Improved Key to New World Species of *Sphecius* (Hymenoptera: Crabronidae)

C. W. HOLLIDAY[1] AND J. R. COELHO[2]

Ann. Entomol. Soc. Am. 99(5): 793–798 (2006)

ABSTRACT The two existing keys (Fox 1895 and Bohart 2000) to the New World species of *Sphecius* (Dahlbom 1843) do not correctly identify a large percentage of female *Sphecius convallis* (Patton 1879) and *Sphecius grandis* (Say 1824). Both keys fail to allow for common variations in the number of gastral segments with yellow markings, and one key has the two species reversed. Here, we present an improved key that correctly identifies both sexes of >4,400 specimens of New World *Sphecius*, which we examined.

RESUMEN Las dos llaves existentes (Fox 1895 y Bohart 2000) de la especie del Nuevo Mundo de *Sphecius* (Dahlbom 1843) no determinan correctamente un gran porcentaje de las hembras de *Sphecius convallis* (Patton 1879), y *S. grandis* (Say 1824). Ambas llaves faltan en acomodar las variaciones comunes en el numero de segmentos gastrales de coloracion amarilla, y uno tiene las dos especies invertidas. Aqui presentamos una llave mejorada que correctamente identifica los dos sexos de mas que 4,400 especimenes de *Sphecius* del Nuevo Mundo que hemos examinado.

KEY WORDS cicada killer, cicada-killer, key, New World, *Sphecius*

During the examination of numerous specimens of *Sphecius* (Dahlbom 1843) (Hymenoptera: Sphecidae) for a forthcoming biogeographic study, we encountered many individuals that were either ambiguous or misidentified by existing keys. The five New World species of *Sphecius* are *S. convallis* (Patton 1879, no type specimen extant), *S. grandis* (Say 1824; p. 2, Plate 2, originally described as *Stizus grandis*; no type specimen extant), *S. hogardii* (Latreille 1809; Plate XIII, Fig. 12), *S. speciosus* (Drury 1773, no type specimen extant), and *S. spectabilis* (Taschenberg 1875). The key of Fox (1895) determines female *S. convallis* by their possession of yellow markings only on the first through third gastral tergites and female *S. grandis* by their possession of yellow markings on all gastral tergites (as described by Say 1824). Unfortunately, this character alone does not work well for most *S. convallis* and *S. grandis*, because it does not take into account the existence of a large percentage of female *S. convallis* with yellow markings only on the first and second or the first through fourth gastral tergites, and an even larger percentage of *S. grandis* females with yellow markings only on the first through fifth gastral tergites. Fox's key also is limited to boreal America and excludes *S. spectabilis*. The key of Bohart (2000, key is on p. 172) has similar problems and has *S. convallis* and *S. grandis* reversed with respect to their yellow gastral markings; no explanation is offered for this change and it may be a typographic error. Here we present a new key based on direct examination of the wasps we obtained for study.

Materials and Methods

We examined 4,451 wasps, distributed among the five species as shown in Table 1. Collection curators loaned us or allowed us access to 3,354 wasps, and the balance was collected by us or given to us by individuals in response to solicitations posted on our Web pages (http://ww2.lafayette.edu/~hollidac/cicadakillerhome.html and http://websites.quincy.edu/~coelhjo/ck/thriller.htm) in summer 2004. The geographic distributions presented below in our key are based on the specimens we examined, label data sent us by collection curators who did not send us specimens, and on reports from the literature. The institutions that loaned us specimens, allowed us access to their collections or sent us label data are listed in *Appendix* 1.

Key to New World Species of *Sphecius* (Dahlbom 1843)

1. Body black, including scutellum and legs (rarely scutellum yellow), gastral tergites I–II only with yellow markings (rarely only I–III

[1] Department of Biology, Lafayette College, Easton, PA 18042 (e-mail: hollidac@lafayette.edu).
[2] Institute for Franciscan Environmental Studies, Biology Program, Quincy University, Quincy, IL 62301

0013-8746/06/0793–0798$04.00/0

Table 1. *Sphecius* species distribution of material examined

Species	Females	Males
S. convallis	180	325
S. grandis	318	571
S. hogardii	19	21
S. speciosus	1,445	1,416
S, spectabilis	100	56
Total	2,062	2,389

or no yellow markings, except on frons and clypeus); South America (see note 1) . . . . . *spectabilis* (Taschenberg)

- Body variously colored and marked, scutellum rufous or yellow, legs rufous; North and Central America or Caribbean islands 2

2. Body rufous, gaster rufous or rufous with posterior half black, gaster without yellow markings; Caribbean islands, southern Florida (see note 2) . . . . . *hogardii* (Latreille)

- Gaster with yellow markings 3

3. Females (10 flagellomeres, tibia of hind leg at junction with tarsus with two greatly enlarged, flat spines; six visible gastral segments) 4

- Males (11 flagellomeres, tibial spines at junction with tarsus with two spines of normal size, seven visible gastral segments 6

4. Gastral tergite II with mesal punctation noticeably less dense than that of gastral tergite I (Fig. 1A), gastral tergites I–III or I–IV only with yellow markings (rarely only I–II) (Fig. 2A), rufous (excepting a few populations with dark thoraces in southeastern Arizona, New Mexico, and in Chihuahua); Mexico, western half of United States (see note 3). . . . . *convallis* (Patton)

- Gastral tergite II with mesal punctation approximately as dense as that of tergite I (Fig. 1B) 5

5. Body black (parts of thorax rufous, occasionally rufous patches only on gastral tergite I) with rufous scutellum, gastral tergites I–III only with yellow markings (rarely only I–IV and very rarely only I–II) (as in Fig. 2A); Canada (southern Ontario), Guatemala, Honduras, northeastern Mexico, eastern two-thirds of United States (see note 4) . . . . . *speciosus* (Drury)

- Body rufous to nearly black with intermediate forms, at least gastral tergites I and II with large rufous patches, gastral tergites I–V only or I–VI with yellow markings (rarely only I–IV and very rarely only I–III) (Fig. 2B); Costa Rica, Nicaragua, Mexico, western half of United States (see note 5) . . . . . *grandis* (Say)

6. Flagellomeres II–IV not curved ventrally at tyloids, tyloids thus are straight or very nearly so (Fig. 3A); flagellomeres II–IV circular in cross section 7

- Flagellomeres II–IV noticeably curved ventrally at tyloids, tyloids thus are curved (Fig. 3B); flagellomeres II–IV produced into a ridge beneath tyloids and not circular in cross section, gastral tergites I–V or I–VI only with yellow markings (very rarely only I–IV or I–VII) (Fig. 2B), body varying from rufous to nearly black; Costa Rica, Nicaragua, Mexico, western half of United States (see note 5) . . . . . *grandis* (Say)

7. Body black (parts of thorax rufous, occasionally rufous patches only on gastral tergite I)

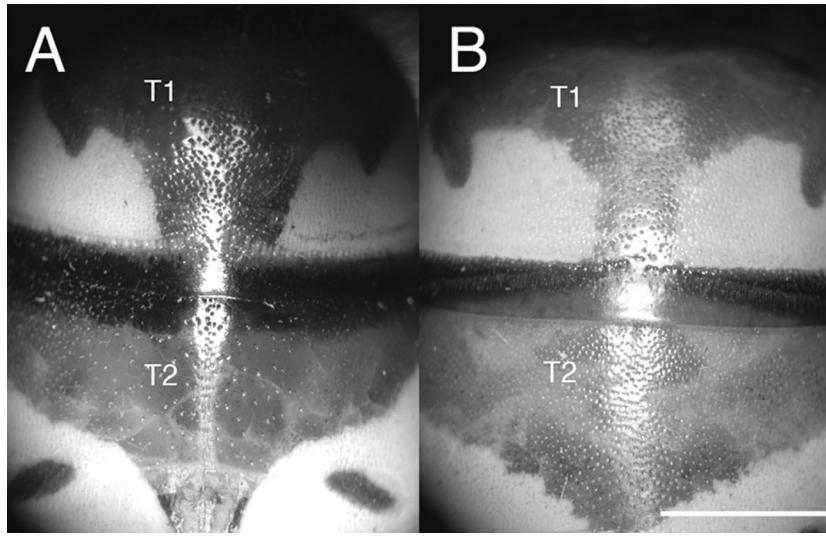

Fig. 1. Punctation density (PD) on gastral tergites I and II in female *Sphecius*. (A) *S. convallis*. (B) *S. grandis*. T1, tergite I; T2, tergite II. Bar = 2 mm. Tergite I and II punctation densities in male *S. convallis*, male *S. grandis* and in both sexes of *S. hogardii*, *S. speciosus*, and *S. spectabilis* are similar to those of female *S. grandis*.

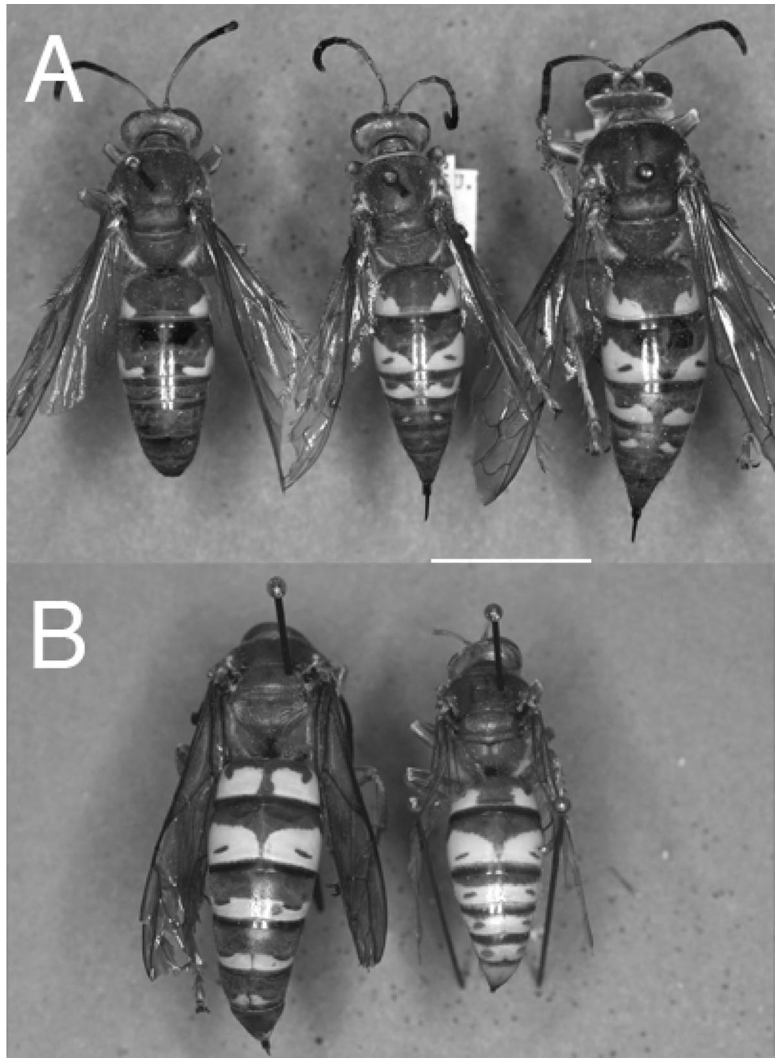

Fig. 2. Yellow gastral tergite markings in female *Sphecius*. (A) *S. convallis*. (B) *S. grandis*. Bar = 1 cm. Yellow tergite markings in male *S. convallis* and *S. grandis* are similar to those in females and such markings in both sexes of *S. speciosus* and *S. spectabilis* are similar to those in *S. convallis*.

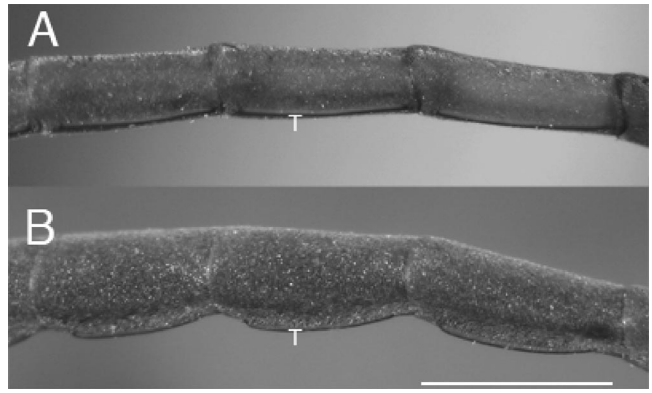

Fig. 3. Flagellomeres II–IV of male *Sphecius*. (A) *S. convallis*. (B) *S. grandis*. T, tyloid (head of "T" is in tyloid). Bar = 1 mm. Flagellomeres II–IV of male *S. hogardii*, *S. speciosus*, and *S. spectabilis* are similar to those of male *S. convallis*.

Table 2. Yellow gastral tergite markings and mesal tergite punctation density (PD) in a subset of 429 *S. convallis* and 611 *S. grandis*

	S. convallis				*S. grandis*			
	Females	%	Males	%	Females	%	Males	%
Tergite markings								
Yellow T1–T2	5	4.0	12	3.9	0	0	0	0
Yellow T1–T3	56	44.8	116	38.2	2	0.7	0	0
Yellow T1–T4	64	51.2	175	57.6	4	1.4	3	0.9
Yellow T1–T5	0	0	1	0.3	249	86.5	137	42.4
Yellow T1–T6	0	0	0	0	33	11.5	175	54.2
Yellow T1–T7	0	0	0	0	0	0	8	2.5
Mesal tergite PD ratio								
T2 = T1	0	0	304	100	288	100	323	100
T2 < T1	125	100	0	0	0	0	0	0

T1, gastral tergite I; T2, gastral tergite II, and so on.

with rufous scutellum, gastral tergites I–III only with yellow markings (rarely only I–IV and very rarely only I–II) (as in Fig. 2A); Canada (southern Ontario), Guatemala, Honduras, northeastern Mexico, eastern two-thirds of United States (see note 4) . . . . . *speciosus* (Drury)

- Body rufous (excepting a few populations with dark thoraces in southeastern Arizona, New Mexico, and Chihuahua), gastral tergites I–III or I–IV only with yellow markings (rarely only I–II) (Fig. 2A); Mexico, western half of United States (see note 3) . . . . . *convallis* (Patton)

Notes

1. *S. spectabilis* reported from: Argentina, Bolivia, Brazil, Chile, Colombia, French Guiana, Paraguay, Surinam, Venezuela.
2. *S. hogardii* reported from: Bahamas, Cayman Islands, Cuba, Dominican Republic, Jamaica, United States (southern Florida). Subspecies *bahamas* (Krombein 1953) has no black markings on gastral tergites.
3. *S. convallis* reported from Mexico (Baja California Norte, Baja California Sur, Chihuahua, Jalisco, Nuevo Leon, Queretaro, San Luis Potosi, Sinaloa, Sonora), United States (Arizona, California, Colorado, Idaho, New Mexico, Nevada, Oregon, Texas, Utah, Washington).
4. *S. speciosus* reported from Canada (Ontario), Guatemala, Honduras, Mexico (Chihuahua, Coahuila, Nuevo Leon), United States (Alabama, Arizona, Arkansas, Colorado, Connecticut, Washington, D.C., Delaware, Florida, Georgia, Illinois, Indiana, Iowa, Kansas, Kentucky, Louisiana, Maryland, Massachusetts, Minnesota, Maine, Mississippi, Missouri, Montana, Nebraska, New Hampshire, New Jersey, New Mexico, New York, North Carolina, North Dakota, Ohio, Oklahoma, Pennsylvania, Rhode Island, South Carolina, South Dakota, Tennessee, Texas, Virginia, Wisconsin, West Virginia, Wyoming).
5. *S. grandis* reported from Costa Rica, Mexico (Baja California Norte, Baja California Sur, Chihuahua, Jalisco, Nuevo Leon, Tamaulipas, Yucatan), Nicaragua, United States (Arizona, California, Colorado, Idaho, Kansas, Nebraska, New Mexico, Nevada, Oklahoma, Oregon, Texas, Utah, Washington).

Results and Discussion

To demonstrate that our key accurately determines *S. convallis* and *S. grandis*, we took the data summarized in Table 2 from a subset of 1,040 wasps (429 *S. convallis* and 611 *S. grandis*). More than half of the female *S. convallis* we examined had yellow markings only on the first through fourth gastral terga (T1–T4); the remainder had yellow only on T1–T2 (rarely) or T1–T3 (per Fox 1895; Fig. 2A). Furthermore, only ≈2% of *S. grandis* had yellow only on T1–T3 or T1–T4; the remainder had yellow only on T1–T5 or T1–T6 (per Say 1824). Thus, for all but 2% of the wasps examined, female *S. convallis* had yellow only on T1–T4 or less (that is, T1–T2, T1–T3 or T1–T4), whereas 98% of *S. grandis* had yellow on T1–T5 or greater (that is, T1–T5 or T1–T6; Fig. 2B). The 2% of female *S. grandis* that overlapped with *S. convallis* in their gastral coloration (yellow only on T1–T3 or T1–T4) were accurately determined by the relative densities of punctation on T2 versus T1 as noted below. Yellow gastral tergite markings in male *S. convallis* and *S. grandis* are similar to those in females and such markings in both sexes of *S. speciosus* and *S. spectabilis* are similar to those in *S. convallis*.

Fox's use of the density of punctation (Fox 1895) on the second gastral tergites of female *S. grandis* ("... punctation of second dorsal gastral segment rather close.") and of female *S. convallis* ("... punctation of second dorsal gastral segment very sparse.") does not do justice to the range of punctation density (PD) we observed in our material. There were many female *S. convallis* with T2 PD approaching that of the average female *S. grandis* and many female *S. grandis* with T2 PD that was less than usual for the species. We found that the diagnostic difference in the PD of T2 in females of the two species is the *ratio* of mesal PD between T2 and T1. In *S. convallis* the PD of T2 was visibly less than that of T1 (Fig. 1A), whereas in *S. grandis*, the PD was approximately equal on T1 and T2 (Fig. 1B); both species varied in overall PD on T1 and T2. This character produced an unambiguous sep-

aration of the two species in all 125 female *S. convallis* and 288 female *S. grandis* in the subset of data presented in Table 2. Thus, the species difference in the T2:T1 PD ratio correlated nearly completely with the difference in the yellow markings on the females' tergites discussed above and allowed unambiguous species determination in the 2% of cases when the females' gastral colorations overlap in *S. convallis* and *S. grandis.* T1 and T2 punctation densities in male *S. convallis*, male *S. grandis* and in both sexes of *S. hogardii*, *S. speciosus*, and *S. spectabilis* are similar to those of female *S. grandis* (Fig. 1B).

The data in Table 2 show that there is only 1% overlap in gastral yellow marking patterns between male *S. convallis* (99.7% with yellow markings only on T1–T4 or less) and male *S. grandis* (98.6% with yellow markings on T1–T5 or greater). In such overlap, the males' tyloid characteristics (expanded in our key beyond those noted by Fox 1895 and Bohart 2000) allowed correct species determination (Fig. 3). Tyloids of male *S. hogardii*, *S. speciosus*, and *S. spectabilis* are shaped as in *S. convallis:* they are not curved ventrally and thus are straight or very nearly so and the flagellomeres bearing them are circular in cross section.

Acknowledgments

We are indebted to the institutions that lent us specimens or provided specimen label data and to >200 individuals who responded to requests for specimens posted on our Web pages. We are also grateful to Jon Hastings (Department of Biological Sciences, Northern Kentucky University, Highland Heights, KY), Arnold S. Menke (USDA, Systematic Entomology Laboratory, Beltsville, MD), Wojciech J. Pulawski (Department of Entomology, California Academy of Sciences, San Francisco, CA), and Douglas Yanega (Entomology Research Museum, University of California, Riverside, CA) for stimulating discussions during the development of our key. This work was funded by grants from the Academic Research Committee, Lafayette College (to C.W.H.) and by the Faculty Development and Welfare Committee, Quincy University (to J.R.C.).

References Cited

Bohart, R. M. 2000. A review of the Gorytini in the Neotropical region (Hymenoptera: Sphecidae: Bembicinae). Contrib. Entomol. Int. 4: 111–259.

Drury, D. 1773. Illustrations of natural history, volume II, p.71, Plate XXXVIII. White, London, United Kingdom.

Fox, W. J. 1895. Synopsis of the Stizini of Boreal America. Proc. Acad. Nat. Sci. Phila. 1895: 264–268.

Krombein, K. V. 1953. The wasps and bees of the Bimini Island group, Bahamas, British West Indies (Hymenoptera: Aculeata). American Museum Novitates 1633: 1–29.

Latreille, P. A. 1809. Genera Crustaceorum et Insectorum secundum ordinem naturalem in familias disposita, iconibus exemplisque plurimis explicate. Amand Koenig, Parisiis et Argentorati [=Paris and Strasbourg]. Tomus quartus.

Patton, W. H. 1879. The American Bembecidae: tribe Stizini. Bull. U.S. Geol. Geogr. Surv. Territories 5: 341–347.

Say, T. 1824. American entomology, vol. I. Mitchell, Philadelphia, PA.

Taschenberg, E. L. 1875. Nyssonidae und Crabronidae des zoologischen Museums der hiesigen Universität, p. 360. Z. Gesammten Naturwissenschaften 46: 359–409.

Received 18 April 2006; accepted 13 May 2006.

Appendix 1

Sources of Material Examined

Albertson College of Idaho, Orma J. Smith Museum of Natural History; American Entomological Institute; American Museum of Natural History; Archbold Biological Station; Arkansas State University, Department of Biological Sciences Insect Collection; Auburn University, Department of Entomology Insect Collection; Ball State University, Department of Biology Insect Collection; Boise State University Entomology Collection; Brigham Young University, Monte L. Bean Life Sciences Museum Arthropod Collection; Buffalo Museum of Science; California Academy of Sciences; California Department of Food & Agriculture Entomology Collection; California State Collection of Arthropods; California State University, Northridge, Department of Biology Insect Collection; Canadian National Collection of Insects; Carnegie Museum of Natural History; Cincinnati Museum of Natural History; Clemson University Arthropod Collection; Cleveland Museum of Natural History; Colorado State University, C. P. Gillette Museum of Arthropod Biodiversity; Cornell University, Department of Entomology Collection; Cranbrook Institute of Science; Dallas Museum of Natural History; Death Valley National Park Arthropod Collection; Denver Museum of Nature and Science; Eastern New Mexico University Natural History Museum; Field Museum of Natural History; Florida A & M University, Department of Entomology Collection; Florida State Collection of Arthropods; Furman University Insect Collection; Great Smoky Mountains Natural History Collection; Harvard University, Museum of Comparative Zoology; Houston Museum of Natural Science; Illinois Natural History Survey, Center for Ecological Entomology; Illinois State Museum; Instituto Nacional de Biodiversidad, Costa Rica; Instituto Tecnologico de Monterrey, Mexico, Departamento Agronomy e Ing. Agricola; Iowa State University, Department of Entomology Collection; Kansas State University Museum of Entomological and Prairie Arthropod Research; Los Angeles County Natural History Museum; Louisiana State University, Louisiana State Arthropod Museum; Michigan State University, A.J. Cook Arthropod Research Collection; Midwestern State University, De-

partment of Biology Insect Collection; Milwaukee City Public Museum; Mississippi State University, Clay Lyle Entomology Museum; Montana State University, MT Entomology Collection; National Museum of Natural History Entomology Collection; Natural History Museum, London, England; Nevada State Department of Agriculture, Entomology Laboratory; New Mexico State University Entomology Collection; New Mexico State University, Department of Entomology, Plant Pathology and Weed Science Insect Collection; New York State Museum; North Carolina State University, Entomology Museum; North Dakota State University, Insect Reference Collection; Ohio Historical Society Insect Collection; Ohio State University, Museum of Biological Diversity; Oklahoma State University, K. C. Emerson Entomology Museum; Oregon Department of Agriculture; Oregon State University, Department of Entomology Arthropod Collection; Pennsylvania Academy of Natural Sciences; Pennsylvania Department of Agriculture, Bureau of Plant Industry; Pennsylvania State University, Frost Entomological Museum; Petrified Forest National Park Insect Collection; Pinnacles National Monument Insect Collection; Purdue University, Department of Entomology Insect Collection; Quincy University Life Science Museum; Rutgers, The State University of New Jersey, Entomological Museum; Saint Cloud State University, Biology Department Insect Collection; Santa Barbara Museum of Natural History; Science Museum of Minnesota; Sonoran Arthropod Studies Institute; South Dakota State University, Severin-McDaniel Insect Research Collection; Southern Illinois University Research Museum of Zoology; State University of New York, College of Environmental Science & Forestry Entomology Collection; Staten Island Institute of Arts and Sciences; Sul Ross State University, Department of Biology Invertebrate Collection; Texas A & M University, Department of Entomology Collection; Universidad Nacional Mayor de San Marcos Museo de Historia Natura, Peru; University of Alberta, E.H. Strickland Entomological Museum; University of Arizona, Tucson, Department of Entomology Collection; University of California, Berkeley, Essig Museum of Entomology; University of California, Davis, Bohart Museum of Entomology; University of California, Riverside, Entomology Research Museum; University of Central Florida Collection of Arthropods; University of Colorado, Museum of Entomology; University of Connecticut, Department of Ecology and Evolutionary Biology Insect Collection; University of Delaware Insect Reference Collection; University of Georgia, Athens, Department of Entomology Collection; University of Georgia, Georgia Museum of Natural History; University of Guelph Insect Collection; University of Idaho, W.F. Barr Entomological Museum; University of Kansas, Snow Entomological Museum; University of Kentucky, Department of Biology Insect Collection; University of Maine at Orono, Department of Entomology Collection; University of Manitoba, J. B. Wallis Museum of Entomology; University of Massachusetts, Amherst, Department of Entomology Collection; University of Michigan, Museum of Zoology; University of Minnesota, Department of Biology Insect Collection; University of Mississippi, Department of Biology Insect Collection; University of Missouri, Wilbur Enns Entomological Museum; University of Nebraska, State Museum of Entomology Collection; University of New Hampshire, Insect and Arthropod Collection; University of New Mexico, Museum of Southwestern Biology; University of Tennessee, Knoxville, Department of Entomology Collection; University of Wisconsin, Department of Entomology Collection; University of Wyoming Insect Museum; Utah State University, Department of Biology Insect Collection; Virginia Museum of Natural History; Virginia Polytechnic Institute, Department of Entomology Collection; Washington State University, M. T. James Entomological Collection; West Virginia State Department of Agriculture; Western Illinois University, Department of Biology Insect Collection; Weymouth Woods Sand Hills National Preserve Insect Collection; and Yale University, Peabody Museum of Natural History.