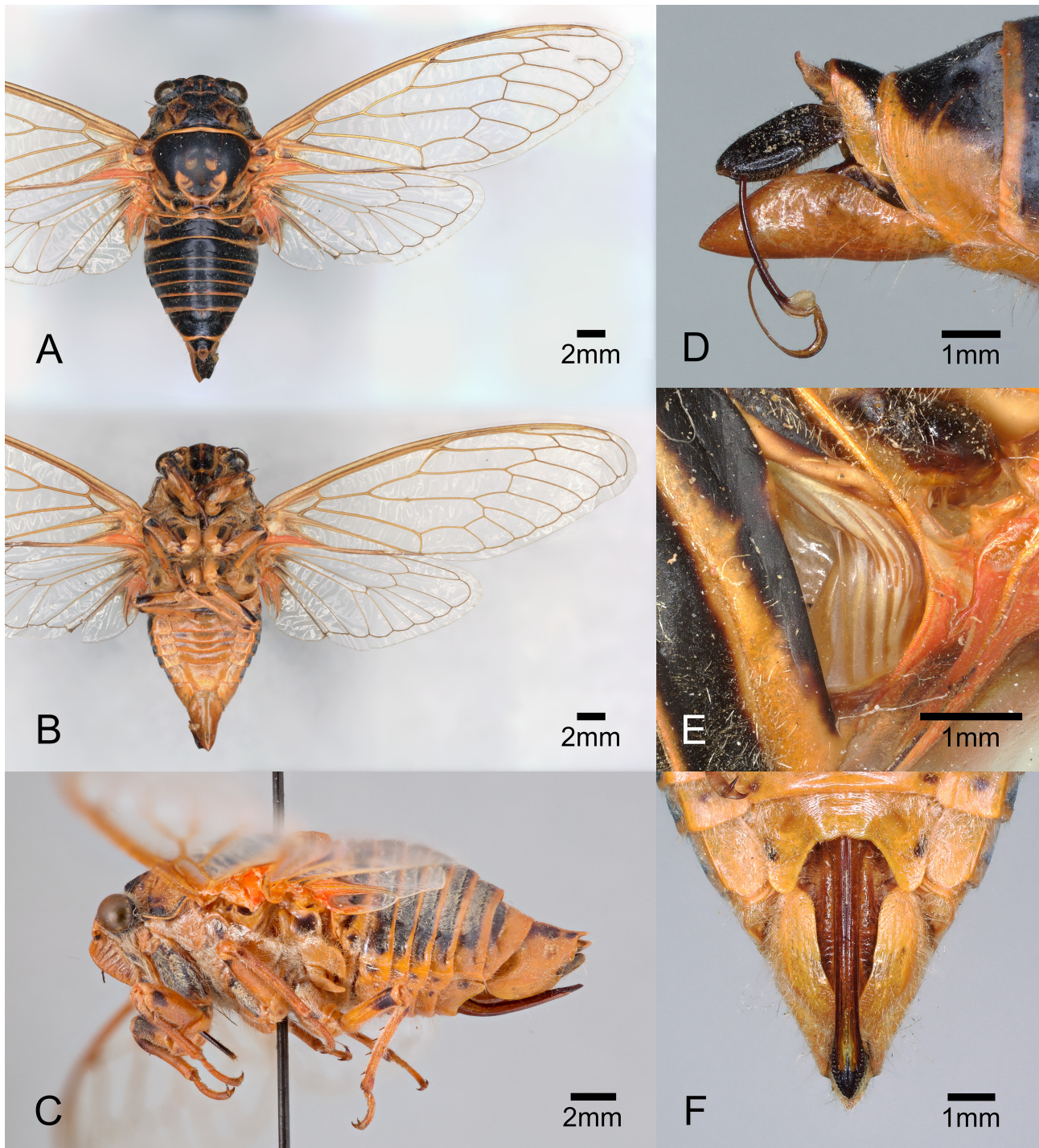
### Rationale for new synonym.

There are a limited number of species with which *O. napa* could be a synonym. The holotype of *O. napa* has 5 long timbal ribs, a feature shared with only 4 other described species: *O. arboraria*, *O. canescens*, *O. magnifica* Davis, 1919, and *O. monochroma* Smeds & Chatfield-Taylor, 2025. *Okanagana canescens* is a strongly pubescent species, the eyes do not distinctly extend past the width of the head, the body is elongate, with t2 to t7 not compact and t8 + pygidium not forming a tapered tip (Davis 1919; Van Duzee 1915; WCT., pers. obs). *Okanagana magnifica* is larger in length; 35 mm vs. 24 mm in *O. napa*, with hairy pubescence, no pale border on the pronotal collar, and wings with infuscated dark apical cells (Davis 1919). The recently described *O. monochroma* is larger, with a body length of 26.4 mm vs. 24 mm and wingspan of 69.9 mm vs. 58 mm. They are entirely black and white, with white basal wing membranes and eyes that do not protrude distinctly past the width of the head (Davis 1919; Smeds & Chatfield-Taylor 2025).

Based on comparisons of their morphology using multiple sources *Okanagana arboraria* (Fig. 2) is identical to *O. napa*. The holotypes are approximately equal in size: with body length 23 mm in *O. arboraria* vs. 24 mm in *O. napa*, width across head 7 mm vs. 7.5 mm, expanse of forewing 64 mm vs. 58 mm, and valve length 5 mm vs. 4.5 mm (Davis 1919; Wymore 1934). The two species share the same diagnostic features as follows. The eyes protrude past the width of the head. The lateral margins of the pronotum are strongly apically constricted with the hind margin bright yellow, broad, and sinuate towards the midline. The abdomen is spindle-shaped with segments



t2 to t7 compact and t8 + pygofer elongated to form a tapered tip. The uncus of *O. arboraria* is also dorso-ventrally subparallel in the lateral aspect with a slight apical curve to the ventral surface forming a small tooth (Fig. 2D.). The tip of the uncus has a distinct lobe when viewed dorsally as in *O. napa*. The valve of *O. arboraria* (stVIII) is structurally the same as *O. napa* (Davis 1919; Wymore 1934; WCT, pers. obs.).



**FIGURE 2.** Holotype of *Okanagana arboraria* n. syn.: A. dorsal habitus, B. ventral habitus, C. female in lateral aspect, D. male genitalia, left lateral view, E. timbal, F. female genitalia.

In his description of *O. napa*, Davis focused on its color pattern, highlighting the extensive dull orange markings on the pronotum and mesonotum, straw-colored wings, and orange venter (Davis 1919). The pigmentation of the holotype is within the range of variation seen in *O. arboraria* which range from dull individuals with little red on the pronotum and mesonotum to the entirely red phenotype formerly known as *O. arboraria* var. *crocea* Wymore, 1934



(Fig. 3C) (Simons 1953; Wymore 1934). The extensive patterning in the mesonotum and pronotum of the holotype of *O. napa* in combination with the pale wing venation is also similar to the pigmentation in some “*lurida*” forms of *O. occidentalis*, the variability of which wasn’t fully known to Davis for many years after he described it in the same paper as *O. napa* (Davis 1919, 1926, 1939). The similarity of some “*lurida*” specimens to *O. napa* likely caused Davis to misidentify several “*lurida*” from Idaho and Washington as *O. napa* (Sanborn & Phillips 2013; WCT, *pers. obs.*).

The individuals of *O. napa* determined by Davis that the lead author has examined from photos or specimens have all been of other species. The only other California record is of an individual from Mendocino County that appears to be an undescribed species near *O. tristis* Van Duzee, 1915 which has a rare but known mutation (GBIF; Simons 1954; WCT, *pers. obs.*). A specimen from Moscow, Idaho held at SEMC was examined by the lead author and determined to be the “*lurida*” form of *O. occidentalis* based on the number of timbal ribs, terminalia and comparison to the other “*lurida*” specimens in the collection. We believe these subsequent misidentifications by Davis led to the species’ range being improperly represented in the literature, further complicating efforts to determine its species status (Cole *et al.* 2023; Sanborn & Heath 2017; Sanborn & Phillips 2013; Simons 1954).

The holotype of *O. napa* was collected by J.J. Rivers sometime prior to his death in 1913 with only “Napa County” given for its locality (Davis 1919; Sanborn & Heath 2017; Sanborn & Phillips 2013). *Okanagana napa* was described 6 years after Rivers’ death from a specimen at the “U.S. National Museum” and its collection date could range back to the late 19<sup>th</sup> century (Davis 1919). The age of the specimen and the vagueness of the locality data are significant because prior to the early 1900’s, the borders of Napa County were poorly defined and in continuous flux (Coy 1923). It would not be unusual for a specimen labeled from Napa County during this time to have come from the adjacent Yolo or Solano Counties where *O. arboraria* is found (Coy 1923; GBIF; Sanborn & Phillips 2013; Wymore 1934). Due to the morphological similarities between *O. napa* and *O. arboraria*, the type location relative to the range of *O. arboraria* **n. syn.** and lack of other correctly identified individuals we submit that there is sufficient evidence to make *O. arboraria* a **new junior subjective synonym** of *O. napa*. For a detailed description of *O. napa* as *O. arboraria* see Wymore (1934).

## Re-description of *Okanagana napa* Davis, 1919

**Head:** Postclypeus variably pronounced. Epicranial suture yellow, incised. Vertex black. Some bilaterally marked with orange. Eyes protruding distinctly beyond width of head. Supra-antennal plates with some orange. Width of head less than anterior border of pronotum.

**Thorax:** Pronotum with apical pronotal margin orange, raised. Pronotal collar broad, distinctly raised and sinuate towards midline. Lateral margins strongly constricted apically. Pronotal margins yellow. Anterior angle of pronotum well defined. Lateral angles of pronotal collar rounded. Paramedian and lateral fissure covered bilaterally with dull orange of varying extent. Mesonotum shining black with orange markings as follows: dull stripe at base of lateral margin; two orange markings centered on scutal depression with two more anterior forming a trapezoidal pattern. Extent of these marks highly variable. Cruciform elevation orange, connecting to scutal depression marks. Hind margin on mesonotum orange. Metanotum visible, black bordered with orange.

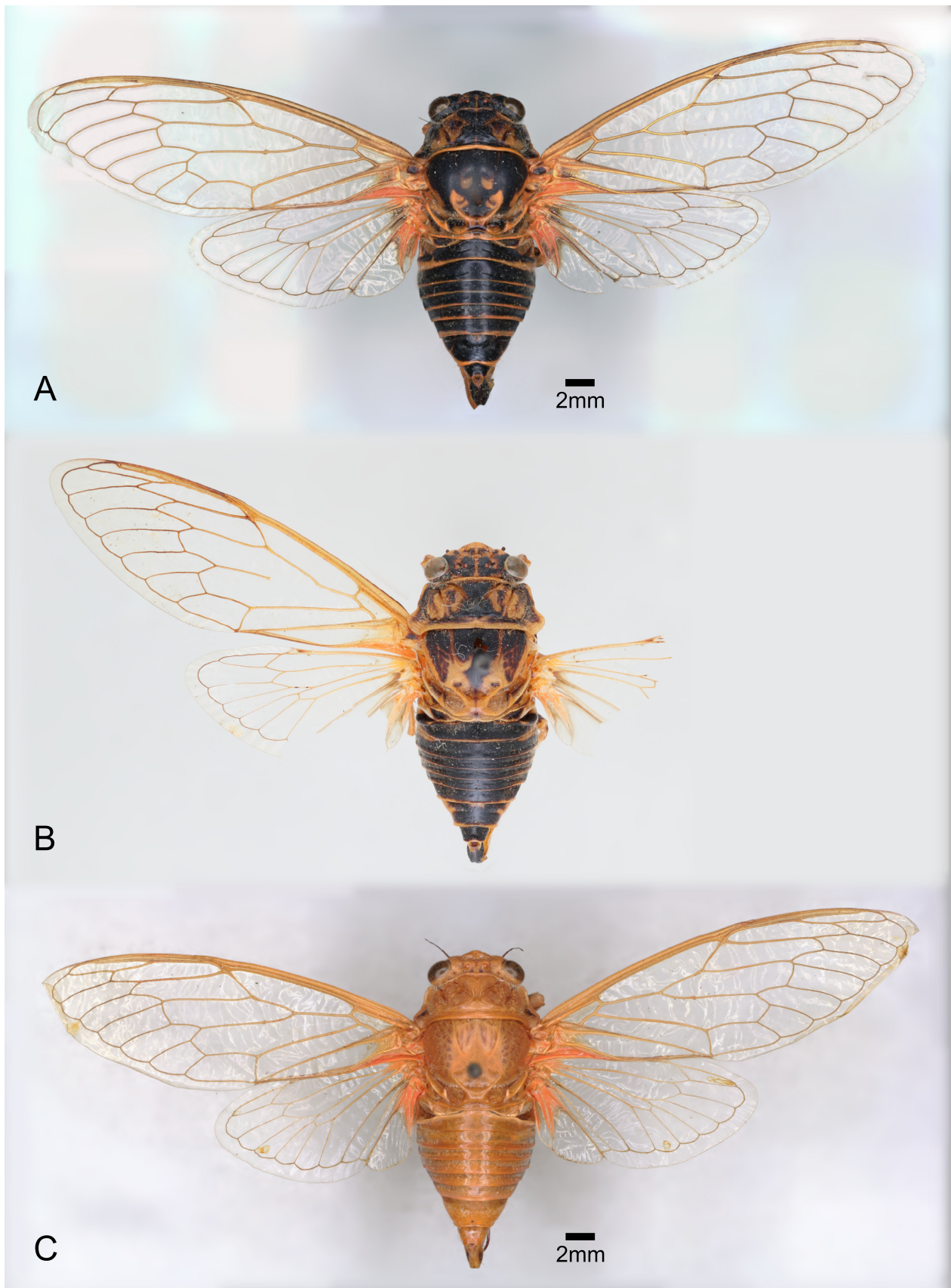
**Wings:** Hyaline with orange basal membrane on fore and hind-wing. Forewings with 8 apical cells, hindwings with 6. Venation straw-colored, darkening towards apical cells.

**Legs:** Largely orange. Base and apex of tibia and femur variably marked with black. Coxae orange marked with black. Metatibia with multiple spines.

**Abdomen:** Tergum shining black. Timbals with 5 long timbal ribs (Fig. 1D). Tergites bordered orange on posterior margin to varying extent with slight golden pubescence. Abdominal segments t2 to t7 compact. Elongated t8 + pygofer forming tapered tip creating an overall spindle-shaped aspect to the abdomen (Fig. 2A). Sternites yellow, stVII concave at tip. Venter with only few short hairs.

**Male Terminalia:** Uncus with dorsal-ventral surfaces subparallel in the lateral aspect. Ventral surface with a slight apical curve forming a small tooth. Tip of the uncus with a distinct lobe in the dorsal aspect. Valve (stVIII) length twice height measured from base. Dorsal surface with gradual curve. Uncus approximately ½ the length of valve (Fig. 1C).

**Female Terminalia:** stVII with notch forming a trapezoidal shape with distinct angles at the apical margin. Secondary notch shallow and broad. Sides of stVII tapering to thin rounded tips (Fig. 2F).



**FIGURE 3.** Comparison of the phenotypic gradient in *Okanagana napa*: A. Holotype of *Okanagana arboraria* **n. syn.** representing the most common phenotype, B. Holotype of *Okanagana napa* representing an intermediate phenotype, C. Holotype of the “variety *crocea*” color form of *O. arboraria* **n. syn.** synonymized by Simons (1953) which is the most extreme expression in pigmentation.



**Size:** Holotype: Length of body 24 mm; Width of head across eyes 7.5 mm; Expanse of fore wings 58 mm; Length of valve 4.5 mm (Davis 1919). From Wymore (1934): Length of uncus in holotype of *O. arboraria* **n. syn.** 2.5 mm; Expanse of forewing in allotype 66 mm.

**Note:** The description provided above pertains to the most common phenotype of *Okanagana napa* which accounts for the majority of specimens (Fig. 3A). However, the species has a wide degree of intraspecific phenotypic variation. The former “*crocea*” variety of *O. arboraria* **n. syn.** described by Wymore (1934) and synonymized by Simons (1953) is entirely red to pale pink (Fig. 3C). Between these two there is a full gradient: the holotype of *O. napa* is characteristic of an intermediate form: with pigmentation more extensive in those areas than it is normally found (Fig. 3B).

## New Revision of Status

### *Okanagana albibasalis* Wymore, 1934 stat. rev.

*Okanagana albibasalis* – Wymore 1934: 167.

*Okanagana alibasilis* [sic] – Simons 1954: 161. Incorrect spelling.

*Okanagana albibasalis* = *Okanagana alibasilis* – Metcalf 1963: 98. Correction of spelling.

*Okanagana canescens* = *Okanagana albibasalis* – Bliven 1964: 91. Incorrect synonymy.

*Okanagana albibasalis* **stat. rev.** (Revised to original species status per Wymore 1934).

**Type Locality:** Holotype: male from Rodeo, Contra Costa County, California, USA. 9 June 1930. Allotype: Mount Hamilton, Santa Clara County, California, USA. 20 June 1922. Deposited at CASC (CASC; Sanborn & Heath 2017).

**Rationale for Status Revision:** Wymore (1934) notes that darker individuals of *O. albibasalis* were previously confused with *O. canescens* and this may have caused the disparity in wing membrane color noted in Davis’s 1919 key, which incorrectly keys specimens of *O. canescens* to the as yet undescribed *O. albibasalis*. There is also the potential that Davis had *O. albibasalis* among the specimens he examined for his revision; their ranges overlap and not all of them were examined by Van Duzee (Davis 1919; Simons 1954; Wymore 1934). Wymore said these darker *O. albibasalis* could be diagnosed from *O. canescens* by their white basal membrane compared to the bright orange membrane in *O. canescens* as well as the shape of the terminalia, venter color, and sound of their call (Wymore 1934). These features described by Wymore were not discussed in the original description of *O. canescens* but are clearly evident in the holotype and allotype (WCT., *pers. obs.*) and also used by Simons’s (1954) revision of California cicadas (Van Duzee 1915; Wymore 1934). A more detailed diagnosis between *O. albibasalis* (Fig. 4) and *O. canescens* (Fig. 5) is here provided to show their status as different species.

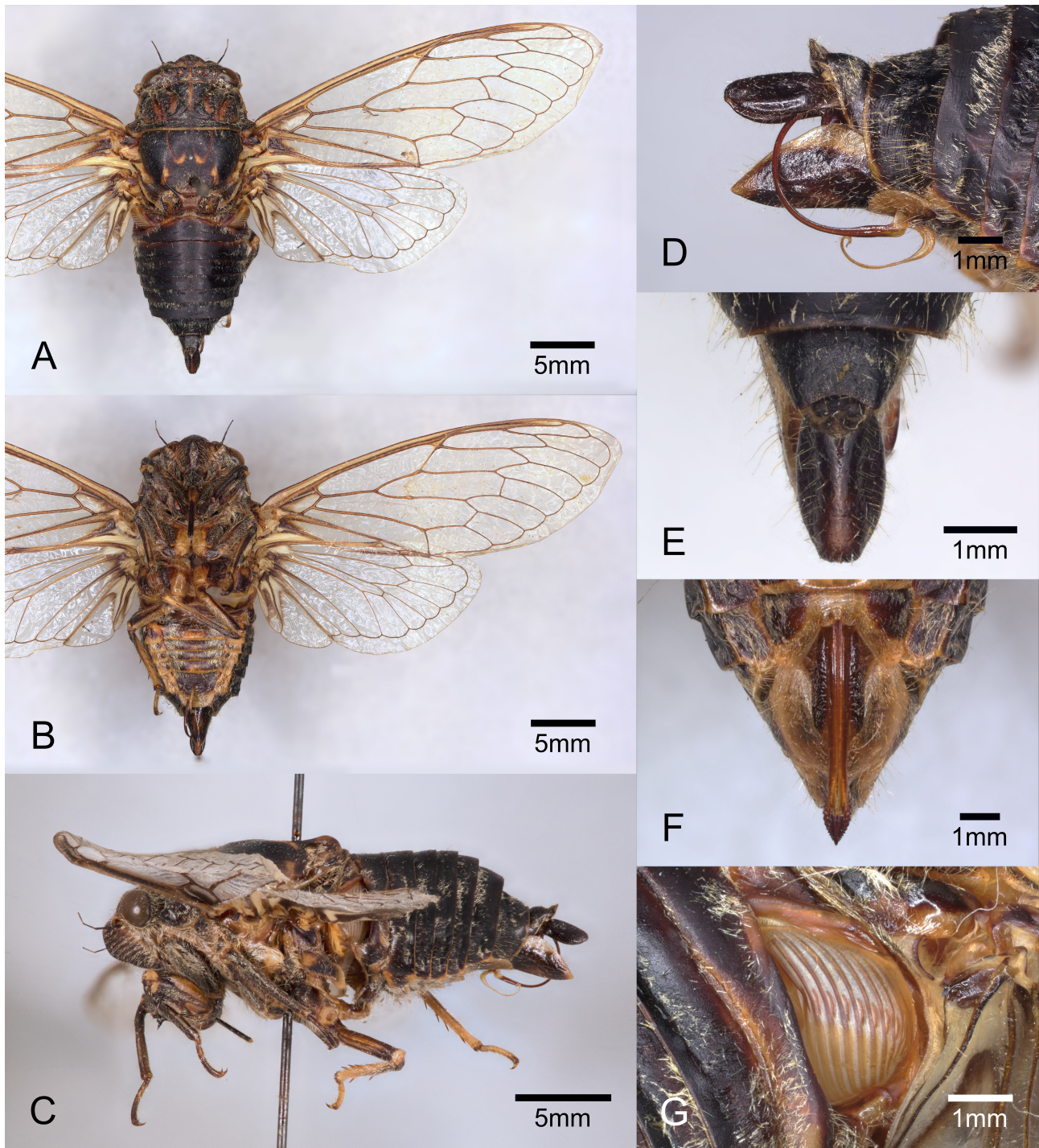
*Okanagana albibasalis* can be diagnosed from *O. canescens* as follows: The postclypeus of *O. albibasalis* is strongly pronounced compared with *O. canescens* and the eyes extend beyond the width of the head. The fore and hind membranes of the wings in *O. albibasalis* are pale white, while they are bright orange in *O. canescens* (Fig. 4A; Fig. 5A). In both male and female *O. albibasalis*, there is a distinct vertical gap between t7 and t8, giving them the appearance of *Tibicinoides* Distant, 1914 and they can be confused in some cases if not examined carefully with other features (WCT., *pers. obs.*). In *O. canescens* t7 and t8 lack this gap and appear as in other *Okanagana* (Fig. 4C; Fig. 5C). This feature combined with the terminalia of either sex is diagnostic.

**Males:** In males the number of timbal ribs is diagnostic; with 10 in *O. albibasalis* and 5 in *O. canescens* (Fig. 4G; Fig. 5H). The valve of *O. albibasalis* is short, equal to the length of the uncus, triangular in the lateral aspect and its height more than ½ the length. *O. canescens* has an elongated valve, with its height less than ½ the length. The uncus of *O. albibasalis* can be most easily differentiated from *O. canescens* dorsally: in *O. albibasalis* it is broadly ovate with a medial ridge that bifurcates the base, while in *O. canescens* the uncus expands at the tip with the medial ridge bifurcating towards the tip.

**Females:** *O. albibasalis* and *O. canescens* can be differentiated by the gap in the t7 and t8 tergites. The stVII of *O. albibasalis* has a strongly angular notch that is sinuate on its apical margin while the sides of the sternite are broad (Fig. 4F). In *O. canescens* stVII lacks a sinuate apical margin to the notch and the sides of the sternite are less rounded (Fig. 5G). Both species have a distinct secondary notch (Simons 1953, 1954; Van Duzee 1915; WCT., *pers. obs.*; Wymore 1934).

The original description of *O. canescens* created almost immediate taxonomic errors likely in part due to the poor description (Davis 1919; Van Duzee 1915), however, *O. albibasalis* is unequivocally a distinct species from

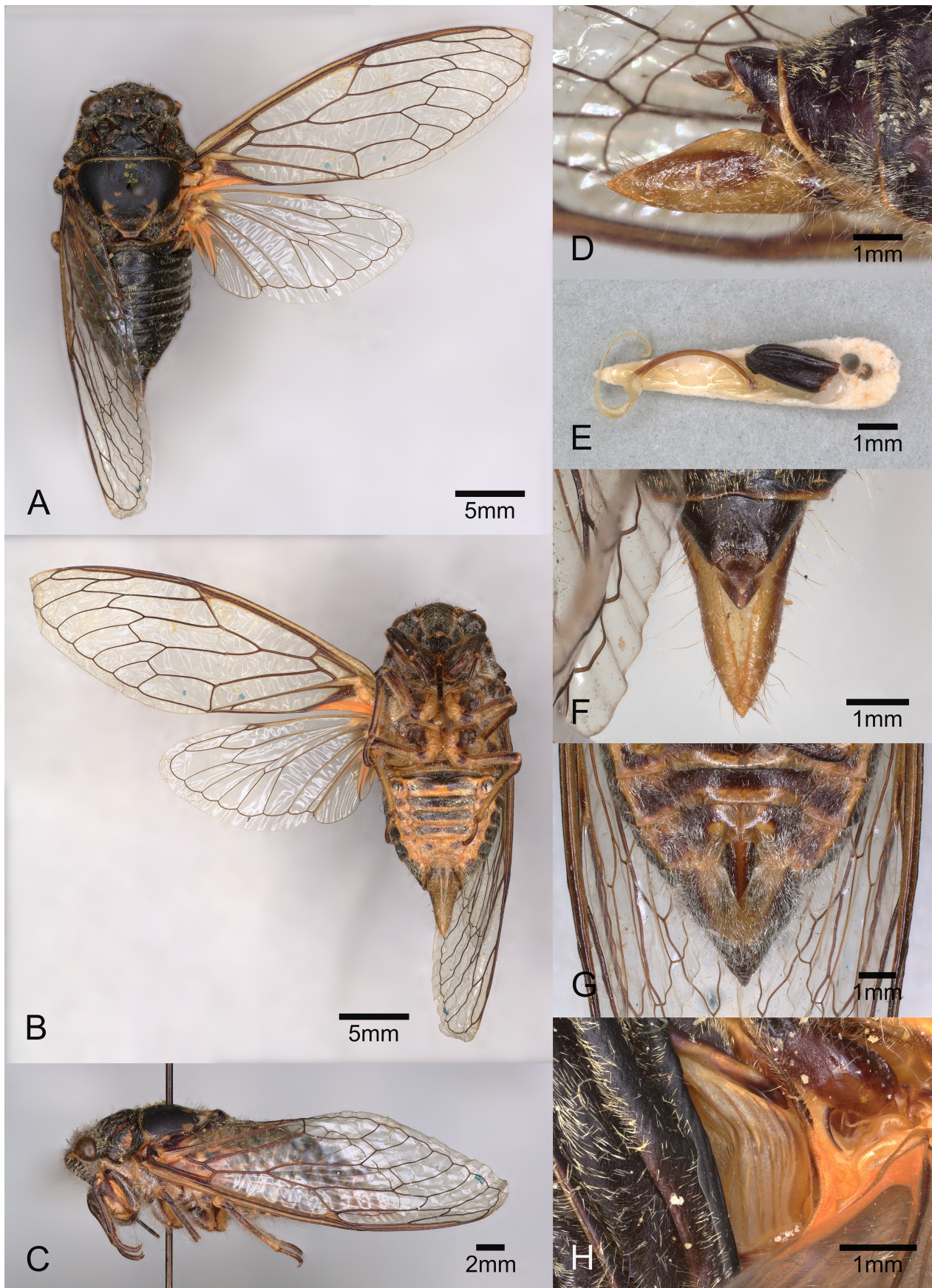
*O. canescens* and the synonymy of the two was a mistake by Bliven (1964). Therefore, *Okanagana albibasalis* will have its **status revised** to full species *Okanagana albibasalis* **stat. rev.** Due to incorrect synonymy the original ranges of the two species have been confused in the literature (Sanborn & Phillips 2013) and we here provide an update on their distributions.



**FIGURE 4.** Holotype and allotype of *Okanagana albibasalis* **stat. rev.**: A. dorsal habitus, B. ventral habitus, C. lateral habitus, D. male genitalia, left lateral view, E. male genitalia, dorsal view, F. female terminalia, ventral view, G. timbal.

**Distribution of *Okanagana albibasalis*.** – This species is endemic to California and is known from Alameda, Contra Costa, Lake, Marin, Napa, Santa Clara, Santa Cruz, San Mateo, San Benito, Solano, Tuolumne, Los Angeles and Ventura Counties (GBIF; Sanborn & Phillips 2013; Simons 1954; Wymore 1934). Interior records are likely incorrectly identified *Tibicinoides*.





**FIGURE 5.** Lectotype and paralectotype female of *Okanagana canescens*: A. dorsal habitus, B. ventral habitus, C. lateral habitus, D. male genitalia with uncus missing, left lateral view, E. point-mounted uncus, left lateral view, F. valve, dorsal view, G. female terminalia, ventral view, H. timbal.



**Distribution of *Okanagana canescens*.** – Endemic to California but its range remains unclear as a result of its synonymy with *O. albibasalis*. Records exist from Alameda, Butte, Contra Costa, Marin, Mendocino, Merced, San Mateo, Santa Clara, Santa Cruz, and Sonoma Counties. Though there is much overlap between the ranges of the two species, *O. canescens* does not extend into southern California (Davis 1919; GBIF; Sanborn & Phillips 2013; Simons 1954). The Butte County record is almost certainly a misidentification.

### Correction to the Phylogeny of Cole *et al.* (2023):

In Cole *et al.* (2023) the *Okanagana canescens* specimens used in the phylogenetic analysis are now considered *O. albibasalis*. The phylogenetic position of *O. canescens* remains unknown (WCT, *unpublished data*). The specimens used as *O. tristis* were not first compared with the lectotype and paralectotypes at CASC and were later determined to not be true *O. tristis* but rather a cryptic and as yet undescribed species (WCT, *unpublished data*).

### Discussion

The morphological analyses in this paper made use of both the available descriptions and either specimens or photos of type series to enact a synonymy of *O. arboraria* under *O. napa* and reverse the synonymy of *O. albibasalis* with *O. canescens*. It remains unclear why Wymore didn't take *O. napa* into consideration as a conspecific of *O. arboraria* when he described it; in that same paper he also described *O. albibasalis* and stated *O. napa* could be confused with its paler forms (Wymore 1934). One hypothesis is that by 1934, Davis had misidentified specimens of *O. occidentalis* from Idaho and Washington as *O. napa*, implying a range far greater than that of *O. arboraria* which is restricted to the Sacramento River Valley (Sanborn & Phillips 2013; Wymore 1934). Without the inflated range, *O. napa* may have been given further scrutiny by Wymore and been identified as his soon-to-be-described *O. arboraria*. Our revision of *O. albibasalis* to species status corrected a synonymy by Bliven (1964) based solely on wing membrane color while ignoring important morphological differences (Van Duzee 1915; Wymore 1934). We provided a more in-depth comparison between the two species and found that differences in the male and female terminalia, abdominal morphology and timbal rib numbers to be diagnostic.

Since the establishment of *Okanagana* in 1905, the taxonomy of several species classified therein has been in a state of confusion, in part due to the way species were described in the 19<sup>th</sup> and early 20<sup>th</sup> centuries (Cole *et al.* 2023; Davis 1919; Sanborn & Heath 2017; Simons 1954; Sueur *et al.* 2007; Van Duzee 1915). The poor quality of descriptions, small type series, and the under-reliance on detailed morphological diagnoses has led to multiple taxonomic errors, the majority have occurred in species where the type series was either lost or described from 1-2 individuals (Cole *et al.* 2023; Sanborn & Heath 2017). Based on our work and other recent taxonomic revisions there is much left to be done in the systematics of *Okanagana* and related genera. Of particular interest are several species described based on very few individuals or that have not been collected in modern times (Sanborn & Heath 2017). Such species may be the results of incorrect taxonomy and invite further study going forward.

### Acknowledgments

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