

TAXONOMIC KEYS AND DISTRIBUTIONAL
PATTERNS FOR NEARCTIC SPECIES
OF *Calopteryx* DAMSELFLIESCLIFFORD JOHNSON¹Department of Zoology,
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ABSTRACT

This paper gives taxonomic keys for adults of the 5 nearctic species of *Calopteryx* damselflies and completes a 3-title series on distributions of calopterygid species occurring in the United States. Separate male and female keys provide species determinations. The accompanying text clarifies intraspecific variability, female morphs, areas of sympatry for similar species, and reviews the taxonomic uncertainty of *C. amata* and *C. angustipennis*. Distributions, totally within the U. S. and Canada, appear for each species by appropriate state or province subunits, and focuses attention on related ecological questions. Flight season data reveal little or no seasonal differences between species. A review of early southwestern records for *C. maculata* appears, and existing literature notes provide a tentative identification of the early type-locality of *C. angustipennis* representing the single species report for Georgia.

This paper gives a key for adult determinations, distributional patterns and flight seasons for the Nearctic species of *Calopteryx* damselflies. The Calopterygidae, represented in the United States and Canada by only 2 genera, *Hetaerina* and *Calopteryx*, constitute our larger and more colorful damselflies. Behaviorists and ecologists have increasingly adjusted their studies to the readily-observed calopterygid behavior and such efforts will doubtless improve our knowledge of evolution and speciation in these damselflies. An objective examination of species distributions revealing likely allopatries and sympatries is timely, and such data appeared for *Hetaerina* and, in part, for *C. dimidiata* in earlier reports (Johnson 1973a,b).

Current literature recognizes 5 nearctic species of *Calopteryx*, *maculata* (Beauvois) 1805; *dimidiata* Burmeister 1839; *aequabilis* Say 1840; *angustipennis* (Selys) 1853; *amata* Hagen 1890. These large, colorful insects attracted collectors early in the entomological explorations of North America, and, as the above dates show, only 1 recognized species description appeared after 1853. Hagen's synopsis of nearctic *Calopteryx*, dated 1889 but officially published on 4 January 1890 (F. M. Carpenter, personal communication 1973), identified and allocated synonyms and amplified species descriptions. Hagen's paper clearly indicated his appreciation of a species' potential for geographic variability. He reduced *C. hudsonica*, a name proposed earlier by him in 1875, to a subspecies of *C. aequabilis* and relegated *C. apicalis* to a synonym of *C.*

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dimidiata. Both decisions arose from a consideration of geographic variation. Larger collections over the respective geographic areas proved his interpretation of *C. apicalis* valid 83 years later (Johnson 1973b). Hagen's same paper included the description of *C. amata* based on four males and females respectively from Dublin, New Hampshire. He had reservations about *C. amata* due to his limited material of *C. angustipennis* available for comparison. When Hagen, in Cambridge, Massachusetts, wrote the 1890 synopsis, the only known male of *C. angustipennis* (the type, presumably from Georgia) was in the British Museum and he possessed only 2 *C. angustipennis* females. The description of *C. angustipennis* appeared as *Sylphis angustipennis* Selys 1853 for the female. Hagen recognized the association of male and female in his 1861 "Synopsis of North American Neuroptera" and commented more fully on the decision in the 1890 Synopsis of North American *Calopteryx* concluding, "The material known for *C. angustipennis* is decidedly not adequate; if a larger number should prove the difference given for *C. amata* not persistent, the two species will belong together." Needham and Heywood (1929), 39 years later, referred to *C. amata* as "... doubtfully distinct."; however Walker's (1953) study, the major diagnostic work following Needham and Heywood, covered northern colonies recognized as *C. amata*. Actually, the name *C. amata* appears more frequently in the literature, regional lists, etc. than *C. angustipennis*, a species still uncommon today in most collections. The only authors directly addressing variability in nearctic *Calopteryx* following Hagen were Cockerell (1913) and Kennedy (1917a, 1918) on subspecies of *C. aequabilis*, Huggins (1927) on a subspecies of *C. maculata*, and Johnson (1973b) on seasonal and geographic variation in *C. dimidiata*. Needham and Heywood (1929) provide the only key, long out-of-print, for the 5 nearctic species. Its brief style omits variation and recognition of female morphs, thus allowing erroneous determinations, and the short distributions accompanying species accounts require considerable updating.

SPECIES KEYS

Mate recognition by *Calopteryx* involves color patterns and flight behavior (Bucholtz 1955; Pajunen 1966). Species criteria consist, therefore, of wing patterns, relative wing width, color of the males' ventral abdominal segments, occasionally stigma size in females and body lengths. Conventional structure of male abdominal appendages, penis, and female ovipositor, often of value in Odonata, have little taxonomic distinction in the nearctic species. Color patterns frequently require a maturation period for full expression and, in conjunction with body size, may vary both seasonally and geographically. Female morphs involve one form typically mimicking the male (the andromorph or homeomorph) and a second morph (the heteromorph) differing distinctly. At least in *C. dimidiata*, females may be andromorphic for only the hind wing pair (Johnson 1973b). These attributes become apparent only in large samples and complicate the writing of taxonomic keys.

Walker (1953), Johnson (1972) and most entomological guides provide definitions and illustrations of key characters. Notes on variability leading to possible confusion in determinations follow the keys.

KEY TO THE MALES

- 1a. Wings dark brown, often appearing opaque black (except occasionally isolated cell(s); wing length equals approximately 3X the greatest width *maculata*

- b. Wings clear or slightly overcast with amber or brown; a dark brownish to black band may occur on the apical end of the wing extending a variable distance toward the nodus; wing length greater than 3.5X the greatest width 2
- 2a. All wings with a dark brown band in the apical end; wing length = 3.5 to 4X the greatest width 3
- b. All wings clear of brown to black pigment *or* only the hind wings with an apical dark band (although often a very pale brown); wing length greater than 4X greatest width 4
- 3a. Apical dark band (usually brown) of hind wing distinctly wider (measured parallel to wing margin) than fore wing band; sternum of abdominal segment 10 white or pale cream colored *aequabilis*
- b. Apical dark bands of fore and hind wings approximately equal in length, rarely varying over 2 mm; sternum of abdominal segment 10 dark green or black *dimidiata*
- 4a. Hind wings only with an apical brown band, apparently never approaching the near-black color seen in some specimens of above species, often very pale; sternum of abdominal segment 10 with irregular whitish spot; ventral surface of metathorax pale, becoming pruinose in older specimens *amata*
- b. All wings clear (rarely with slight amber overcast); sternum of abdominal segment 10 and ventral surface of metathorax variable, see following notes *angustipennis*

KEY TO THE FEMALES

- 1a. Wing length approximately 3X the greatest width; wings light to dark brown over entire surface (except occasional and irregular cells), sometimes darker apically *maculata*
- b. Wing length greater than 3.5X the greatest width; wings clear, occasionally with amber or brown overcast, or clear basally and with a dark brown apical band 2
- 2a. Wing length 3.5 to 4X the greatest width; hind margins of wings rounded and not parallel to front margins; wings often with apical dark brown bands; pre-antennal ridge with some dark green or black color; abdomen usually less than 40 mm. 3
- b. Wing length greater than 4X the greatest width; hind margins of wings rather straight, nearly parallel to the front margin in the apical half; wings without apical dark brown bands or very weakly expressed in the hind wings only; pre-antennal ridge with pale coloration; abdomen usually greater than 40 mm 4
- 3a. Labrum and labium largely pale; pre-antennal ridge with some pale markings, often entirely pale; apical brown bands, if present in wings, usually wider in the hind wings (measured parallel to wing margin) than fore wing bands *aequabilis*
- b. Labrum, labium and pre-antennal ridge predominantly dark in color; if apical brown bands present in wings, they are

- approximately equal in length, rarely varying more than 2 mm *dimidiata*
- 4a. Stigma present but may be crossed by veins and sometimes very small; wings overcast with amber, occasional specimen with pale apical hind wing band similar to male *amata*
- b. Stigma absent; wings clear or very slightly touched with amber, no apical band in any known specimen *angustipennis*

The wide-ranging *Calopteryx maculata* stands distinctly apart in color and morphology from its congeners, and distributional patterns supplement the key in recognizing the other species. Coexistence of the superficially similar *C. dimidiata* and *C. aequabilis* exists in only a small northeastern region (Figure 2), and only *C. amata* of the *C. amata*—*C. angustipennis* pair ranges north of Pennsylvania (Figure 3). Southward, both *C. amata* and *C. angustipennis* occur, though uncommonly, and our limited knowledge of southern colonies leaves some uncertainty of the species criteria.

Large samples of *C. angustipennis* and *C. amata* over their geographic range are still unavailable; however, criteria used for these species remain diagnostically recognizable in the available material (16 males and 6 females of *C. angustipennis* from Kentucky, North Carolina, Pennsylvania, South Carolina, Tennessee, and West Virginia; 15 males and 30 females of *C. amata* from Massachusetts, New Hampshire, New York, North Carolina, Pennsylvania, Tennessee, and West Virginia). Determinations of older specimens in the series were by E. B. Williamson, E. M. Davis, and P. P. Calvert. Carl Cook, Leonora K. Gloyd, Paul Harwood, M. J. Westfall, the author and others have determined more recent materials. While the sample is not large by statistical standards, the above odonatologists concur in determinations, and the sample represents the best comparative series available. In this material, all male *C. amata* possess the apical brown band of the hind wing. The band is present but pale in young specimens and intensifies somewhat with advancing age. The silhouetted photograph in Robert (1963), Fig. 41, p. 67, of a male *C. amata* wing from Quebec, is essentially devoid of the hind wing band; nonetheless, Robert's key utilizes the band as a character. Walker's (1953) photograph, plate 8, clearly shows the band in a Quebec male; Robert's specimen was perhaps very young or the photograph lost contrast in reproduction. The dark band appears in only 1 *C. amata* female of the sample, is very pale, and the specimen is mature. The only other nearctic *Calopteryx* species known to possess apical dark bands on only the hind wings is a female morph of *C. dimidiata* (Johnson 1973b); however, a similar study of *C. aequabilis* may reveal similar females. The wing band of *C. amata* is pale in some mature specimens, and, judging from behavioral work on European and Eurasian species by Buchholtz (1955), it is doubtful that such bands function well in species recognition.

The most definitive attributes for *C. angustipennis* are the key characters given above; however, a puzzling variation exists in the series for this species. The white or pale cream-colored sternum of abdominal segment 10 is a constant male attribute of species possessing it (e.g., all examined males of *C. maculata*, *C. aequabilis* and *C. amata* have the whitish sternum and all *C. dimidiata* males have a greenish-black sternum). Reproductive behavior involves display of the white spot, when present, to the female (Williamson 1904;

Johnson 1962; Pajunen 1966). In *C. angustipennis* from Kentucky, Pennsylvania, and Tennessee, the sternum of abdominal segment 10 is black, and 4 additional males in the British Museum from Pennsylvania also possess black sterna (P. Ward, personal communication 1973). Specimens from North Carolina, South Carolina and West Virginia have a whitish sternum of abdominal segment 10. Unfortunately, the terminal segments are missing on the male holotype (from Georgia) in the British Museum (Kimmins 1969). Intensity of black pigmentation increases with age; however, these differences exist in clearly mature specimens. Since the abdominal white spot is a known component of behavioral releasers in species-specific behavior, it is natural to question its variability in *C. angustipennis*. Specimens are somewhat more numerous than during Hagen's day; however, questions now include behavior. Relative to this trait, one may repeat Hagen's observation, the knowledge of *C. angustipennis* is "...decidedly not adequate".

DISTRIBUTIONS

The complete range of Western Hemisphere *Calopteryx* species occurs in the United States and Canada with 2 species, *C. angustipennis* and *C. dimidiata*, confined to the eastern United States. Calopterygid damselflies are stream to riverine species and will typically occur only about such habitats within the specific ranges given below. Distributions appear by county or parish for each state; the Canadian distributions follow Walker (1953) giving counties for all provinces except Manitoba and Saskatchewan where the few sites have other locations. These localities form the range maps in Fig. 1-3 where each point lies approximately in the center of the represented county. Johnson (1973b) reported a detailed distribution for *Calopteryx dimidiata* earlier and only the subsequent new record follows. Literature listed chronologically, personal communication sources, and collection(s) providing documentation for the data follow county lists. I cite only papers giving specific localities. Initial reports of a species for some states do not therefore appear. Collections cited carry the following abbreviations: CJ Coll.—author's coll., GHB Coll.—G. H. Bick's Coll., PM Coll.—Paul Milliotis' Coll., Clem. U. Coll.—Clemson University Coll., Corn. U. Coll.—Cornell University Coll., U. C. Coll.—University of Connecticut Coll., U. A. Coll.—University of Arkansas Coll., U. N. Coll.—University of Nebraska Coll., U. M. Coll.—University of Michigan Coll., U. V. Coll.—University of Vermont Coll., INHS Coll.—Illinois Natural History Survey Coll., and FSCA—Florida State Collection of Arthropods.

Calopteryx aequabilis distributional records.

UNITED STATES: *California*: Humboldt County. Kennedy (1917). *Colorado*: Boulder and Larimer counties. Cockerell (1913); Kennedy (1918). *Connecticut*: Litchfield, New Haven, New London and Tolland counties. Woodruff (1914); Garman (1927); U. C. Coll. *Idaho*: Benewah, Blaine, Latah, Owyhee, Twin Falls and Valley counties. Barr (personal communication 1973); FSCA. *Illinois*: Boone and Kane counties. INHS Coll.; U.M. Coll. *Indiana*: Elkhart, Fulton, Starke and White counties. Montgomery (1941). *Iowa*: Black Hawk County. Wells (1917). *Maine*: Androscoggin, Kennebec, Knox, Lincoln, Oxford, Penobscot and Washington counties. Howe (1917); Borror (1951). *Massachusetts*: Berkshire, Essex, Franklin, Middlesex, Norfolk and Worcester counties. Howe (1917, 1919, 1921); PM. *Michigan*: Alger,

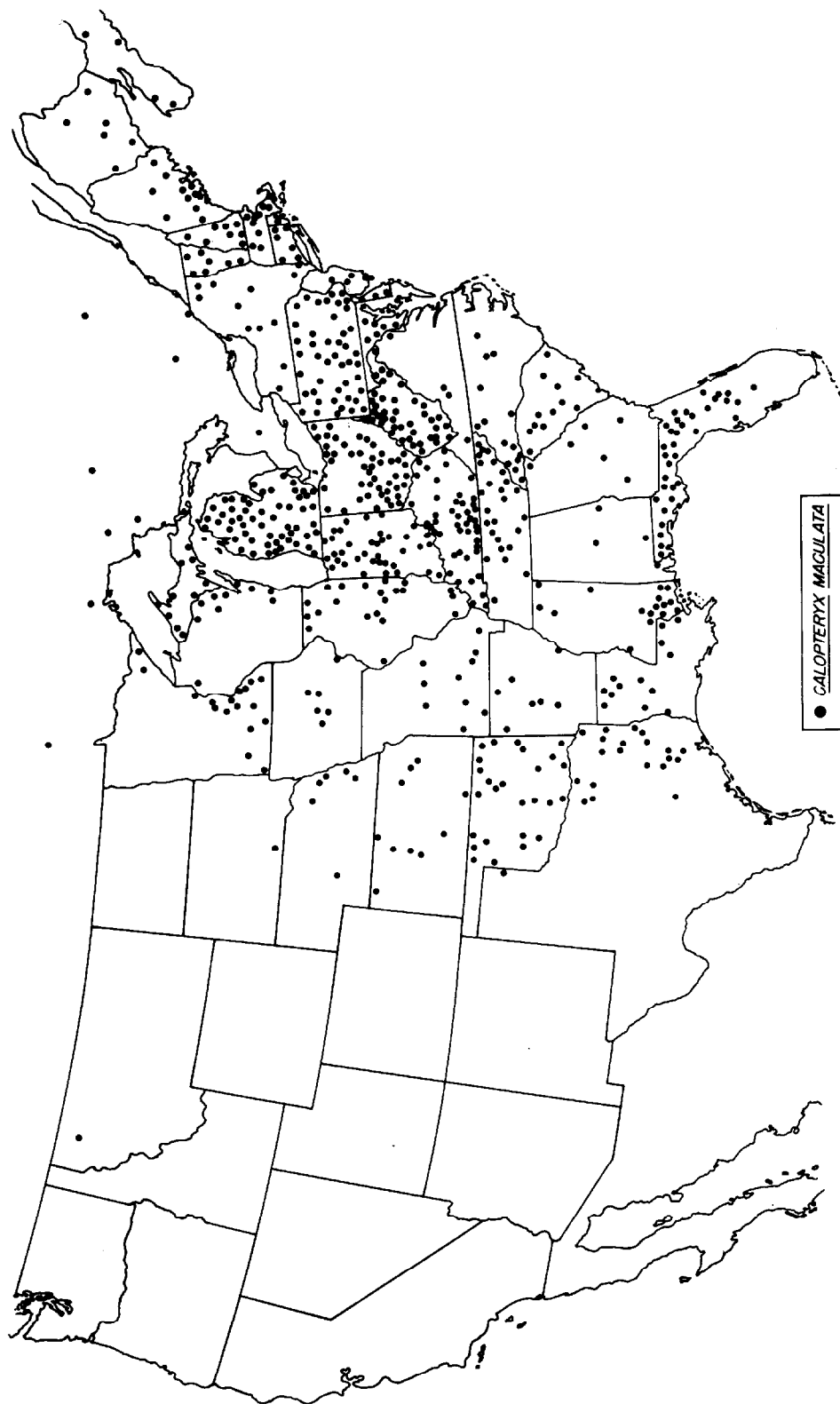


Fig. 1. Distributional pattern of *Calopteryx maculata*.

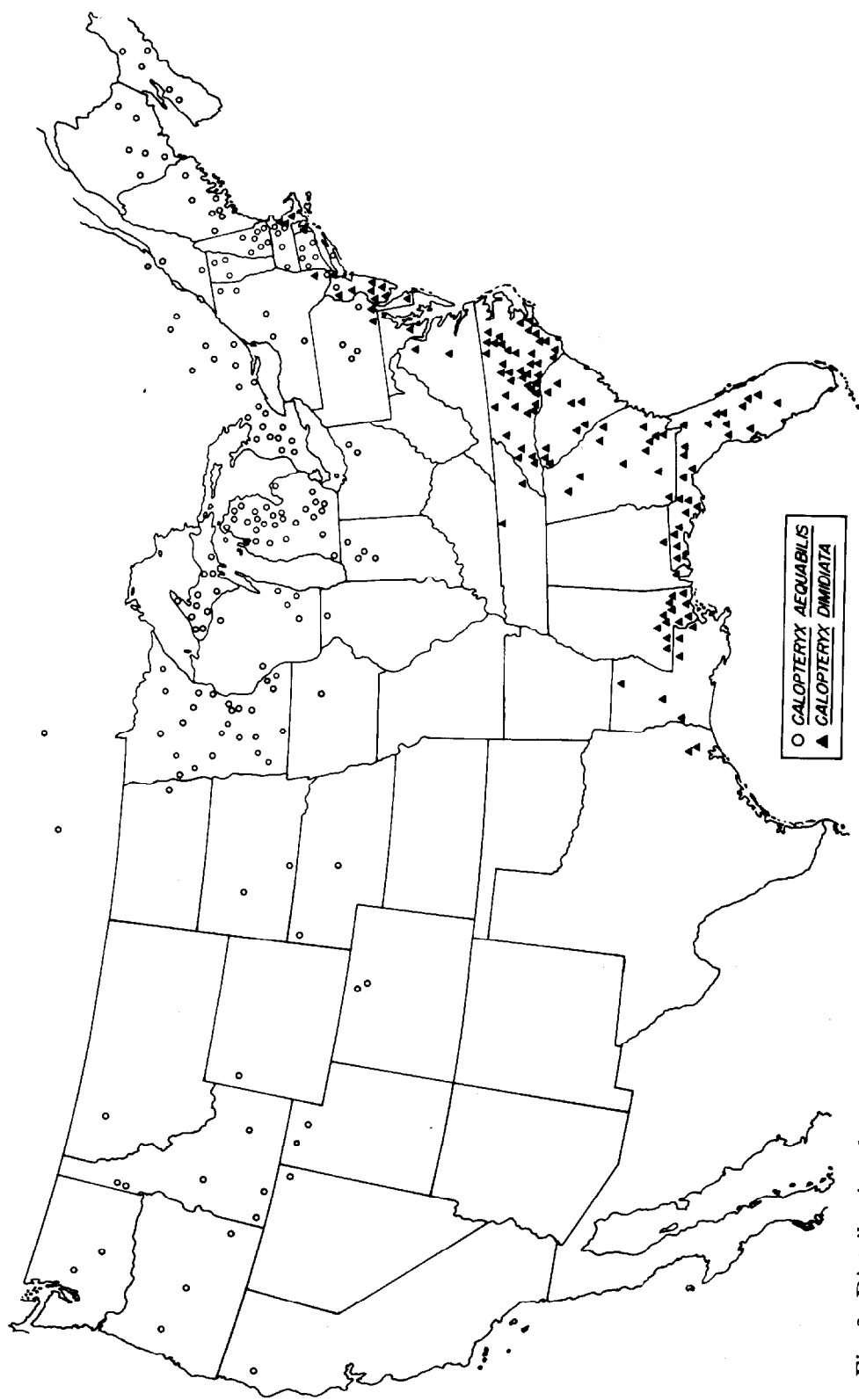


Fig. 2. Distributional patterns of *Calopteryx aequabilis* and *C. dimidiata*.
The northern North-western Territories record of *C. aequabilis* not shown.

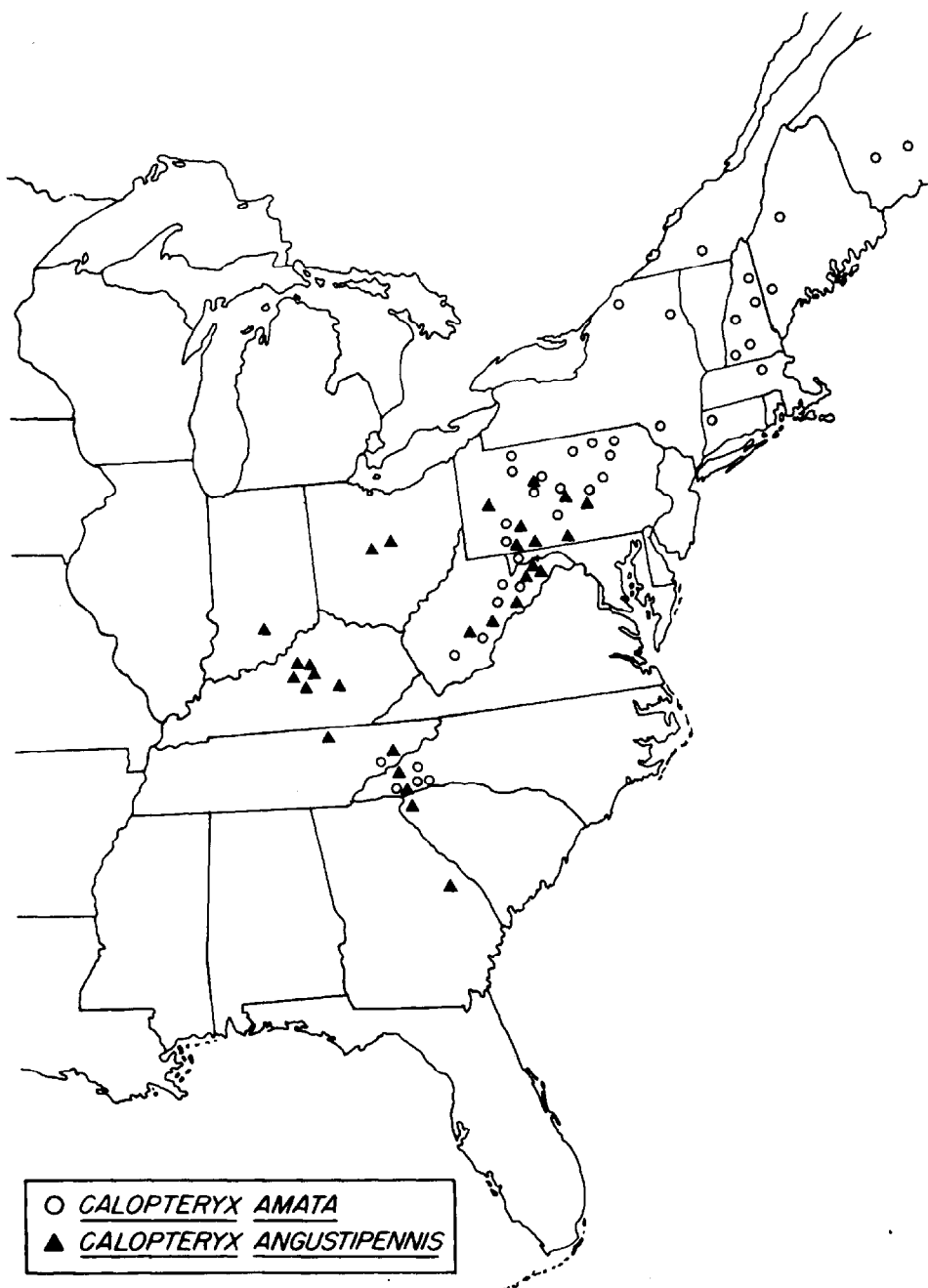


Fig. 3. Distributional patterns of *Calopteryx amata* and *C. angustipennis*.

Alpena, Arenac, Baraga, Berrien, Cheboygan, Clare, Crawford, Delta, Dickinson, Emmet, Gladwin, Gogebic, Grand Traverse, Gratiot, Houghton, Huron, Ingham, Iron, Isabella, Jackson, Kalamazoo, Keweenaw, Lake, Livingston, Marquette, Midland, Missaukee, Oakland, Ontonagan, Oscoda, Otsego, Presque Isle, Roscommon, Schoolcraft, Shiawassee, Washtenaw and Wexford counties. Kormondy (1958). *Minnesota*: Aitkin, Anoka, Carlton,

Cass, Clay, Clearwater, Douglas, Hennepin, Hubbard, Lake, Lyon, Martin, Mille Lacs, Morrison, Nicollet, Norman, Olmstead, Pine, Ramsey, Red Lake, Redwood, Scott, St. Louis, Stearns, Wabasha and Winona counties. Wilson (1909); Clausen and Hamrum (personal communications 1973); FSCA. *Montana*: Flathead County. Newell (1970). *Nebraska*: Logan and Sioux counties. FSCA; U. N. Coll. *Nevada*: Elko County. La Rivers (1940). *New Hampshire*: Belknap, Carroll, Grafton, Hillsboro, Merrimack, Rockingham and Strafford counties. Howe (1917); White and Morse (1973); PM. *New Jersey*: Passaic County. Howe (1921). *New York*: Bronx, Clinton, Essex, Herkimer, Oswego, Suffolk and Tompkins counties. Calvert (1895a); Needham (1903, 1928); FSCA. *North Dakota*: Grand Forks and Pembina counties. Post (personal communication 1973); FSCA. *Ohio*: Portage and Summit counties. Borror (1937). *Oregon*: Benton, Deschutes and Malheur counties. Kennedy (1915, 1918); FSCA. *Pennsylvania*: Bucks, Centre, Mifflin and Union counties. Beatty, Beatty and Shiffer (1969, 1970). *South Dakota*: Bennet and Meade counties. Balsbaugh (personal communication 1973); Corn. U. *Utah*: Box Elder and Weber counties. Brown (1934); Waage (personal communication 1974). *Vermont*: Caledonia, Chittenden and Orleans counties. Howe (1917); U. V. Coll.; FSCA. *Washington*: King and Yakima counties. Kennedy (1915, 1918). *Wisconsin*: Dane, Milwaukee, Saint Croix, Sheboygan, Vilas and Washington counties. Muttkowski (1908, 1909); Howe (1921). *Wyoming*: Teton County. Bick (1972).

CANADA: *Manitoba*: Treesbank and Winnipeg. Walker (1953). *New Brunswick*: Carlton, Charlotte, Kings, Sunbury, Westmoreland and York counties. Walker (1953). *Northwestern Territories*, District of Mackenzie, Fort Simpson. Waage (personal communication 1974). Northern-most *Calopteryx* record in the western hemisphere and not shown on distribution map. *Nova Scotia*: Annapolis, Halifax, Hants, Kings and Pictou counties. Walker (1953). *Ontario*: Brant, Carlton, Cochrane, Dufferin, Frontenac, Grey, Hastings, Huron, Lanark, Leed, Middlesex, Nipissing, Oxford, Parry Sound, Peel, Prince Edward, Renfrew, Simcoe, Timiskaming, Waterloo, Wellington and York counties. Walker (1953); Waage (personal communication 1974). *Quebec*: Brome, Gatineau, Labelle, Liette and Vercheres counties. Walker (1953); Waage (personal communication 1974). *Saskatchewan*: Waskesiu Lake. Walker (1953).

Calopteryx amata distributional records.

UNITED STATES: *Connecticut*: Litchfield County. Woodruff (1914). *Maine*: Oxford and Somerset counties. Harwood (1959); FSCA. *Maryland*: Garrett County. Howe (1921). *Massachusetts*: Middlesex County. Howe (1917); PM Coll. *New Hampshire*: Carroll, Cheshire, Coos, Grafton and Merrimack counties. White and Morse (1973); PM Coll. *New York*: Essex, Saint Lawrence and Sullivan counties. Needham (1928). *North Carolina*: Buncombe, Henderson, Macon and Transylvania counties. FSCA. *Pennsylvania*: Cameron, Centre, Clearfield, Fayette, Forest, Huntingdon, Luzerne, Potter, Sullivan, Susquehanna, Tioga, Union, Warren and Westmoreland counties. Ahrens, Beatty, and Beatty (1968); Beatty, Beatty and Shiffer (1969). *Tennessee*: Blount County. Goodwin (1968). *West Virginia*: Grant, Pocahontas, Raleigh, Randolph and Tucker counties. Cruden (1962); Harwood (personal communication 1973); FSCA.

CANADA: *New Brunswick*: Sunbury and York counties. Walker (1953). *Quebec*: Brome County. Walker (1953).

Calopteryx angustipennis distributional records.

UNITED STATES: *Georgia*: Burke-Screven counties. (?) See Discussion. *Indiana*: Crawford County. Williamson (1917). *Kentucky*: Breckinridge, Ed-

monson, Grayson, Hart, Marion and Rockcastle counties. Resner (1970); Cook (personal communication 1973); FSCA. *North Carolina*: Haywood County. C.J. *Ohio*: Ashland and Richland counties. Williamson (1899); Borror (1937). *Pennsylvania*: Butler, Cameron, Centre, Fayette, Franklin, Somerset, Union and Westmoreland counties. Williamson (1899); Ahrens, Beatty and Beatty (1968); Beatty, Beatty and Shiffer (1969). *South Carolina*: Oconee County. Clem. U. Coll. *Tennessee*: Fentress and Sevier counties. Trogdon (1961); FSCA. *West Virginia*: Grant, Hampshire, Mineral, Nickolas, Pendleton and Webster counties. Harwood (1972); FSCA.

Calopteryx dimidiata distribution supplement.

Tennessee: Pickett County. C.J.

Calopteryx maculata distributional records.

UNITED STATES: *Alabama*: Baldwin, Covington, Lee and Shelby counties. Huggins (1927); Wright (1943). *Arkansas*: Johnson, Marion, Montgomery, Phillips, Stone, Washington and Yell counties. Adams (1900); U. A. *Connecticut*: Fairfield, Litchfield, New Haven, New London, Tolland and Windham counties. Howe (1917); Garman (1927); U. C. *Delaware*: Kent, New Castle and Sussex counties. Roback and Westfall (1967); Kelsey (personal communication 1973). *Florida*: Alachua, Baker, Bradford, Calhoun, Clay, Columbia, Escambia, Gadsden, Hamilton, Hardee, Highlands, Hillsborough, Jackson, Jefferson, Lake, Leon, Levy, Liberty, Madison, Marion, Okaloosa, Orange, Osceola, Polk, Putnam, Santa Rosa, Seminole, Suwannee, Taylor, Union, Volusia, Wakulla, Walton and Washington counties. FSCA; C.J. *Georgia*: Clarke, Dooly, Jefferson, Lee, Rabun and Wayne counties. Root (1924); Byers (1931); FSCA. *Illinois*: Carroll, Champaign, Christian, Clark, Coles, Cook, De Kalb, Hardin, Iroquois, Mason, McHenry, McLean, Ogle, Peoria, Piatt, Pike, Pope, Stephenson, Union, Vermillion, Will and Winnebago counties. Garman (1917); FSCA; INHS Coll. *Indiana*: Allen, Benton, Boone, Carroll, Clark, Clinton, Crawford, Elkhart, Fountain, Fulton, Gibson, Hamilton, Harrison, Howard, Jackson, Jasper, Johnson, Kosciusko, La Porte, Madison, Marshall, Monroe, Montgomery, Noble, Orange, Parke, Porter, Posey, Pulaski, Randolph, Starke, Tippecanoe, Union, Vigo, Warren, White and Whitley counties. Williamson (1900); Montgomery (1935, 1937, 1941, 1951, 1953, 1955, 1971); FSCA. *Iowa*: Black Hawk, Boone, Muscatine, Polk, Story and Tampa counties. Elrod (1898); Wilson (1912); Wells (1917). *Kansas*: Douglas, Ellis, Kiowa, Phillips, Rawlins, Riley, Rooks, Rush, Shawnee and Summer counties. Kennedy (1917); Roback and Westfall (1967); FSCA. *Kentucky*: Adair, Allen, Ballard, Barren, Bell, Breckinridge, Bullitt, Butler, Carter, Casey, Cumberland, Edmonson, Fayette, Fulton, Graves, Green, Greenup, Hart, Henderson, Jefferson, Kenton, Knott, Lewis, Logan, Lyon, Marion, McCreary, Meade, Metcalfe, Monroe, Muhlenberg, Nelson, Ohio, Oldham, Pike, Powell, Pulaski, Rockcastle, Taylor, Todd, Trigg, Union, Warren, Wayne and Whitley counties. Resner (1970); Cook (personal communication 1973); FSCA. *Louisiana*: Beauregard, Bossier, Claiborne, East Baton Rouge, East Feliciana, Jackson, La Salle, Lincoln, Natchitoches, Quachita, Rapides, St. Tammany and Washington parishes. Bick (1957). *Maine*: Androscoggin, Franklin, Hancock, Kennebec, Knox, Lincoln, Oxford, Penobscot, Waldo and Washington counties. Borror (1944, 1951); Milliotis (personal communication 1973). *Maryland*: Anne Arundel, Baltimore, Charles, Frederick, Montgomery and Prince Georges counties. Root (1923); Huggins (1927); Donnelly (1961); FSCA. *Massachusetts*: Barnstable, Bristol, Essex, Franklin, Hampshire, Middlesex, Norfolk, Plymouth, Suffolk and Worcester counties. Howe (1917, 1919, 1920); Gibb and Gibb (1954); PM Coll.; FSCA. *Michigan*: Alcona, Alger, Allegan, Alpena, Arenac, Barry, Benzie, Berrien, Branch, Cheboygan, Clare,

Crawford, Dickinson, Emmet, Gladwin, Gogebic, Grand Traverse, Gratiot, Houghton, Huron, Ingham, Ionia, Iosco, Isabella, Jackson, Kalamazoo, Kalkaska, Kent, Keweenaw, Lake, Lapeer, Lenawee, Livingston, Mackinac, Macomb, Manistee, Marquette, Mason, Mecosta, Menominee, Midland, Missaukee, Monroe, Montcalm, Montmorency, Muskegon, Newaygo, Oakland, Oceana, Ogemaw, Ontonagon, Osceola, Oscoda, Otsego, Presque Isle, Roscommon, Saint Clair, Saint Joseph, Schoolcraft, Shiawassee, Tuscola, Van Buren, Washtenaw, Wayne and Wexford counties. Kormondy (1958). *Minnesota*: Anoka, Cook, Fairbault, Goodhue, Hennepin, Lake, Lyon, Nicollet, Olmstead, Pine, Ramsey, Rock, Scott, Steele, Wabasha, Washington and Winona counties. Wilson (1909); Whedon (1914); Clausen and Hamrum (personal communications 1973). *Mississippi*: Claiborne, Covington, Forrest, George, Hancock, Harrison, Jackson, Lafayette, Lamar, Marion, Marshall, Noxubee, Pearl River, Perry, Stone and Tishomingo counties. GHB.; FSCA. *Missouri*: Barry, Boone, Carter, Greene, Jasper, Johnson, Pulaski, Shannon, Stoddard and Warren counties. Williamson (1932); Roback and Westfall (1967); C.J. *Montana*: Flathead County. Newell (1970). *Nebraska*: Antelope, Cass, Cuming, Douglas, Lancaster and Lincoln counties. U. N. Coll. *New Hampshire*: Carroll, Cheshire, Coos, Grafton, Hillsboro, Merrimack, Rockingham and Strafford counties. Howe (1917); White and Morse (1973). *New Jersey*: Camden, Cape May, Mercer and Ocean counties. Roback and Westfall (1967); FSCA. *New York*: Clinton, Erie, Essex, Franklin, Herkimer, Madison, Oneida, Schenectady, Suffolk, Tompkins, Ulster and Wyoming counties. Needham (1928); FSCA. *North Carolina*: Ashe, Cherokee, Durham, Graham, Henderson, Macon, McDowell, Mecklenburg, Orange, Swain, Transylvania, Wake, Wilkes and Wilson counties. Brimley (1903); Byers (1931); FSCA. *Ohio*: Adams, Allen, Ashland, Ashtabula, Auglaize, Brown, Butler, Carroll, Champaign, Clark, Clinton, Coshocton, Cuyahoga, Darke, Delaware, Erie, Fairfield, Franklin, Gallia, Geauga, Greene, Guernsey, Hamilton, Highland, Hocking, Holmes, Huron, Jackson, Lake, Licking, Logan, Lorain, Lucas, Marion, Montgomery, Morrow, Paulding, Perry, Portage, Ross, Trumbull, Union, Vinton, Warren, Wayne and Williams counties. Borrer (1937, 1938, 1942); Montgomery (1943); Harwood (1960); Roback and Westfall (1967). *Oklahoma*: Adair, Alfalfa, Caddo, Choctaw, Cleveland, Comanche, Craig, Delaware, Ellis, Harper, Kay, Marshall, McCurtain, Murray, Nowata, Oklahoma, Osage, Ottawa, Pawnee, Payne, Pittsburg, Pushmataha, Sequoyah, Washita, Woods and Woodward counties. Bick and Bick (1957). *Pennsylvania*: Allegheny, Armstrong, Beaver, Berks, Blair, Bucks, Butler, Centre, Chester, Clinton, Crawford, Cumberland, Delaware, Elk, Erie, Fayette, Forest, Franklin, Fulton, Greene, Huntingdon, Indiana, Lancaster, Lawrence, Lebanon, McKean, Mifflin, Monroe, Montgomery, Northampton, Perry, Philadelphia, Pike, Potter, Snyder, Somerset, Sullivan, Susquehanna, Tioga, Union, Venango, Warren, Washington, Wayne and Westmoreland counties. Ahrens, Beatty and Beatty (1968); Beatty, Beatty and Shiffer (1969, 1970). *Rhode Island*: Kent County. Howe (1917). *South Carolina*: Allendale, Charleston, Florence, Greenville, Greenwood, Horry, Laurens, Lexington, Newberry, Oconee, Orangeburg and Sumter counties. Montgomery (1940); Roback and Westfall (1967); Clem. U.; FSCA. *South Dakota*: Bennet County. Balsbaugh (personal communication 1973). *Tennessee*: Anderson, Blount, Campbell, Cheatham, Cocke, Coffee, Cumberland, Davidson, Dickson, Fentress, Greene, Hardin, Hawkins, Jackson, Johnson, Marion, Montoe, Montgomery, Obion, Overton, Pickett, Roane, Sevier, Sullivan, Trousdale, Washington and Williamson counties. Williamson (1923); Trogdon (1961). *Texas*: Anderson, Angelina, Bastrop, Bowie, Cherokee, Collin, Dallas, Denton, Grayson, Gregg, Grimes, Hemphill, Houston, Marion, Montgomery, Nacogdoches, Robertson, Rusk, Shelby, Walker and Wood counties. Johnson (1972). *Vermont*: Bennington, Caledonia, Chittenden, Grand Isle, Orleans, Rutland and Washington counties. Howe (1917); U. V. Coll.; PM Coll. *Vir-*

ginia: Fairfax, Montgomery, Roanoke and Washington counties. Williamson (1903); Gloyd (1951); Donnelly (1961); Johnson (1962). *Washington, D. C.*: Hagen (1874); Donnelly (1961). *West Virginia*: Boone, Braxton, Brooke, Cabell, Doddridge, Gilmer, Grant, Greenbrier, Hampshire, Hardy, Jefferson, Kanawha, Lewis, Lincoln, Logan, McDowell, Marion, Marshall, Mason, Mercer, Mineral, Monongalia, Monroe, Ohio, Pendleton, Pleasants, Pocahontas, Preston, Putnam, Raleigh, Randolph, Ritchie, Roane, Summers, Taylor, Tyler, Upshur, Wayne, Webster, Wetzel, Wood and Wyoming counties. Huggins (1927); Cruden (1962); Harwood (personal communication 1973); FSCA. *Wisconsin*: Burnett, Door, Forest, Langlade, Marinette, Milwaukee, Oconto, Sheboygan, Vilas and Waukesha counties. Muttkowski (1908); Clausen (personal communication 1973); FSCA.

CANADA: *Manitoba*: Waugh. Walker (1953). *New Brunswick*: Carleton, Charlotte, Northumberland, Queens, Sunbury and Westmoreland counties. Walker (1953). *Nova Scotia*: Annapolis, Digby, Halifax and Pictou counties. Walker (1953). *Ontario*: Algoma, Muskoka, Nipissing, Parry Sound and Waterloo counties. Walker (1953). *Quebec*: Gatineau, Huntingdon and Labelle counties. Walker (1953).

Seasonal flight times clearly do not isolate the species where their ranges overlap as particularly noted by Woodruff (1914) and Wells (1917) for northern areas. I have observed *C. maculata* and *C. dimidiata* co-existing in Florida, on occasion taking both species in one swing of the net. Walker (1953) gave 27 May to 10 September for *C. maculata* in Canada, and it may occur as adults the full year in south-central Florida during mild winters. Johnson (1973b) found the season for *C. dimidiata* in New Jersey (near its northern boundary) as 28 May to 25 August, and it approaches a full-year existence in Florida (26 February to 5 November). Walker's (1953) dates for *C. aequabilis* in Canada are 3 June to 2 September. An earlier date, 6 May (New Jersey) exists in the FSCA series; however, no later specimens occur than reported for Canada. The known seasonal ranges for *C. amata* and *C. angustipennis* are 31 May (Massachusetts) to 6 August (Tennessee), and 18 April (Georgia-Abbott's type) to 5 July (North Carolina) respectively. Harwood's experience in West Virginia (personal communication 1973) suggested local populations of *C. amata* and *C. angustipennis* have short flight seasons.

DISCUSSION

Colonies of *C. maculata* have occurred over most riverine conditions in the eastern half of the United States and southeastern Canada (Fig. 1). Pollution has doubtlessly reduced populations, and the species fails naturally to colonize more open, non-forested streams of the west. Nonetheless, 3 reports of *C. maculata* appeared for California, Nevada and New Mexico, and have been cited by later authors. The earliest report was by Calvert (1895b) for California giving only, "One male, California . . ." The specimen was in a consignment sent to Calvert for study from the California Academy of Science Collection. Fire later destroyed the collection and Calvert's specimen will remain a mystery. Muttkowski (1910) first utilized Calvert's record, and Kennedy (1917b), who had considerable prior field experience in California, first questioned its validity. Seeman (1927) and Smith and Pritchard (1956) nevertheless included the species in the California fauna based apparently on Calvert's early report. R. Garrison (personal communication 1973) searched collections of the University of California without finding California specimens and no such specimens exist to my knowledge. Smith and Pritchard

also give Nevada for *C. maculata*, once again without specific localities, and substantiating specimens are unknown. I. La Rivers (personal communication 1973) never encountered the species in his experiences with Nevada Odonata. Without additional data I assume the California and Nevada reports reflect errors. The New Mexico report originated with Kennedy (1917b) who gave a general distribution statement for species occurring in Kansas, and it formed the basis of Montgomery's (1947) reference of *C. maculata* from New Mexico 30 years later. I collected Odonata regularly for 5 years in New Mexico without finding *C. maculata* and can find no evidence of New Mexico specimens. Kennedy was at the University of Kansas when writing his 1917 Kansas paper and George Byers (personal communication 1973) stated that a specimen of that period, with a handwritten label, still exists in the Snow Museum (University of Kansas) Collection. The locality is "Wolfeboro, N.H." but is "readable" as "N.M.". I suggest Kennedy misread the label. The western Montana record by Newell (1970) is based on a badly broken specimen sent to the FSCA. This Montana colony would appear to be distinctly isolated from the major gene pool of the species and warrants study for possible divergence.

The range of *C. aequabilis* forms roughly a horizontal band over the northern United States and southern parts of central and eastern Canada (Fig. 2). Factor(s) determining its southern boundary pose an interesting ecological question, and Martin's (1939) life cycle studies suggest possible lines of investigation. The spotty distribution in the west appears to involve isolated populations, and the resulting subspecific names (*C. a. californicum* Kennedy 1917; *C. a. coloradicum* Cockerell 1913; *C. a. yakima* Hagen 1890; *C. a. hudsonica* Hagen 1875) reflect variation largely in the pattern of wing bands. Western samples are too small to evaluate quantitatively. Recent Colorado specimens are unknown since Cockerell's work.

The distributional hiatus in the range of *C. dimidiata* mentioned by Johnson (1973b) for North Carolina and Virginia narrows specifically to Virginia by incorporating data in the addenda of that paper. The new Tennessee record places *C. dimidiata* quite close to Kentucky, Burmeister's 1839 type locality, and the reservations on that locality raised in the above paper have less justification.

The ranges of *C. amata* and *C. angustipennis* shown in Fig. 3 correlate largely with mountain or up-land type streams. Records of *C. angustipennis* to the west in Indiana and Ohio represent old, single event occurrences, and south of West Virginia, the data show a spotty distribution of low-density colonies. The single Georgia locality for *C. angustipennis* comes from the 1853 type. The larger Odonata collections possess no additional Georgia specimens, and I have sought possible specimens from local insect collections in Georgia, Alabama and South Carolina to no avail. Efforts to specifically trace the type locality follow.

Selys (1853) gave only "Georgia" for distribution with the original description and P. Ward (personal communication 1973) informed me that the type label gave only Georgia. Hagen (1861) identified the collector as Abbott, and, in 1863, sketched John Abbott's contributions to entomology. From Abbott's notes for *C. angustipennis*, he gave "April 18, Briar Creek, and rarer". Presumably, Hagen studied Abbott's notes when he visited London in 1857. Since the type was still the only male known to Hagen in 1890, there is no

question that the data represent other specimens. Murphy (1945) gave a brief history of Abbott's contributions to ornithology indicating that he spent most of his life in Screven County, Georgia, in the late 1700's. The major drainage creek in Screven County appears on maps currently as Brier Creek, also occurring largely in Burke County. I suggest, therefore, the type locality is the Burke-Screven County area. The region is currently unlike the known habitat of *C. angustipennis* but its range is possibly diminishing, judging from the single early collections noted in Indiana and Ohio to the west. Abbott apparently found it uncommon ("rarer") on Brier or Briar Creek in the 1700's.

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ADDENDUM

The following entry, received from R. W. Garrison subsequent to writing the above paper, increases the scanty California distribution for *Calopteryx aequabilis*.

Mendocino Co., 15-16 June 1972. CIS Collection, Univ. of Cal., Berkeley.

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