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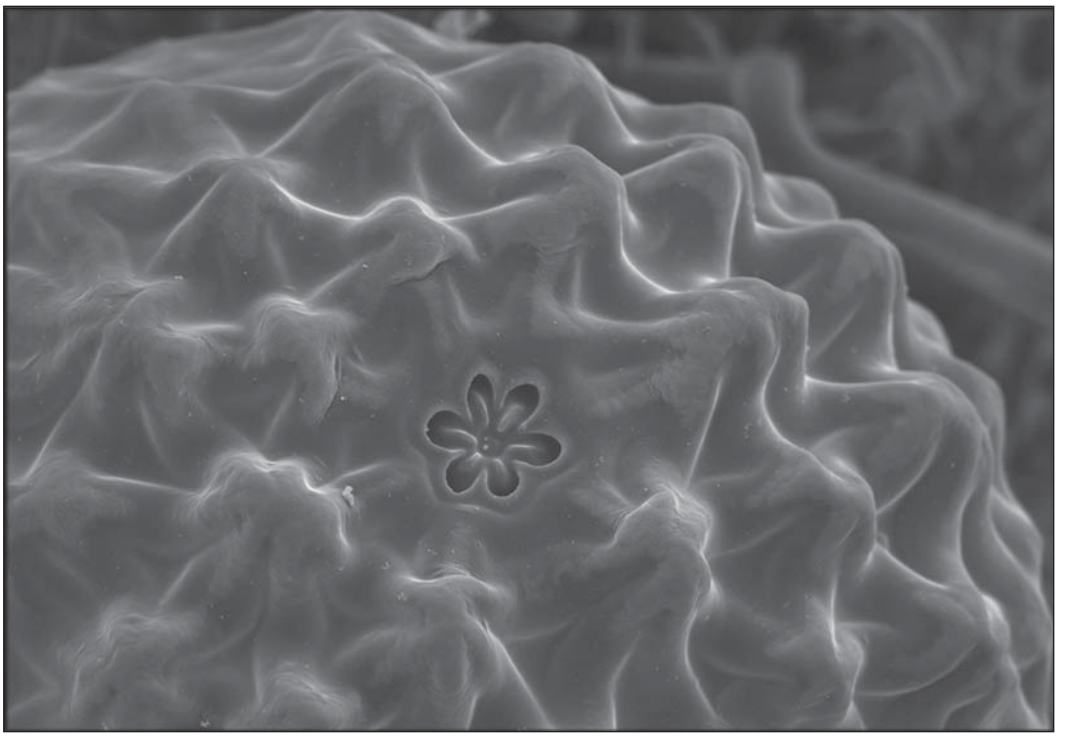

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Cover Illustration: Egg of ***Metharmostis* n. sp.** (Cosmopterigidae) showing chorionic topology and micropylar rosette on apical end. See article on page 111.

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THE EXTRAORDINARY STORY OF AN ARTISTIC AND SCIENTIFIC MASTERPIECE: *THE BUTTERFLIES OF NORTH AMERICA* BY WILLIAM HENRY EDWARDS, 1868-1897

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ABSTRACT. The creation of the book *The Butterflies of North America* by William H. Edwards is traced in detail. Much new information is presented, derived mostly from Edwards' extensive correspondence. It was issued from 1868 to 1897 in three series (volumes) of 42 separate parts. The first volume was published by the American Entomological Society, while the second and third volumes were published by Houghton, Mifflin & Company under several different names. The 152 hand-colored lithographic plates were drawn by five artists: Shelly W. Denton, Edward A. Ketterer, Mary Peart, Daniel Wiest, and an unidentified artist under the supervision of John Cassin. Most of the resulting prints were colored by sisters Lavinia (Lydia) Bowen and Patience D. Leslie, though many additional colorists were involved. Four plates were replaced after publication; the originals and their replacements are figured together for the first time. The first volume included a synopsis of species, which Edwards intended to revise in the second volume, but abandoned in favor of a simple list of taxa. Severe monetary constraints forced Edwards to sell his butterfly collection to help finance the third volume. Complete copies of the first and second volumes were assembled and sold for many years. Revised citations are proposed for each volume and their associated publications. New biographical information about Mary Peart is provided, including her portrait.

Additional key words: lithography, chromolithography, Mary Peart, publication, stereotype.

> "[H]e who loves a book will never want a faithful friend and a cheerful companion, and he may innocently divert and pleasantly entertain himself in all weather" – W. H. Edwards, 1901

Arguably possessing the most exquisite illustrations of butterflies ever produced, the three-volume magnum opus entitled *The Butterflies of North America* by William Henry Edwards (1822-1909) (Fig. 1) is one of the most important entomological publications of the 19th century. Originally issued in 42 installments from 1868 to 1897, it comprised three volumes, each of which Edwards considered to be a "series" of parts. The book was lauded by the entomological community. After the completion of the second volume, Scudder (1885) wrote, "The perseverance with which Mr. W. H. Edwards has continued his study of the butterflies of this country, and the liberality with which he has illustrated their various forms, ever since he first began the task, are worthy of all praise." Bethune (1909) believed that it "will long continue to be an authoritative book of reference and to form the foundation of all further studies of these most interesting and lovely creatures." Skinner (1909) considered the book to be "one of the greatest ever published on the subject." Twenty years after its publication, Grinnell (1917) asserted that *The Butterflies of North America* "will rank with Audubon's 'Birds of America' as a classic in natural history and it will probably never be exceeded in quality, scientific value, or interest." Well into the 20th century, Walton (1921) defined the book as the "most luxurious work on entomology that ever has appeared in this country." Other flattering reviews, mostly extracted from personal letters to Edwards, were included in a publisher's advertisement for the second volume (HMC 1884).

Edwards issued 152 splendid color plates of North American butterflies, but he failed to comprehend the difficulties that he would encounter along the way. The project dominated over thirty years of his life and required the sale of his beloved butterfly collection to

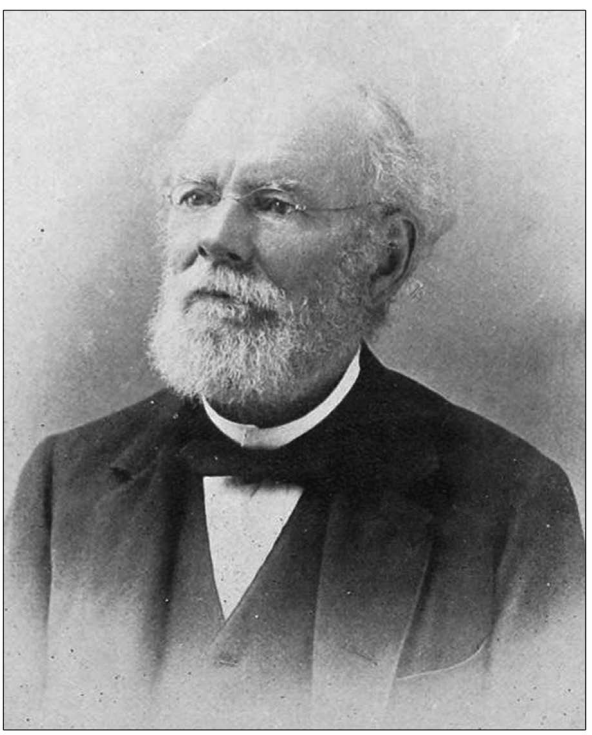


FIG. 1. William H. Edwards, ca. 1880, during the production of the second volume of *BNA* (from Bethune 1909).

generate the necessary funds. The production of the book was tremendously expensive to Edwards, both financially and emotionally. It came to symbolize the end of an era, when fine hand-colored illustration was being replaced by more efficient and inexpensive methods of color lithography and photography. As early as the 1920s, the third volume was described as "excessively scarce," while complete sets were considered quite rare (Sherman 1925). Today, the book seldom surfaces in the antiquarian book market. When it does, copies are expensive and usually incomplete. Rare complete sets of the book now sell for $7,000–$10,000 US. Despite the book's significance, I was surprised to learn how little is known about its history. Published information is scanty and largely inaccurate. I recently renewed my fascination with this influential work and decided to conduct a long-overdue investigation into its production.

This is the story of the creation of *The Butterflies of North America*, gleaned mostly from Edwards' writings and conveyed as much as possible in his own words. To call Edwards a prolific writer is an understatement; thousands of his letters and postcards are preserved in various museums and libraries. He wrote so many letters that he often repeated information to the same correspondents without realizing his redundancy. Edwards' inexhaustible pen documented a great deal of the book's production. This study does not attempt to explore the numerous taxonomic quandaries or other aspects of Edwards' entomological labors. Useful summaries of Edwards' life and contributions were offered by Bethune (1909), dos Passos (1951), Mallis (1971), Sorensen (1995), and Weeks (1911). Leach (2013) considered Edwards within the broad context of 19th century natural history and examined how his discoveries significantly impacted the study of Lepidoptera in America.

METHODS

Multiple copies of *The Butterflies of North America* (hereafter referred to as *BNA*) were analyzed, including my own. Also consulted were several thousand unpublished documents, mostly from Edwards' correspondence. Photocopies and scans of letters, postcards, and other manuscripts were obtained from the following: Research Library of the American Museum of Natural History (New York, New York: AMNH), Library of the California Academy of Sciences (San Francisco, California; CAS), Ernst Mayr Library (Museum of Comparative Zoology, Harvard University, Cambridge, Massachusetts; MCZ), Lyman Library (Museum of Science, Boston, Massachusetts: BMS), McGuire Center for Lepidoptera and Biodiversity (Florida Museum of Natural History, Gainesville; MGCL), Ewell Sale Stewart Library (The Academy of Natural Sciences, Philadelphia, Pennsylvania; ANSP), Archives and Special Collections, Olin Library, Rollins College (Winter Park, Florida; RC), Charles C. Wise, Jr. Library (West Virginia State Archives, West Virginia University, Morgantown; WVSA), and the personal library of James R. Wiker (Greenview, Illinois).

Extremely valuable were photocopies, microfilm prints, and photographs of hundreds of letters and postcards which were collected from many sources during the 1960s by the late F. Martin Brown. Initially donated to the Allyn Museum of Entomology (Sarasota, Florida), these copies are now preserved in the archives of MGCL. The original manuscripts are deposited in the AMNH, MCZ, and WVSA, as well as the library of the Carnegie Museum of Natural History (Pittsburgh, Pennsylvania; CMNH), the library of the Field Museum of Natural History (Chicago, Illinois; FMNH), and the Smithsonian Institution Archives (National Museum of Natural History, Washington, D.C.; USNM).

Among the manuscripts studied were letters and postcards from W. H. Edwards to Spencer F. Baird (SB) (1824–1887) (many of these were published by Brown (1958, 1959a, 1959b, 1960)), Henry Edwards (HE) (1827–1891), Hermann A. Hagen (HH) (1817–1893), William J. Holland (WH) (1848–1932), Edith K. A. Mead (EM) (1852–1927) (W. H. Edwards' daughter), Theodore L. Mead (TM) (1852–1936), Carl R. Osten Sacken (CS) (1828–1906), Samuel H. Scudder (SS) (1837–1911), Henry Skinner (HS) (1861–1926), F. H. Herman Strecker (FS) (1836–1901), Philip R. Uhler (PU) (1835–1913) and William G. Wright (WW) (1830–1912). Letters and postcards to W. H. Edwards include those from Louis Agassiz (LA) (1807–1873), Henry W. Bates (HB) (1825–1892), Charles J. S. Bethune (CB) (1838–1932), Augustus R. Grote (AG) (1841–1903), John Hamilton (JH) (1827–1897), Gilbert M. Levette (GL) (1833–1889), and John W. Weidemeyer (JW) (1819–1896). Also examined were 49 original letters from W. H. Edwards to T. L. Mead which were recently discovered in the archives of the McGuire Center. These letters were obtained in 1981 by F. M. Brown from the great-grandson of Edwards.

Because of the enormous amount of correspondence consulted, I have chosen to not cite all the letters and postcards parenthetically within the text. Instead, I cite each with a superscript number which corresponds to an entry in Table 1. For brevity, each letter citation is formatted using the correspondent's initials (as given above), followed by the recorded date (day, month, year), and the acronym of the repository of the original manuscript (as above). Each entry is prefixed by a lower

TABLE 1. Cited correspondence of William H. Edwards by section.

Conception and Tragedy															
1	tSB 13.iv.1865 USNM	5	tSB 13.iv.1866 USNM	34	tSS 2.v.1886 BMS	63	tHE 5.vi.1880 AMNH	92	tWH 12.xii.1885 CMNH	121	tSS 3.iii.1886 BMS				
2	tSB 12.xii.1867 USNM	6	tSB 10.xii.1866 USNM	35	tHH 20.i.1883 MCZ	64	tHE 15.ix.1881 AMNH	93	tWH 12.xii.1885 CMNH	122	tTM 10.i.1886 RC				
3	tSB 12.xii.1867 USNM	7	tSB 10.xii.1866 USNM	36	tTM 22.v.1881 RC	65	tHE 15.ix.1881 AMNH	94	tTM 10.i.1886 RC	123	tTM 10.i.1886 RC				
4	tTM 2.vii.1893 RC	8	tSB 11.xii.1866 USNM	37	tTM10.vi.1881 RC	66	tSS 14.x.1885 BMS	95	tTM 31.i.1886 RC	124	tSS 3.iii.1886 BMS				
5	tSB 20.vii.1868 USNM	9	tSB 5.ii.1867 USNM	38	tWW 27.x.1884 CAS	67	tHE 15.ix.1881 AMNH	96	tWH 1.ii.1886 CMNH	125	tSS 10.vii.1886 BMS				
6	tHH 10.v.1870 MCZ	10	tSB 3.v.1867 USNM	39	tWW 2.i.1889 CAS	68	tHE 7.ix.1882 AMNH	97	tTM 31.i.1886 RC	126	tSS 16.vi.1886 BMS				
7	tSS 18.iv.1901 BMS	11	tSB 3.v.1867 USNM	40	tSS 17.iii.1888	69	tSS 14.x.1885 BMS	98	tTM 10.i.1886 RC	127	tSS n.d. BMS				
8	tWW 6.xi.1886 CAS	12	tSB 2.vi.1867 USNM	41	tWW 3.i.1889 CAS	70	tHE 30.xii. 1883 AMNH	99	tTM 10.i.1886 RC	128	tSS 3.iii.1886 BMS				
9	tHE 22.ii.1871 AMNH	13	tSB 2.vi.1867 USNM	42	tSS 2.i.1893 BMS	71	tEM 3.iv.1884 RC	100	tTM 10.i.1886 RC	129	tHE 10.v.1886 AMNH				
10	tFS 27.ii.1871 FMNH	14	tSB 12.xii.1867 USNM	43	tSS 16.ii.1893 BMS	72	tTM 1.viii.1884 RC	101	tTM 5.ii.1886 RC	130	tSS 2.v.1886 BMS				
11	tHE 10.i.1876 AMNH	15	tSB 11.i.1868 USNM	44	tHE 22.vi.1871 AMNH	73	tSS 3.iii.1886 BMS	102	tSS 3.iii.1886 BMS	131	tSS 2.v.1886 BMS				
12	tTM 11.v.1871 RC	16	tSB 11.i.1868 USNM	45	tWH 3.iii.1889 CMNH	74	tEM 3.iv.1884 RC	103	tWW 5.iii.1892 CAS	132	tSS 16.vi.1886 BMS				
Publishers		17	tSS 14.x.1885 BMS	46	tSB 26.vi.1874 USNM	75	tHE 30.xii. 1883 AMNH	104	tHE 23.ii.1876 AMNH	133	tSS 3.iii.1987 BMS				
1	tSB 15.xii.1867 USNM	18	tSS 14.x.1885 BMS	47	tSB 10.xi.1868 USNM	76	tSS 7.xii.1887 BMS	105	tHE 16.x.1876 AMNH	134	tWW 22.iii.1887 CAS				
2	tSB 11.i.1868 USNM	19	tTM 17.iii.1876 RC	48	tSB 20.xi.1868 USNM	77	tTM 11.iv.1884 RC	106	tTM 5.ii.1886 RC	135	tSS 10.vii.1886 BMS				
3	tHE 20.vii. 1870 AMNH	20	tSS 2.i.1886 BMS	49	tSB 8.xi.1869 USNM	78	tSS 7.xii.1887 BMS	107	tWH 1.ii.1886 CMNH	136	tWH 12.vii.1886 CMNH				
4	tWW 12.iii.1891 CAS	21	tSS 3.iii.1886 BMS	50	tSB 8.xi.1869 USNM	79	tEM 3.iv.1884 RC	108	tWH 6.ii.1886 CMNH	137	tHE 13.i.1887 AMNH				
5	tSS 16.v.1893 BMS	22	tSS 2.i.1886 BMS	51	tHE 22.vi.1871 AMNH	80	tSS 29.iii.1887 BMS	109	tSS 2.v.1886 BMS	138	tSS 29.iii.1887 BMS				
Design and layout		23	tHE 21.ii.1883 AMNH	52	tHE 24.v.1872 AMNH	81	tSS 7.xii.1887 BMS	110	tSS 3.iii.1886 BMS	139	1.i.1888 tSS BMS				
1	tSB 12.xii.1867 USNM	24	tHE3.xii.1875 AMNH	53	tHE 19.xii.1872 AMNH	82	fPL 26.x.1885 WVSA	111	tSS 2.v.1886 BMS	140	tSS 26.x.1888 BMS				
2	tHH 11.x.1882 MCZ	25	tWW 5.v.1885 CAS	54	tFS 10.i.1873 FMNH	83	tSS 10.ii.1888 BMS	112	tWH 5.v.1886 CMNH	141	tSS 30.i.1888 BMS				
3	tHH 20.x.1882 MCZ	26	tTM 22.vii.1881 RC	55	tSS 14.x.1885 BMS	84	tSS 7.xii.1887 BMS	113	tSS 16.vi.1886 BMS	142	tHE 1.x.1887 AMNH				
4	tSS 14.x.1885 BMS	27	tTM 8.ix.1881 RC	56	tHE 22.v.1877 AMNH	85	tSS 7.xii.1887 BMS	114	tSS 10.vii.1886 BMS	143	tHE 1.x.1887 AMNH				
5	tHE 4.xii.1883 AMNH	28	tTM 18.vi.1893 RC	57	fET 5.viii.1876 WVSA	86	tSS 7.xii.1887 BMS	115	tWH 13.v.1886 CMNH	144	tHE 1.x.1887 AMNH				
Production		29	tSS 25.ix.1887 BMS	58	fET 11.iv.1877 WVSA	87	tSS 7.xii.1887 BMS	116	tSS 18.i.1886 BMS	145	tHE 27.xi.1887 AMNH				
1	tHH 10.v.1870 MCZ	30	tSS 30.iv.1893 BMS	59	fET 7.v.1877 WVSA	88	tWH 10.x.1888 CMNH	117	tHE 18.ii.1886 AMNH	146	tWH 10.x.1888 CMNH				
2	tSB 10.xii.1866 USNM	31	tTM 18.vi.1893 RC	60	tPU 6.ii.1874 MCZ	89	tSS 26.ii.1888 BMS	118	tWW 2.iv.1886 CAS	147	tWH 18.ii.1886 CMNH				
3	tSB 13.iv.1865 USNM	32	tWW 20.x.1886 CAS	61	fPU 27.ii.1874 MCZ	90	tEM 3.iv.1884 RC	119	tTM 5.ii.1886 RC	148	tHE 18.ii.1886 AMNH				
4	tSB 18.ii.1866 USNM	33	tSS 14.vi.1893 BMS	62	fPU 28.vii.1874 MCZ	91	tTM 31.i.1886 RC	120	tSS 2.i.1886 BMS	149	tHE 7.ix.1887 AMNH				

TABLE 1. Cited correspondence of William H. Edwards by section (continued).

150	tWH 10.x.1888 CMNH	180	tSS 3.ii.1889 BMS	3	tSS 21.ix.1890 MCZ	33	tSS 18.iv1901 BMS	26	tWH 12.vii.1886 CMNH	23	tSS 25.ix.1890 MCZ
151	tSS 7.xii.1887 BMS	181	tSS 24.ii.1889 BMS	4	tWW 12.iii.1891 CAS	34	fHS 25.ix.1922 MGCL	27	tWH 9.x.1890 CMNH	24	tSS 7.ii.1894 BMS
152	tSS 18.ii.1888 BMS	182	tSS 24.ii.1889 BMS	5	tWW 17.iii.1892 CAS	35	fCB 2.xii.1897 WVSA	28	tSS 6.viii.1899 BMS	25	tWW 25.iv.1897 CAS
153	tTM 11.iii.1887 RC	183	tHH 11.x.1889 MCZ	6	tWH 3.v.1896 CMNH	36	tSS 18.iv.1901 BMS	29	tSS17.ii.1893 BMS		**Publication particulars**
154	tWH 14.iii.1887 CMNH	184	tWH 3.ii.1890 CMNH	7	tWH 10.v.1896 CMNH		**Financial obstacles**	30	tSS 10.ii.1888 BMS	1	tSS 5.xii.1896 BMS
155	tHE 27.v.1887 AMNH	185	tTM 31.xii.1887 RC	8	tWH 11.xii.1893 CMNH	1	tSB 10.xi.1868 USNM	31	fSM 11.vi.1869 WVSA	2	tTM 11.vi.1871 RC
156	tTM 23.i.1888 RC	186	tSS 11.iv.1894 BMS	9	tSS 10.ii.1899 BMS	2	tSB 13.v.1869 USNM	32	tSS 26.x.1888 BMS	3	tHE 5.i.1872 AMNH
157	tWH 5.vii.1888 CMNH	187	tSS 18.ix.1893 BMS	10	tSS 27.iv.1899 BMS	3	fBC 19.viii.1869 ANSP		**Edwards' collection**	4	tTM 15.x.1872 RC
158	tHE 11.i.1888 AMNH	188	tWH 24.x.1893 CMNH	11	tWH 3.v.1896 CMNH	4	tHE 7.vi.1871 AMNH	1	tWH 21.xi.1885 CMNH	5	tWW 20.x.1886 CAS
159	tWH 17.xii.1885 CMNH	189	tWH 27.xi.1893 CMNH	12	tWH 16.iii.1896 CMNH	5	tHH 25.ix.1890 MCZ	2	tWH 16.i.1894 CMNH	6	tHE 31.xii.1879 AMNH
160	tWH 10.vii.1888 CMNH	190	fCD 29.iii.1895 WVSA	13	tWW 14.iii.1896 CAS	6	tSS 25.ix.1890 MCZ	3	tCS 14.iv.1858 MCZ	7	tHE 12.i.1880 AMNH
161	tSS 6.ii.1888 BMS	191	tSS 27.iii.1897 BMS	14	tWH 3.v.1896 CMNH	7	tHE 19.iii.1879 AMNH	4	tHH 10.v.1870 MCZ	8	tWW 23.x.1886 CAS
162	tHE 11.i.1888 AMNH	192	tSS 20.i.1897 BMS	15	tWH 3.v.1896 CMNH	8	tHE 22.i.1883 AMNH	5	fLA 29.v.1871 WVSA	9	tWW 12.xi.1896 CAS
163	tSS 8.i.1889 BMS	193	fPL 26.x.1885 WVSA	16	tWH 29.iv.1896 CMNH	9	tSS 8.v.1883 BMS	6	tWH 3.viii.1885 CMNH	10	tWH 12.xii.1885 CMNH
164	tSS 21.ix.1890 MCZ	194	tSS 7.xii.1887 BMS	17	tWH 3.v.1896 CMNH	10	tSS 8.v.1883 BMS	7	tWH 23.vi.1884 CMNH	11	tSS 3.iii.1886 BMS
165	tWH 4.xi.1892 CMNH	195	tTM 16.i.1893 RC	18	tWH 3.v.1896 CMNH	11	tHE 16.xi.1883 AMNH	8	tWH 23.vi.1884 CMNH	12	tWH 10.x.1888 CMNH
166	tSS 26.ii.1888 BMS	196	tSS 5.vi.1885 BMS	19	tWH 12.v.1896 CMNH	12	tHH 10.v.1870 MCZ	9	tWH 23.vi.1884 CMNH	13	tWH 11.x.1889 CMNH
167	tWW 3.ix.1887 CAS	197	tWW 6.xi.1886 CAS	20	tWH 17.iv.1896 CMNH	13	tWH 21.xi.1885 CMNH	10	tWH 3.viii.1865 CMNH	14	tSS 3.iv.1886 BMS
168	tWW 26.iv.1888 CAS	198	tTM 23.i.1888 RC	21	tWH 3.v.1896 CMNH	14	tWH 8.xii.1886 CMNH	11	tHE 5.v.1886 AMNH	15	tHE 15.v.1872 AMNH
169	tSS 17.ii.1893 BMS	199	tTM 23.i.1888 RC	22	tWW 4.x.1895 CAS	15	tSS 6.x.1887 BMS	12	tTM 2.xii.1885 RC	16	tHE 9.xii.1878 AMNH
170	tWW 5.iii.1892 CAS	200	tTM 24.iii.1888 RC	23	tWW 3.iv.1896 CAS	16	tWW 22.iii.1887 CAS	13	tHE 5.v.1886 AMNH	17	tSB 13.xi.1872 USNM
171	tSS 17.ii.1893 BMS	201	tSS 5.vi.1893 BMS	24	tSS 28.i.1897 BMS	17	tSS 6.x.1887 BMS	14	tWH 25.i.1886 CMNH	18	tSB 9.i.1873 USNM
172	tSS 30.iv.1893 BMS	202	tSS 17.ii.1893 BMS	25	tWH 11.iii.1897 CMNH	18	tWW 4.x.1895 CAS	15	tTM 31.i.1886 RC	19	tTM 12.x.1872 RC
173	tWW 14.iv.1893 CAS	203	tSS 7.ii.1894 BMS	26	tWW 8.viii.1897 CAS	19	tSS 6.iv.1896 BMS	16	tWW 10.ix.1887 CAS	20	tHE 19.xii.1872 AMNH
174	tSS 16.v.1893 BMS	204	tWH 11.iii.1897 CMNH	27	tSS 20.xi.1898 BMS	20	tWW 20.vii.1882 CAS	17	tWH 11.x.1889 CMNH	21	tHE 19.xii.1872 AMNH
175	tSS 3.v.1894 BMS	205	tSS 7.x.1895 BMS	28	tSS 20.xi.1898 BMS	21	tWH 3.ii.1890 CMNH	18	tWH 18.xii.1886 CMNH	22	tSB 16.xii.1873 USNM
176	tSS 2.i.1888 BMS	206	tSS 7.x.1895 BMS	29	tSS 20.xi.1898 BMS	22	tHE 18.vi.1884 AMNH	19	tHE 24.iii.1886 AMNH	23	tHH 5.i.1879 MCZ
177	tSS 6.ii.1888 BMS		**Approaching the end**	30	tTM 7.vii.1878 RC	23	tWW 20.vii.1882 CAS	20	tSS 28.viii.1888 BMS	24	tHH 5.i.1879 MCZ
178	tSS 3.ii.1889 BMS	1	tHH 12.ix.1886 MCZ	31	tSS 6.viii.1899 BMS	24	tHE 18.vi.1884 AMNH	21	tTM 18.vi.1893 RC	25	tHH 14.i.1879 MCZ
179	tWH 22.i.1889 CMNH	2	tHH 21.ix.1890 MCZ	32	tSS 27.iv.1899 BMS	25	tSS 27iii.1897 BMS	22	tHH 25.ix.1890 MCZ	26	tWH 24.x.1881 CMNH

TABLE 1. Cited correspondence of William H. Edwards by section (continued).

	tHH 30.x.1882		tHE 16.ii.1871		tSS 1.viii.1898		tHH 11.x.1882		tSS 6.iv.1896		tSS 2.iv.1888
27	MCZ	2	AMNH	19	BMS	6	MCZ	4	BMS	21	BMS
	tHH 27.xi.1883		tHE 6,v,1871		tWW 6.ix.1891		tHH 11.x.1882		tSS 17.xi.1887		tSS 30.ix.1888
28	MCZ	3	AMNH	20	CAS	7	MCZ	5	BMS	22	BMS
	tSB 26.vi.1874		tHE 2.vi.1872		tWW 6.ix.1891		tHH 11.viii.1882		tHE 7.iv.1876		tSS 18.iv.1901
29	USNM	4	AMNH	21	CAS	8	MCZ	6	AMNH	23	BMS
	tHH 11.x.1882		tSB 25.vii.1872		tWH 1.xii.1885		tHH 11.x.1882		tHE 15.v.1876		tSS 18.iv.1901
30	MCZ	5	USNM	22	CNMH	9	MCZ	7	AMNH	24	BMS
	tWW 30.x.1885		tSB 30.v.1872				tHE 3.x.1882		tHE 4.vi.1876		tTM 21.viii.1875
31	CAS	6	USNM		**Synopsis**	10	AMNH	8	AMNH	25	RC
	tWW 2.iv.1886		tSB 25.vii.1872		tSB 15.xii.1867		tHE 14.x.1882		tHE 22.v.1877		
32	CAS	7	USNM	1	USNM	11	AMNH	9	AMNH	26	tSS 5.i.1886 BMS
	tWW 26.xii.1884		tSB 23.i.1873		tSB 25.ii.1868		tHE 6.i.1883		tHE 14.iv.1876		tHE 5.v.1886
33	CAS	8	USNM	2	USNM	12	AMNH	10	AMNH	27	AMNH
	tSS 15.ix.1887		tHE19.xii.1872		tHE 21.ii.1872		tHH 20.i.1883		tHE 4.vi.1876		fMP 3.i.1886
34	BMS	9	AMNH	3	AMNH	13	MCZ	11	AMNH	28	WVSA
			fSS 7.ix.1882		fLG 26.iv.1873		tTM 1.i.1883		tTM 25.vi.1877		fLJ 10.xii.1889
35	tSS 2.i.1888 BMS	10	WVSA	4	WVSA	14	RC	12	RC	29	WVSA
	tTM 12.vii.1890		tHS 16.iii.1873		tHE 16.ii.1873		tHH 7.ii.1883		tHE 22.vi.1877		tTM 22.xii.1889
36	RC	11	JWC	5	AMNH	15	MCZ	13	AMNH	30	RC
	tWH 5.vii.1888		tSS 28.ix.1887		fJH 9.x.1894		tHH 21.i.1883		tHE 22.vi.1877		tWW 13.ii.1890
37	CMNH	12	BMS	6	WVSA	16	MCZ	14	AMNH	31	CAS
	tHE 24.ix.1888		tSS 6.x.1887						tWW 13.iii.1889		fMP 25.ii.1900
38	AMNH	13	BMS		**Revised synopsis**		**List of species**	15	CAS	32	WVSA
	tSS 11.ii.1893		tSS 28.ix.1887		tHE 16.iv.1877		tHH 7.ii.1883		tTM 8.ii.1889		tSS 11.v.1896
39	BMS	14	BMS	1	AMNH	1	MCZ	16	RC	33	BMS
	tSS 11.ii.1893		tSS 28.ix.1887		tHH 11.x.1882		**Portrait of Mary Peart**		tHE 9.ii.1883		tSS 21.ix.1894
40	BMS	15	BMS	2	MCZ			17	AMNH	34	BMS
	tWW 27.xi.1896		tWW 22.viii.1897				tTM 11.iv.1884		tTM		
41	CAS	16	CAS	3	tTM 5.ii.1882 RC	1	RC	18	11.viii.1888 RC		
			tWW 14.iii.1898		tHH ii.x.1882		tHE 9.iii.1881		tSS 27.xii.1887		
	Replacement plates	17	CAS	4	MCZ2	2	AMNH19	19	BMS		
	tHE 11.ii.1871		tSS 1.viii.1898		tHE 3.x.1882		tSS 25.ii.1895		tSS 27.xii.1887		
1	AMNH	18	BMS	5	AMNH	3	BMS	20	BMS		

case letter to indicate whether the correspondence was sent **to** (**"t"**) or **from** (**"f"**) W. H. Edwards. For example, "tWH 12.xii.1885 CMNH" refers to a letter sent **to** W. J. Holland, dated 12 December 1885, deposited in the Carnegie Museum of Natural History. The citation "fSS 7.ix.1882 WVSA" refers to a letter sent **from** Samuel H. Scudder, dated 7 September 1882, deposited in the West Virginia State Archives.

A photocopy of W. H. Edwards' typescript autobiography (Edwards 1900–1901, 1902) was generously furnished by Douglas M. Willis, great-great-grandson of Edwards. It includes much information not given in Edwards' "Entomological Reminiscences," published by dos Passos (1951).

In an attempt to determine dates of issue for the parts of *BNA*, I searched numerous publications for advertisements, announcements, library donation lists, and reviews that alluded to specific parts of *BNA*. State and federal census records, city directories, and burial records were consulted to reveal information about the various people involved in the creation of the book.

RESULTS

Conception and tragedy. About the year 1865, William Henry Edwards resolved to publish a series of colored figures of North American butterflies of the genus *Argynnis* (=*Speyeria*). He announced, "I propose publishing a monograph of the Argynnides of this country after the style of Hewitson's Exotics" [i.e. early parts of Hewitson 1852–1877].[1] Edwards soon decided to alter his original concept and include additional genera, publishing what he could and letting "the numbers run along" until he made a full volume.[2] His initial plan was summarized in a "Prospectus," in which he proposed to issue a book in installments (parts) at three-month intervals and offer it for sale at $2.50 per part. Each part would contain several hand-colored plates, with accompanying letterpress, which portrayed species "mostly new, or, if old, those that have heretofore been incorrectly described or figured" (see Edwards 1869). Edwards initially proposed that his book be titled, "Illustrations of the Butterflies of the U.S. & British America," but S. F. Baird of the

Smithsonian Institution suggested other alternatives, which Edwards adapted into the final title, *The Butterflies of North America*: *With Colored Drawings and Descriptions.*

Edwards struggled with the content of the text, asking Baird if he should "say anything of the habits/localities" or confine himself strictly to descriptions.[3] Edwards ultimately settled on a format that incorporated all this information. He considered segments of text to represent "papers," similar to what would be published in a scientific journal.[4] He also decided to issue a "Synopsis of Species" in installments, which would be concluded within the volume (Edwards 1869). This *Synopsis of North American Butterflies* was furnished separately as the sheets appeared for $1.00 extra. The first part of *BNA* was published "as an experiment" in 1868 and its success encouraged Edwards to continue. During the summer of 1868 he proudly declared, "My book is taking well I believe, & appears to be appreciated."[5]

Edwards began writing the text for *BNA* at his home in Newburgh, New York. In late 1868 he permanently moved to Coalburg (formerly "Coalburgh"), West Virginia, to more effectively manage the Kanawha and Ohio Coal Company, which he co-founded several years before (Edwards 1902). For two years he and his family lived in a small house, after which they moved into a larger two-story home on another property. Edwards, however, was frustrated about his relative isolation in West Virginia. "I work under great disadvantages in the absence from Libraries and from the artists and printers employed," he wrote. "In this remote corner of Virginia the mails are often ten days from New York or Phila."[6] West Virginia had become a state only seven years earlier, having seceded from Virginia during the Civil War. Edwards and his family often wintered in Charleston, West Virginia, located about 22 km (13.7 mi) northwest of Coalburg.[7]

On 21 February 1871, during the production of the first volume of *BNA*, Edwards' home was consumed by fire. Edwards recorded this traumatic incident in his autobiography (Edwards 1900–1901):

> *At about 2 PM, I was in the lower garden by the river with our gardener, Johnny Mulcahy, engaged in moving a shrub, when I heard a cry from the house, about six hundred feet distant. Turning to the cry, I saw flames issuing from the stable behind the house. Before we could get there the stable was a mass of flames. The miners were at work but it was not long before every man of them was down the mountain and had reached the scene. There was a wash house between the house and stable, else the fire might have been confined to the latter. But, when the wash house began to burn, the doom of the house was sealed. There was no water available and no provision for fighting the fire. A hundred men set to work and brought everything out of the house. Fortunately the day was clear. Also, it happened that a railway fill was being made not far below the house and a number of carts were in use. The boss on the ground at once offered his teams, and the furniture and the goods were carted to the sawmill and one or two houses nearby, and before night all was under cover.*

Edwards attributed the fire to "the pipe of our colored boy, Wesley Bowles, who was in the habit of smoking after his dinner" (Edwards 1902). The home was a total loss and Edwards carried no insurance.[8] Edwards' butterfly collection was saved, but was "more or less injured" because the small boxes in which he kept his insects were "grabbed by all sorts of fellows & deposited on the grass at a distance."[9] Edwards went in search of his collection "with anxious heart," and managed to find nearly everything, which actually suffered very little damage. Relieved, he supposed it may have been irreparable "if the fire had broken out in the night & my collections pitched out in the darkness." Edwards' collection in West Virginia contained his rarer species, as well as all those intended to be used for figures for *BNA* "for some time to come."[10] Its loss certainly would have terminated production of *BNA*. Edwards kept his "old collection" in New York, and did so for many years.[11] A brief notice about the destruction of Edwards' home was published by Bethune (1871).

Edwards quickly rebuilt his home, which was "on a different plan from the other & a prettier one."[12] Edwards' granddaughter, Catherine Tappan Willis (nee Smith) (1884–1968) lived in the home for much of her life and spent a great deal of time with Edwards. She vividly described the home's immediate surroundings: "Mr. Edwards built his house at the mouth of a wooded ravine where the land sloped down to the Kanawha River. The first settlers had cleared away several acres, leaving a few large trees, but the forest covered the mountain down to the clearing. The place had a natural setting of mountain, hillside and river. … They laid out their garden carefully with beds and borders full of old fashioned flowers, roses and gay annuals to attract butterflies. While fruit trees, berry bushes, and vegetable garden were planted on hillside and river bottoms" (Willis1901). Thus was the setting in which Edwards conducted his entomological research and produced the three volumes of *BNA*. A black and white photograph of the home, with Catherine standing on the porch, was published by dos Passos (1949). I obtained a more recent image (Fig. 2) from Leigh

Mann, Catherine's great-granddaughter. Through the dedicated efforts of Catherine's son, John A. Willis, Jr., and his wife, Harriet, the house was placed on the National Register of Historic Places (NPS 1990). The property has served as home for five generations of the Edwards family. Today, Edwards' great-great-grandson, Thomas O. Willis (great-grandson of Edwards' youngest daughter, Anne), resides in the house, which sits on a property roughly 3.2 ha (8 ac) in size (NPS 1990). This represents only a tiny fraction of the 34,641 ha (85,600 ac) of land that Edwards once owned in the region, much of which he sold during the 1850s for a handsome profit (Edwards 1900–1901, 1902). Regrettably, strip mining for coal, the unforeseen progeny of Edwards' own local mining operations, has removed the summit of the mountain directly above the house (T. O. Willis, pers. comm.).

Fig. 2. William H. Edwards' former home in Coalburg, West Virginia, ca. 1991 (courtesy Leigh Mann).

Contemporary works. *BNA* is often compared with another outstanding 19th century book, *The Butterflies of the Eastern United States and Canada* by Samuel H. Scudder (1888–1889). Scudder was an erudite systematist, while Edwards described a greater quantity of taxa and documented the life histories of countless butterflies. Edwards strongly disagreed with Scudder's use of generic names that were derived from the works of the early German entomologist Jacob Hübner. Scudder's insistence on these names fueled many heated discussions with Edwards and others within the entomological community.

Although Scudder's opinions often diverged from those of Edwards, he published anonymous reviews of *BNA* at least eight times (Mayor 1919) and his meticulous critiques reflected the overwhelmingly positive reception of the book. Although Scudder was a literary and scientific competitor of Edwards, these entomologists enjoyed a fruitful correspondence. Scudder visited Edwards at his home in West Virginia and even helped obtain funding for the production of *BNA*. They often sought advice from one another and freely shared specimens of insects and plants, as well as proofs of illustrations for their respective books. Edwards loaned Scudder many original drawings and allowed him to reproduce some figures from *BNA* for Scudder (1888–1889, 1895). Edwards also published advertisements to Scudder's book, which were printed on the rear wrapper of at least two parts of *BNA*. Despite their disagreements, these zealous naturalists shared a lengthy relationship dominated by mutual respect (Leach 2013).

Edwards was not on such friendly terms with another entomologist who was issuing a book concurrently with *BNA*. Between 1872 and 1878, Herman Strecker published 15 parts of his *Lepidoptera, Rhopaloceres and Heteroceres, Indigenous and Exotic*. Strecker, who was known for his acerbic rhetoric and discontent with other entomologists, attempted to undermine Edwards by being the first to describe and figure new species. This dispute was familiar to their shared correspondents. The lepidopterist Henry Edwards advised Strecker, "I do not think it is good either for yourself or for science as Edwards' book was first in the field, & he is likely to get the earliest and most abundant help" (11.x.73 FMNH). Strecker nonetheless continued to seek specimens from the same sources as W. H. Edwards. The quest to acquire and name new species was highly competitive. Squabbles were frequent and often spilled over into the published literature.

Publishers. It was suggested by S. F. Baird that Edwards employ a high profile publisher for *BNA*, such as B. Westermann & Company or Hurd & Houghton, both of New York.[1] Edwards instead decided to publish it through the Entomological Society of Philadelphia,[2] which changed its name in 1867 to the American Entomological Society. Subscriptions for the book were directed to Ezra T. Cresson, Sr., who was one of the founders of the Entomological Society of Philadelphia. The text was printed by Cresson and another member, Charles A. Blake, on a hand press located in the society's room at The Academy of Natural Sciences, Philadelphia (Edwards 1900–1901; dos Passos 1951). Cresson rolled on the ink, while Blake, being the stronger of the two, pulled the press (Anonymous 1903). After the first volume was completed, Cresson was no longer connected with the publication of *BNA*. Cresson was "obliged from the state of his health" to stop doing work for the American Entomological Society, forcing Edwards to find a new publisher.[3] Edwards therefore

made arrangements with the firm now known as Houghton, Mifflin and Company to publish a second volume. Edwards paid the cost of publishing the book, while Houghton Mifflin covered all costs associated with production and marketing, deducting a ten percent commission for their efforts.[4] Needless to say, *BNA* was a very expensive affair for Edwards. Although Cresson no longer acted as the publisher, he continued to accept orders for the second volume, at least for the early parts.

During the production of the second volume of *BNA*, contemporary advertisements for Parts 1–4 directed subscribers to either the Boston firm of Houghton Oscar Houghton & Company, or the New York firm of Hurd & Houghton. At that time, the latter was considered the publisher, while the former controlled the manufacture of books (RP 1899). The title pages of these parts identified the publisher as Hurd & Houghton. In 1878, Houghton Oscar Houghton became Houghton, Osgood & Company, and the name Hurd and Houghton was discontinued. As a result, Parts 7 and 8 of *BNA* bore the name of Houghton, Osgood & Company. The company name changed again in 1880 to Houghton, Mifflin & Company, thus this name was used on the title pages of Parts 9–13. All parts of the third volume carried the publisher's imprint of "Boston and New York: Houghton, Mifflin & Company". The second and third volumes were printed at Riverside Press (Cambridge, Massachusetts), which was established by Henry Houghton as a production facility for his book business. The individual at Riverside Press who arranged printing of the third volume was apparently named Weise.[5] Beginning with Part 2 of the second volume and continuing throughout the production of the third volume, publisher's imprints also referred to the London publisher Trübner & Company, who were American literary agents located at 60 Paternoster Row in London. Trübner's sold *BNA* from the very beginning, even when it was published by the American Entomological Society (Anonymous 1868). Consistent with today's marketing practices, advertising of the book increased prior to the holiday season.

Early parts of the first volume were offered at a price of $2.00, but increasing production costs required that beginning with Part 3 new subscribers paid $2.50. This price is equivalent to about $40 today. Depending upon the number of plates included, parts of the second volume were available for $1.50–$3.50 each. Early parts of *BNA* were offered by Trübner & Company in London for 10 shillings each (Anonymous 1869), while later parts sold for 12 shillings (TC 1889).

Design and layout. Each part of *BNA* was issued in sewn signatures with paper wrappers (covers) that displayed the purported date of publication. The parts were mailed flat between pasteboards to prevent damage. The entire title as printed on the wrappers was *The Butterflies of North America*: *With Colored Drawings and Descriptions*. The unnumbered pages and plates were printed in quarto size (approx. 23 × 28.58 cm/9 × 11.25 in), dimensions which were comparable to other Lepidoptera books that Edwards had examined.[1] Incorporated into the last installment of each volume were a title page, author's preface, and a "Systematic Index" which enabled the binder to arrange the plates into their proper order. A "Dates of Issue" sheet also was included, which listed all the parts for that volume and the dates when they were purportedly published (Scudder had suggested the inclusion of this page for each volume[2]). A "General Index" was provided at the completion of the third (last) volume, which indexed the entire work.

The text was printed using the stereotype method, a decision that Edwards ultimately regretted. More expensive than moveable type, stereotype allows the printer to produce small runs over great periods of time without having to reset the type each time. However, because each letter was not a single piece of type, changes could not easily be made without re-casting the entire page.

Upon completion of each volume, it was recommended that the plates and pages be numbered in pencil according to an "Alphabetical Index", which was also issued with the last part. This elicited complaints from subscribers (e.g. [Scudder] 1874) who thought the lack of numbering was awkward and cumbersome. Edwards defended this format, telling H. A. Hagen in 1882, "If you will look at Hewitson's Ex. But. [Hewitson 1852–1877] you will see that I followed his example and at the end of his introduction to Volume 1 he says he publishes an index for the binder, and also an Alphabetical index of which the volumes may be numbered on pages with pencil. I follow him in all this."[3] Edwards insisted, "I don't see any better or any other way than the one I adopted."[4] This format allowed Edwards the flexibility of issuing plates in whatever order he chose, without regard for taxonomic consistency. It was left up to the subscribers to bind the parts into proper order when the volumes were completed. Although this strategy benefited Edwards, it remained contentious among subscribers for many years. As a concession, Scudder suggested that a general index also be included, which Edwards accepted with some reluctance.[5]

Subscribers typically bound each volume when they received all the parts. Late subscribers often purchased the first two volumes complete, and then bound the parts of the third volume to match. The original

wrappers were usually discarded prior to binding, thus very few copies of the book preserve them. Rarer still are several publisher's notices which were issued separately or were printed on the rear covers of the wrappers.

Production. Edwards endeavored to make the "artistic execution" of the plates for *BNA* as perfect as possible, "sparing no expense or trouble for this purpose."[1] To this end, he decided to take advantage of stone lithography, which imparted far greater detail than customary engraving methods. He wrestled, however, with the actual production of the plates and found the greatest difficulty "in getting the figures drawn" on stone.[2] Many years later, Edwards wrote about the early development of his first plates (Edwards 1900–1901; dos Passos 1951), but his recollections were not entirely consistent with his correspondence, which documented the events as they unfolded. The following is primarily extrapolated from Edwards' letters to S. F. Baird.

Edwards first approached John Cassin (1813–1869) about "issuing a trial plate or two," thereby "leaving it to the future to determine whether a general work on butterflies would be advisable" (Edwards 1900–1901). Cassin was a talented lithographer and co-proprietor of the lithographic firm of Bowen & Company in Philadelphia. He was also a renowned ornithologist, who served as the Curator and Vice-President of The Academy of Natural Sciences of Philadelphia (Stone 1901).

Around April 1865, the first two trial plates for *BNA* were drawn on stone by "an Englishman" under the employ of Cassin (Edwards 1900–1901). One portrayed the female of *Speyeria diana* (Cramer) and the other the male and female of *Speyeria atlantis* (W. H. Edwards). Edwards obtained a third plate by February 1866.[3] Based on the numbering system subsequently employed for these plates, the third illustration possibly portrayed *Speyeria cybele* (F.). Edwards hoped to have two more plates drawn before issuing the first part of *BNA*.[4] Two months later, Edwards received a proof of a fourth plate,[5] ostensibly depicting *Speyeria aphrodite* (F.). However, Edwards observed that two of these four plates were "imperfect" and needed to be redone.[6] Subsequent events suggest that he was referring to the plates of *S. diana* and *S. atlantis*. To color the early proof plates, Edwards evidently used Susan Clark Gray (1821–?), wife of the artist Henry P. Gray of New York.[7] Edwards met her in 1857 when she boarded at the same Massachusetts hotel (Edwards 1900–1901).

To help alleviate Edwards' anxiety about delays in preparing his plates, S. F. Baird suggested that Edwards try John H. Richard (1807–1881), an artist and colorist from Philadelphia who had worked at the Smithsonian.[8] Edwards also briefly contemplated using the London-based entomological artist Edward W. Robinson (1835–1877), who had previously worked on illustrations of American sphinx moths, a project begun in 1862 with Edwards' involvement. These moth plates were later published in a limited edition by Weidemeyer et al. (1903). However, Edwards had misgivings about sending specimens overseas, writing, "I should be sorry to send those fine things over there and have them come back ruined."[9] In the end, Edwards did not use either of these artists for *BNA*.

The two plates created in 1866 (*S. cybele* and *S. aphrodite*) were drawn by Daniel Wiest (1842–1901), a Philadelphia artist who was introduced to Edwards by E. T. Cresson, Sr. (dos Passos 1951). Little is known about Wiest, but city directories and census records reveal that he was born in Bayern, Germany and lived with his wife and daughter at 1222 Stiles Street in Philadelphia. His occupation was variably listed as artist, lithographer, and engraver. He is likely the same Daniel Wiest who was elected in 1861 as a member of the Entomological Society of Philadelphia (Anonymous 1861). Wiest is best known for creating the popular lithographic illustration "In Memory of Abraham Lincoln: The Reward of the Just", which was issued in 1865 by the Philadelphia publisher William Smith. Like E. W. Robinson, Wiest had previously rendered plates of sphinx moths, published decades later by Weidemeyer et al. (1903). He later drew plates for several other publications about Lepidoptera, including Robinson (1869). Wiest's plates for *BNA* were struck (printed) by Bowen & Company (Edwards 1900–1901).

In early 1867, Wiest was asked to render a new plate of *S. diana*, this time portraying both the male and female.[10] Edwards described the results as "handsome."[11] A month later, Edwards' remarked, "I find that the artist who drew my 3 plates of Argynnis [presumably *S. cybele, S. aphrodite*, and the revised *S. diana*], is willing to go ahead, and I will therefore have 2 more drawn."[12] Wiest ultimately completed only one additional plate, that of *Speyeria nokomis* (W. H. Edwards).

The completion of Wiest's four plates took over a year and Edwards grew tired of waiting. He had hoped to complete all the plates and issue the first part of the book during 1867.[13] Edwards therefore decided to utilize the earlier plate of *S. atlantis*, combining it with the four created by Wiest, thus reaching his goal of five plates for the first part. The style of the plate of *S. atlantis* is more primitive than those rendered by Wiest and was not signed. "I believe I have 5 plates of the Agynnides now drawn ready for coloring," Edwards

wrote, "and I have nearly prepared the text to accompany them."[14]

As the first part of the book was nearing completion in early 1868, Edwards revealed, "I have made full arrangements for the issue of No. 1 of the 'Butterflies of N. Am[a] about 1st Ap[ril]."[15] Still running behind schedule, Edwards finally issued the five plates, with accompanying letterpress, during the first week of June. Using the genus recognized at that time, the plates were entitled *Argynnis* I – *Argynnis* V. Looking forward to a second part, Edwards wrote, "If I can get Weist [sic] to proceed with drawing I will put in his hands 5 more."[16]

Although the first part of *BNA* was well received, Edwards was still disappointed with the quality of his plates. Rather than continue with Wiest as he had proposed, Cassin suggested another artist employed by Bowen & Company, the very talented Mary Peart (1837–1917), who resided about 2.4 km (1.5 mi) from The Academy of Natural Sciences in Philadelphia. Peart was engaged to draw plate *Argynnis* VI (*Speyeria callippe* (Boisduval)), which was much more satisfactory. Peart was thereafter engaged to draw all the remaining plates for the first volume, as well as all those for the second. Describing Peart's early work, Edwards (1900–1901) remarked, "She, at the beginning, knew nothing of butterflies, but made drawings of the material put before her. I called her attention to the peculiarities of the legs and antennae and gave her a net with which to take live butterflies in order to study these organs, and soon her drawings became exact." Edwards later considered his discovery of Peart "as important a find as a new planet almost."[17] For many years thereafter Edwards declined employing any other hand to draw his plates, even though it delayed production of his book.[18]

Edwards sent Mary Peart adult butterflies, as well as specimens and sketches of early stages. To reduce the possibility of damaging adult specimens during the preparation of the plates, Edwards sometimes fastened them into special boxes with two glass sides, "in which the insect is placed on cork."[19,20] He described these boxes as "6×8, 2 inches deep inside . . . one half shuts down on the other, tight."[21] Such boxes, similar in construction to those Edwards used to store portions of his own collection, were apparently inspired by the storage boxes of the Philadelphia naturalist Titian R. Peale, whom Edwards met during the 1860s (Edwards 1900–1901). The specimens thus protected, Peart was "able to work just as well so as if she had the naked insect to handle."[22]

While the purpose of the first volume of *BNA* was intended to illustrate species that were "incorrectly described or figured," Edwards' attention ultimately turned to documenting the early stages of each species. Although this added a great deal of complexity to the project, it significantly improved the usefulness of the book. Edwards urged others to send drawings and specimens of early stages to Peart for illustration, sometimes offering to exchange copies of his book for their help: "[I]f that will not fetch it, I don't know what will."[23] Edwards could be quite insistent in his efforts to encourage correspondents to provide material, even scolding Henry Edwards, "for heaven sake don't neglect it!!!"[24] Edwards suggested that eggs be sent in blocks of wood with holes drilled in them[25] and larvae be accompanied by "a supply of the hostplant" (Edwards 1873). He kept a large number of vials on hand which he sent to correspondents who offered to supply early stages, asking that they send them back in "a tin box or a cigar box."[26,27] Edwards abhorred badly preserved inflated ("blown") larval specimens, like some of those figured by Scudder (1888–1889), which Edwards described as "looking like a coffee sack."[28] Curiously, Edwards readily accepted inflated larvae from Scudder.[29] Edwards successfully cultivated a network of many naturalists who provided important specimens for his work.

Edwards reared and documented the early stages of countless species. "When Vol. I. was undertaken," he explained, "nothing was known by myself or any one else, of eggs, larvae, or chryasalids, except of the more common butterflies…But in 1870 I discovered an infallible way to obtain eggs from the female of any species of butterfly, namely, by confining her with the growing food-plant." Using this method, he "reared larvae without end" (Edwards 1887–1897). This process was facilitated by the opening of the Chesapeake & Ohio Railroad in 1870, which allowed Edwards to more rapidly convey living early stages to Mary Peart in Philadelphia. Edwards was thereby able to rear numerous species for the first time. He bagged female butterflies and larvae over their hostplants in order to rear them and erected a greenhouse in which to maintain plants during the winter.[30,31] To preserve larvae and pupae during the winter months, he kept some in his bedroom and occasionally sent others to be stored in an ice house located in Clifton Springs, New York.[32] He used a similar "ice box" in attempts to induce "torpidity" in larvae that came from cooler climates.[33] He had trouble, however, rearing species of Hesperiidae, especially "such as pass the winter in larval stage."[34]

Edwards grew increasingly obsessed with documenting the biology of the species he figured in *BNA*. For example, it took nearly thirty years to reveal

the entire life history of *Parnassius smintheus* Doubleday (Edwards 1900–1901). Edwards boasted, "I may venture to say that I have bred butterflies from the egg to a greater extent than any living man no matter who he is or where he lives."[35] Despite his rearing prowess, Edwards displayed little understanding of ecology, a science that was still taking shape during the late 19th century. For example, he "turned loose" near his home about 100 adults of the Old World swallowtail (*Papilio machaon* L.) which emerged from chrysalids that T. L. Mead had obtained from Germany (Edwards 1882). Edwards caught and released one of them about a week later, but never saw any others.[36,37]

Mary Peart also reared many species in order to figure their early stages, thereby contributing a great deal of new biological information. Edwards (1874–1884) wrote, "I have been seconded to the utmost by Mrs. Mary Peart, who has not only drawn the early stages on the stone, but previously on paper, making in each case colored figures; and in order to do this has had to aid in rearing the larvae, and to take a vast amount of trouble upon herself." Peart meticulously recorded dates of transformations and measurements of the larvae. Edwards once quipped that Peart had contributed more toward his work on butterflies than he had (Walton 1921). After drawing the early stages, Peart preserved representative specimens in alcohol vials which were then sent to Edwards. This added immensely to Edwards' collection of early stages, about which he often boasted. Peart also drew eggs and larval structures with the use of a microscope owned by J. Gibbons Hunt (1826–1893), a prominent Philadelphia physician, botanist, and microscopist who sometimes conducted microscopic work directly for Edwards.[38] Probably using Hunt's microscope, Peart rendered illustrations of plant structures for Hunt (1870). On at least one occasion Peart borrowed a microscope from Edwards to draw larval details.[39] She later used a solar microscope to examine adult and larval morphology.[40,41,42]

Mary Peart prepared colored pattern plates that the colorists used to properly tint the resulting prints.[43] The prints of the first and second volumes were colored by Lavinia (Lydia) Bowen (nee Davis) (1820–1888), with the assistance of her sister, Patience Davis Leslie (1826–1893). Although imprints on many plates of *BNA* indicate that they were colored by L. Bowen, Patience was responsible for a large number. Lavinia Bowen was previously a colorist for John T. Bowen, whom Lavinia married prior to 1838. John Bowen had established the lithographic firm of J. T. Bowen & Company, who published *The Viviparous Quadrupeds of North America* and the royal octavo edition of *The Birds of America*, both by John James Audubon. Lavinia and P. D. Leslie reportedly colored prints for these famous works. Lavinia took control of the company after John Bowen's death in 1856 (Barnhill 2010). The female artists and colorists employed by Lavinia's firm worked out of their homes to conceal their service, as domestic affairs were culturally favored for women (Penny 1863). This is supported by Edwards who wrote, "Mrs Bowen the colorist … undertakes to do the coloring for me personally at her house as Miss Peart does the drawing."[44] As L. Bowen's health declined, Leslie evidently took over most of the coloring duties for the second volume.

With few exceptions, all the figures on the plates of *BNA* were hand-colored. Some green larvae, as well as the silver coloring of at least one plate, *Argynnis* IV (*Speyeria coronis* Behr), were colored using the process of chromolithography (color lithography).[45] The printed inscriptions on the plates were done by lettering artists who specialized in this work.[46] The plates were typically lettered before Edwards wrote the accompanying text, thus he sometimes worked feverishly at the eleventh hour to ensure that he used correct names on the plates. The names on the plates essentially established the nomenclature that he employed in the associated letterpress.

From 1859 until 1867, Lavinia Bowen partnered with J. Cassin (Groce & Wallace 1957), who managed the lithographic work for the firm. During the early production of the first volume, Edwards wrestled with the high production costs of Bowen & Company. "Cassin charged $30 per plate for the drawing, and 30 cents per sheet for coloring (including paper & printing)," he complained. "The drawing shd be but $15 per plate & coloring not over 20 c[ents]."[47] Threatening to find other artists, Edwards met with Cassin, who was persuaded to agree to "more reasonable terms."[48] After Cassin's death, Bowen took Edward Turnbull as a partner and continued the firm under the name Bowen & Company. However, Edwards was very unhappy with this affiliation, writing, "Since Cassin's death and Turnbull's advent, there has been nothing but misunderstandings. They have altered the prices twice since Cassin's time, and I never know what to expect from them."[49] Peart also was dissatisfied, prompting her to inform E. T. Cresson, "I was almost ready to enter a protest against receiving any more work at the hands of Bowen & Co. as that means Turnbull." She learned that Edwards' work was being badly neglected and suggested that "some other arrangement can be made" (29.xii.1870 ANSP). Apparently, Bowen's personal mail was often intercepted at the firm, prompting her to ask that letters from Edwards be sent to Cresson.

Experiencing ongoing delays in drawing his plates, Edwards scoffed, "I mean to finish the work … if Bowen & Co. do not drag it along for the rest of my life."[50] In 1871, Edwards withdrew all pending work from Bowen & Company "on account of a partner in that firm [Turnbull] who is unreliable and of bad habits."[51] To avoid having to deal with Turnbull in the rendering of his plates, Edwards arranged to work directly with Peart, while the resulting illustrations continued to be printed and colored by Bowen & Company (Edwards 1900–1901; dos Passos 1951). The completed plates were sent to Edwards, who forwarded them to the publisher as needed.

At the conclusion of the first volume, Edwards was relieved: "I feel as if a big thing was off me."[52] Its positive reception prompted him to continue publication. Wasting little time, he engaged Peart to begin drawing plates for the second volume, asking that she "keep at it for six months if her health allows & then I will begin to talk of publishing."[53] Although it was his goal to receive 20 plates from Peart before he issued the first part of the second volume,[54] this plan was not realized. In 1874, Edwards was able to devote more time to the book during a temporary cessation of work at the Kanawha and Ohio Coal Company, which soon after was reorganized (Edwards 1902).

During production of the second volume, Edwards remarked, "It is a fact that I did not foresee the delays in publishing when I began."[55] Because of such delays, the publisher suggested that Edwards augment Peart's work with another artist in their employ. Edwards was urged to send specimens for a trial plate, but he worried that this artist would be unable to restore specimens to a natural state prior to illustrating them, as "Miss Peart can do that to perfection."[56] Hermann A. Hagen recommended that another artist, Étienne L. Trouvelot (1827–1895), contact Edwards and offer his services for drawing plates.[57] Trouvelot is inauspiciously recognized for inadvertently introducing the destructive gypsy moth (*Lymantria dispar* (L.)) into North America in 1869 (Spear 2005). Although Trouvelot completed some illustrations of early stages for *BNA*, prior commitments prevented him from working on the plates.[58,59] Trouvelot later completed 112 illustrations for Scudder (1888–1889).

The letterpress for plate *Chionobas* II (*Oeneis nevadensis* C. Felder & R. Felder), which was issued with Part 3 of the second volume, included wood cut engravings that portrayed the hindwing patterns of four nominal taxa of the genus *Chionobas* (=*Oeneis*). This is the only instance where Edwards provided such an illustrated comparison of taxa. Because Edwards' access to relevant publications was limited, he asked P. R. Uhler of Baltimore to copy the original description and provide an outline drawing of the ventral hindwing of *Chionobas nevadensis* as published by Felder and Felder (1865–1875).[60] Uhler obliged by "placing the thin paper over the colored lithographs and tracing their details of markings with lead pencil."[61] Edwards was therefore able to include this taxon in his line-up of *Chionobas* hindwings.[62] All the taxa so represented are now generally considered synonymous with *Oeneis nevadensis* (Pelham 2008). This is an example of the type of assistance that Edwards routinely sought while preparing parts of *BNA*.

In 1880, Edwards was growing tired of the work. "I am nearing the end of my 2nd vol., and do not propose to continue it," he told Henry Edwards. "It is a vast trouble and great expense to me."[63] Later the following year, Edwards was still unsure if he would be able continue beyond a second volume.[64] He confessed that this was dependent upon several things, not the least of which was the cooperation of Mary Peart, without whose help he "certainly would not proceed."[65] Edwards remarked, "I have probably 1000 figures by Mrs. Peart in my albums & she is all the time adding to them, so I have the materials for a 3rd vol in hand."[66] He boasted that because many of the figured species were rare, no one could rival this collection of illustrations.[67] He aspired to "live long enough to publish a 3rd volume with all these fine things."[68] Edwards proposed that if he could not continue, perhaps "some one hereafter can go on with successive vols by the aid of my drawings."[69]

Although the continuation of *BNA* was in doubt, Edwards remained hopeful: "If I can find the artists I would go on with Vol III & should like to."[70] His wishes were realized in 1884, when Houghton Mifflin told Edwards that they were "considering the proposition of a 3rd volume of the Butterflies."[71] Edwards recommended that he stop the second volume at 50 plates, ending with plate *Papilio* XIII (early stages of *Papilio rutulus* Lucas).[72] Having ended the second volume, he quickly started on the third, vowing to "push it to an end in 4 or 5 years if it is possible"[73]

While working on new parts for the second and third volumes, Edwards continued to assemble copies of the first volume. Beginning around 1884, he was employing two additional colorists besides Bowen and Leslie to complete outstanding orders for the first volume.[74] One of these was the art student Mary Caroline "Lina" Beard (1852–1933), a very talented artist in New York who wrote and illustrated several books of her own. It was Houghton, Mifflin & Co. who previously suggested that Edwards contact her, "a lady equal to doing my coloring … daughter of the great artist Beard [James H.

Beard]."[75] Edwards noted that Beard could "only work mornings as she is studying at the League" [Cooper Union and Art Students League in New York City].[76] With her younger sister, Adelia, Lina co-founded the Girl Pioneers of America, a precursor to the Camp Fire Girls and Girl Scouts of America (Haverstock et al. 2000). Youth organizations led by their brother, Daniel C. Beard, resulted in the formation of the Boy Scouts of America. In addition to coloring plates for new copies of the first volume, Lina Beard also colored half the prints for plate *Papilio* VII (*P. rutulus* Lucas) of the second volume.[77] Beard was a friend of Edwards' youngest daughter, Anne Edwards Smith (nee Anne Scott Edwards) (1858–1930), who sometimes did coloring work for *BNA*. Edwards mentioned that Anne "complains of her eyes whenever called to do caterpillars, even my enlarged ones," yet he proudly proclaimed, "My daughter Anne is my best artist after Mrs Leslie."[78] Also employed to work on plates for new copies of the first volume was Shelley W. Denton (1859–1938) of Wellesley, Massachusetts, who also rendered two plates and colored 125 prints of plate *Colias* II (*Colias harfordii* H. Edwards) for the third volume.[79,80] Edwards initially described Denton as "one of the best artists I have found"[81] (though he later disliked Denton's lithographic work; see below). In a brief prefatory biography of her father, Vanessa Denton mentioned her father's contribution to *BNA* (Denton 1949).

Drawing and coloring plates for the third volume proved problematic from the start. During the mid-1880s, Lavinia Bowen's health continued to decline, forcing the very elderly P. D. Leslie to take on more work herself, to "get on as fast as possible."[82] Bowen was then doing no coloring for Edwards, but was occasionally able to "aid Mrs. Leslie by her advice as to making colors."[83] In 1887, Edwards reported that Leslie too was "getting old & does much less than she used [to]," adding, "Mrs. Bowen is infirm & nervous to a degree that interferes greatly with Mrs. Leslie's work."[84] The sisters lived together and had no servants, thus Leslie did the housework and cared for Bowen in addition to coloring plates for Edwards.[85] Bowen's death in 1888, coupled with Leslies' declining abilities, made it more difficult for Edwards to complete the plates for the third volume. Edwards lamented, "when I lose Mrs Leslie I shall feel it badly."[86] Edwards therefore employed others for this purpose, but he found it "exceedingly hard to get the coloring done." He explained, "Most of the ladies who do it take it up but temporarily … they have been art students in New York generally so that I am constantly having to search for a colorist. … These inexperienced persons are sure they can do my work & ruin no end of plates for me before they all [are] convinced that this work is not their vocation."[87,88] In early 1888, Edwards indicated that he had "4 good colorists whose work I can depend on."[89] Evidently, they were Leslie, Beard, Denton, and Edwards' daughter, Anne.

Edwards devised a plan to use multiple artists to draw plates for the third volume in order to "proceed a great deal faster" than he had with the second.[90] Because S. W. Denton was also a talented lithographic artist who did work for Houghton, Mifflin & Company,[91] Edwards sent him specimens of *Colias chrysomelas* (=*Colias occidentalis chrysomelas* H. Edwards), stating, "If that is done well, I ought to give the artist steady work."[92] Denton had three brothers, William D. Denton (1865–1923), Robert W. Denton (1868–1959), and Sherman F. Denton (1855–1937), all of whom also studied natural history and collected butterflies. Their younger sister, Carrie Denton (1869–1959), sometimes accompanied her brothers into the field (Anonymous 1956). In addition to his many famous chromolithographs of fish, Sherman is best known for publishing the two-volume book *Moths and Butterflies of the United States* (Denton 1897–1900). The four brothers collaborated on the booklet *The Butterfly Hunter's Guide* (Denton Bros. 1900).

Still in search of additional artists, Edwards sent specimens of two other species, *Argynnis lais* (=*Speyeria hesperis dennisi* dos Passos & Grey) and *Argynnis nitocris* (=*Speyeria nokomis nitocris* (W. H. Edwards)), to the lithographic firm of J. Sinclair & Company of Philadelphia.[93] If he found their work to be acceptable, Edwards desired to retain them for drawing and printing ten plates per year for up to three years.[94,95,96] Edwards, however, was unsure of their ability to do the work as he desired, stating, "they are in the dark & it is proposed that I let them try 2 or 3 plates & then they [can] calculate terms."[97] Edwards worried that if they did not accept the work, he would "not know where to find artists."[98] He pointed out that Peart could complete six plates per year if not called upon to do larval drawings, which were also necessary for the book.[99] Edwards hoped to "get a dozen plates ahead before publishing,"[100] but he complained about the cost of doing business with Sinclair & Son. "Sinclair charges so high a price that unless he moderates I shall go to him very little," he wrote, adding, "His estimate was $75 for drawing alone. I paid Mrs. Peart $25 to $50."[101] Because of Sinclair's high cost, Edwards doubted that he would continue doing business with him.[102] Sinclair's plates would be drawn by Edward A. Ketterer (1860–1909), an artist who lived with his wife, Marie, on South 5th Street in Camden, New Jersey. Edwards

described Ketterer as "a fat German fond of his beer."[103] Sinclair's firm had previously produced all the plates for Mead (1875), many of which were based on plates and figures that appeared in the first volume of *BNA* (*Argynnis* IV, *Limenitis* II–IV, *Satyrus* I). Referring to the illustrations in Mead (1875), Edwards noted, "There are 5 or 6 plates of Diurnals, some from my vols," which were "gotten up under my direction."[104,105] Unlike the hand-colored originals in *BNA*, Mead's reproductions were chromolithographed and of substandard quality.

Edwards received the proofs for Denton's first plate, which he initially called, "fairly done."[106] Edwards soon after sent specimens of *Argynnis liliana* (=*Speyeria callippe liliana* (H. Edwards)) to Denton for a second trial plate.[107,108] Denton evidently employed assistants, as Edwards mentioned that Denton had "lost his labor & proposed at his own risk to do the *Argynnis*."[109] Denton "begged to be allowed to try another [plate] on same terms."[110] However, Edwards soon reconsidered the quality of Denton's earlier plate of *C. o. chrysomelas* and decided not to use it, complaining that the "spots & nerves as well as outlines" were "all more or less wrong."[111] Although Edwards was skeptical about Denton's ability to provide a satisfactory illustration ("I fear it will not be accepted"), he initially was pleased with the second attempt, stating, "Denton has succeeded very well with a plate of *Arg[ynnis] Liliana* of which I got the proof yesterday. Considering the wretched work he made of *Colias Chrysomelas* it is a wonderful advance."[112] He called the *liliana* plate "a hundred times better than the other plate."[113] Although Denton's drawing of *liliana* had some defects, Edwards considered it a "fair plate & when colored looks well."[114] This drawing was used for plate *Argynnis* III in Part 3 of the third volume. Denton, however, proved too expensive and Edwards questioned using him for another plate."[115] Denton received no more lithographic business for *BNA*, though he continued to work as a colorist. He also submitted drawings of larvae to Edwards, but they were likewise unacceptable and "passed upon by Mrs Peart."[116] In the end, Edwards even replaced Denton's plate of *liliana* with another by Mary Peart (see Replacement Plates, below).

Edwards was still confident that he would find another artist, asserting, "I will push along even if I go to Mintern Bros. of London for half the plates."[117,118] Suggested to Edwards by the English entomologist A. G. Butler, the lithographic firm of Mintern Bros. offered to do the work for about $20 per plate, much less than what Sinclair charged, and "in better style" than Edwards could obtain in this country.[119,120] Encouraged by S. F. Baird, Edwards thought that Mintern could complete up to 15 plates.[121] He considered asking Butler or another English entomologist, William F. Kirby, "to superintend each plate, say for £2 per plate perhaps."[122] Despite these offers, Edwards never employed Mintern Bros. because of his nagging fear of losing specimens during transit.[123]

Houghton, Mifflin & Co. again suggested that Edwards send specimens to "a man proposed by them."[124] This was Charles Armstrong (1836–1906), an artist and lithographer affiliated with Riverside Press, who operated a firm under the name of Armstrong & Company in Cambridge, Massachusetts (Last 2005). Edwards sent specimens to Armstrong, but upon receiving the trial plate Edwards wrote, "Mrs. Peart utterly condemns the plate … every one of the figures is out of drawing [poorly drawn], wings misshapen, antennae of irregular length, bodies awful … nerves wrong. It is as bad as the first plate Denton drew."[125] Edwards considered Armstrong's trial plate to be "shockingly" poor.[126] Not surprisingly, Armstrong was not engaged for *BNA*. An undated letter to S. H. Scudder, probably from the mid-1880s, indicates that Edwards also attempted a trial plate with the firm of O. H. Bailey & Company of Cambridge, Massachusetts. Oakley H. Bailey (1843–1947) is best known for producing hand-colored bird's-eye view lithographic maps of many U.S. cities. Edwards described the results of Bailey's plate as "all out of drawing, not one figure was decently done."[127]

In March of 1886, Edwards visited Sinclair & Son to see Ketterer's work first-hand. He observed that Ketterer was working on two *Argynnis* plates, which "seemed excellent," noting that "Mrs. Peart approves what she has seen."[128] Two months later, Mary Peart informed Edwards that the trial plates by Ketterer for the third volume were good, but she had to "correct them a good deal."[129,130] Edwards insisted, "In time after half a dozen plates, Ketterer would do satisfactory work, without oversight."[131] He cautioned, however, that Ketterer knew "nothing of butterflies & the points that are most important."[132] Edwards accepted Ketterer's first efforts and they served as plates *Argynnis* I and *Argynnis* II in Part 1 of the third volume. Nearly a year later, Edwards noted that Peart "has not yet got Ketterer up to the higher mark, but he improves."[133] Later that year, Edwards stated that Peart's supervision was affording Ketterer "good training."[134]

Edwards next sent specimens of *C. o. chrysomelas* to the lithographic firm of J. Bien & Company of New York to replace the failed attempt at this plate by Denton. Bien, however, mistakenly colored their plate using chromolithography rather than hand-coloring.[135,136] Although Edwards initially accepted the results, he reconsidered, declaring that they "made such a bad

work of things that I can't use it & did not pay for it."[137] Edwards disliked the coloring and compared the legs to those "of a shrimp!"[138] He argued that it was impossible "to catch delicate color with chromo."[139,140] He sent the plate back twice to have it corrected, along with more specimens, but both times it came back without perceptible improvements, thus he "refused the whole."[141] Moreover, Bien's artist mistakenly left the box open in which Edwards' specimens were kept, allowing cockroaches to damage some of them. "It was no use to scold," he wrote, "but I privately lamented."[142] Edwards finally decided to send specimens of *C. o. chrysomelas* to Ketterer at Sinclair's firm,[143] resulting in a plate that was "beautifully done." Ketterer's illustration was therefore used for plate *Colias* IV in Part 4 of the third volume.[144,145] Because of her declining health, Peart initially declined to undertake any plates for the third volume,[146] but her devotion to Edwards induced her to stay involved (see below).

Edwards liked the work provided by Sinclair, thus most other plates of the third volume were rendered by Ketterer under the supervision of Mary Peart, who was pleased with Ketterer's skills.[147,148] Peart worked on the composition of the plates, reviewed the proofs, and arranged for coloring.[149,150] Edwards was happy that Peart relieved him of "all trouble in that department." The figures of the early stages in Ketterer's plates were based on colored drawings by Peart, some of which were derived from sketches sent by Edwards' correspondents. Although Edwards worried about Ketterer's ability to accurately reproduce Peart's drawings, he conceded, "I suppose however there is no help for it."[151] Peart allowed Edwards to examine her drawings of early stages before she turned them over to Ketterer.[152]

The first part of the third volume sold very quickly, with one half of its copies exhausted by March of 1887.[153] Edwards announced, "The publishers wrote last week that Part 1 was going off well and that they thought there was to be a larger sale than for Vol. 2."[154] He humorously added, "I hope to live to end of vol. 3 & go out, if go I must, in a blaze of Entomol[ogical] glory."[155] Early the following year, Edwards boasted, "there never has been such an enquiry for [*BNA*] as now."[156] He soon became less optimistic, observing that although sales slowly increased, he was "behind all the time with the artists … and in debt."[157] This was especially upsetting, as he "put heart & soul" into the book's production.[158]

Edwards hoped to complete the third volume "inside 5 years,"[159] but it actually took twice that long. The extended period required to produce the book resulted in additional problems. "When I began Vol. 3 it was considerably with different subscribers from what I had with Vol. 2," Edwards recalled in 1888. "Many of the old ones, in the 20 years since Vol 1, had died. Others found it impracticable to continue the volumes."[160] By that time, the number of subscribers had fallen from 160 to about 112, yet Edwards was still selling up to 15 sets of the first two volumes annually, mostly to libraries. Edwards wished that more libraries would order his book, noting, "There are enough large Libraries in this country to absorb all the editions of the Butterflies."[161] Fortunately, the book was selling well overseas, particularly in Germany.[162,163]

In July 1890, Edwards calculated the number of bound copies of the first and second volumes that had been sold, exclusive of subscriptions. This totaled 174 copies of the first volume and 66 of the second. He had less than 100 plates remaining for the first volume and claimed that it was still being sold ten years after the completion of the second volume.[164] In all, Edwards estimated that by 1890 he had produced 390 copies of the first volume, which included those sent to subscribers. In 1892, Edwards noted an increase in the sale of the first two volumes for reasons unknown.[165]

Bound copies of the first and second volumes of *BNA* were being offered during the 1880s and early 1890s for $35–$45. Seemingly inexpensive, this is equivalent to over $1,000 in our present economy. Individual parts of the third volume were still being issued at a price of $2.25–$3.50 each (HMC 1884). Volumes and separate parts were offered with colored or uncolored (plain) plates, the latter at a substantial discount. All three volumes were available in comparable formats for many years (RP 1899). Edwards often wrote about sending plates to the publisher for the assembly of additional sets. Over a period of about 60 days, he could arrange to color enough plates to assemble seven copies of the second volume.[166] Nonetheless, coloring plates for new copies of the first two volumes interfered with work on the third volume.[167] In 1888, new bound sets of the first volume were offered for $30 each.[168]

As the third volume progressed, Ketterer became increasingly difficult and unreliable, leading Edwards to lament, "Ketterer is [so] infernally slow with the plates that I am afraid I may be an Octn [octogenarian] before I get thro [vol.] 3."[169] Edwards learned from Mary Peart that Ketterer was an orchestra leader in Camden, New Jersey, which Edwards suspected accounted for "the great delays in my plates."[170] Edwards needed to rely on Ketterer, as Peart was engaged in "making pencil drawings" and "supervising the execution of the plates on the stone."[171] In early 1893, Ketterer wrote that he was giving up every other piece of work and intended to devote himself to plates for *BNA*, completing two every

six weeks. Edwards was confident that Ketterer would "do no such thing," adding, "It looks as if he was in earnest, but he is so giving to promising & not performing that I can't tell."[172,173] True to form, Ketterer soon informed Edwards that he was delayed because of "somebody's death."[174] Despite this aggravation ("Ketterer vexes me out of years growth"), Edwards admitted that Ketterer's plates were "good" when they finally arrived.[175] As consolation, Sinclair proposed that Edwards did not have to pay for any plate until it was drawn and printed.[176] Despite this agreement, Ketterer did not improve, prompting Edwards to condemn Sinclair's "intolerable slowness."[177]

Sinclair evidently suffered from financial difficulties.[178] In 1889, he sold his business to George S. Harris & Sons, who through this purchase became the largest lithographic firm in Philadelphia (Piola 2012). Edwards was thankful that "all the artists go along … and they promise great care in my works."[179] Optimistic of this new relationship, Edwards wrote, "This firm promises to do my work as well as Sinclair's & I hope they will."[180] Soon after, however, Edwards was again complaining of delays and errors, noting that two initial proofs for Part 7 of the third volume were "badly printed," calling them "worse than any I ever had from Sinclair."[181] Edwards remained hopeful that "they may however do better."[182]

Well into the third volume, coloring plates remained Edwards' biggest headache. He "tried and rejected" many colorists during the production of the third volume.[183] He admitted that he suffered "great worry and trouble over colorists," explaining, "they work a few months & get used to it & change for something that pays better. Then I have to search again and try several perhaps before I find one who can & will do such work carefully."[184] Edwards mentioned the possibility of employing a "Miss Grace Stend,"[185] but I have been unable to confirm that she was retained.

In 1890, Edwards began work with a colorist named Mary Ann "Donalda" Downie (1860–1894) (WE journal "W" WVSA), who lived in Winnipeg, Manitoba, Canada. Edwards described her as "one of the best artists I have had."[186] The last 55 prints that she completed were for plate *Chionobas* IX (*Oeneis* spp.) in Part 15 of the third volume. Edwards received the finished plates on 11 April 1894. Downie was spending the winter of 1893/94 in Mexico City, where she enjoyed "time and plenty of light." Among Edwards' manuscripts (WVSA) is an express receipt for a shipment of "Estampas" (pictures, i.e. printed plates) to Mexico, dated 19 March 1894. This suggests that Edwards sent her another set of plates, but they remained unfinished due to Downie's untimely death on 7 May 1894.

In 1893, Edwards considered the idea of advertising for colorists in New York.[187] Not long after, he learned that P. D. Leslie was too feeble to continue working on his plates, thus ending their long relationship.[188] A few weeks later, he heard that Leslie was "affected in the head and can attend to nothing"[189] (she died soon after). Edwards continued to fill the void with other colorists, including Clara H. Dutton (1857–?) of Wolcott, New York, who worked on at least one plate, that of *Satyrus* III (*Cercyonis oetus charon* (W. H. Edwards)). After coloring 75 prints of this plate for Part 16, she confessed, "I have never felt so tired from an order as from these … since they are finished I really feel rested."[190] Another colorist who apparently worked on plates for *BNA* was Mary C. Drew (1866–?), daughter of Thomas B. Drew, who was the first curator and librarian of the Pilgrim Museum in Plymouth, Massachusetts. Edwards described her as an "expert colorist."[191] Edwards' wife, Katherine T. Edwards (1827–1901), also colored plates for *BNA* (Edwards 1902), but her involvement was likely minimal. Edwards often shared coloring jobs among different colorists, allowing the work to progress much more quickly. This was done for the very last plate of the third volume.[192]

The colorists often provided detailed information to Edwards about how they painted the plates. Edwards copied some of this information into his personal journals so it could be passed on to other colorists. For the figures of *S. diana* in the first volume, P. D. Leslie advised, "In *Diana* the black is made of indigo blue, carmine, & enough gamboge to change the color." Carmine was a bright red pigment, while gamboge was mustard yellow. Referring to the figures of *Argynnis lais* (=*Speyeria hesperis dennisi* dos Passos & Grey) in the third volume, Leslie related, "We have always used gamboge & carmine. These flies look as tho' they would require a little dull color. We should use a little umber carefully put on, as there is danger of getting these colors too dark. If when done, they are too light, a little pale umber should be passed over them, that is better than having them too dark at first … it is best to take an old plate to try the colors on and work them up as strong as wanted." The colorists usually "sized" the plates with a solution to prevent the pigment from penetrating too deeply into the paper.[193] Because some colorists "spoiled as many [plates] in sizing as they did in coloring," Edwards sized the prints himself before sending them to those who were inexperienced in this method.[194]

Certain colors were especially difficult to reproduce. For example, silver powder ("silver saucer"), used to create silver markings on figures, often turned black

and required correction.[195] Edwards remarked, "I have found nothing that will wear as silver on my plates. I have consulted artists & Mrs. Bowen knows of nothing." He resolved to "leave the white of the paper," noting that the effect was "a great deal better than tarnished silver."[196] He solved this problem in 1886 when he discovered that aluminum powder could be mixed with water and applied with a brush.[197] Edwards also observed that the green colors being used for larvae were insufficient.[198] At the urging of Peart and Ketterer, Edwards decided to use chromolithographic coloring for greens, which was then "touched with brush afterwards."[199] This method was apparently used for several plates of satyrid butterflies of the third volume (e.g. plates *Satyrodes* I and *Neonympha* II). The cost of doing this was no more than a standard plate.[200]

The artist Lillie Sullivan (1855–1903), who long served as the Chief Illustrator in entomology for the U.S. Department of Agriculture, contributed some drawings for the third volume. She rendered some illustrations of larvae (WE journal "S" WVSA) and her figures of adult *Oeneis macounii* (W. H. Edwards), which were originally completed for the Canadian entomologist James Fletcher, were reproduced by Ketterer for plate *Chionobas* X.[201]

In early 1893, Edwards noted that he had on hand twelve bound copies of the first two volumes and 100 parts of the third. In addition, he had about 150 uncolored copies of each plate from the first volume and 175 of each from the second. Edwards wanted to keep the colorists busy during down time in the production of the third volume. He remarked, "I am compelled to give the ladies work [in] order to keep them."[202] By early 1894, however, new sales were tapering off. Edwards informed S. H. Scudder that the publisher had sold fewer parts of the book, and only two bound copies, during the previous six months.[203] Three years later, Edwards said that Houghton Mifflin possessed six sets of the first volume, two of the second, and 15 of the third. Although the preparation of additional copies of the first two volumes was very time-consuming,[204] they continued to be assembled long after their original parts were issued. These copies combined newly colored plates with remaining letterpress. In 1895, Edwards anticipated a call for further copies of the first two volumes for subscribers who "held back till the [third] volume was completed."[205] Edwards planned to sell copies of the third volume for $50 each.[206]

Approaching the end. Edwards often remarked that the creation of *BNA* absorbed all of his spare time.[1,2,3] "If I had known what I had to go thro when I began the Butt. N. A.," he wrote, "I never should have made the beginnings. It grew on me as I proceeded." The second volume was not anticipated, but once started it dominated all his "summers and winters" for ten years. When he reached the third volume, he suspected that he would be "tied by the leg at least 8 years from the difficulty in getting work done."[4] Edwards thought that he could keep going with the third volume, maybe issuing as many as 100 plates, "if everything favored."[5]

Nearly 30 years after proposing to publish illustrations of North American butterflies, Edwards thought he would "never get to the end."[6] He remained optimistic about the possibility of a fourth volume, which Scudder urged him to consider.[7] William J. Holland previously told Edwards about a "new process" which would facilitate the production of color plates, supposedly to encourage Edwards to continue on to a fourth volume.[8] This was possibly a reference to color photographic reproduction. In the end, it was Holland himself who used this less expensive method for the plates in his widely popular *The Butterfly Book* (Holland 1898). By making his book much more affordable, Holland ushered in a new era of Lepidoptera study in North America. Instead of fearing that Holland's book would render his own obsolete, Edwards confidently predicted that its success would boost sales of his own book. "It seems to me the larger the sales of this book the better for both of us," he advised Scudder. "Many will become interested who will push these studies farther & more for our books."[9] Holland disclosed to Edwards that he had to sell 8000 copies of *The Butterfly Book* to see any financial return.[10] Greatly exceeding this goal, the book was reprinted until 1931, when it was revised and reprinted until at least 1949.

Forging ahead, Edwards visited Ketterer in May 1895 and discovered that he was also doing work for the lithographic firm Ketterlinus Printing House of Philadelphia, who was engaged in a large job to draw bird eggs for the second volume of *Life Histories of North American Birds* (Bendire 1895).[11] Later that year, Edwards asked Ketterer to complete one more plate, which was not yet done by March of 1896. Edwards complained that Ketterer had been working on it for four or five months, "tho at any time he could have drawn the plate in one week."[12]

Discouraged, Edwards wrote in 1896 that Ketterer was still "fooling with" his last plate.[13] Edwards trusted Peart, but his confidence in Ketterer was still shaken. Ketterer repeatedly told Edwards that the last plate was nearly drawn, yet he was not working on it: "He works for the great lith[ographic] houses & slights my work."[14] At his wits end, Edwards maintained that if it had not

been for Ketterer's "lies and delays," the third volume would have been done three years earlier.[15] By this time, Edwards regretted ever doing business with Ketterer and avowed that if he continued with a fourth volume, he would not utilize the artist.[16,17] To complicate matters, Edwards discovered that W. J. Holland retained Ketterer to draw an illustration for Holland (1896).[18] This frustrated Edwards, who thought Ketterer should be concentrating on completing his last plate for *BNA*. Ketterer assured Edwards that the final plate for the third volume would be completed "in 2 or 3 days."[19] Edwards finally received the proofs of this plate four weeks later, a full seven months after Ketterer supposedly began work on it.[20] Between May 1895 and May 1896, Ketterer completed only this single plate for *BNA*.[21] As a result of these delays, Mary Peart agreed to complete plates *Parnassius* I and *Chionobas* XIII (Edwards 1887–1897).

Edwards desired to devote at least one entire plate in the third volume to a swallowtail butterfly which he and the artist-naturalist David Bruce had collected in 1894 in Glenwood Springs, Colorado.[22] Edwards had previously described this species as *Papilio brucei* (=*Papilio machaon bairdii* Edwards). He hoped that he could raise the extra money to produce an additional part of the book to accommodate this plan. To this end, Scudder tried to obtain a grant of $125 from the Elizabeth Thompson Fund.[23] Presumably this money did not come through, as the plate was never published. Nonetheless, Edwards issued eight pages of text on *P. brucei* in the last part (18) of *BNA*.

The third volume was completed in early 1897, when Edwards sent the remaining text to the printer. "[T]hat ends the matter," he wrote, "Glad to get this printing business off my hands."[24] Although he was thankful to be done with the third volume, Edwards admitted, "I shall take a rest, but if I see hereafter that I can begin another series of Plates, I mean to have them drawn."[25] He envisioned issuing no more than "about a dozen" additional plates.[26] The following year, Edwards informed Scudder, "I have so many species of rare larvae to figure that I can't stop … if I have the money to go farther."[27] Although Edwards surmised that he could "go to 60 plates comfortably," he was concerned that so many would make the third volume too bulky. He proposed to "cut it into 2 vols, 30 plates each!"[28] Excited by this possibility, he wrote, "It seems to me that is a good idea."[29]

Unfortunately, events precluded the enlargement of the third volume or the production of additional volumes. Edwards later recalled, "I was urged to go on with the fourth volume, for which I had on hand a great deal of material, both insects and drawings. … But as I was well advanced in years, I felt that I had better stop now" (Edwards 1900–1901). Although Edwards once entertained the idea of passing the production of *BNA* on to his son-in-law, Theodore L. Mead ("I hope you may take up the Butterflies of NA where I leave it, or continue it"[30]), the project came to an abrupt end.

Sales of the book had slowed considerably by 1899. In six months, only two copies of the third volume were sold, and none of the others.[31] Edwards wrote about "a great lot of superfluous plates of the 3 vols." stored in the attic and various other rooms of his home. Disappointed, and perhaps somewhat resentful that he could not continue his book, he considered the remaining plates to be a nuisance and threatened to "burn all but 50 sets."[32] Edwards believed they were of value only to him: "After I go to Kingdom Come there is no one who can do anything with my plates."[33] He presumably gave many of these extra plates to Mead, who in 1922 asked the Philadelphia entomologist Henry Skinner for advice on how to dispose of them.[34] Skinner suggested that he contact the entomological bookseller John D. Sherman, Jr. of Mount Vernon, New York ("I don't know what he would pay as the policy of dealers is to buy cheap and sell dear"). The fate of these plates is unknown, as they were not listed among Sherman's catalogues during the 1920s. However, a set of 93 plates (mostly uncolored) were offered by the same bookseller earlier that same year on behalf of Edwards' daughter, Anne (Sherman 1922). It was noted in Sherman's catalog that all the remaining text of the book had previously been destroyed.

Soon after the completion of the third volume, Edwards' interest in Lepidoptera waned. He instead dedicated his energy to publishing books about the spelling of Shakespear's name and the history of the Edwards family (Edwards 1900–1901; Bethune 1909). The entomologist Charles J. S. Bethune reassured Edwards that his work "will long endure & keep your name in deserved honor during many generations to come."[35] A few years later, Edwards professed, "I stand the years pretty well. Have good appetite & good digestion and sleep the sleep of a naturalist." He amused himself by working in his flower garden and trimming his shrubbery. His last publication on butterflies appeared in 1898, only a year after finishing *BNA*: "I have let them fly since the end of my vol 3."[36]

Financial obstacles. Not long after embarking on *BNA*, Edwards became extremely concerned about its cost, writing in 1868, "I am troubled about the expense … to get my drawings made and colored."[1] The following year, Edwards disclosed that he lost up to 20 cents in commission on each part of the book that was sold through booksellers.[2] Bowen & Co. went so far as

to suggest to E. T. Cresson that he consider coloring the plates using chromolithography to "much lessen the cost of this fine work."[3] In 1871, Edwards revealed that he had lost $3,000 on the publication of the first volume.[4] According to an expense sheet maintained by E. T. Cresson (ANSP), Edwards personally paid at least $1,714.50 to see the first volume published. This amounts to about $31,000 today. The first volume grossed the American Entomological Society only $20 (about $369 today). Expenses included type for the letterpress, binding, lithography, coloring, and ink, as well as postage for mailing proofs, plates, and lithographic stones. Edwards was very self-conscious about his expenses for the first volume, confessing that he "burned all the bills so that no one should see how extravagant I had been."[5,6] In 1879, Edwards observed that it was "very expensive publishing these things … I am out of pocket with every Part I issue." He explained that he could take no less than one dollar per plate to cover his costs in drawing and coloring the plates, as well as printing the text."I should hate to do the work in a cheaper manner with second rate artists," he wrote.[7] He revealed that it took every cent he could raise to enable him to finish the book.[8,9] He was forced to increase the price per full volume from $30 to $40, but this only covered expenses.[10] Resolute, he declared, "I have any way to publish the Butterflies, money or none!"[11]

Although Edwards called work on *BNA* "a labor of love,"[12] it became increasingly more difficult to publish the parts and he ran short of funds after the completion of the second volume. "I desire exceedingly to proceed with Vol. 3," he wrote in 1885, "but am restrained for lack of money to meet the payments to artists &c." Edwards admitted that he had "sunk a great sum of money in publishing the 2 vols," but was "willing to pay out another considerable sum to get Vol 3 done."[13] Edwards hoped that the production of the third volume would "run itself" if he reached sufficient sales of the parts, but this proved disappointing. Before any parts of the third volume were published, Edwards confessed, "Vol III is costing me more to get started than I had calculated."[14]

To conserve funds during the production of the third volume, Ketterer produced two drawings on one lithographic stone, which limited the choice of species that Edwards could use for each plate. He was forced to "select two [species] of somewhat equal degree of darkness and light," thus he often had to re-arrange his planned order of species.[15] At the beginning of the third volume, Edwards recalled that his first outlay was $800 before he even received any drawings for the first two parts.[16] Fortunately, Houghton, Mifflin & Co. had great faith in the book and did not force Edwards to pay arrears. He referred to the firm as "remarkably kind people."[17] In early 1895, Edwards was indebted to the publishers for $600.[18] The following year, Edwards was afraid to ask Houghton Mifflin to continue covering his expenses, as he was "on their books at least $700 now." Still self-conscious of his situation, he asked Scudder to "say no more about it."[19]

According to Edwards' writings, lithographic work cost $20–50 per plate. Because colorists were required to complete multiple copies of each plate, their pay could be five times greater than that of the lithographic artists. Coloring expenses for the first and second volumes were typically 25–50 cents per sheet ($5–$12 today), yet he paid up to 75 cents for more complex plates, such as *Lycaena* II of the second volume.[20,21,22] Edwards lost money on this plate, as he charged subscribers only 50 cents each.[23] Edwards worried what Lavinia Bowen would charge to color the complex plate *Lycaena* III of the second volume: "I have not yet learned and I don't want to for all that matter!"[24] Coloring costs for the third volume remained the same.[25] Up to 450 copies of each plate were struck before the lithographic stones were cleaned to produce other plates.[26,27]

Something that Edwards always regretted was using the stereotype method to print his text. "I made a great mistake in having the text stereotyped", he recalled, "this cost me $3000 for the 3 vols."[28] Printing the text cost about 3.5 cents per sheet. He believed that it would have been cheaper to strike a large number (i.e. 500) of typeset parts at one time, rather than stereotyping small amounts over an extended period. Edwards considered stereotyping to be a "useless expense."[29]

Costs were not just associated with production. During the publication of each volume, Edwards provided gratis copies to a number of people, including E. T. Cresson, H. Edwards, and S. H. Scudder. Referring to Cresson, Edwards later admitted, "I do send Cresson the Parts as they appear & have always done so for the reason that he helped me so much with vol. 1 & got little for his pains."[30] In addition to her pay, Edwards gave Mary Peart free copies of each part of the book (WE journal "D" WVSA). He also provided a copy of the first volume to Samuel F. B. Morse, who co-invented the single-wire telegraph system and the original Morse code signal language (Morse called the plates "exceedingly beautiful"[31]). Edwards also granted "special exceptions" to any lepidopterists who applied for a payment plan.[32] Though generous and politically savvy, these practices were fiscally unwise.

Edwards' collection. To help reduce his financial burden and allow him to produce a third volume of

BNA, Edwards settled on a notion to make his collection "subservient to the book."[1] In 1885 Edwards struck a deal to sell his collection to W. J. Holland for $2,500 (equivalent to about $58,000 today). Holland, who in 1884 had purchased the collection of Edwards' son-in-law, T. L. Mead, desired to unite these important collections. Although Edwards described his collection as "the most complete N.A. collection of diurnals that ever has been made or probably ever will be," it comprised only 4,417 adult specimens. Considered fairly large at that time, this is a small collection by today's standards (some present-day private collections contain well over one million specimens). Edwards also had a great number of early stages preserved in alcohol vials, noting that there were "many rare species represented & altogether such a collection is not likely to be made again."[2]

Edwards "started down the butterfly path" in 1856 when he lived in New Hamburgh, New York. His collection "increased largely" shortly after moving to Newburgh, New York in 1859 (Edwards 1900–1901). "I may expect to bring together a large Collection of Lepidoptera in no long time," he eagerly announced.[3] Edwards credited the Lepidoptera catalog by Morris (1862) with helping him "know whether a given insect had been named and described or not" (Edwards 1900–1901).

In 1870, Edwards expressed an interest to bequeath his collection to the Museum of Comparative Zoology (Harvard University),[4,5] but his relationship with H. A. Hagen subsequently deteriorated. He claimed that Hagen was not "admirably decent" and declared "as the Museum is now managed I will not send them a fly."[6] After his falling-out with Hagen, Edwards thought his collection would probably go to the Smithsonian Institution, where he hoped it would be kept intact and not "stolen piece meal."[7] He did not trust public collections, fearing that thieves would eventually remove the best specimens.[8] He also distrusted certain other lepidopterists, such as Herman Strecker, who was long suspected of illicitly removing specimens from various collections that he visited[9] (McClain et al. 2002; Leach 2013). Although Holland (1909, 1928) maintained that Edwards contemplated selling his collection to the British Museum, I found no firm offers to that affect among Edwards' correspondence. Edwards' letters clearly indicate that his collection was formerly promised to MCZ.[10] Holland possibly wished to conceal the fact that Edwards' collection was intended for another domestic repository to avoid making his own acquisition appear self-serving. "I have always pleased myself with the thought that I was rendering a service to the cause of American science by retaining in this country Mr. Edwards's types," he wrote, "I think I ought to have credit for doing what I did" (Holland 1909). Of course, this was written after Edwards' death.

Edwards did not publicize the sale of his collection for some time, even keeping it from his wife and children.[11] Edwards asked Holland to consider the sale confidential, but he doubted that Holland could keep it a secret.[12] Although the sale helped to pay the bills of the third volume, Edwards was depressed about it, recalling the following year, "It was painful to part with the collection. … It was [like] pulling eye teeth."[13]

Holland paid Edwards $500 up front and committed $1000 towards publishing expenses for each half of the third volume. This was Edwards' idea to ensure that he would not spend the money too quickly. Edwards received Holland's first payment on 14 January 1886, and Edwards shipped the first specimens of Hesperiidae in cigar boxes two weeks later.[14] Specimens of Lycaenidae followed, along with other specimens that Edwards did not need for the third volume. Sending extra specimens allowed Edwards to "have room to display better" what remained.[15] Their agreement did not include any specimens that Edwards would collect after the sale.[16]

Edwards continued to ship portions of his collection to Holland for many years and regularly advised Holland when payments were due. He often asked him to send bank drafts directly to those requiring payment (colorists, printers, etc.). On several occasions, Edwards admonished Holland for being late with payments and once reprimanded him by quoting a section of their contract: "Holland agrees to forward to Edwards drafts as for the amount from time to time required, on receiving notice thereof from said Edwards."[17] In the end, Edwards did not use the initial $500 for the third volume, but rather for "clearing all arrears on Vols 2 & 1."[18] Still dejected about the extreme impact of *BNA* on his finances, he lamented, "It has nearly squelched me … this and business matters here make life not worth living. It certainly would not be had I not Entomological mental relief."[19] By late 1888, Holland had paid "all he agreed to & something over."[20]

Although Holland's payments enabled the continuation of *BNA*, Edwards also obtained funds from other sources. He received an unsolicited grant of $500 from the National Academy of Science (Edwards 1887–1897), which Scudder had arranged without his knowledge.[21] Additional grants totaling $350 were received from the Elizabeth Thompson Science Fund (Edwards 1887–1897; Anonymous 1889). Edwards also applied profits from the continuing sale of the first two volumes toward the publication of the third, noting, "it

takes all these to pay for vol 3."[22,23] He later confirmed that all the proceeds from the sales of the first two volumes ("every cent") went into producing the third volume.[24]

Shipments of specimens to Holland continued at least through April 1897, when Edwards wrote, "I am packing up the greater part of the butterflies remaining to go to Dr. Holland." Although he would miss having the specimens, Edwards confessed that it was "a relief to get rid of the collection."[25] By that time, he had surely grown tired of its maintenance and it probably served as a constant reminder of his inability to realize his dream of producing a comprehensive book on all the North American butterflies.

Publication particulars. The title pages issued at the completion of each volume were dated as follows: 1868–1872 (vol. 1), 1884 (vol. 2) and 1897 (vol. 3). It is very difficult, however, to ascertain the true dates of issue for the associated parts of each volume. Holland (1928) attempted to clarify some dates of issue, but he relied almost entirely on the dates as they appeared on the original wrappers for each part. Evidence indicates that some wrapper dates preceded the actual dates of issue by as much as five months.

I discovered that Edwards rarely recorded the actual dates of issue. For the second volume, he received this information from Scudder, who had asked a librarian at the Boston Society of Natural History (BSNH) to record the dates as they received each part from the publisher, who was located in nearby Cambridge, Massachusetts. Edwards then applied these dates for his "Dates of Issue" page, which was included with the last part of the volume. In 1896, Edwards again asked Scudder to obtain the dates of receipt for the third volume. He admitted, "I thought I regularly entered them as they issued, but I find I did so to 7 [parts] out of the 17."[1] Edwards was more confident of his data for parts of the third volume, deciding to list specific dates instead of just the month and year as he had previously done. Edwards provided the dates of issue to the publishers, who evidently did not record this information themselves.

I reviewed published and unpublished evidence related to the dates of issue for parts of *BNA*, which was then compared against the dates given on the title pages of the individual parts, as well as those listed on the "Dates of Issue" sheets for each volume. This information is presented in Tables 2–4. The literature contains many additional references to the dates of issue, but most are invalid estimates only. Published library donation records are helpful, but they do not embrace all the parts. I include only those references which appear to best indicate the actual dates of issue.

Edwards often struggled with forthcoming issue dates in his correspondence, complaining on numerous occasions about the delays of various parts. A publisher's "Notice", printed on the wrapper of Part 5 of the first volume, explains the reason for many of these problems. This part was issued in April of 1870, but the wrapper reflected the date when the text was printed, namely December 1869 (Table 2).

> *This part has been unavoidably delayed by difficulties in preparing the plates, the text having been finished and in waiting since last December. The artists have promised greater expedition in the execution of the plates now in preparation for Part 6, the text of which is already completed.*

Such interruptions were not uncommon during the production of all three volumes. A trip to Europe by Mary Peart in 1871 resulted in a delay in completing Part 9 of the first volume.[2] Edwards worried that another delay in issuing this part was due to a small pox epidemic in Philadelphia.[3] Corrections to the lithographic stones and coloring sometimes stalled production[4,5] A fire at the publisher's in Cambridge in 1877 caused a loss of 50 completed parts that were ready for distribution[6] (a second fire at the same location in 1879 did not damage any materials for *BNA*[7]). In 1886, a labor strike in Philadelphia delayed the printing of the first two plates for the third volume.[8] As the third volume was coming to a close, the last two plates were held up after the elderly printer fell down in the street and bruised himself so badly that he was unable to work for several days.[9]

In his Preface for the second volume, Edwards (1874–1884) attributed further delays to the inclusion of "much original matter on the early stages" and the associated "labor of preparing and coloring the Plates." Edwards told Holland that these delays were "caused by the inability of Mrs. Peart to draw the figures on stone any faster," yet he was "unwilling to employ any other person on that part of the work."[10] In 1886, Edwards remarked that Peart "is much of an invalid at present & I can't count at all on active aid."[11] Two years later, Edwards again noted that delays were due to Peart's infirmity, revealing, "She has always been an invalid and ended up work on my plates of Vol. 2 as the body would permit."[12] The difficulty in retaining skilled colorists after the loss of Bowen and Leslie also slowed publication.[13] In addition, production was affected by natural events, such as flooding during the spring of 1886.[14] Probably in an attempt to conceal such interruptions, most parts of the second volume and all parts of the third bore only the year on the wrappers. Some parts were issued in portions, thereby allowing completed copies to be distributed, followed by the

TABLE 2. Issuance of parts for the first series (volume 1) of *BNA*.

Part	Publisher Imprint	Wrapper date	"Dates of Issue"	Corrected "Dates of Issue"	Published references*	Unpublished references
1	Philadelphia: American Entomological Society	April 1868	April 1868	June 1868	- recorded library donation, 8 June 1868[1]	- "Part I . . .Is issued" (tSB 5.vi.1868 USNM)
2	same	August 1868	August 1868	October 1868	- recorded library donation, 9 Nov. 1868[2]	- "have directed publisher to send Parts 1 & 2 (tHE 24.xi.1868 AMNH)
3	same	December 1868	December 1868	May 1869	- "now before us" [June 1869][3]	- "I received Part 3 (fSB 13.v.1869 USNM)
4	same	April 1869	April 1869	September 1869	- recorded library donation, 13 Sept. 1869[4]	- "I'm glad you like No. 4" (tSB 8.xi.1869 USNM)
5	same	December 1869	December 1869	April 1870	- 1 April 1870[5]	- "Part V is out" (tSB 14.iv.1870 USNM)
6	same	June 1870	June 1870	August 1870		- "I have just rcd here Part VI" (tHE 10.viii.1870 AMNH)
7	same	January 1871	January 1871	March 1871	- "has just been published" [4 May 1871][6]	- "will surely be out now in a few days" (tHE 4.ii.1871 AMNH)
8	same	August 1871	August 1871	September 1871	- "Will be ready in a few days" [Aug. 1871][7]	- "Part VIII is out" (tTM 25.viii.1871 RC)
9	same	December 1871	December 1871	January 1872		- "ought to be out" (tHE 14.i.1872 AMNH) - "Part IX is highly interesting" (fJW 13.ii.1872 WVSA)
10	same	July 1872	July 1872	September 1872		- "I have just rcvd. Part X" (tTM 5.ix.1872 MGCL)
Suppl.	same	1872	--	January 1873		- "I recd my Supplement part last night" (tHE 16.i.1873 AMNH)

***Published references: 1.** Donation by Edwards (Trans. Amer. Entomol. Soc. 2:iv); **2.** Donation by Edwards (Trans. Amer. Entomol. Soc. 2:xi); **3.** Review (Amer. Entomol. 1:205); **4.** Donation by Edwards (Trans. Amer. Entomol. Soc. 2:xviii); **5.** Publisher's notice (BNA, Part 5 wrapper); **6.** Announcement (Nature 4:11); **7.** Announcement (Can. Entomol. 4:78).

remainder of the copies at a later date.[15,16] Paid subscribers were given priority over those receiving free copies.

A supplemental part for the first volume was issued in January of 1873. Seventeen pages in length, it included the title page for the volume, indexes, and eleven replacement pages for the *Synopsis*. Also included was a new "Dates of Issue" page on which an entry for the supplement was inserted. As the supplement was being assembled, the new publisher (Hurd & Houghton) decided to offer 40 leather-bound sets of the first volume for $30 each, "for the Holidays."[17,18,19,20] They distributed a one-page advertisement announcing that a "limited edition has been printed … complete in itself and independent of any subsequent ones." However, like many of the individual parts of the book, it appears that this edition was delayed. Although Edwards asked Lavinia Bowen to color 50 additional sets, he estimated that this work would take at least two or three months and feared this was "too slow for anything of a demand."[21] A year later, Edwards remarked that Bowen "shall soon have 50 more sets ready," but this seemingly relates to Edwards' earlier request, which was still not completed.[22] During the spring of 1874, Hurd & Houghton asked E. T. Cresson, who had originally arranged the publication of the first volume, to send them the electrotype plates for the text in order to "print a new edition" (24.iv.1874 ANSP). The 50 additional sets of plates were presumably used to assemble copies of the "limited edition", which probably were not available until mid-1874; well over a year after the edition was proposed. Unlike previous copies of the first volume, this edition included a

revised title page designed like that of the original wrappers, bearing the longer title *The Butterflies of North America with Colored Drawings and Descriptions.* It was imprinted with the name of the new publisher, Hurd and Houghton, with a date of 1874. Its *Synopsis* also possessed a new title page, dated 1874. Although Holland (1828) suggested that only new title pages were printed in 1874, evidence indicates that the entire text was reprinted and combined with newly colored plates.

Prior to the commencement of the second volume, Edwards issued a lengthy "Notice", dated November 1872, in which he mentions the planned availability of the first series of parts as a bound volume (i.e. the "limited edition"). Printed on the rear wrapper of the supplemental part was the following:

> *Volume I. of The Butterflies of North America will shortly be published by Messrs. Hurd & Houghton, of New York. Part ~~2~~ 1* [the number "2" crossed out and the number "1" added in manuscript to correct the error] *of Volume II. will issue from same house about June 1st, 1873, and to insure regularity of delivery (quarterly) the several Parts will contain but three or four Plates, the price per Part being at the rate of 50 cents per Plate.*
>
> *Subscriptions to Volume II. will be received by Hurd & Houghton, New York, or E. T. Cresson, Post Office Box 31, Philadelphia. That some idea may be formed of the size of the edition required, it is desirable that subscriber's names should be sent in early, the subscription money will not be payable until the Parts are ready for delivery.*
>
> *The general style of the work will be as heretofore, but the Plates and descriptions will not be limited strictly to hitherto unfigured species.*

Although Edwards indicated that the first part of the second volume would issue "about 1 June 1873," it actually appeared a year later (Table 3). This is an excellent example of how difficult it was for Edwards and the publisher to accurately forecast dates of publication.

In 1879, Edwards observed that no copies of the first volume had been available "in the past year."[23] He remarked that the publisher "wrote to ask how many copies of the text they should print of my vol 1 for the new Plates that I am having colored."[24] He instructed them to print another 100 copies of text, but asked that they add the year 1879 to the title page, which was reconfigured by Edwards. After using a longer title for the 1874 reissue, Edwards reverted back to *Butterflies of North America* on the advice of H. A. Hagen.[25] This reissue, published by Houghton, Osgood & Co., also included the revised "Dates of Issue" sheet and a corrected "Alphabetical Index". As noted by Hemming (1931), a copy of the first volume which Edwards presented in 1879 to the Entomological Society of London (now Royal Entomological Society of London) possesses penciled corrections to these pages. I examined images of these corrections and found that they were possibly written by Edwards himself. Annotations on the "Dates of Issue" sheet are consistent with the dates given in the 1879 reprinting, of which Hemming (1931) was apparently unaware. In the original "Alphabetical Index" there was an error in citing the letterpress for *Parnassius eversmanni* [Ménétriés] which began on page 27, not page 25 as initially indicated.

By 1881, reprinted text for the first volume was again exhausted. Edwards mentioned that "a number of new parties" wanted the first two volumes, but they were unavailable. He informed Holland, who requested an extra copy of the first volume, that he would receive it "within a year."[26] In 1882, Edwards realized that there was a greater demand than he could possibly keep up with.[27] New copies of the first volume were assembled whenever possible, but only when the colorists were "out of work" with the second volume."[28] Due to the continued demand, text for the first volume was reprinted once again in 1888, this time by Houghton Mifflin. It was titled like the 1879 reissue and incorporated the same corrections.

During the production of the second volume, Edwards complained about errors in several parts. He discovered two mistakes in the lettering of the plates and noted that the printers "had made 3 blunders in printing Parts of vol 2 so that the genera in these cases could not come together."[29] He corrected these errors where possible, thus enabling subscribers to have "Plates & pages bound correctly."[30] In addition, the 16 pages of letterpress that accompanied plates *Lycaena* II and *Lycaena* III of Part 12 were mistakenly paginated by the printer. This was never corrected and it remains the only portion of the book with printed page numbers.

As the second volume was nearing completion, Edwards issued a "Notice To Subscribers" with Part 12, dated 1 May 1884 (despite the reference to a second plate in Part 13, it was not issued):

> *The present Volume will close with Part XIII., in which will be two Plates; one illustrating the larva, etc., of Rutulus, the other larvae of Zolicaon and Machaon, with figures of P. Machaon var. Aliaska. The text of Rutulus, begun in XII., will be continued in XIII.*

Part 13, issued in January of 1885, also included the title page, preface, supplementary notes, and a list of species (see below).

TABLE 3. Issuance of parts for the second series (volume 2) of *BNA*.

Part	Publisher imprint	Wrapper date	"Dates of Issue"	Published references*	Unpublished references
1	New York: Published by Hurd and Houghton; Cambridge: The Riverside Press	May 1874	July 1874	- is just in hand" [June 1874][1]	- "is issued" (tHE 2.vi.1874 AMNH)
				- "has just been issued" [17 June [1874]][2]	- "glad you like Part 1" (tHE 28.vi.1874 AMNH)
					- "Part 1 . . . has come to hand" (fGL 9.vi.1874 WVSA)
2	New York: Hurd and Houghton; Cambridge: The Riverside Press; London: Trübner & Co.	1874	March 1875	- "has just been issued" [31 October 1874][3]	- "just in receipt of the second number" (fJH 9.x.1874 WVSA)
					- "appeared in October" (tSB 3.xi.1874 USNM)
3	same	1875	June 1875		- "Part 3 . . . is out" (tSB 18.vi.1875 USNM)
4	same	November 1875	December 1875	- "end of December last"[4]	- "I have recd. Part IV" (tTM 29.xii.1875 RC).
5	same	July 1876	September 1876	- "have issued" [by Jan. 1877][5]	- "let me have Part V sent [to] him" (tHE 16.x.1876 AMNH)
6	same	1877	December 1877	- review, Feb. 1878[6]	- "will issue 1st Dec." (tSB 22.xi.1877 USNM)
					-"Hope by this time Part VI has reached you" (tHE 1.i.1878 AMNH)
7	Boston: Houghton, Osgood and Company; The Riverside Press, Cambridge; London: Trübner & Co.	1878	December 1878		- "I recd my copy on 7th [Dec] (tHE 9.xii.1878 USNM)
8	same	1879	December 1879	- review, Feb. 1880[7]	- "you should have recd Part VIII" (tSB 7.ii.1880 USNM)
9	Boston: Houghton, Mifflin and Company; The Riverside Press, Cambridge; London: Trübner & Co.	1880	October 1880	- "1880" in Review, Jan. 1881[8]	
10	same	1882	June 1882		- "will issue in a few days (tHH 14.v.1882 MCZ)
11	same	1883	April 1883	- 1 April 1883[9]	- "Part XI will be out in a few days" (tHE 24.iii.1883 AMNH)
				- recorded library donation, 11 May 1883[10]	-"I am glad you fund Part 11 what it should be" (tSS 8.v.1883 BMS)
				- "has just come to hand" [4 May 1883][11]	
12	same	1884	June 1884		- "Part XII came out last week" (tHE 27.vi.1884
13	same	1885	November 1884	- recorded library donation, 26 Jan. 1885[12]	- "Part XIII ought to be out (tHE 31.xii.1884 AMNH)

***Published references: 1**. Review (Can. Entomol. 6:120); **2.** Review (Atlantic Mo. 34:113-115); **3.** Announcement (Every Saturday 2:496); **4.** Review ([Scudder, S. H.]. 1875. Amer. Nat. 10: 108-109); **5.** Advertisement (Can. Entomol. 2: rear cover); **6.** Review (Entomol. Mo. Mag. 14:211-212); **7.** Review (Entomol. Mo. Mag. 16:215); **8.** Review (Entomol. Mo. Mag. 17:189); **9.** Notice to Subscribers from Edwards (BNA, Part 11); **10.** Donation by Edwards (Trans. Amer. Entomol. Soc. 10:xvii). **11.** [Letter to Edwards] (Papilio 4(9-10): advertisement insert): **12.** Donation by Edwards (Trans. Amer. Entomol. Soc. 11:xii).

In late 1885, Edwards instructed Mary Peart to begin working on plates for the third volume, but she had a backlog of other drawings to finish.[31] As a result, Edwards did not receive completed copies of the first two plates until April of 1886.[32] Subscribers later received a lengthy "Advertisement," for the third volume, dated 25 December 1886. A copy of this document was date-stamped by the Smithsonian Institution as having been received one day before the first part of the third volume, suggesting that it was mailed separately. In the advertisement, Edwards stated that he envisioned publishing ten plates per year, and "probably three or four will contain figures of eggs exclusively." He also suggested that it may be desirable to include sixty plates in the third volume instead of fifty. None of these plans were realized. Rather than ten plates appearing each year, an average of only 5 plates was issued each year during the volume's ten-year production between 1887 and 1897. After 1891, only three plates were issued in most years, and none were issued in 1896. Instead of 60 plates, only 51 were completed, and none exclusively portrayed eggs. Because he had so many drawings of eggs, Edwards had previously proposed issuing them in a separate book, which never transpired.[33]

During production of the third volume, Edwards discovered an error on the proof for plate *Coenonympha* I, on which the lettering artist misspelled the plate name as "*Ceonympha*". Edwards attempted to correct the error, but the printer had already struck all 450 prints. Edwards took the advice of Scudder and resolved to "take the plates as they were, noting the error in the text."[34,35] A similar error previously affected plate *Anthocharis* I of the second volume, on which the species name *Olympia* was misspelled as "*Olimpia*".

Part 10 of the third volume was delayed due to "bad work on the third plate, which required that it be reprinted."[36] In addition, two pages of Part 15 had to be reprinted and reissued in Part 17. Various corrections to lithographic stones and to the lettering on the plates delayed the issuance of other parts.[37] Part 6 was previously delayed due to the artist (Ketterer) using one lithographic stone to complete two plates, one of which was for Part 7.[38] Ketterer also made various mistakes on his drawings which Peart worked to correct.[39] Ketterer sometimes struggled with accurately portraying details, such as eggs or the legs of adult butterflies.[40]

A separate publisher's notice, dated February 1897, was issued with Part 17. It referred to the printer's errors and indicated that an 18th part would be issued. The publication of this additional part is not widely known, as it was not included on the "Dates of Issue" sheet for that volume. The notice read:

> *In sending you Part XVII. of this work, we beg to call your attention to two separate leaves accompanying it, one containing the first page of Chionobas VIII., and the other the last page of Argynnis VII. When Part XV. was printed, these pages were accidentally printed back to back, which was a mistake, because in the final arrangement of the plates and accompanying text for binding, these two subjects will appear in different parts of the volume. The two leaves now sent, therefore, are to be used in substitution for the single leaf containing both pages which went out in Part XV., and subscribers are requested to notify their binders to this effect. Part XVIII., which will conclude the work, will be sent to you shortly without charge, and will contain the index, title-page, etc., for the volume.*

Edwards sent the last proof plates for the third volume to the publisher in November 1896, after which he started preparing the title page, preface, supplements and index.[41] Part 17 was issued during early March of 1897. Part 18, which also included text (but no plates) for *Papilio* IV and *Papilio* V, was issued during late May of 1897.

Two versions of the title page for the third volume were issued. One featured the ornament (emblem) of Houghton Mifflin, while the other bore the ornament of the printer, Riverside Press. The latter ornament was created in 1885 (RP 1899), after the completion of the second volume, on which the Houghton Mifflin ornament appeared. Because the Houghton Mifflin ornament was used for the title page of the second volume, as well as that of the 1888 reissue of the first volume, a similar title page was probably preferred for later copies of the third volume. This consistency was important when all three volumes were sold as a set.

Replacement plates. In 1871, when Edwards was nearly done with the first volume, he decided to redraw three plates. He had recently received new specimens of *Argynnis leto* (=*Speyeria cybele leto* (Behr)), which convinced him that he needed to improve plate *Arygnnis* X of 1869 (Fig. 3). He initially thought the best way to do this was to simply ask the colorist, P. D. Leslie, to recolor the female on the original plate to conform to the new specimens.[1,2] Unfortunately, the cost of doing this was prohibitive (ten cents more than a standard plate), thus Edwards resolved to have Mary Peart redraw the plate[3] (Fig. 4). The following year, Edwards received male and female specimens of *Speyeria nokomis* which were collected in 1871 in Arizona. Because Daniel Wiest's original plate of the species (Fig. 5), issued in 1868 as *Argynnis* IV, was drawn from a single male specimen in poor condition, Edwards instructed Peart to create a new illustration

FIGS. 3–6. Original plates (left) and replacement plates for *BNA*. **3,** *Argynnis* X by M. Peart. **4,** *Argynnis* X by M. Peart. **5,** *Argynnis* IV by D. Wiest. **6,** *Argynnis* IV by M. Peart.

(Fig. 6).[4,5] Upon sending an Arizona specimen of the species to S. F. Baird in 1872, Edwards wrote, "The *Argynnis* in the first box is really *Nokomis*, figd from a poor specimen (and unique till now) in Part 1 … probably I will figure both sexes & make a new plate for [Part] 1."[6] Although Skinner (1918) claimed that the original plate of *S. nokomis* was not published, it obviously was sent to subscribers.

Unfortunately, Edwards' replacement of the plate of *S. nokomis* resulted in some later confusion, as the taxon portrayed on the original plate differs from that depicted in the replacement (Skinner 1918; Holland 1928; Brown 1965, 1983). Variation in the coloration of various copies of the original plate heightened this confusion (Holland 1928). The source of the lost holotype originally figured by Edwards is uncertain (Brown 1965). Its condition was poor, thus Edwards likely did not recognize differences between it and those from Arizona.

Edwards was also forced to create a new plate for *Speyeria diana*, which had originally been drawn by D. Weist for plate *Argynnis* I, issued in 1868 (Fig. 7). Although Edwards had previously described this plate as "handsome," he now realized that "the plate as it stood was such as to make coloring doubly expensive."[7] As with the other replacements, the new *diana* plate was drawn by Mary Peart (Fig. 8).

Edwards intended to issue all three new plates with Part 10 of the first volume, but this would have delayed its publication. He therefore decided to include them in the supplemental part, issued in January 1873. In a "Notice To Subscribers" printed on the wrapper for Part 10, Edwards explained,

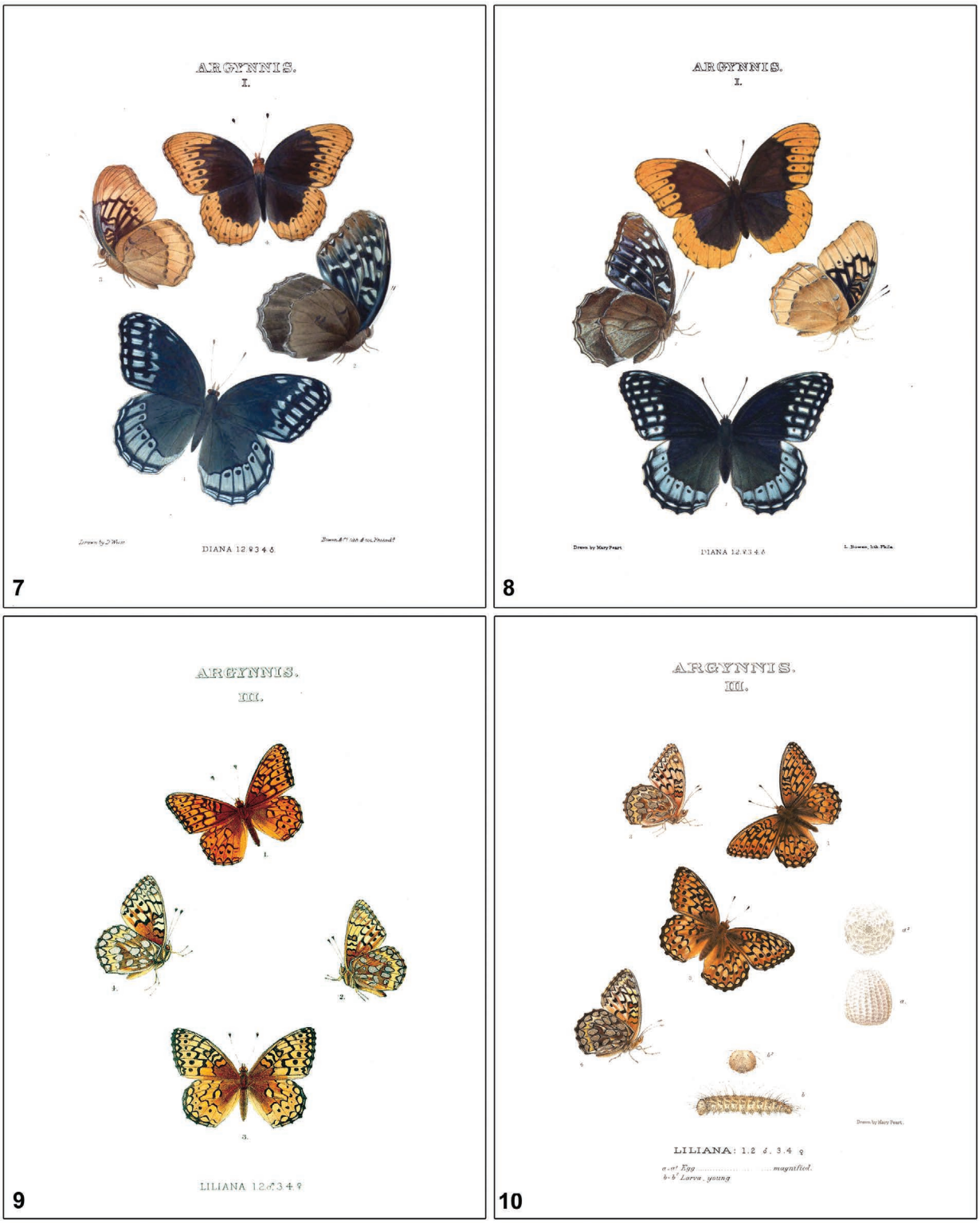
> *It was intended to issue the new plates of Argynnis Diana and Leto with part 10, according to notice heretofore given. But within the last two months specimens of Argynnis Nokomis, of both sexes, have been received from Arizona, and the female being remarkable for its coloration, belonging to same group with Leto, and in some respects resembling Diana, it was deemed of importance to redraw the plate. The coloring of these three plates would have retarded the issue of Part 10 two months. Therefore it was concluded to deliver this Part immediately, and as soon as possible follow it with a supplementary number, containing plate of Nokomis furnished gratis to each subscriber, and the other two to such as have ordered them. The title page and Index will then also be given.*

The new plates of *S. nokomis* and *S. leto* were accompanied by updated letterpress. Upon the publication of the new plates, Edwards wrote, "Those three butterflies are the finest in North America and Miss Peart and Mrs. Bowen are equal to portraying them. It is a satisfaction to work with such artists."[8] Referring to the supplement, Edwards asserted, "if you don't say it contains three remarkable species I give up."[9]

Edwards obviously possessed an extreme fondness for *S. diana*, which he considered to be the most beautiful species of its genus, if not all butterflies. He saw his first live male of this species in 1864 and wrote an account of finding a female a few days later, which was thought to be the first female known to science (Edwards 1868–1872) (per Strecker (1900), a female had actually been found in Missouri around the year 1853). It even seems that Edwards commissioned a song, the "Diana March", in its honor.[10] Edwards claimed that *S. diana* became "scarce" in the vicinity of his home after 1865, when two visiting collectors took about 100 specimens (dos Passos 1951). In 1873, he told Herman Strecker, "Either Mr. Ridings [James Ridings] or the fires in the woods have extinguished the breed hereabouts."[11] It seems, however, that the butterfly had not become as rare as Edwards maintained, as he continued to record observations of adults in the area for decades thereafter.

It has long been known that the first volume contained three replacement plates (e.g. Holland 1928; dos Passos 1951), but another replacement went unnoticed. In 1887, shortly after S. W. Denton's plate of *Speyeria c. liliana* was issued as *Argynnis* III in Part 3 of the third volume, Edwards began to express his dissatisfaction with its quality, noting that it was "not very well drawn nor very well printed."[12] He resolved, "Probably before end of the volume I will have the *Liliana* plate re-drawn & sent out gratis."[13] Edwards had argued with the firm who had struck the 450 prints from Denton's *liliana* plate. They were printed on poor paper and the impressions were not as clear as the proof which Edwards had approved. In addition, Edwards was displeased with the coloring, noting that "It ended with Denton scraping somewhat the dark parts."[14] Edwards identified the printing firm as "Morse & Co.," possibly referring to George H. Morse, Jr., a Boston printer whom Denton presumably hired to strike his plates for Edwards. Because of these problems, Morse reprinted the entire lot of this plate at his expense,[15] yet Edwards still regarded these prints as unacceptable.

Edwards ultimately replaced Denton's *liliana* plate (Fig. 9) with another drawn by Mary Peart (Fig. 10). There are very few references to the new *liliana* plate among Edwards' letters. In August 1897, he told W. G. Wright, "As to *Liliana*, Mrs. Peart began a plate of this on stone from the fine example you sent me last year. When it will be finished I do not know, but sometime



FIGS. 7–10. Original plates (left) and replacement plates for *BNA*. **7,** *Argynnis* I by D. Wiest. **8,** *Argynnis* I by M. Peart. **9,** *Argynnis* III by S. W. Denton. **10,** *Argynnis* III by M. Peart.

this fall probably."[16] When he later compared the new plate with the original version, he was "more disgusted with the latter than ever."[17] In the letterpress for the original plate of *liliana*, Edwards (1887–1897) remarked, "By an oversight, the egg and young larva were not figured on the present Plate, but will be given on Plate V of this series of *Argynnis*." In fact, the early stages of *liliana* did not appear on *Argynnis* V, which was issued in Part 9, but instead were later incorporated into Peart's new version of the *liliana* plate (Fig. 10). After the book was completed, Edwards remarked that he was finally able to pay Peart for drawing the *Liliana* plate, "for which the beneficent Gods be thanked."[18] Probably referring to the new *liliana* plate, Edwards expressed his regret in late 1898 that Scudder "did not get one of the new prints."[19] Because of its belated appearance, the new *liliana* plate was apparently not sent to all the original subscribers and instead was incorporated into later bound copies of the volume. This explains why Edwards (1887–1897) indicated that only two plates of the third volume were drawn by Peart (*Parnassius* I and *Chionobas* XIII), while some existing copies of the volume (including my own) have an additional plate that bears her name. This replacement plate is perhaps even more rare than the three replaced in the first volume.

Other plates received modification, but were not completely redone. Edwards was sometimes unhappy with the initial results and ordered new pattern plates be created to correct early attempts. For example, the male figure on plate *Chionobas* II (*Oeneis nevadensis gigas* Butler) of the second volume was derived "not from life," but from a drawing of the holotype in the British Museum.[20] The drawing was sent to Edwards by A. G. Butler, who had previously described the taxon as *Oeneis gigas*. Edwards considered the original coloration of this figure on plate *Chionobas* II to be inaccurate. In 1891, the San Francisco lepidopterist W. G. Wright collected additional specimens of the species in British Columbia, which Edwards used to correct new copies of the plate.[21] In addition to such corrections to prepared plates, the pattern plates were sometimes "renewed" to prevent the colorists from migrating away from the original colors.[22] Replication of previous errors was often a problem during the production of hand-colored illustrations.

Synopsis. In 1867, S. F. Baird suggested that Edwards increase demand of his book by including a "list of all described N. Am. species of the different genera figured and even Synopsis."[1] Edwards agreed, but jokingly asked, "Should I adopt all of the new genera of Tom, Dick & Harry, or have I discretion to do as I think best about that?"[2]

The publication of the *Synopsis of North American Butterflies*, which accompanied the first volume of *BNA*, was very complex. Its production reveals that Edwards was struggling to keep up with a rapidly changing taxonomy. When considering the usage of names, he sometimes asked the advice of other entomologists, such as H. Edwards[3] and T. L. Mead. In his personal journal of 1871 (see Calhoun 2010), Mead mentioned helping to proofread parts of the *Synopsis* while he was visiting Edwards in Coalburg.

The *Synopsis* was issued with Parts 3–10 of the first volume of *BNA*. Pages five and six, issued in Part 4, were replaced with Part 5 less than eight months later. With Part 10 came additional changes, when Edwards revised at least seven more pages (1–4, 10, 11, 19). I obtained copies of the original nine pages that Edwards issued in five separate parts between December 1868 and January 1871. These pages came from a copy of *BNA* once owned by the lepidopterist Paddy B. McHenry, who published a brief historical summary of the *Synopsis* (McHenry 1952). These pages reveal that Edwards changed the format of some citations and altered the arrangement of many taxa to reflect more current research. Upon ordering an extra copy of the entire *Synopsis*, T. L. Mead was advised by E. T. Cresson that "there have been many corrections," thus Mead's order was held until all the corrected sheets could be sent within the supplemental part of the first volume (27.ix.1872 WVSA). Perhaps somewhat sardonically, Mead later called the *Synopsis* "very interesting" (TM journal entry, 9.x.1871). The original version of the *Synopsis*, as issued in installments, is very rare.

Probably in December 1872, the updated *Synopsis* was separately offered for sale by the American Entomological Society in the same size (quarto) as *BNA*. After receiving the separately-published version, the botanist Lewis R. Gibbs considered it to be the "authoritative one," in preference over the version sent in installments.[4] In early 1873, after the first volume was concluded and the *Synopsis* had been separately issued, Edwards discovered yet another error, the omission of the species *Gonepteryx clorinde* (=*Anteos clorinde* (Godart)).[5] This page was corrected and the new version was included in newly assembled copies of the first volume. Although the *Synopsis* was considered helpful, the generic arrangement and meager citations were criticized ([Scudder] 1874). The entomologist John Hamilton considered the *Synopsis* to be "valuable to those who have acquired some proficiency, but of little account to the beginner."[6]

Revised Synopsis. About the year 1877, Edwards decided to issue a revised *Synopsis* for the second

volume of *BNA*. At that time, Edwards was preparing the more comprehensive *Catalogue of Lepidoptera of America, north of Mexico* (Edwards 1877). He believed that such a catalogue was necessary because "a large number of new species have been described, belonging to the North American fauna." Edwards intended to base the revised *Synopsis* in *BNA* on his 1877 catalogue. He asked Henry Edwards to review proofs of his catalogue, whose comments would also apply to the *Synopsis*.[1] The revised *Synopsis* was meant to update the original version by "adding only reference to species named or found to be N. Am[n] since 1872."[2] Edwards characterized the new *Synopsis* in 1882 as "barely a list except that all species names since 1872 … will have references."[3] He added, "I don't intend this to take the place of a catalogue for general use and I propose in course of a year to issue a new edition of my Cat[alogue] of 1877 for sale."[4] (This was not actually published until 1885.)

Virtually unknown, this publication was entitled *Synopsis of North American Butterflies. Revised and Brought Down to 1882.* It was begun in Part 10 of the second volume of *BNA*, yet it was plagued with problems from the start and never completed. After receiving a letter from H. A. Hagen, who had identified several errors, Edwards bemoaned the fact that this *Synopsis* lacked two species through "omissions in copying," and the printer had forgotten to paginate the first installment.[5,6] Edwards was also uncertain about the status of several taxa and felt that he needed to correct those treatments. Justifiably frustrated, Edwards wrote, "I should not have issued this Synopsis now had I not promised to give it … it will cost me $100, perhaps $150, and I shall get no return."[7]

The first (and only) installment of this *Synopsis* was only eight pages in length. It contained species numbers 1–143, beginning with *Papilio Ajax* (=*Eurytides marcellus* (Cramer)) and ending with *Argynnis Polaris* (=*Boloria polaris* (Boisduval)). Edwards continued to work on it, noting that the publisher was setting type "from *Erebia* to and into *Lycaena*."[8] Like the *Synopsis* that accompanied the first volume of *BNA*, Edwards intended to include a preface, lists of authors and abbreviations, addenda, and corrigenda.[9] He made a few changes to the sheets he had already printed, adding page numbers and replacing some species names.[10,11] However, Edwards soon questioned the continuation of the revised *Synopsis* and decided to suppress the pages he had already printed, planning to "rewrite as complete a Catalogue as I possibly can & issue it as Part XIII" of the second volume.[12] He soon reversed this decision as well, doubting the logic of even including such a compendium in the book. After asking for advice from H. A. Hagen, Edwards decided to discontinue the revised *Synopsis* and prepare a much more detailed second edition of his 1877 catalogue for publication elsewhere.[13] He explained, "I had my intention to carry the Syn[opsis] to 1883 adding new matter but I will make it as perfect as I can now" [as a separate catalogue].[14] He also noted that the inclusion of a detailed catalogue in *BNA* would have increased the size of the second volume, making it "too bulky." Still wanting to include some kind of summary in the second volume, Edwards reconciled this dilemma by deciding to issue in Part XIII "a List of species with no references at all—a bare list."[15] The revised *Synopsis* purportedly reached 26 pages,[16] but no more were distributed beyond the eight in Part 10.

Subscribers were notified of the discontinuation of this *Synopsis* in a notice dated 1 April 1882, which was issued with Part 11 of the second volume:

> *I had intended supplementing the Synopsis of Species which closed Volume I by the addition of all species named, and all late references, and so close Volume II with a Revised Synopsis on this plan. Some pages were accordingly sent out with Part X. But it has been urgently pressed upon me, that if I gave anything it should be a new and full Synopsis, so that students should not be compelled to refer to the original and the revision. Volume II will have one half more pages of text than Volume I, and to add sixty or seventy more of the Synopsis would make it uncomfortably bulky. I therefore have concluded to recall the pages which were issued with Part X, and to close this volume with a List of Species only, giving the names of the families, genera, and species.*

Edwards recalled copies of the revised *Synopsis*, thus very few have survived. I examined images of a copy in the Ernst Mayr Library (Harvard University), which bears an inscription at the top of the first page: "This Synopsis of vol. II was stopped 1882 on my suggestion, to be replaced by a new one." The handwriting matches that of H. A. Hagen, who donated his personal library to MCZ. While working at Harvard College (later Harvard University), Hagen retained his books in his office, along with all others on entomology belonging to the College (Winsor 1880). Hagen subscribed to *BNA* and was a regular correspondent of Edwards for many years. This evidence confirms that it was indeed Hagen who dissuaded Edwards from completing the revised *Synopsis*.

List of Species. After Edwards abandoned the revised *Synopsis* for the second volume, he decided to include a basic list only, "for the reason that many subscribers to Vol 1 probably know of no change in arrangement since Vol 1 issued" and such a list "would

show that an entire change had been made, or many superfluous genera rejected."[1] Entitled *List of Species of the Diurnal Lepidoptera of America North of Mexico*, it included its own title page, dated 1884. Introductory comments by Edwards were dated 1 November 1884. This list was issued with the last (13th) part of *BNA* in January of 1885. This list was merely intended as a compendium of the names and varieties presented in Edwards' updated catalogue (Edwards [1885]). The *List of Diurnal Lepidoptera* was separately offered for sale by Houghton Mifflin for $0.50 each and could be ordered from the publisher or Edwards himself.

Complete citations. Based on this study, I suggest the following citations for *The Butterflies of North America* and related publications. This is the first time that such comprehensive citations have been offered for the book. Citations for the third volume include only the month of issue, as the specific days given on the "Date of Issue" sheet for that volume (Table 4) are the dates of receipt by BSNH, not the actual dates of publication. These citations essentially follow the bibliographic format of Pelham (2008).

EDWARDS, WILLIAM HENRY

1868–[1873]. The butterflies of North America [with colored drawings and descriptions]. Philadelphia: American Entomological Society 1: (1) ii, [63–76], pls. [20–24] (Apr [Jun] 1868), (2) [41–44, 77–80, 135–136], pls. [12, 13, 25, 26, 45] (Aug [Oct] 1868), (3) [81–84, 127, 128, 141–144, 149–152], pls. [27, 28, 41, 47, 49] (Dec 1868 [May 1869]), (4) [45–52, 85, 86, 129, 130, 145–148], pls. [14, 15, 29, 42, 48] (Apr [Sept] 1869), (5) [53, 54, 87, 88, 99, 100, 131, 132, 153–156], pls. [16, 30, 35, 43, 50] (Dec 1869 [Apr 1870]), (6) [37, 38, 55, 56, 89–92, 133, 134], pls. [10, 17, 31, 32, 44] (Jun [Aug] 1870), (7) [17–20, 39, 40, 57, 58, 97, 98, 137–140] pls. [4, 11, 18, 34, 46] (Jan [Mar] 1871]), (8) [29–36, 93–96, 101–110], pls. [8, 9, 33, 36, 37] (Aug 1871), (9) [1–16, 111–120], pls. [1, 2, 3, 38, 39] (Dec 1871 [Jan 1872]), (10) [21–28, 59–62, 121–126], pls. [5, 6, 7, 19, 40] (Jul [Sept] 1872), (Suppl.) t.p, [ii], [4 pp.], [73, 74, 85, 86, 157–164], pls. [20, 23, 29; all replacements] (1872 [Jan 1873]).

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Table 4. Issuance of parts for the third series (volume 3) of *BNA*.

Part	Publisher imprint	Wrapper date	"Dates of Issue"	Published references*	Unpublished references
1	Boston and New York: Houghton Mifflin and Company; The Riverside Press, Cambridge; London: Trübner & Co.	1887	9 Jan. 1887		- "I got my copy 11th [Jan.] " (tWW 23.i.1887 CAS; tSS 13.i.1887 BMS)
					- "I have just received Part I" (fSB 24.i.1887 USNM)
2	same	1887	20 April 1887	- available by 30 April 1887[1]	-"Glad you like Pt 2" (tSS 24.iv.1887 BMS)
				- "is just ready" [May 1887][2]	- received by Smithsonian Institution, 22 April 1887
3	same	1887	12 Sept. 1887	- "Part 3 just ready" [Oct. 1887][3]	- "Pt. 3 is out" (tSS 12.ix.1887 BMS)
					- "I hope Pt. III has reached you" (tWW 28 ix.1887 CAS)
4	same	1887	22 Jan. 1888	- "will be ready for delivery 1st January" [1888][4]	- "Part IV will reach you in a few days" (tTM 23.i.1888 RC)
					- "Glad you approve of Pt. IV (tSS 30.i.1888 BMS)
5	same	1888	28 May 1888	- "will be ready for delivery 1st June" [1888][5]	- " Part V is about to issue" (tHE 24.v.1888 AMNH)
				- recorded library donation, 11 June 1888[6]	- "I believe Pt. V is delivered" (tWH 30.v.1888 CMNH)
6	same	1888	14 Dec. 1888	- recorded library donation, 24 Jan. 1889[7]	- "You saw Pt. VI" (tWW 3.i.1889 CAS)
7	same	1889	11 March 1889	- recorded library donation, 28 March 1889[8]	- "Pt. VII ought to be out" (tSS 22.ii.1889 BMS)
8	same	1889	2 June 1889	- 1 June 1889[9]	- "Part VIII will issue in a few days" (tHE 8.vi.1889 AMNH)
					- "have you rcd. Pt. VIII?" (tHE 29.vi.1889 AMNH)
9	same	1890	5 Feb. 1890	- recorded library donation, Feb. 1890[10]	- Part IX will issue abt. 10 Jany" (tTM 22.xii.1889 RC)
					- "should have issued 10th or 15th Jan (tWH 31.i.1890 CMNH)
10	same	1890	1 Oct. 1890	- 1 Oct. 1890[11]	- Part X came in today" (tWW 2.x.1890 CAS)

TABLE 4. Issuance of parts for the third series (volume 3) of *BNA* (Continued).

Part	Publisher imprint	Wrapper date	"Dates of Issue"	Published references*	Unpublished references
11	Boston and New York: Houghton Mifflin and Company; The Riverside Press, Cambridge; London: Trübner & Co.	1891	17 April 1891	- 15 April 1891[12]	- "I rcd Part XI yest." (tWW 20.iv.1897 CAS)
12	same	1891	4 Jan. 1892	- 2 Jan. 1892[13]	- Part XII came today" (tWW 5.i.1892 CAS)
				- "appeared in early January" [1892][14]	
				- available by 23 Jan. 1892[15]	
13	same	1892	10 Dec. 1892	- "now ready" [Dec. 1892][16]	- "Hope you approve of XIII" (tTM 3.i.1893 RC)
14	same	1893	17 Nov. 1893	- "will issue 1st November 1893"[17]	-"Rcd. Pt. XIV this AM" (tWW 18.xi.1893 CAS)
15	same	1894	17 July 1894	- "now ready" (July 1894)[18]	- "Mrs. P [Peart] recd. Pt XV 18 July 1894" (WE journal "X", WVSA)
16	same	1895	5 Oct. 1895	- "appeared early in October" [1895][19]	- "Thank you for your kind words on Part 16" (tSS 7.x.1895 BMS)
17	same	1897	1 March 1897	- available by 6 March 1897[20]	- "will be ready some time this March" (tWW 10.i.1897 CAS)
					- "Glad you approve of 17" (tWW 20.v.1897 CAS)
18	same	1897	--	- available by 29 May 1897[21]	- "in 18 will be much valuable matter" (tWW 20.v.1897 CAS)

* **Published references: 1.** Advertisement. (Can. Entomol. 19(11):rear cover); **2.** Advertisement (Andover Rev. 7:[10]). **3.** Advertisement (Andover Rev. 8:[17]); **4.** Advertisement. (Can. Entomol. 20(1):rear cover); **5.** Advertisement (Can. Entomol. 20(6):front cover); **6.** Donation by Edwards (Trans. Amer. Entomol. Soc. 15:vii); **7.** Donation by Edwards (Trans. Amer. Entomol. Soc. 16:i); **8.** Donation by Edwards (Trans. Amer. Entomol. Soc. 16:vii). **9.** Advertisement. (Can. Entomol. 21(9.):rear cover) and notice from Edwards (BNA, Part 8); **10.** Donation by Edwards (Trans. Amer. Entomol. Soc. 17:iii); **11.** Advertisement (Can. Entomol. 22(12):rear cover); **12.** Advertisement (Can. Entomol. 23 (5):rear cover); **13.** Advertisement (Can. Entomol. 24(2):rear cover); **14.** Review (Psyche 6:221-222); **15.** Recent lit. (Publ. Weekly 43); **16.** Advertisement (Entomol. Mo. Mag. 28:rear cover); **17.** Advertisement (Can. Entomol. 25(8):rear cover); **18.** Advertisement (Can. Entomol. 26(7):rear cover). **19.** Review (Science n.s. 2:584); **20.** Recent lit. (Publ. Weekly 51:425). **21.** Announcement (Entomol News 8:137).

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1888. The butterflies of North America. Boston; Houghton, Mifflin & Co.; third reissue of vol. 1: [ii]+[4]+[164]+vi+52 pp, 50 pls. {1888}.

Portrait of Mary Peart. In 1898, one year after the completion of *BNA*, Mary Peart's portrait was painted by her niece, the artist Caroline Peart (1870–1963). It represents the only known likeness of Peart, which has never before been published in connection with entomology (Fig. 11). A stylized depiction of the Asian swallowtail butterfly, *Teinopalpus imperialis* Hope, is hung above her right shoulder in reference to her many years of work with butterflies. Also represented is her deep affection for cats, a passion she shared with Edwards when they visited a cat show together in Philadelphia in 1884: "No end of pretty kittens of all colors."[1] Rendered in oil on canvas, the portrait measures 105.4 × 80 cm (41.5 × 31.5 in) and is preserved in The Phillips Museum of Art, Franklin & Marshall College, Lancaster, Pennsylvania

Mary Peart was one of several talented artists in her family. Besides her niece, she was the great aunt of the celebrated 20th century Pennsylvania artist, Andrew Wyeth (1917–2009). Wyeth viewed the portrait of Mary in 1963, when it was bequeathed with other paintings by Caroline Peart to Franklin & Marshall College (Lestz 1963).

With the exception of Edwards' brief comments in connection with *BNA*, very little has been published about Mary Peart. Born in Pennsylvania on 16 April 1837, her parents were Quakers from Chester County (Futhey & Cope 1881). During her younger years she shared a residence in Philadelphia with fellow Quaker Graceanna (Grace Anna) Lewis (1821–1812), a prominent naturalist who is most recognized for her work in ornithology (Bonta 1991). Peart's religious affiliation probably led to her later association with the naturalist and lithographer John Cassin, another Quaker from Chester County, Pennsylvania. Cassin also was acquainted with Lewis and named the white-edged oriole, *Icterus graceannae* (Icteridae) in her honor. Census records reveal that Peart and Lewis were neighbors in Philadelphia during the 1880s.

Peart was credited as having "no living compeer in her special department of Butterflies" (Anonymous 1902). Her long-time friend, Graceanna Lewis honored her as a fellow woman-scientist, "Gifted with true genius for her art," someone who had "chosen to devote herself to the illustration of scientific subjects, and has succeeded so well as to prove the fitness of her choice" (Lewis 1874). As a testament to Peart's "extraordinary ability in figuring insects on stone," six plates from *BNA* were exhibited in 1876 at the Women's ("Ladies'") Pavilion at the Centennial Exposition in Philadelphia (Dimmock 1876). Peart was greatly admired by entomologists, including Henry Edwards.[2] Henry Skinner of Philadelphia characterized her as "a delightful woman; cultured, refined and modest to a high degree" (Walton 1921). Skinner also pronounced her "a wonderful artist," whose work "was as good as any in the world" (25.ix.1922, Mead corresp., MGCL).

It is obvious that Peart's contributions elevated the quality of *BNA* far beyond that initially envisioned by Edwards. In honor of her thirty years of dedicated service, Edwards described the butterfly *Chionobas peartiae*, which is now recognized as a junior subjective synonym of *Oeneis polyxenes subhyalina* (J. Curtis). Edward Ketterer illustrated this butterfly on plate *Chionobas* XIV in Part 17 of the third volume of *BNA*. "I intend to name the species from my lovely assistant Mrs. Peart," Edwards revealed to Scudder in 1895.[3] Originally proposing the name *peartii*, he finally settled on *peartiae*, explaining, "It strikes me that [if] named for a lady the ae would imply as much."[4]

Edwards credited Peart with rendering 2,500 figures for *BNA*, "the beauty and precision of which it has not been possible to copy on the lithographic stones" (Edwards 1887–1897) (Fig. 12). Edwards considered Peart to be irreplaceable, both professionally and personally. He stated that she had "that sort of eyes & sees many things that I never should see."[5] Edwards obviously held a special place in his heart for Peart and visited her whenever he was in Philadelphia. They continued to correspond for at least a decade after the book was finished.

FIGS. 11–12. Mary Peart and her lithographic work for *BNA*. **11,** portrait of Peart, 1898 (courtesy Franklin & Marshall College, Phillips Museum of Art). **12,** studies of eggs and larvae from plate *Lycaena* III, second volume (at bottom is an enlarged attribution from plate).

During the production of the second volume of *BNA* in 1876, Edwards was afraid that he would lose Peart's services as an artist. In a panic, he incorporated extensive passages about Peart in several letters, which reflected his high regard for her. "I heard distressing news (to me) that my Miss Peart was to be married some time this season and could do but little more work for me," he worriedly wrote. "It took all the breath out of me … she has taken a personal interest in the work and troubled herself more than any other one can and will." Edwards continued his praises at length: "If I find one who can make a passable drawing of a butterfly, I can't hope to get one who will make a tolerable caterpillar. It took Miss P. some time to catch the limits of these butterflies, as you will see of comparing the plates of vol. 1. It was only by taking living butterflies and watching their ways of standing, and of using legs and antennae that she reached the present perfection on this point. She is lovely in character and as gentle in her manners as her work is beautiful. Miss Peart it seems is to marry an Englishman [John S. Peart] of the same name as herself & no relation. It is so remarkable a name that it is one of the oddest things."[6,7,8] Edwards considered the marriage of the two Pearts to be "a singular coincidence."[9]

Peart thought that she would relocate abroad after her marriage, thus ending her work for Edwards. Although Edwards immediately sought contingencies ("I have heard of a young lady in Phila and I hope to induce her to take hold"[10]), the work on *BNA* would have been irrevocably impacted following the loss of Peart's artistic talent, not to mention her expert rearing abilities. To Edwards' relief, Peart soon assured him that she would stay in Philadelphia after her marriage and continue to do work for him, at least occasionally.[11] Peart married on 28 May 1877 and moved from 533 North 4th Street to 422 Wetherill Street (now S. Carlisle St.) in Philadelphia. Edwards visited them at their "nice little house" a few weeks after their marriage.[12] He described her husband as "an intelligent man English by birth but has no accent and seems to have lived a good deal at Cape [of] Good Hope."[13] Edwards, however, still worried that "the petty cares of housekeeping on a limited scale will fritter away the time of Mrs. Peart."[14] As it turned out, Peart continued to work with Edwards for another two decades.

Peart's husband died unexpectedly in January of 1889. Troubled by this event, Edwards stated that Peart was "too afflicted to make drawings. … She is so delicate that there is always cause for apprehension lest she too may

suddenly fail me in which case the *Butterflies* [*BNA*] would be in a bad way."[15,16] Peart worked on *BNA* during the most productive time of her life, between the ages of 31 and 60. In addition to the many plates for *BNA*, she rendered illustrations for various articles, including Edwards (1878, 1883).[17]

Regrettably, Edwards did not have the opportunity to publish most of Peart's drawings of eggs, larvae, and chrysalids. He loaned them in 1887 to S. H. Scudder,[18] who published chromolithographs of some for his book (Scudder 1888–1889). Many of the same figures on Scudder's plates were later reproduced by Holland (1898, 1931) and Klots (1951). Among Scudder's correspondence at BMS is Edwards' list of these drawings, dated November 1887, which includes Scudder's annotations. Edwards worried about the well-being of these drawings and hoped that no harm would come to them while in Scudder's hands.[19] He remarked that Peart's drawings among Scudder's plates can always be recognized by their "accuracy & beauty of outline or position."[20] Edwards requested that Scudder return the originals in short order. "I really need the drawings for pigment reference in coloring," he wrote, "they are very valuable."[21] Having not received them five months later, Edwards chided Scudder, "If you have done with my drawings send them home soon."[22]

After the completion of *BNA*, Edwards wondered what to do with all of Peart's unused renderings. "I wish I could dispose of my drawings," he wrote, "much by Mrs Peart—fully 2500 figures, arranged in 8 or 10 albums." Peart needed the money and had an "equal interest" in their sale."[23] Edwards wished to see them deposited in a public institution where they would be available for reference (Lyman 1900). He asked Scudder if he knew of a buyer, stating, "They are too beautiful to be lost sight of."[24] Some of these drawings are now preserved at WVSA.

Peart's frail physical condition was an ongoing concern to Edwards. In 1875, he noted that Peart's health "would not permit her working at drawing at present."[25] A decade later, he reported, "Mrs Peart is so great an invalid that I am never sure when she will be able to make drawings," revealing that she was "confined to her bed a great deal."[26,27] Peart downplayed a particular bout of illness as an "attack of indisposition."[28] In 1889, a Mrs. L. S. Johnson informed Edwards that Peart was unable to write: "I am writing for her. … She will write more particularly when she can use her hand"[29] Edwards described this affliction as a "swollen fore finger on [her] right hand."[30] By February 1890, Peart's hand was healing and she could again hold a pen.[31] After the completion of *BNA*, she joyfully announced, "I get out of the house on good days and call myself well."[32]

During the last years of her marriage, Peart lived at 1901 Vine Street in Philadelphia, "just across the square" from The Academy of Natural Sciences.[33] After the death of her husband, she resided for a time with her sister, Rebecca Bean, in Schuylkill, Chester County, Pennsylvania. She also lived briefly in Pawling, Chester County, Pennsylvania,[34] where she had spent her summers during the 1870s (20.viii.1873, Mead corresp., RC).

Probably as a result of the many years she spent rearing larvae for Edwards, Mary developed an interest in botany and during the 1890s became a member of the Botanical Society of Pennsylvania (Harshberger 1899). Around 1898 she moved to 113 N. Woodstock Street, where she boarded with the Joseph F. Bamback family. Mary died on 12 April 1917 in the Homeopathic Hospital of Pottstown, Pennsylvania at the age of 80. She was buried next to her husband in Morris Cemetery, Phoenixville, Chester County, Pennsylvania. Peart's invaluable contributions to *BNA* are a testament to her unrelenting dedication to her very good friend and benefactor, William Henry Edwards.

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DESCRIPTION AND EVALUATION OF *METHARMOSTIS MULTILINEATA* (COSMOPTERIGIDAE) AND *IDIOPHANTIS SOREUTA* (GELECHIIDAE) (LEPIDOPTERA: GELECHIOIDEA) FOR BIOCONTROL OF DOWNY ROSE MYRTLE, *RHODOMYRTUS TOMENTOSA* (MYRTACEAE)

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ABSTRACT. Two species of Gelechioidea (Lepidoptera), ***Metharmostis multilineata*** Adamski, **n. sp**. (Cosmopterigidae), and *Idiophantis soreuta* Meyrick, 1906 (Gelechiidae), were collected in southeastern Asia for evaluation as potential biocontrol agents against downy rose myrtle, *Rhodomyrtus tomentosa* (Aiton) Hassk. (Myrtaceae), which has become an invasive weed in Florida, USA. *Metharmostis* Meyrick is reviewed and transferred from Yponomeutidae to Cosmopterigidae (Antequerinae). All life stages of *M. multilineata* are described and illustrated, with notes on its biology. In addition, protocols for rearing and host testing of *M. multilineata* are described in detail. *Idiophantis* appears to be associated with Myrtaceae, and the adult stage of *I. soreuta* is redescribed. Neither species was suitable for release in Florida.

Additional key words: classical weed biological control, Gelechioidea, Hong Kong, immatures, life-history, Myrtaceae, Southeast Asia, Taxonomy, Thailand

Downy rose myrtle, *Rhodomyrtus tomentosa* (Aiton) Hassk. (Myrtaceae), is an evergreen shrub typically growing to about 2 m in height, but some individuals reach nearly 4 m (Figs. 1–2). Native to the tropical regions of Asia, its distribution extends from India to Japan and in Southeast Asia from Thailand, Malaysia, and Indonesia east to the Philippines (Scott 1978, Herklots 1932). It is cultivated as an ornamental because of its multiple buds and attractive pink flowers (Figs. 3–4); for its edible berries, which are used as fruit and in jam; as a fire retardant species for use in fire breaks in the Himalayas; and for some medicinal purposes (World Agroforestry Centre 2011).

Scott (1978) lists the habitat of downy rose myrtle as shrubby forest, coastal scrub, or secondary forest, generally below 300 m elevation, but it may occur as high as 1300 m. It also thrives in open sandy soils, along the shore, and on river banks, and can tolerate full sun and flooding (World Agroforestry Centre 2011). Its life history characteristics make it a successful invader; it is

FIGS. 1–4. Exotic native habitat and development of *Rhodomyrtus tomentosa* in Hong Kong, SAR, China. **1**, Plants near hilltop, Luk Wu Country Trail, Sai Kung. **2**, Budding and flowering plant, Tei Tong Tsai Country Trail, Lantau Island. **3**, Budding plant, Tei Tong Tsai Country Trail, Lantau Island. **4**, Flowering and budding plant, Tei Tong Tsai Country Trail, Lantau Island.

fast growing and drought resistant (Hong Kong Herbarium 2004) and is able to withstand some frost and many soil types (Langeland & Craddock Burks 1998). Furthermore, it will re-sprout prolifically after fire and is spread by seed drop as well as by birds and mammals, which eat its fruit (EDD-MapS, Center for Aquatic and Invasive Plants 2009).

Rhodomyrtus tomentosa was available for sale from Florida nurseries as early as the late 1880s and was introduced into Highland and Lake Counties in Florida in 1905. It was first reported as "wild" (naturalized) in 1906 (Austin 2008), and was available for sale from Florida nurseries as early as in the late 1880s. It is likely that there were multiple introductions into Florida from several locations throughout its native range, although it is unclear whether all introductions contributed to the current populations in Florida (Paul Madeira, Invasive Plant Research Laboratory, pers. com.). By the 1970s *R. tomentosa* had formed extensive thickets near Orlando (Orange County), Bradenton and Oneco (Manatee County), Bonita Springs and Estero (Lee County), and Naples (Collier County) (Morton 1976). Today, there are infestations reported between Pasco and Collier counties on the west coast, in Polk and Highlands counties in central Florida and between Brevard and Dade counties on the east coast (Employment Development Department MapS, Center for Aquatic and Invasive Plants 2009). *Rhodomyrtus tomentosa* can alter native plant communities by displacing native species and changing community structure or ecological functions. In Florida it is displacing native vegetation with dense uniform thickets in the understory of native pinelands (Langeland & Craddock Burks 1998). Consequently, it is now considered a Category I noxious weed, and its use as an ornamental in Florida is prohibited according to the List of Invasive Plant Species of the Florida Exotic Pest Plant Council (2009).

Rhodomyrtus tomentosa is also a serious pest in Hawaii. Krauss (1966) reported that it was introduced there in the 1920s and had established on the islands of Kauai and Hawaii, infesting over 8,000 acres by the mid-1960s. On Kauai it forms essentially mono-dominant stands that successfully exclude most natives and even many other alien invasives (Burney & Pigott-Burney 2007).

The USDA, ARS, Australian Biological Control Laboratory (ABCL) commenced exploration for biological control agents of *Rhodomyrtus tomentosa*. In April 2001, a one-year survey of *R. tomentosa* herbivores in Thailand was conducted by the Thailand Department of Agriculture with support by ABCL. Six species were identified as having potential for further study as biocontrol agents (Winotai et al. 2005). This included two moth species, *Idiophantis soreuta* Meyrick and *Metharmostis multilineata*, with the latter species the most common insect found in the surveys ranging across six eastern and southern provinces, often encountered in large numbers boring and feeding inside young flower buds and young fruit (Winotai et al. 2005). The genus *Metharmostis* was proposed by Meyrick (1921), with the description of its type species *M. asaphaula*, collected from Nasik, Bombay, India. Prior to this research nothing was known of the biology and little of the distribution of the genus. *Idiophantis* also was proposed by Meyrick (1904). The genus includes about 20 species found principally in the Indo-Australian region, but it also is reported from the Seychelles, Madagascar, and South Africa (Moriuti 1993). *Idiophantis* appears to have a host preference for Myrtaceae (Bradley 1968; Scott Miller, Smithsonian Institution and The Papua New Guinea Binatang Research Center, pers. com.).

Starting April 2001, in collaboration with the Invasive Plant Research Laboratory (IPRL) in Florida, surveys of *R. tomentosa* have been conducted by ABCL staff throughout Hong Kong SAR; and since 2009 in the southern Chinese province of Guangxi.

Rhodomyrtus tomentosa is Hong Kong's most abundant flowering shrub, growing from sea-level to the top of the hills (Herklots 1932) (Figs. 1–4). The plant flowers from late April to July, with fruits present between June and September, coinciding with the hot and humid summer months. Young leaf shoots are prevalent between September and November before the cool and dry winter, from December to February. A study of the reproductive ecology of *R. tomentosa* undertaken in Guangdong Province, China, indicates that it took 20 days for a flower bud to develop and another 10 days for a blooming flower to develop into fruit. Almost two months were needed for a fruit to mature (Wei et al. 2009).

The purposes of this paper are 1) to document the identity, early stages, and life-history of the moth species collected from *R. tomentosa* by the Australian Biological Control Laboratory, and 2) to evaluate the potential of these species as biocontrol agents against *R. tomentosa* in Florida.

Materials and Methods

Plants of *Rhodomyrtus tomentosa* were obtained from parcels of the South Florida Water Management District Land, Palm Beach County, Florida, and from the Lake Lizzie Nature Preserve, Osceola County, Florida. These plants were transported to a secure site at the Florida Department of Agriculture and Consumer Services (FDACS), Division of Plant Industry (DPI), Alachua County, Florida, and transferred into 3.8–26.5-liter pots, and maintained for rearing and testing of potential biocontrol candidates. Plants of two nontarget native myrtaceous species, *Calyptranthes pallens* Griseb. and *Myrcianthes fragrans* (Sw.) McVaugh, were purchased from various Florida nurseries and plants of a third myrtaceous ornamental species, *Myrtus communis* L., were obtained from Woodlanders, Inc., Aiken, South Carolina and O'Toole's Herb Farm, Madison, Florida.

Cut shoots of field collected *Rhodomyrtus tomentosa* infested with *Metharmostis multilineata* were shipped directly from Hong Kong to the USDA, ARS Invasive Plant Research Lab located at the FDACS, DPI Florida Biological Control Laboratory, Gainesville, Florida in order to establish a laboratory colony under quarantine conditions. Exotic plant material was searched for wandering larvae and cocoons with viable pupae. Larvae were transferred with a small brush to fresh cut shoots of Florida *R. tomentosa*, which were held in 0.18-liter vials (1–2 shoots per vial) to complete development. Each shoot had at least one bud suitable for larval development and sites suitable for pupation. Cocoons present on leaves, stems, or buds of exotic shoots were excised along with a small section of plant material and put into 55.5-ml vials, one cocoon/vial. A small amount of honey was vertically streaked on the inner surface of each vial as a food source for adults after eclosion. The opening of each vial was covered with a square of paper toweling that was fastened with a rubber band. These vials of shoots and pupae were placed in a ventilated Plexiglas™ cage, 0.4 × 0.4 × 0.4 m, modified by placement of Horizon Total Wipes, nylon reinforced scrim wipes, 25.4 × 42.2 cm, over the screened side of the cage to maintain a higher humidity (Fig. 5).

As wandering larvae from Hong Kong were collected from plant material and placed on *R. tomentosa* from

FIGS. 5–8. Laboratory materials used to encourage development of immature stages of exotic *Rhodomyrtus multilineata*, and for adult mating and oviposition under quarantine conditions. **5**, Plexiglas® cage containing cut shoots of Florida *Rhodomyrtus tomentosa* for larval development and pupation. Also enclosed are several harvested cocoons in 55.5 ml vials, one cocoon/vial. **6**, Sub-irrigated rearing containers for infested plant material from Hong Kong. **7**, Adult mating and oviposition cage. **8**, Top view of mating and oviposition cage with three *Metharmostis multilineata* adults indicated by arrows.

Florida, the proximal ends of Hong Kong shoots with green leaves were cut and the ends placed in two floral foam Oasis® discs saturated with water to sustain shoots for any remaining larvae that might be feeding internally in the stems. Each disc of shoots was set in one half of a petri dish, 100 × 15 mm, placed in a 3.8-liter plastic container with a screened top and bottom, resting on supports about 3 cm above damp sand contained in a sub-irrigated holding container, an 18.9-liter inverted carboy with the bottom removed. The inverted carboy rested on the rim of a 7.6-liter bucket half-filled with water so that an absorbent cotton wick, which had been inserted through the neck of the carboy interfaced with a 15-cm layer of sand above to maintain the dampness of the sand. Two large Kimwipes®, 37.3 × 42.2 cm, secured by an elastic band spanned the opening of the sub-irrigated container to retard evaporation (Fig. 6). A standard institutional multifold paper towel, 23.5 × 24.1 cm, was opened and spread across the Kimwipes and tucked at the four corners into the elastic band for the same purpose.

An adult cage for mating and oviposition, Fig. 7, was fabricated from a 591-ml cold drink cup and lid, 32 mm in diameter, with screened openings on the sides for ventilation. One 16-ml opening was made for insertion and removal of adults. The opening was closed with a No. 0 stopper when not in use. A 44-mm opening was made in the bottom for insertion of cut shoots. These shoots were pushed through small slits in three layers of Parafilm® stretched across an opening of a 185-ml water-filled vial. The vial was secured to the cage vial with three 2.5 × 10 cm strips of Parafilm®. The cages were provisioned with three 1.3-ml Samco® fine-tip bulb pipettes containing a Lemon-Lime Gatorade Perform™, a Perky-Pet Brand Instant Nectar for Hummingbirds, and tap water. The transfer pipettes were inserted through holes in lids. The lid and diet bulbs were changed weekly. Old shoots with eggs were exchanged for fresh shoots, with egg-laden shoots placed in a container similar to that in Fig. 5. These shoots were checked weekly for cocoons, and when found, were placed in 14.8 ml glass shell vials, one/vial, shown next to the base/vial of the cage in Fig. 7. The opening of the vial was secured by the insertion of a square of "noseeum" screen pushed downwards into the vial and held in place with a 16 × 18 mm piece of irrigation tubing. A small drop of honey was applied to the outside of the screen with a toothpick to sustain an adult until it was collected.

Cages of exotic material and rearing containers were held under maximum security at 27°C, 16L:8-D. They were monitored daily for wandering larvae, pupae, adults, and parasitoids. Larvae and pupae were treated as above. Adults were transferred to mating and oviposition cages held in a quarantine greenhouse at 25°C, 60% RH, 16L:8D (Figs. 7–8). Inquilines and parasitoids were collected in 70% isopropyl and submitted to FDACS, DPI taxonomists for identification.

No-choice rearing trials using cut shoots of *R. tomentosa*, *C. pallens*, *M. fragrans*, and *M. communis*, were conducted in an environmental chamber at 27°C, 60% RH. Shoots were held in 55.1-ml vials and placed horizontally in plastic deli boxes, Genpak® AD48, 20.3 × 20.3 × 6.35 cm, lined with two Horizon Total Wipes.

Gross morphological observations and measurements of all life-stages were made using a Leitz RS dissecting microscope (using reflected and transmitted light) with a calibrated micrometer. Genitalia were dissected as described by Clarke (1941), except mercurochrome and chlorazol black were used as stains. The Methuen Handbook of Colour (Kornerup and Wanscher 1978) was used as a color standard.

For SEM study, larvae and eggs were cleaned in a full-strength solution of Formula 409TM detergent, and subsequently dehydrated in increasing concentrations of EtOH (10, 25, 50, 70, 95 %), ending with absolute EtOH. After dehydration, specimens were critical point dried using a BAL-TEC 030 critical point dryer. Larvae and some eggs were mounted on SEM stubs using carbon paste. The remaining portion of eggs were mounted on SEM stubs with Tempfix Mounting Adhesive. All mounted specimens were coated with gold-palladium (40/60%) using a Cressington sputter coater. The fine-structure of the larva and egg was studied with a Zeiss EVO MA15 scanning electron microscope at an accelerating voltage of 10 kV.

The holotype and paratypes from this study are deposited in The United States Museum of Natural History (USNM), Smithsonian Institution, Washington, D.C. Voucher specimens of adults and immatures are deposited in the USNM; the Australian National Insect Collection, CSIRO, Canberra (ANIC); the Florida State Collection of Arthropods, Gainesville, Florida (FSCA); Steven Passoa Insect Collection of the United States Department of Agriculture, Animal and Plant Health Inspection Service, Plant Protection and Quarantine, Columbus, Ohio (SPIC); and the Agriculture, Fisheries, and Conservation Department Insect Museum, Plant Protection Section, Tai Lung Experiment Station, Lin Tong Mei, Hong Kong AFDC, China. Setal nomenclature of the larva follows Stehr (1987). Pupal nomenclature follows Mosher (1916).

Adult genitalic nomenclature follows Klots (1970). Plant taxonomy, including nomenclature and authorship, follows GRIN (2008).

RESULTS

Metharmostis Meyrick, 1921

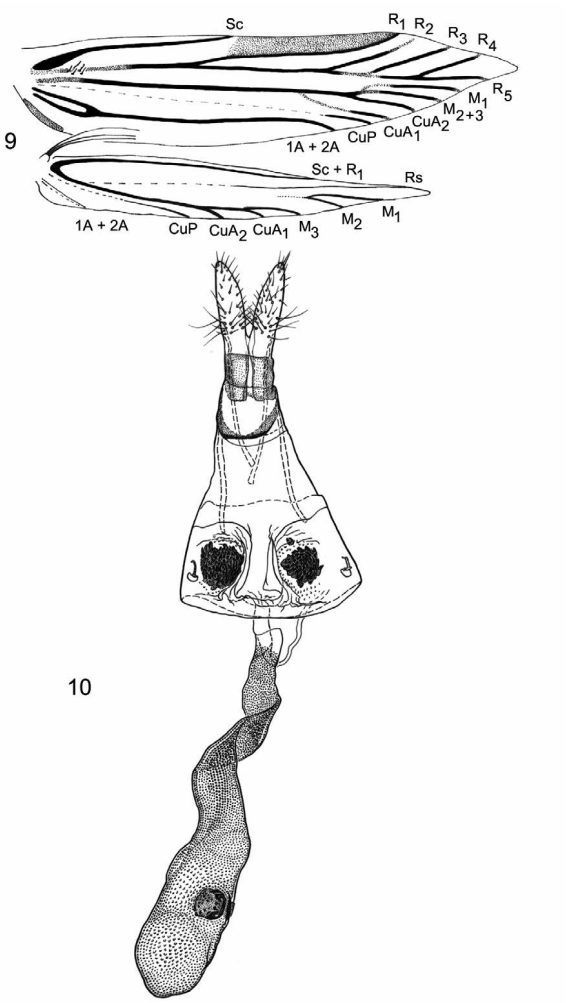
Type Species: *Metharmostis asaphaula* Meyrick, 1921: 439 [by monotypy]

Metharmostis is defined by a distinct forewing pattern that includes two rows of grayish-yellow streaks from base of cell to crossvein, the discal cell open in the forewing and hindwing, vein M_3 stalked with vein CuA_1 and separate from vein M_2 in the hindwing, a cluster of long hair-pencils from the base of the frenulum in the male, and the divided halves of the female seventh sternum bearing a dense cluster of sex scales.

Taxonomic Placement. Kyrki (1984, 1990) demonstrated the monophyly of the Yponomeutoidea with two synapomorphies: the presence of pleural lobes on the eighth abdominal segment in males and a transverse ridge on the second abdominal sternite in both sexes. In addition, yponomeutoids have a naked proboscis, a female frenulum with two acanthae, and abdominal terga with sparse spinelike setae on the abdominal terga. Whereas, the Gelechioidea are united by a scaled proboscis, with most species having a female frenulum with 3 acanthae, and abdominal terga with or without sparse spinelike setae (Hodges 1999). These contrasting adult features convincingly exclude *Metharmostis* from Yponomeutoidea and placed it in Gelechioidea. Pupal characters also support the placement. The antennae meet at the meson in *Metharmostis*: this character is considered unique to the Gelechiidae by Kaila (2004) and a probable apomorphy for the superfamily by Hodges (1999).

Meyrick (1921) placed *Metharmostis* in Hyponomeutidae (= Yponomeutidae) without explanation. Clarke (1955) suggested that *Metharmostis asaphaula* should be assigned to Cosmopterigidae on the basis of the similarity of its female genitalia to those of *Stilbosis devoluta* Meyrick. We agree with Clarke (1955) and hereby transfer *Metharmostis* from Yponomeutidae to Cosmopterigidae (Antequerinae). We base our decision on the evidence from several sources detailed below.

Hodges (1978, 1999) characterized Cosmopterigidae, comprised of three subfamilies, primarily on features of the adult. One of the subfamilies, Antequerinae, has male genitalia with paired lobes on the dorsolateral surface of the tegumen (part of the uncus or gnathos?) a free phallus, and a female ostium bursae that is associated with the seventh segment. Hodges (1978) also showed that cosmopterigids have a hindwing with a



FIGS. 9–10. Wing venation and female genitalia of *Metharmostis asaphaula*, Lectotype. **9**, Forewing and hindwing, female, J.F.G. Clarke slide no. 7494. **10**, Female genitalia, J.F.G. Clarke slide no. 7494.

frenulum with 3 acanthae in the female, a 4-branched cubitus, and a cell that is usually open. *Metharmostis multilineata* possesses all of the above features. Scoble (1992) stated that the cosmopterigid forewing lacks a pterostigma, although this feature is found in *M. asaphaula*, it is absent in *M. multilineata*, suggesting that this feature is more variable than Scoble realized.

Pupal features do not contradict placement of *Metharmostis* in the Cosmopterigidae. Although many pupal Cosmopterigidae have wings that extend almost to the end of the abdomen, this is not unique to the family (Patočka and Turčáni 2005: plates 81–83). Hidden labial palpi are also common to Cosmopterigidae and relatives (Passoa, pers. comm.).

These features of the wing and labial palpi are present in *Metharmostis*, and are consistent with other known cosmopterigids. The most striking feature of the *Metharmostis* pupa is the leglike structure of the 10th segment (Fig. 34–35). Similar structures are illustrated by Common (1990: Fig. 1) and Patočka and Turčáni (2005: Pl. 65, Figs. 22, 31, 34, 41; Pl. 76, Figs. 30, 34, 36–37, 41, 43) for species of Agonoxenidae and *Ethmia* (Elachistidae). Undoubtedly these structures have evolved independently several times within Gelechioidea, and may have limited phylogenetic value at higher levels.

The larva of Cosmopterigidae is characterized by Stehr (1987) as lacking a hairlike SD1 seta on A9, the presence of which is characteristic of many Gelechioidea. *Metharmostis multilineata* lacks this feature as well, SD1 on A9 is setaform (not hairlike). The presence of secondary setae in the SV-V1-group of A9 is unusual.

Metharmostis asaphaula Meyrick, 1921
(Figs. 9–10)

Diagnosis. *Metharmostis asaphaula* is most similar to *M. multilineata* by sharing a similar forewing pattern and a cluster of long hair-pencils from the base of the frenulum in the male. *Metharmostis asaphaula* differs from *M. multilineata* by having a pterostigma between Sc and R_1 of the forewing, a narrower eighth sternum in the female, paired lateral flanges fused from the inner margin of the seventh sternum to the anterior part of the ductus bursae to near the enlarged base of the ductus seminalis, and a signum with two pairs of larger denticles on the same side.

Redescription. *Head*: Vertex and frontoclypeus naked; labial palpus recurved; outer and inner surfaces of labial palpus naked; scape of antenna and most of flagellum naked. Proboscis scaled. *Thorax*: Tegula and mesoscutum naked. Legs pale yellow [faded]. Forewing length 3.5 mm (n=1), pale yellow [badly faded and many scales missing]; lanceolate; venation (Fig. 9) with pterostigma between Sc-R1; cell open; M_2-M_3 fused. Hindwing pale yellow [badly faded]; male with a long pencil of ochreous-whitish hairs lying along costa from base to 4/5 according to Meyrick (1921); frenulum with three acanthae in female; venation (Fig. 9) with cell open; M_1-M_2 stalked, separate from M_3; cubitus 3-branched. *Abdomen*: Male genitalia unknown. *Female genitalia* (Fig. 10) with papillae anales setose throughout, longer setae on basal 1/3. Apophysis posterioris about 1.6X longer than apophysis anterioris; eighth sternum narrow, semicircular, apically fused with apophyses posteriores. Ostium within membrane between divided seventh sternum; divided parts broadly rounded and ridged along inner margin, slightly recessed medially, bearing a dense cluster of sex scales. Ductus bursae smooth from ostium to slightly beyond anterior margin near swollen base of ductus seminalis, denticulate anteriorly, including corpus bursae; signum rounded, spinulate, with two large denticles along margin of one side.

Type (examined). Lectotype ♀, "Lectotype" [round label with a red circle in middle]; "[India], Nasik, Bombay, CB, 10[October] [19] 19"; Lectotype, *Metharmostis asaphaula* Meyrick, [designated by] JFGC Clarke, 1948"; "♀ genitalia on slide 25, 1948, JFGC 7494" [right wings slide mounted separately with same number], "*Metharmostis asaphaula* Meyr. 1/1, E. Meyrick det., in Meyrick Coll[ection]"; "Meyrick Coll[ection], BM 1938-290"; "*asaphaula* Meyr." [hand-written label]; "*Metharmostis* Meyr."

Remarks. *Metharmostis asaphaula* was described from three specimens (Meyrick 1921) including both sexes. Clarke (1965) found a single female specimen, concluded that the other two specimens were lost, and designated the female as the lectotype. A search for the remaining two specimens in the collections of the British Museum was unsuccessful.

Meyrick (1921) described *Metharmostis* as having a forewing with "faint brassy-ochrous longitudinal streaks of pale brassy-ochreous suffusion above fold." His description of the forewing pattern is similar to that of *M. multilineata*, and this pattern is considered a synapomorphy for the genus. In addition, Meyrick (1921) described *Metharmostis* as having posterior ocelli and lacking pecten on the scape; however, he was in error or based these details of the description on the two missing specimens which possibly represented a different species.

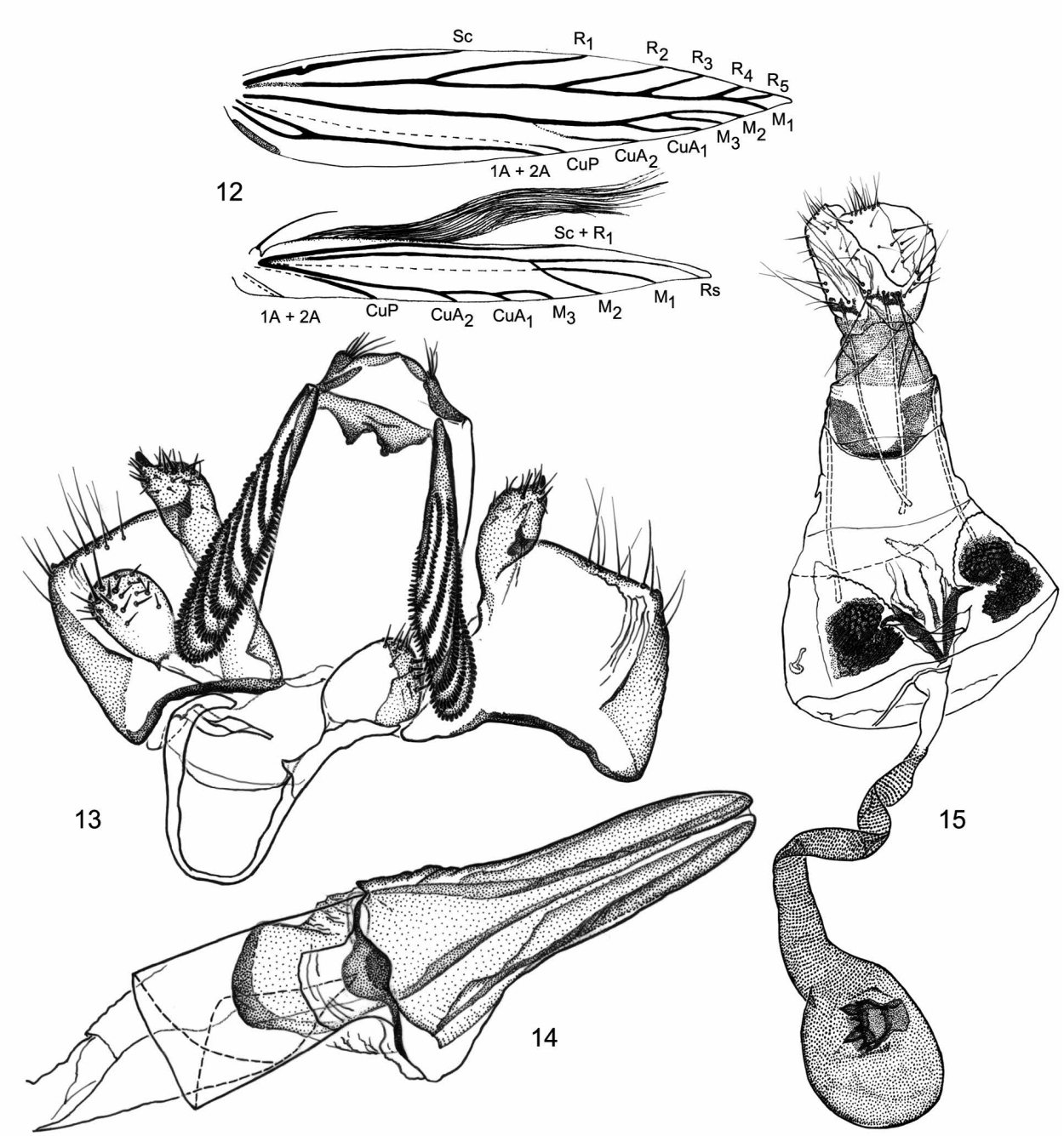
Clarke (1965) illustrated the forewing venation of *M. asaphaula* with five radial veins, but it has only four (Fig. 9).

Metharmostis multilineata Adamski, **new species**
(Figs. 11–41)

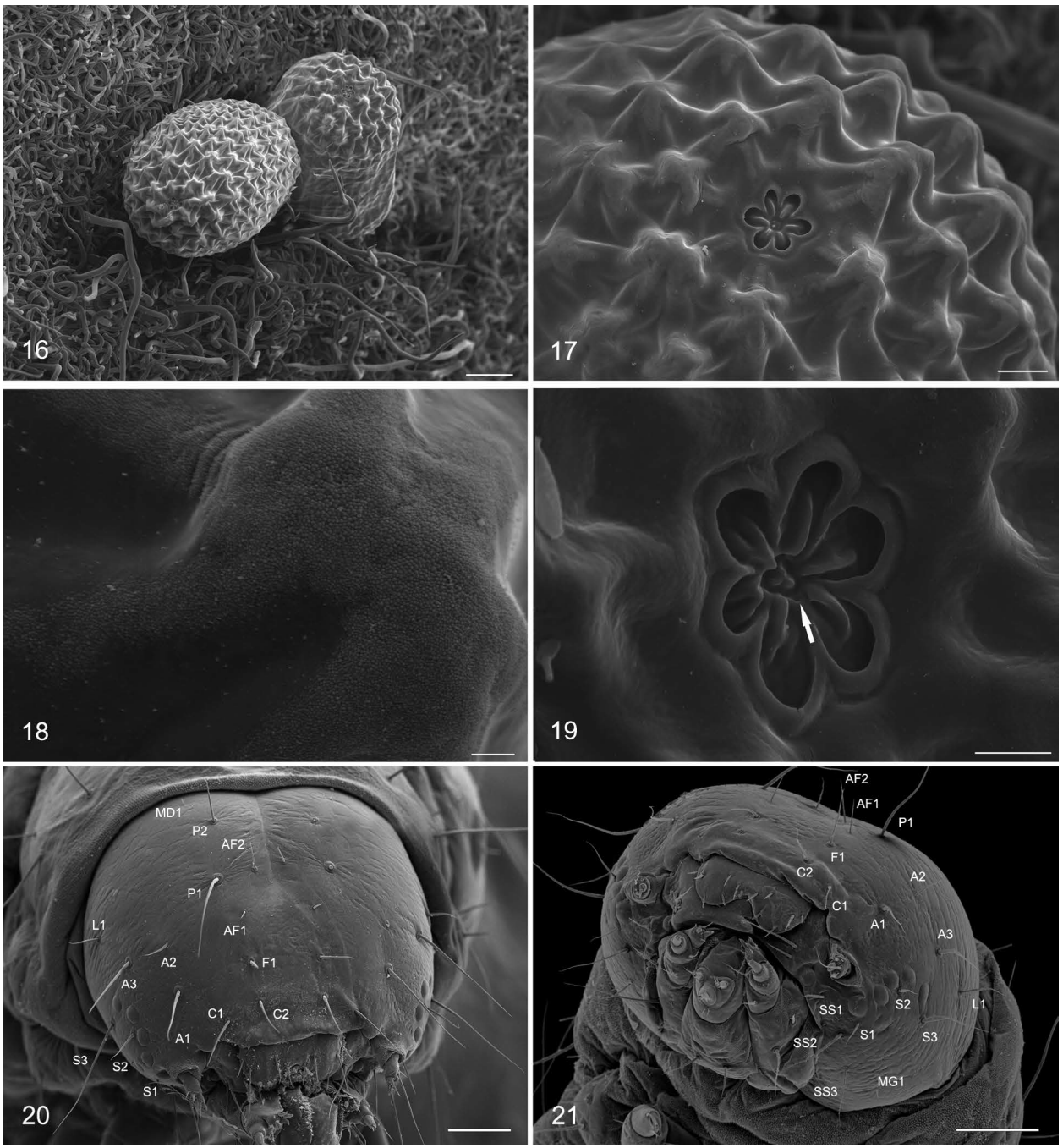
Diagnosis. *M. multilineata* is most similar to *M. asaphaula*: the two share a similar forewing pattern and a cluster of long hair-pencils from the base of the frenulum in the male. *M. multilineata* can be distinguished from *M. asaphaula* by the absence of a pterostigma between Rs and R_1 of the forewing, its wider eighth sternum, and its signum with one pair of smaller denticles on the same side.

Description. *Head*: Vertex and frontoclypeus with scales with transverse, irregular, and alternating bands of white and gray or pale gray. Labial palpus three segmented, curved in parallel with frontoclypeus, extending beyond vertex; basal segment very short, second segment slightly longer than terminal segment; second

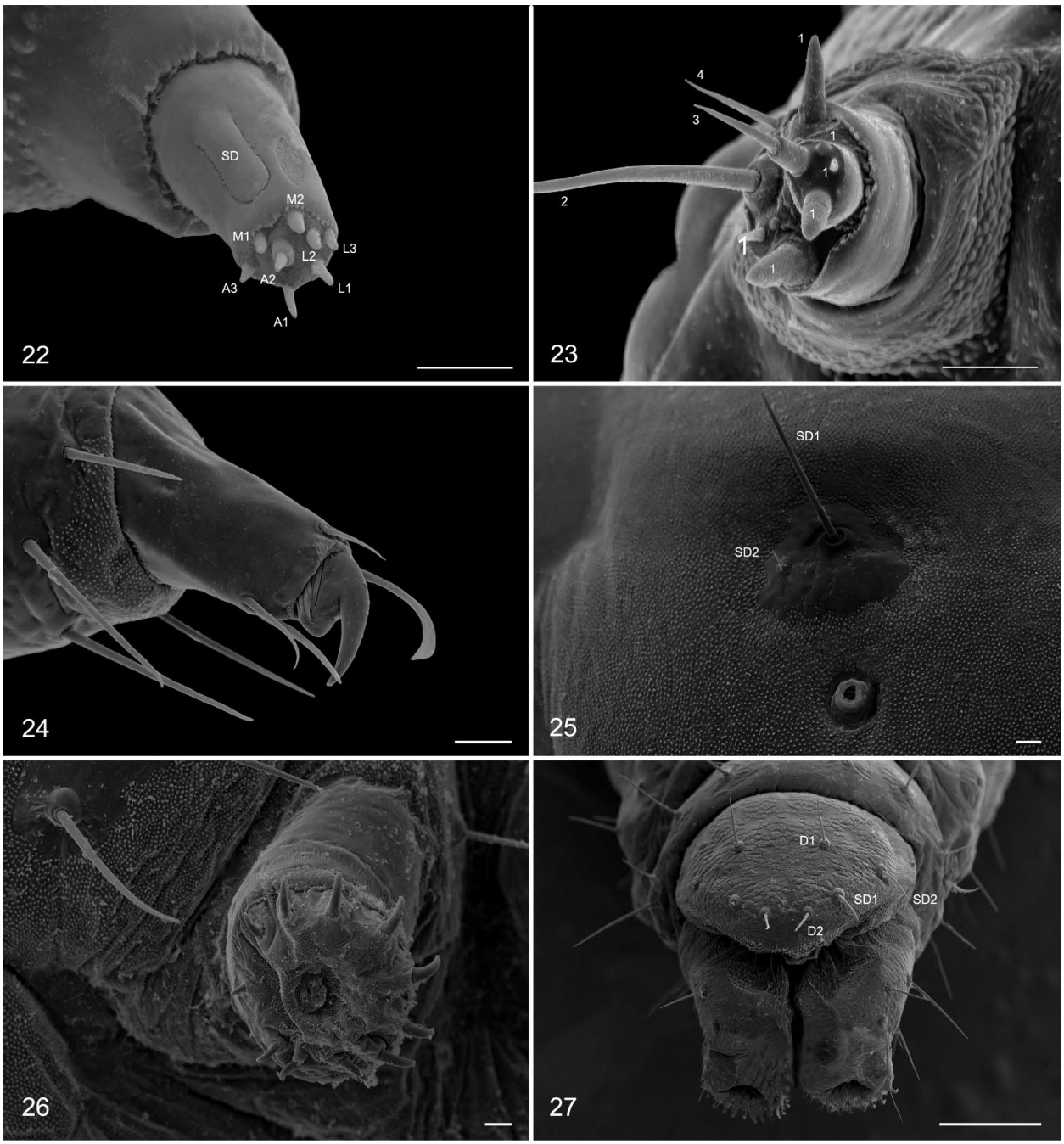
FIG. 11. Adult of *Metharmostis multilineata*, male, paratype, Hong Kong, China.



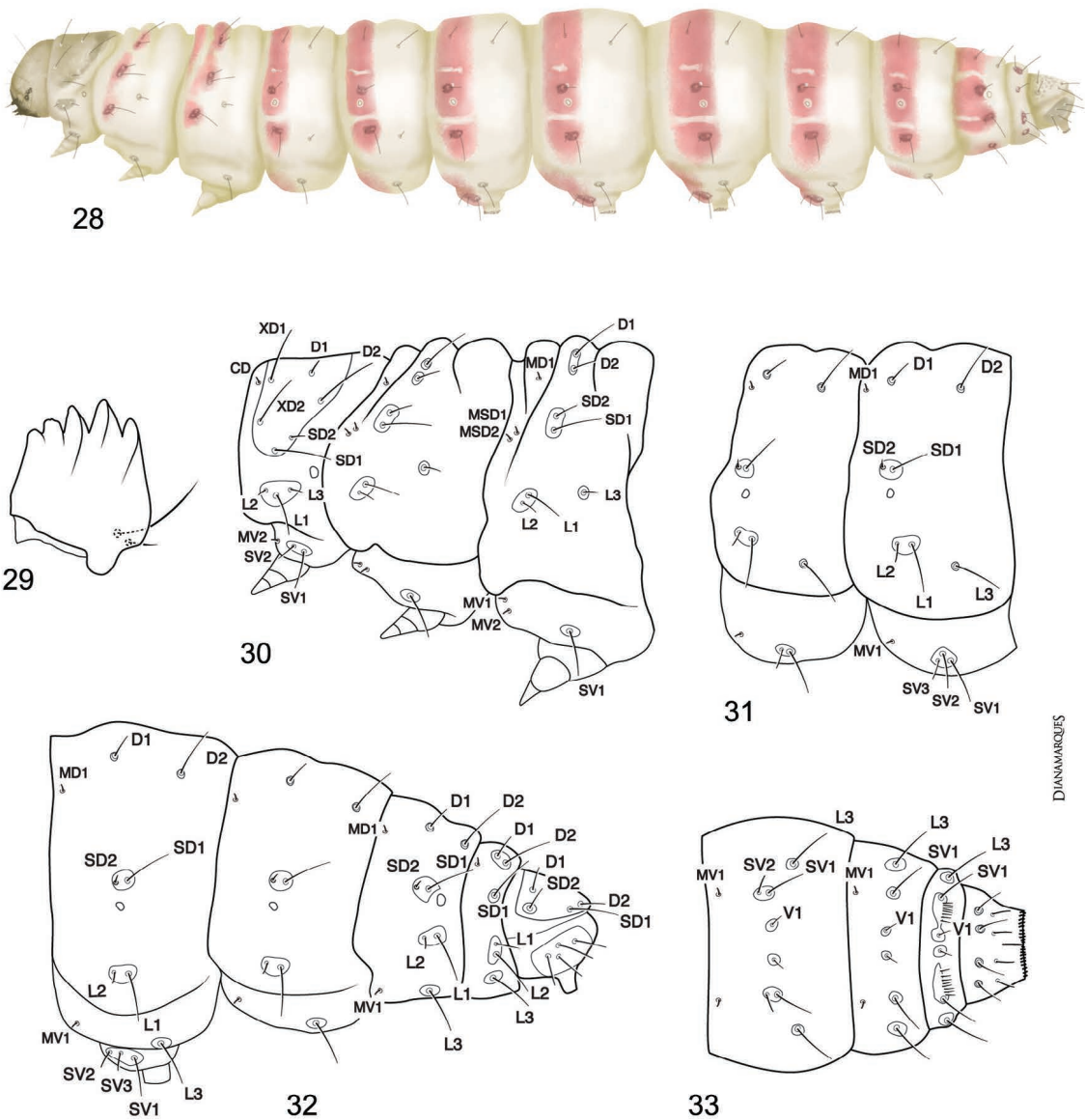
FIGS. 12–15. Wing venation, male genitalia, and female genitalia of *Metharmostis multilineata*.**12**, Forewing and hindwing, male voucher slide. **13**, Genital capsule, holotype, USNM slide 84156. **14**, Phallus, holotype, USNM slide 84156. **15**, Female genitalia, paratype, USNM slide 84163.



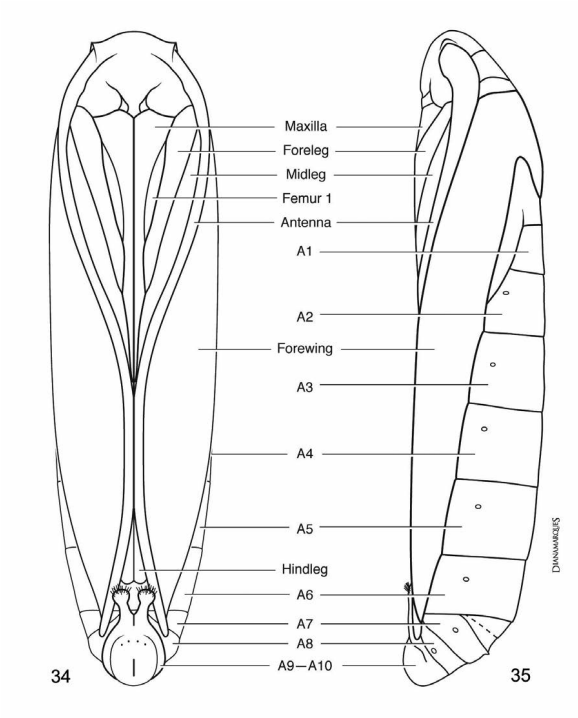
FIGS. 16–21. Scanning electron micrographs of egg and larval head capsule of *Metharmostis multilineata*. **16**, Two eggs on leaf of host. Scale = 100 µm. **17**, Apical end of egg showing micropylar rosette and chorionic relief radiating from rosette. Scale = 20 µm. **18**, Fine structure of chorionic relief. Scale = 2 µm. **19**, Micropylar rosette with arrow pointing to entrance to micropyle. Scale = 10 µm. **20**, Head capsule, frontal view. Scale = 100 µm. **21**, Head capsule, ventrolateral view. Scale = 100 µm.



FIGS. 22–27. Scanning electron micrographs of larval maxillary palpus and antenna, and thoracic and abdominal appendages and regions of *Metharmostis multilineata*. **22**, Left maxillary palpus and associated sensilla, frontoapical view; A2 = sensillum styloconicum, A1, A3, M1, M2, L1, L2, and L3 = sensilla digitiform. Scale = 10 µm. **23**, Right antenna and associated sensilla, apical view; 1 = sensilla basiconica, 2, = sensilla chaetica, 3 = sensillum styloconicum, 4 = sensillum trichodeum. Scale = 10 µm. **24**, Left mesotarsus, inner view. Scale = 10 µm. **25**, Spiracular area of A4, lateral view. Scale = 10 µm. **26**, Right proleg on A5. Scale = 10 µm. **27**, Anal plate on A10, caudal view. Scale = 100 µm.



FIGS. 28–33. Mandible and larval chaetotaxy of *Metharmostis multilineata*. **28**, Illustration of entire larva showing color pattern. **29**, Right mandible, inner surface. **30**, Thorax, lateral view. **31**, A1–A2, lateral view. **32**, A6–A10, lateral view. **33**, A7–A10, ventral view.



FIGS. 34–35. Pupa of *Metharmostis multilineata*. **34**, Ventral view. **35**, Lateral view.

segment elongate, alternating tufted, white narrow bands with wider, dark-gray bands ventrally, with a large, white apical tuft; terminal segment with alternating tufted, narrow white bands with wider, dark-gray bands. Antennal scape with basal and apical 1/4 gray or dark gray, middle 1/2 pale gray; pecten dark gray or dark gray tipped with white; flagellomeres basally gray or dark gray, apically pale gray or white. Proboscis white-scaled. *Thorax*: Tegula dark gray on basal 1/2, pale gray on apical 1/2. Mesonotum pale gray intermixed with few gray scales. Legs dark gray with narrow white bands along apical margins of all segments and tarsomeres. *Forewing* (Fig. 11) length 3.9–5.1 mm (n = 8); pale gray intermixed with gray scales, patterned with two rows of grayish-yellow streaks from base of cell to crossvein; streaks interrupted by narrow, pale gray or white scale tufts, partially demarcated by distinct or suffuse dark-gray streaks from above veins; basal region with a single grayish yellow streak; area posterior to CuP with two wide grayish-yellow patches; area from crossvein to apical margin gray intermixed with few pale-gray scales, marginal spots grayish yellow; venation (Fig. 12) with pterostigma absent between Sc and R_1; cell open; R_5-M_1 stalked; M_1 separate from a stalked M_2-M_3; cubitus 4-branched. Undersurface pale gray except, dark gray within distal 2/3 area of cell. Hindwing pale gray with gray fringe; male with an elongate, medially crooked, cluster of hair pencils originating from slightly beyond base of frenulum to 4/5, with a narrow dark-gray streak extending from base of Rs to 1/5, and a dark-gray margin to posterior margin; venation (Fig. 12) with Rs arched apically; M_1-M_2 stalked, separate from M_3; cubitus 3-branched. *Abdomen*: Male genitalia (Figs. 13–14) with uncus rudimentary, basally fused with short, apicolateral arms of tegumen, each arm bearing a small setal cluster near apical margin. Gnathos narrow laterally, widening towards a broadly rounded medial emargination, forming two angular teeth pointed ventroposteriorly; two decumbant, oblanceolate, and slightly asymmetrical processes originating from dorsolateral apices of tegumen, each process with deeply crenulate outer margins and deeply crenulate, curved struts within. Vinculum U-shaped, narrower than valval length. Juxta quadrate. Valva subquadrate, with basiventral margin extending to dorsal apex of vinculum, inwardly-curved outer margin, a stalked setose and bulbous structure near middle, and a stout digitate, setose process arising from basidorsal margin; process also bearing a short apical spine. Phallus free and not ankylosed, elongate, widened near 1/3, apical part parallel-sided throughout most of length, gradually narrowed apically; apical 2/3 divided along median longitudinal axis. *Female genitalia* (Fig. 15) with papillae anales setose throughout, longer setae on basal 1/3. Apophysis posterioris about equal in length to apophysis anterioris; eighth sternum wide, semicircular, apically fused with apophyses posteriores. Ostium within membrane between divided seventh sternum; divided parts broadly rounded and ridged along inner margin, slightly recessed medially, bearing a dense cluster of sex scales; two narrow flanges divergent from lateral walls of anterior part of antrum to inner margin of seventh sternum. Corpus bursae smooth from ostium to slightly beyond anterior margin near swollen base of ductus seminalis, denticulate anteriorly, including corpus bursae; signum rounded, spinulate, with two large subequal denticles along margin of one side.

Holotype ♂, "THAILAND: Nakhon Si Thammarat Province: Muang District: Tambol Pak Poon, Ban Pak Poon School; Coll. A. Winotai, 15.IV.2001; 08°31.28N, 99°58.56E; Reared from striped larva boring flower bud & fruit of *Rhodomyrtus tomentosa*", "♂ genitalia slide by D. Adamski, USNM 84156." [USNM]

Paratypes (2 ♂, 5 ♀): 1 ♀, Same label data as holotype except, "♀ genitalia slide by D. Adamski, USNM 84157": 1 ♂, 1 ♀, same label data as holotype except, "Ban Yang Tia, 31.V.2003, Ex. *Rhodomyrtus tomentosa*", "♂ genitalia slide by D. Adamski, USNM 84158": "♀ genitalia slide by D. Adamski, USNM 84159": 1 ♂, 1 ♀, Same label data as above except, "Trat Province: Klong Yai District: nr. Haad Sai Kaew; 3.IV.2001; 11°54.83N, 102°48.59E", "♂ genitalia slide by D. Adamski, USNM 84160", "♀ genitalia slide by D. Adamski, USNM 84161": 1 ♀, "CHINA: Hong Kong: New Territories, Ngau Liu, 20 July 2009; 22°21.255'N, 114°13.854'E; [Coll.] J. Makinson, ABCL 2009942.P001", "Adult reared from fruit of *Rhodomyrtus tomentosa*. Larva pupates on leaf vein", "♀ genitalia slide by D. Adamski, USNM 84162": 1 ♀, "ABCL Quarantine Colony, ex. [CHINA] HONG KONG, Nov. 2009, [Coll.] J. Makinson, ABCL Idiophantes from *Rhodomyrtus tomentosa*", "♀ genitalia slide by D. Adamski, USNM 84163." [USNM]

Etymology. The species epithet, *multilineata*, is a compound word formed from the Latin *multi* meaning many and *linea* meaning line, together referring to the many streaks on the forewing of the adult moth.

Early Stages. Egg (Figs. 16 – 19): About twice as long as wide, apically domelike (Fig. 16). Chorionic relief with longitudinal rows of stellate projections radiating from perimeter of micropylar rossette (Fig. 17), each connected by 5–6 struts; dorsal surfaces of raised projections and struts granulate, giving a velvety appearance to their dorsal surface (Fig. 18). Micropylar rossette on exposed end, with six petal-like depressions radiating from a small central circle; each depression with a longitudinal ridge extending from outer margin of central circle to 2/3; inner circle with 2–3 shallowly pointed projections; entrance to micropyles appear on proximal end of fused, adjacent, outer ridges of each pair of petal-like depressions (Fig. 19).

Larva (Figs. 20–33). Length 4.1–4.7 mm; body cylindrical, slightly dorsoventrally flattened from A7–A10 (n = 4 preserved larvae). Head capsule, prothoracic shield, thoracic legs, and anal shield pale brown or brownish yellow; pinacula small, brown. Body pale gray to white interrupted with transverse pale-red patches encompassing D-group, SD-group, and L-group pinacula on T2-T3 (Fig. 28); T3 with a narrow, transverse pale red stripe near dorsoanterior margin; A1-A8 with wide, transverse, pale-red stripes, interrupted by a small, linear, pale-gray patch of tonofibrillary platelets between D-group and SD-group pinacula, a circular, pale-gray spot encompassing the spiracle, areas above and below L-group pinaculum, and anteriorventral to L3 pinaculum and SV-group setae. Spiracles on T1 and A8 slightly above and slightly larger than those on A1-A7.

Head (Figs. 20–23, 29): Hypognathous; epicranial suture extending to epicranial notch, beyond apex of frons, dividing head

into two hemispheres (Figs. 20–21); adfrontal sclerites delimiting frons; frons wide basally, abruptly narrowed at 1/3 length from base, gradually narrowing to apex; AF2s slightly above or at same level of apex of frons; AF2 and AF1 about same length, slightly shorter than F1; distance between AF1 and AF2 about 3× distance between AF1 and F1; distance between F1 and AF1 about 3× distance between F1 and C2; C1 slightly longer than C2; P1 and A1 longest cranial setae; P1 about 4× length of P2, both below AF2, P2 slightly dorsal to P1; P2 in straight diagonal line with MD1, MD2, MD3 (not shown); L1 about ¼ length of and posteroventral to A3; A3 above and between stemmata 1–2; A1 about 1/3 longer than A2, in near straight line with C2, both perpendicular to median longitudinal axis; five stemmata (1–4 and 6) in a semicircle, stemmata 3–4 approximate; stemma 5 beneath antenna (Fig. 21); S3 beneath stemma 1, about 3× longer than S1 and S3; S3 on lower aspect of gena, and posterolateral of SS3; S2 slightly beneath and between stemmata 2–3; SS1 beneath antenna; SS2 between stemmata 5–6; SS3 posterior to and closer to midline than SS2; clypeus with six pairs of setae, two subequal pairs medially; two subequal pairs along proximolateral margin, and two pairs of equal length along margin lateral to notch; mandible with two large dentitions flanked by two smaller dentitions, and bearing two subequal setae dorsally (Fig. 29); sensilla of maxillary palpus (Fig. 22) sensilla of antenna (Fig. 23); posterior part of labium with two divergent setae slightly anterior to submental pit; spinneret cylindrical and elongate. Dorsal cervical seta ventroposterior to epicranial notch (Fig. 20, partially shown).

Thorax: (Figs. 24, 28, 30): T1 shield pale brown or brown along posterior and lateral margins; XD1 and XD2 equal in length, along anterior margin; SD1 slightly longer and slightly posterior to XD1 and XD2 (Fig. 30); SD2 about 1/5 length of and slightly dorsoposterior to SD1; D2 about equal in length to SD1, along posterior margin, equidistant to XD1 and XD2, forming a large triangle; D1 about equal in length to SD2, slightly anterior to D2 and close to median longitudinal axis; L-group trisetose, L1 about 5–6× longer than L2; L2 slightly shorter than L3; SV1 about 2× longer than SV2, both setae on same pinaculum; MV2 anterior to SV-pinaculum; coxae approximate, about 1/4–1/5 closer than on T2–T3 (not shown); V1s approximately about 1/4 closer than on T2-T3 (not shown); pretarsus with two setae above claw and two setae beneath claw, dorsal seta on outer surface flattened distally (Fig. 24). T2-T3 (Figs. 28, 30): D1 about 2–2 1/2× longer than D2, each on separate pinaculum on T2, same pinaculum on T3; MD1 anterioventral to SD1; SD1 about 2–2 1/2× longer than SD2, each on same pinaculum; SD-pinaculum ventroanterior to D2 pinaculum; MSD1 and MSD2 anterioventral to SD-pinaculum; L1 about 2–2 1/2× longer than L2, each on same pinaculum ventroanterior to SD-pinaculum; L3 same length as L2, slightly dorsal to, and posterior to L1-L2 pinaculum, and above and slightly posterior to SV1; MV1 and MV2 anterior to SV1.

Abdomen: A1–A2 (Figs. 25, 28, 31) with D2 ventral to and about 2–2 1/2× longer than D1; MD; MD1 on anterior margin ventral to D2; SD setae on same pinaculum dorsoanterior to spiracle (more so in A1); SD1 about equal in length to L1, SD2 minute (Fig. 25, 31–32, enlarged); L1 about 2–2 1/2× longer than L2, on same pinaculum; L3 about equal in length to L1, in line with or slightly anterior to D2; SV-group bisetose on A1, each seta on same pinaculum, with SV1 about 2–2 1/2× longer than SV1; SV-group trisetose on A2, in a triangular pattern on same pinaculum, SV1 about 2 1/2–3× longer than SV3 and slightly longer than SV2; MV1 along anterior margin in line with SV-pinaculum; V1s about equidistant apart to V1s on A8 (not shown); A3-A6 (Figs. 28, 32) as above except, SD1 dorsal and slightly posterior to spiracle, planta of prolegs bearing uniserial and uniordinal crochets in a lateral penellipse (Fig. 26); A7 as above except, SV-group bisetose, with SV1 about 2× length of SV2 (Figs. 28, 32–33); A8 as above except, spiracle on posterior half of segment, SD-group pinaculum dorsoanterior to spiracle, L1–L2 pinaculun ventroanterior to spiracle, and L3, SV1, and V1 in a straight line; V1s about 2× farther apart than V1s on A9; A9 (Figs. 28, 32–33) with D2 about 2× longer than D1, both on same pinaculum; SD1 about equal in length to D2; L2 about 2× longer than L1, each on same pinaculum; L3 about as long as L2; SV-pinaculum transversely elongate with SV1 on dorsolateral end and 6–8 hairlike setae on posterior margin (enlarged); some specimens with pinaculum bearing V1 fused with elongate SV-pinaculum (Figs. 28, 32–33); A10 with shield bearing four pairs of setae (Figs. 27-28, 32-33); SD1 slightly longer than SD2; SD2 slightly longer than D1 and D2; SD1 about 3X distance from SD2 than distance from D2; D2 and D1 in straight line parallel with median longitudinal axis; planta of prolegs with 10–11 uniserial and uniordinal crochets, crochets on each end about 1/2 length of middle crochets.

Pupa (Figs. 34–35): Length 3.4–3.7 mm (n = 6). Slightly flattened dorsoventrally; smooth; golden yellow, with thin brown lines demarcating sclerites; vertex rounded; frontoclypeus convergent, broadly rounded distally; antennae broadly rounded from vertex, encircling sclerites of maxillae, forelegs and midlegs, meeting medially near 2/3, extending in parallel, diverging distally beyond apices of forewings, exposing sclerites of hindlegs; maxillae and sclerites of midlegs extending to a common point with convergent antennae posterior to sclerites of midlegs; segments A7–10 movable from proximal end, decumbent; cremaster with two anteriorly-directed, slightly-divergent, spatulate processes, extending to near apices of hindlegs; each process with many hooked spinules on distal end.

Biology. Eggs of *Metharmostis multilineata* are typically laid singly or in small clutches at the junction of the basal part of the terminal twig and the lateral leaf-buds or at the junction of the midvein and lateral veins on the undersurface of the terminal or subterminal leaves (Figs. 36–37). Newly hatched larvae usually migrate to a flower bud (Fig. 38) or leaf bud (Fig. 39) and mine into it. The mature larva tunnels proximally out of the flower bud or leaf stalk, leaving a drooping terminal part (Fig. 40), and makes a silken cocoon on a new bud, a stem beneath the previously mined portion (Fig. 40), or on the undersurface of a nearby leaf parallel to the midvein or lateral veins or at the leaf's edge (Fig. 41). In the laboratory, development from oviposition to adult stage takes about 45–48 days; 3–6 days for the egg, 30 days for the larva, and 12 days for the pupa at 27°C. The total number of instars for larval development was not determined. Six generations were maintained in the laboratory from March 2011 to March 2012. Although larvae were found in stems and in old fruits of *Rhodomyrtus tomentosa* throughout the year, the number of generations could not be determined from field observations in Hong Kong and in Thailand. In quarantine, adults lived from 6–8 wks: one female lived 22 wks. Females have a preovipositional period of about 2 weeks or slightly longer.

Distribution. *Metharmostis multilineata* was collected in Thailand and Hong Kong, China. It probably occurs throughout the tropical Indo-Asian region.

Parasitoids. Eighteen specimens of *Apanteles* sp. and 20 specimens of *Cotesia* sp. (Braconidae) were reared from pupae of *Metharmostis multilineata* collected from Hong Kong.

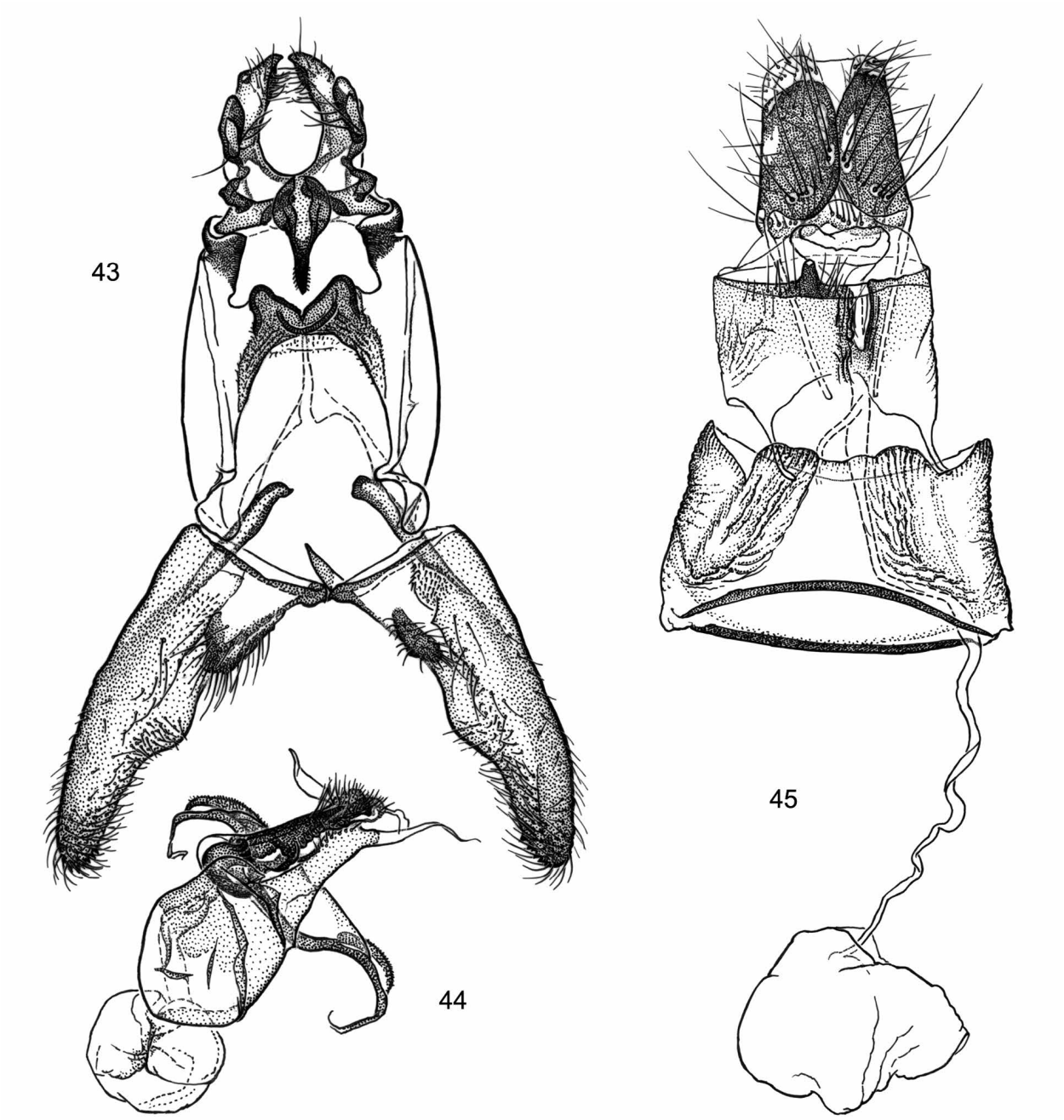
Idiophantis soreuta Meyrick, 1906
(Figs. 42–45)

Redescription. *Head*: Vertex and frontoclypeus pale grayish orange. Labial palpus sickle-shaped, long, extending beyond vertex; outer surface gray basally, gradually darkening to dark brown apically, inner surface pale grayish brown. Antennae with scape and pecten brown, flagellum grayish orange. Proboscis with pale grayish orange scales.

Thorax: Tegula and mesonotum grayish orange. Legs gray. *Forewing* (Fig. 42) length 5.0 mm (n = 2) grayish orange with area from base of costa to CuP apically to near crossvein of cell dark brown, continuing as a series of alternating pale grayish-orange and pale-gray strigulae to apex; subapical margin deeply and broadly excised, forming a posteriorly-curved, apical digitus and a larger, more broadly-rounded, apicoposterior margin; cell with a dark-brown

FIGS. 36–41. Oviposition sites, larval damage, and pupation sites of *Metharmostis multilineata*. **36**, Arrow indicating egg between small bud and base of petiole of lateral leaf. **37**, Arrows indicating eggs on undersurface of leaf at junction of midvein and lateral veins. **38**, Arrow pointing to frass indicating larva feeding within flower bud. **39**, Arrow pointing to frass indicating larva feeding within terminal part of stem. **40**, Larval feeding causing drooping of apical part of stem. Arrow pointing to cocoon. **41**, Pupa teased from cocoon on undersurface of leaf.

FIG. 42. Adult of *Idiophantis soreuta*, male, voucher specimen, Thailand.



FIGS. 43–45. Male genitalia and female genetalia of *Idiophantis soreuta*. **43**, Genital capsule, USNM slide 84164. **44**, Phallus with juxta attached, USNM slide 84164. **45**, Female genitalia, USNM slide 84165.

streak near middle, a minute dot near 2/3, and a larger, crescent-shaped marking demarking border of excised area. Undersurface yellow brown. Hindwing translucent pale gray, gradually darkening to apex.

Abdomen: *Male genitalia* (Figs. 43–44) with uncus widened basally, extending dorsally, with two crescent-shaped processes; base with a large, Y-shaped median process, connected apically from its arms by two lateral arms, each fused onto an apically excavated part of a dilated lateral process of tegumen. Gnathos emarginate medially, forming two dorsolaterally projecting angular processes juxtaposed laterad to a ventrally projecting base of median process of uncus. Tegumen near parallel-sided. Valva elongate, nearly 3× longer than basal width, gradually narrowing and more densely setose apically; dorsal articulations elongate, separate; ventral articulation fused; ventral margin with a swollen medial lobe; base with a darkly pigmented shallow, setose, lobe. Vinculum narrow medially, bifurcate laterally, fusing with juxta. Juxta elongate and setose apically, supporting phallus. Phallus bulbous basally, narrowed apically, with a lanceolate membranous projection on one apicolateral side. *Female genitalia* (Fig. 45) with papillae anales large, darkly-pigmented, setose lobes; longer setae on ventral margin; apophyses posteriores about 3× longer than apophysis anterioris; apophysis anterioris extending from a widened eighth sternum; eighth sternum widely emarginate anteriorly, deeply and narrowly notched mediolaterally on posterior end, juxtaposed to a median, posteriorly-pointed tooth-like projection. Ostium wide, within membrane posterior to eighth sternum. Ductus bursae long, about 4× longer than apophysis posterioris, narrowed from a widened, membranous antrum, narrowing gradually from region anterior to inception of ductus seminalis near posterior margin of seventh sternum. Seventh sternum divided medially, deeply wrinkled from inner margin to a broadened emargination on posterior end. Corpus bursae subspherical and membranous.

Type (examined). Lectotype ♂, [round label with a red circle in middle]; "[Sri Lanka] Ceylon, Puttalam, 12 [December] [19]04, Pole [Coll.]"; "Lectotype, *Idiophantis soreuta* Meyrick, [designated by] JFGC Clarke, 1948"; "♂ genitalia on slide 17.x.1948, JFGC 8391", "*Idiophantis soreuta* Meyr., 4/1 E. Meyrick det., in Meyrick Coll[ection]"; "Meyrick Coll[ection]", "*soreuta* Meyr." [handwritten label]; "Meyrick Coll[ection], BM 1938-290."

Other Specimens Examined (1 ♂, 1 ♀). "THAILAND: Trat Province: Klong Yai District; Mai Root Trat; 11°50.03'N, 102°50.51'E; A. Winotai [Coll.]; 18.VI.2001; ABCL 2001431; Reared from striped larva boring fruit of *Rhodomyrtus tomentosa*", "♂ genitalia slide by D. Adamski, USNM 84164", ♀ genitalia slide by D. Adamski, USNM 84165." [USNM]

Biology. *Idiophantis soreuta* Meyrick was reared from fruits of *Rhodomyrtus tomentosa* in Thailand. Other host records for *Idiophantis* were reported by Meyrick (1914, 1931), Gater (1926), and Bradley (1968). Meyrick (1931) reported that *Idiophantis acanthopa* Meyrick was reared from *Eugenia jambolana* Lam. (Myrtaceae) from India, and that *I. chirodota*, which occurs in India, Sri Lanka, Java, and Malaya, was reared from psyllid galls on *Eugenia* sp. (Meyrick 1914). Gater (1926) also reported *I. chirodota* from galls on *Durio zibethinu*s Murray (Malvaceae). Finally, Bradley (1968) reported that *I. eugeniae*, a closely allied species to *I. chirodota*, was reared from galls on leaves of *Eugenia* sp. on New Ireland in Papua New Guinea.

Distribution. *Idiophantis* inhabits principally the Indo-Australian region, but extends eastward to the Seychelles Islands, Madagascar, and South Africa.

Remarks. *Idiophantis soreuta* was previously misidentified as *Agriothera* sp. (Roeslerstamiidae) by Winotai et al. (2005). This species is similarly patterned with red stripes on the body as *Metharmostis multilineata*. Unfortunately, only two larvae were collected and reared to the adult stage, and no larval pelts are available for examination.

DISCUSSSION

A range of herbivores were found feeding on *R. tomentosa* in Hong Kong, but as with surveys in Thailand, *M. multilineata*, was the most common. Larvae had been collected from almost every field site surveyed. In 2009 *M. multilineata* was selected as the first candidate for evaluation at the IPRL Gainesville Quarantine Laboratory. Six generations of *M. multilineata* were successfully obtained during the quarantine trials. When a viable colony was established, host range-tests were initiated. Trials using an ornamental, *M. communis*, and two threatened species native to Florida, *C. pallens* and *M. fragrans*, exhibited positive rearing results; hence, all further plans to test *M. multilineata* as a biocontrol agent against *R. tomentosa* in Florida were aborted. *I. soreuta* was not found in suitable numbers in Asia and was never considered for quarantine rearing trials on *R. tomentosa*.

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THE BITING MIDGE, *FORCIPOMYIA (MICROHELEA) ERIOPHORA* (WILLISTON) (DIPTERA: CERATOPOGONIDAE), AN ECTOPARASITE OF LARVAL *PHOEBIS SENNAE* (PIERIDAE) IN SOUTH FLORIDA

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ABSTRACT. Cloudless sulphur larvae (*Phoebis sennae*, Pieridae) were observed in an experimental plantation and also in a natural setting being fed on by the ectoparasitic biting midge, *Forcipomyia* (*Microhelea*) *eriophora* (Williston) (Diptera: Ceratopogonidae). Larvae parasitized by midges died at higher rates in captivity, in contrast to normal levels of mortality in rearings of this species, providing circumstantial evidence for the potential role of these flies in disease transmission.

Additional key words: multi-trophic interactions, ectoparasitic biting midges, natural enemies, *Senna*, *Cassia*, *Chamaecrista*, Fabaceae

A caterpillar is a feeding machine, little more than a sclerotized head with chewing mouthparts, its body a soft-sided bag in which the organs are bathed in haemolymph. Such a body is delectable to predatory wasps, ants, and other predators, and the potential for biological control by these animals has been demonstrated in numerous studies (e.g., Cuautle & Rico-Gray 2003, Rico-Gray & Oliveira 2007, Stamp & Casey 1993). The attack of larval Lepidoptera by biting midges was first noted by De Geer (1752), and was reviewed extensively by Wirth (1956). Wirth (1972a) asked lepidopterists to "look out for these minute caterpillar pests during their field work", as he felt they were widespread, though available data suggested at the time they were extremely rare. Records of their distribution in North America are continuously being updated (Borkent & Grogan 2009, Grogan et al. 2010), but studies of their biology are few. Notable among these are descriptions of Ceratopogonidae attacking wings of butterfly adults (Lane 1977, 1984, Kawahara et al. 2006), libellulid dragonflies (Clastrier et al. 1994), and reduviid bugs (Clastrier & Delecolle 1997).

Phoebis sennae L. (Lepidoptera: Pieridae) occurs throughout North America, and is abundant in Florida, the West Indies (Smith et al. 1994) and south to Argentina (DeVries 1987). In Florida, this species utilizes both native and ornamental species of *Senna*, *Cassia*, and *Chamaecrista* (Fabaceae) as hostplants (Daniels 2003, Minno et al. 2005).

MATERIALS AND METHODS

During ongoing studies of *Phoebis* sulphurs on native *Bahama senna* (*Senna mexicana* var. *chapmannii* (Isely) H.S. Irwin & Barneby), we monitored individual plants in an experimental site on the grounds of the University of Florida's Tropical Research and Education Center in Homestead, FL. We recorded the occurrence of caterpillars on plants, and also collected them for rearing to obtain information on parasitization and disease (results reported elsewhere).

On 14 November 2003, 5th instar *P. sennae* larvae (n = 3) were encountered, each with several ectoparasitic flies attached to their cuticles (Fig. 1). The parasitic flies were collected for determination, and the caterpillars for rearing. On the same date, additional late instar *P. sennae* larvae (n = 5) observed on the same plants as the parasitized individuals were collected and reared to note any deleterious influence possibly resulting from parasitism. Three of the collected biting flies were slide-mounted in Canada balsam and deposited in the Florida State Collection of Arthropods, Gainesville, FL as vouchers.

RESULTS AND DISCUSSION

Three engorged midges were slide-mounted and determined to be *Forcipomyia* (*Microhelea*) *eriophora* (Williston) (Diptera: Ceratopogonidae), a moderately common, primarily Neotropical ectoparasitic biting

midge known to attack caterpillars (Wirth 1972b). This observation represents the first known report of *F.* (*M.*) *eriophora* parasitism on *P. sennae*. Similar interactions were also documented in Everglades National Park (Fig. 2). This ectoparasitic biting midge was recently discovered while feeding on a larva of the rare Florida leafwing butterfly, *Anaea troglodyta floridalis* F. Johnson and Comstock (Nymphalidae) (Salvato et al. 2012). The species is also known to feed on larvae of *Melanchroia geometroides* Walker, on Cuba (Baker 1907); the Tobacco hornworm, *Manduca sexta*, (Sphingidae) in Puerto Rico (Wolcott 1951); and more recently on a larva of the swallowtail butterfly, *Papilio demoleus*, on Puerto Rico (Grogan pers. obs.). *Forcipomyia eriophora* has been previously recorded in Collier, Dade, Jackson and Monroe counties in the state of Florida (Wilkening et al. 1985). However, it is not nearly as common or widespread as its relative, *F.* (*M.*) *fuliginosa* (Meigen), which occurs throughout New and Old World tropical and temperate regions (Borkent & Grogan 2009).

Each of the three *P. sennae* larvae parasitized by *F.* (*M.*) *eriophora* died prior to pupation. Two caterpillars died within two weeks of their collection, turning black and white, becoming covered with fuzzy mold; the third caterpillar transformed into a malformed prepupa, turning colors (black, pink, and white), and died. Of the five non-parasitized *P. sennae* larvae also collected on 14 November 2003, three pupated and eclosed as adult butterflies, and the other two pupated but did not eclose (one chrysalis became black from a suspected virus). Average rates of death from viruses or other pathogenic organisms, for all caterpillars reared in the larger study (collected for rearing from the 3rd instar onward), were 13% over all treatment groups, approximately equal to the average rates of parasitoid attack (13%); on average, around 60% of all caterpillars (collected in the third or later instar) survived to adulthood.

The remains of the dead caterpillars and pupae were examined by Dr. Leellen Solter (Illinois Natural History Survey) for evidence of visible viruses or microsporidia. She found a variety of bacteria (both pathogenic and saprophytic) and fungi; some of which may have been organisms that grew postmortem, as the specimens were left in tubes at room temperature for various periods after dying. No one common pathogenic agent could be identified from these specimens. Recently, spiroplasmas have been determined to be present in the bodies of ceratopogonid biting midges (Frana et al. 2001, Koerber et al. 2005). Some spiroplasma isolates are known pathogens to their insect hosts, including Lepidoptera (Herren et al. 2007), where they can affect larval growth rate, adult size, and survival (Dowell et al. 1981, Klein & Purcell 1987), and population sex-ratio (Jiggins et al. 2000).

Our observational data also suggest that these ectoparasitic biting midges may transmit disease causing micro-organisms as all three parasitized *P. sennae* larvae failed to develop to the adult stage. Although our sample size was small, we had expected mortality similar to the 40% recorded throughout our long-term studies of *P. sennae*. In addition, the feeding activity of biting midges on Lepidoptera is not always fatal. Salvato et al. (2012) reared late instar *A. t. floridalis* larvae (n = 2) to the adult stage following instances of *Forcipomyia* parasitism, and similar instances of sub-lethal *Forcipomyia* ectoparasitism on Lepidoptera larvae have been noted by Sevastopulo (1973) and Young (1983).

The parasitized *P. sennae* in our studies were not "sucked dry" as Baker (1907) described for the larvae of *M. geometroides* that he observed in Cuba; they continued to feed throughout their development. Mayer

Fig. 1. Fifth instar caterpillar of *Phoebis sennae* studded with numerous *Forcipomyia eriophora* biting midges on *Senna bahamensis* var. *chapmannii* hostplant in Homestead, Florida.

Fig. 2. Caterpillar of *Phoebis sennae* with the same species of midge in Everglades National Park. Photo by John H. Geiger.

(1955) later suggested that the empty, black, hanging skins of the *M. geometroides* described by Baker were caused by virus or other disease, and that the feeding habits of the biting midges enabled them to transmit disease to their hosts. Definitive experiments demonstrating transmission of caterpillar disease via bloodsucking flies remain to be performed. Such experiments could take caterpillars known to be infected with virus, microsporidia, or spiroplasmas; allow them to be fed upon by the flies, which in turn are allowed to feed on other pristine caterpillars; and if those uninfected caterpillars contract disease, the transmission will be demonstrated (a variation on Koch's postulates).

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HYPERCHIRIA INCISA INCISA (LEPIDOPTERA: SATURNIIDAE) ON PLANTS OF *CLITORIA FAIRCHILDIANA* IN VIÇOSA, MINAS GERAIS STATE, BRAZIL

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ABSTRACT. *Clitoria fairchildiana* Howard (Fabaceae) is a rustic and rapidly growing species with a broad leafy crown. This species naturally occurs in secondary forest of the Amazon region. In Brazil, this plant is also used in landscaping of streets, squares, roads and parking lots. This study identified a lepidopteran defoliator of *C. fairchildiana* at the Federal University of Viçosa in Viçosa, Minas Gerais State, Brazil. This species was identified as *Hyperchiria incisa incisa* Walker, 1855 (Lepidoptera: Saturniidae: Hemileucinae). Larvae of this insect are yellowish-brown at early instars and pale green in the last ones with its body almost completely covered with stinging spines at all stages. *Hyperchiria incisa incisa* should be included in pest monitoring programs of *C. fairchildiana*.

Additional key words: caterpillar, herbivory, pest management, urban afforestation

Clitoria fairchildiana Howard (Fabaceae) is a fast-growing tropical tree that naturally grows in secondary forests in the Amazon region. This plant has a large canopy, so it is also considered an important species for urban shading in several regions in Brazil. The present study identified an important Lepidoptera defoliator of *C. fairchildiana* in Viçosa, Minas Gerais State, Brazil.

Approximately three hundred larvae of an insect were found under leaves of *C. fairchildiana* from December 2010 to April 2011 by the campus of the Federal University of Brazil (UFV) (20° 45'S, 42° 52'W and 648 m above sea level). Leaves with early instar larvae were detached from the plant, placed in plastic containers and brought to the Laboratory of Biological Control of Insects in the Institute of Biotechnology Applied to Agriculture (BIOAGRO) where they were maintained at 25 ± 2°C, 70 ± 5% RH and 12 h photophase in screened wooden cages (30 × 30 × 30 cm). Branches containing leaves of *C. fairchildiana* were changed daily to feed larva until the adult stage.

Adults were sent and deposited in the Department of Zoology (UFPR) and identified by comparison with material deposited in the collection as *Hyperchiria incisa incisa* Walker, 1855 (Lepidoptera: Saturniidae, Fig. 1a) by Dr. Olaf Hermann Hendrik Mielke, and this is the first report of this species feeding on *C. fairchildiana* in Brazil.

Females of *H. incisa incisa* lay eggs in double, parallel rows on the adaxial surface of the *C. fairchildiana* leaves (Fig. 1b). Eggs are white with a

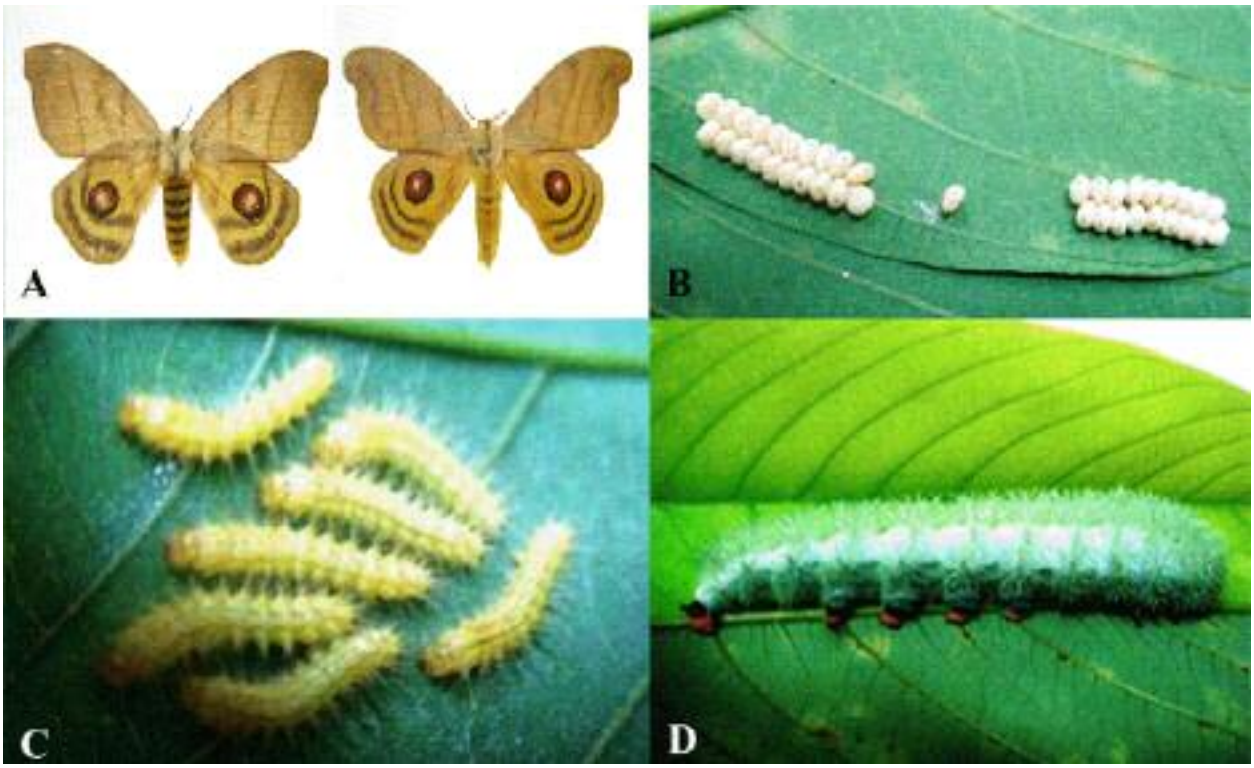

FIG. 1. Female and male (**A**), egg masses (**B**) and caterpillars of first (**C**) and last (**D**) instars of *Hyperchiria incisa* (Lepidoptera: Saturniidae).

sub-conical shape and flat sides. First instars are yellowish-brown with about 5 mm long (Fig. 1c) becoming pale green after few days (Fig. 1d). Caterpillars are gregarious at all stages and usually walk in lines on the leaves, as observed for larvae of *Hyperchiria pamina* Neumoegen, 1882 (Lepidoptera: Saturniidae) (Kunzé, 1900), *Dirphia avicula* Draudt, 1930 and *Dirphia moderata* Bouvier, 1819 (Lepidoptera: Saturniidae) (Pereira et al. 2008), *Euselasia eucerus* (misidentified as *Euselasia apisaon* Dalman 1823) (Lepidoptera: Riodinidae: Euselasiinae) (Zanuncio et al. 2009, Nishida 2010), *Euselasia chrysippe* H. Bates 1866 (Lepidoptera: Riodinidae) (Allen 2010), *Hylesia lineata* Fabricius, 1775 (Fitzgerald & Pescador-Rubio 2002) and *Hylesia paulex* Dognin, 1822 (Lepidoptera: Saturniidae) (Pereira et al. 2009). When fully developed, caterpillars of *H. incisa incisa* form a cocoon on the leaves or in the soil layer at the bottom of the cage and metamorphose into pupae.

Spine-like bristles (Figure 1c–1d) cover almost the entire body of *H. incisa incisa* larvae and they are important for protection against natural enemies (Cambridge 1882). They can also produce substances responsible for dermatitis, what can limit the use of *C. fairchildiana* in urban areas. In a personal experience, one of the authors (JCZ) had the misfortune of touching a caterpillar of this species, which left his skin red, swollen and burning. The irritation persisted for a few days.

Although the abundance of *H. incisa incisa* on trees of *C. fairchildiana* in a native planting at the Federal University of Viçosa was high, its impact on this tree species is unknown. Many trees were infested and younger ones were totally defoliated over the course of a few weeks. The high number of *H. incisa incisa* larvae on *C. fairchildiana* plants may be related to the polyphagous feeding habit of the caterpillar. It is known to feed on native species as *Ateleia glazioviana*, *Bauhinia forticata, Caesalpinia peltophoroides, Cassia fistula, Cassia grandis, Cassia javanica, Centrolobium tomentosum, Copaifera sp., Erythrina crest, Laburnum sp., Machaerium opacum, Myroxylon baisamum, Wisteria* sp. (Fabaceae), *Clethra scabra* (Cletraceae), *Fagus sylvatica, Quercus coccifera, Quercus ilex* (Fagaceae), *Ficus* sp. (Moraceae), *Lafoensia glyptocarpa* (Lythraceae), *Maytenus ilicifolia* (Celastraceae), *Nectandra lanceolata* (Lauraceae), *Plantanus acerifolia, Plantanus orientalis, Plantanus* sp. (Platanaceae), *Sapindus divaricatus, Serjania laruotteana* (Sapindaceae) and *Trema micranta* (Cannabaceae) (Mabilde 1896, Biezanko et al. 1978, Biezanko 1986, Corseuil et al. 2002, Nunes et al. 2003).

The migration of insects of the native fauna to exotic plants as found for *H. incisa incisa* on *C. fairchildiana* is common in tropical crops such as cocoa (*Theobroma cacao*), sugarcane (*Saccharum officinarum*) and eucalyptus (*Eucalyptus* spp.) (Strong 1974, Oliveira et al. 2005). *Hyperchiria incisa incisa* have been reported on eucalyptus plantations (Zanuncio et al. 1993, Pereira et al. 2001) and its damage on *C. fairchildiana* indicate that it should be included in monitoring programs of pests of this plant. This species can reach high populations with significant damage to trees in urban areas and its larvae may represent a minor threat to human health.

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SEASONAL CHANGE IN NECTAR PREFERENCE FOR A MEDITERRANEAN BUTTERFLY COMMUNITY

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ABSTRACT. A decline in butterfly diversity and abundance has been observed all over Europe, even for rather widespread species. The reasons for this trend are not clear, with one of the possible mechanisms being a decrease in available nectar sources. In the scope of these observations, the nectar sources used by a Mediterranean butterfly community have been analyzed. Clear differences between specialist and generalist species could be observed. However the specialization rate was not stable throughout the year, both considering the butterfly community as a whole and for individual species. When analyzing the temporal variability in nectar use between the seasons, an increasing specialization in nectar use was observed in autumn. While a seasonal trend could be attributed to a change in butterfly species composition, the trend towards more specialization from summer to autumn was related to a change in relative abundance of flowering plants relative to the richness of butterfly species and abundance present. Significantly fewer flowering plants were present in degraded Mediterranean systems during autumn.

Additional key words: Mediterranean, butterfly community, seasonality, flower use, nectar plants

European butterfly species have showed a strong decline over the last several years, with 12% of the species considered threatened and 31 % appearing vulnerable (Van Swaay et al. 2004, Van Swaay & Warren 2006). This problem is not restricted to rare species. Rather, recent evidence suggests that common European species are experiencing a decrease in abundance and distribution (Van Dyck et al. 2009). This does not seem to be a local West-European trend, with similar tendencies observed in NE Spain (Stefanescu et al. 2011) and northern California (Forister et al. 2010). The reasons for this strong decline are not clear but probably have to do with the complex ecology of different butterfly species, making them more sensitive to the current global change (e.g. land-use change, modification in landscape structure, and climate change) (Forister et al. 2010, Munguira et al. 1997, Stefanescu et al. 2011). The reasons for butterfly decline seem to be human induced, as indicated by Konvicka et al. (2006), who found a clear correlation between socio-economic factors and butterfly decline in Europe. Van Swaay and Warren (2006) identified agricultural intensification as the major threat for butterfly conservation in Europe. Similar results were obtained by Stefanescu et al. (2004) and Forister et al. (2010) for Mediterranean regions, where presence of intensive agriculture negatively influenced butterfly species richness.

Previous studies of species decline have emphasized the abundance of host plants, while most other parts of the butterfly ecology were marginally taken into account. More recently, other aspects of the butterfly ecology were investigated such as morphology of host plants, microhabitat, presence of ant communities, habitat structure and fragmentation (e.g. van Swaay et al. 2012). The availability of nectar sources is a factor often neglected in conservation plans, but could play an important role in butterfly conservation (Erhardt & Mevi-Schütz, 2009). It is known that nectar is the main energy source for a large variety of butterfly species, influencing their abundance, fitness and reproductive success (Porter et al. 1992, O'Brien et al. 2004, Ouin et al. 2004, Mevi-Schütz & Erhardt 2005). When nectar sources are limited or lacking during a certain time of the year, adverse effects on the reproductive success of butterfly individuals could be expected. This was already hypothesized to be one of the key factors to explain butterfly decline by Van Dyck et al. (2009). In addition, Ebeling (2008) observed that a reduction in flower diversity caused a decline in pollinator diversity. These studies obviously cannot be extrapolated to the Mediterranean region, but they do indicate the importance of nectar sources on the abundance and distribution of butterflies and other insects, as has been indicated for other regions (Schultz & Dlugosch 1999, Biesmeijer et al. 2006).

Butterfly sensitivity to nectar availability also depends on the level of specialization towards certain plant species. In the past it was generally assumed that butterflies were generalists, nectaring from a wide range of plant species (Shreeve 1992). In recent papers, it has been made clear that a large part of the butterfly

communities could be considered specialists nectar feeders (Tudor et al. 2004, Hardy et al. 2007, Stefanescu & Traveset 2009). Furthermore, it was observed that butterfly species of conservation interest were those with the highest degree of specialization on nectar sources and that this specialization is linked to a specialization in host plant as well (Tudor et al. 2004). Due to differences in adult butterfly morphology, different plant species are more suitable for them than others and therefore at least some of the butterfly species are specialized on certain plant species (Corbet 2000, Hardy et al. 2007, Stefanescu et al. 2011). In the scope of conservation, it could be vital to know the nectar plants of the different species considered. This aspect of conservation has already been proved useful by Baz (2002) who observed that the threatened Apollo butterfly only used a limited amount of the nectar plants present in central Spain.

Because the availability of nectar sources could be an important factor in explaining the decreasing trends in butterfly distribution and density, it seems interesting to study the nectar use of butterfly communities in a Mediterranean environment in greater detail. The Mediterranean region is characterized by extremely variable climatic and environmental conditions throughout the year, causing a high inter-annual variability in the presence of flowering plant species. Therefore, we were interested to know how butterfly species cope with this temporal variability in available nectar sources. This study is a first attempt to assess and characterize the temporal trends in flower visits by butterflies in a Mediterranean environment. We studied: 1) The presence of generalist and specialist butterfly species of a Mediterranean butterfly community, 2) The differences in flower use specialization over time at a community and species level, 3) The factors influencing these changes.

Material and Methods

Study area. The study area, "Los Cerros de Alcala", is a protected area located at 40º28'N, 3º20'W at an altitude of 650–700m, just outside the city of Acalá de Henares, province of Madrid, Spain. It is a hilly area, characterized by a high variety in vegetation types, forming a mosaic of different habitats. Due to the large heterogeneity between vegetation types, the area represents parts of the typical central peninsular landscape. The vegetation types present in the area are all shaped by human influence. This has resulted in a low abundance of woody vegetation, except for some *Pinus halepensis* plantations. The climax vegetation of the area would be a closed *Quercus ilex* forest, with presence of *Q. faginea*. No climax vegetation is present anymore, but a garrigue vegetation with a relative high cover of *Q. ilex* and *Q. coccifera* can be found in part of the study area. A vegetation of large graminoids, mainly *Stipa tenacissima*, dominates large parts of the hilly areas where this species was cultivated in the past. Due to sheep grazing, the flatter areas in the region are covered by a pasture like vegetation with a high abundance of *Retama sphaerocarpa*. The valleys, road verges and agricultural field margins are characterized by more disturbed, nitrofile vegetation. All of these vegetation types are a representation of different degraded series from the natural vegetation. Therefore, it is not surprising that part of the native plant species became locally extinct. Recently some efforts were undertaken to re-introduce some of these plant species, which is the case for *Rosmarinus officinalis*.

Data collection. Field surveys were conducted during the year 2009 between March and October with an average two week time interval. A total of 16 field surveys were conducted, covering the major part of the flight period for the present butterfly community. A fixed route of 3.5 km was sampled during the morning and midday (between ±10am and 3pm). The field survey was only conducted under favourable flight conditions for butterflies, with a cloud cover <50%. Therefore some variation is present in the 2 week time span between visits. In midsummer no visit was conducted during the month of August because abundance of flowering plants was extremely low. When butterflies were seen nectaring during the field survey, the number of individuals, the butterfly species, and nectar source used were recorded. A visual check to determine if the individual was truly nectaring was performed to avoid confusion with individuals that were resting on top of flowers.

Analysis. The specialization of the different butterfly species was analyzed by relating species richness to the amount of nectar sources used, excluding species that were observed only once. This approach was first proposed by Gleason (1922) and has been used for similar analysis by Tudor et al. (2004). This relationship typically shows a logarithmic trend, where a deviation from the trend (large residuals) indicates a specialization or generalization in the use of the different nectar sources. Species with residuals $>|4|$ were considered deviating from the trend and thus specialist or generalist species.

To identify temporal differences in nectar use by the butterfly community, the data was split up in three seasonal groups, spring (March–beginning of May) the hibernating and early first generation of spring species, summer (May–June) the moment of maximum species presence and autumn (July–October) with the

migratory and multi-generation species present. The Lorenz curve (Gastwirth 1972) was drawn for each of these temporal groups by plotting the cumulative amount of butterfly species (%) observed on each plant species over the cumulative percentage of plant species considered, starting with the plant species where the lowest number of butterfly species has been observed. The same was done for the number of butterfly individuals on each plant species. If a straight line from 0 to 100% would occur, every plant species would have the same percentage of butterfly species visiting it (or number of butterflies for the second case). When some plant species are used by more butterfly species and individuals than others, the result is an upwards curve towards 100%. By drawing such a plot for each season we can identify the temporal differences in flower specialization by the butterfly community studied. However, multiple factors could influence these differences over time. The factors considered in this study are: 1) change in butterfly species composition over time, 2) change in butterfly number over time, 3) change in plant species diversity over time, 4) change in relative abundance of butterfly species/individuals over plant species.

The observed trends will be affected by changes in butterfly species composition over the year. To exclude species composition as an explicatory factor we tested whether we could detect a similar trend towards specialization over the year for individual species. Many indexes that indicate changes in population composition exist. Here we use the Shannon's Equitability Index:

$$E = (-\sum_{i=1}^{S} p_i \ln p_i) / \ln S$$

Where E is the Equitability with values between 0 and 1 with 1 indicating complete evenness, S is the total number of species in the community and p_i is the proportion of the ith species in the population.

This index is an adaptation of the Shannon's Diversity index which is widely used to calculate species diversity (Magurran 1988). However the Shannon's Diversity index is influenced by abundance and evenness of the community. Therefore we used the Equitability index which is just sensitive to changes in evenness of the community. Using the Equitability index, changes in the homogeneity of the nectar sources used can be indicated. The Shannon's Equitability Index for the used nectar sources was calculated for individual butterfly species over the different seasons. Only the butterfly species with the highest number of individuals (>30) and present in more than one season were analyzed. The changes observed in the Equitability index over time indicate a change in the homogeneity/heterogeneity of the nectar sources used over the seasons. If the homogeneity index stays stable between seasons, no temporal variation takes place.

To study the effect of the other factors on the temporal trend in specialization observed we calculated the flower specialization over time with the Shannon's Equitability Index. The index was calculated using the variation in number of butterflies on the different plant species at a daily basis, considering each field visit as a sample. The Pearson correlation analysis was used to relate the Equitability index with the Julian day, the number of butterfly species present, the number of butterfly individuals present, the number of plans species present, the relative abundance of butterfly species over plant species and the relative abundance of butterfly individuals over plant species to study the factors influencing the variation in nectaring specialization over time

RESULTS

A total of 1022 butterfly individuals comprising 39 species were observed nectaring on a total of 57 flowering plant species during this field survey (tables 1, 2). The most common species seen nectaring was *Syrichtus proto*, the most common skipper present in the area. Other species that were seen nectaring frequently are "shade" species (genus *Pyronia*), migratory species (genus *Cynthia*, *Lampides* and *Leptotes*) and the common blues and copper of the area. These represent most of the species present in the area, although some characteristic species which are common in spring, such as *Pseudophilotes panoptes* and *Issoria lathonia*, were not seen nectaring or only few times.

The number of butterfly individuals seen nectaring oscillated between only a few individuals to over more than 200 a day, with a clear peak in May–June and another one in October (Fig 1). The number of species observed changed as well, with relative low numbers in early spring and the same high peak in spring-summer and a lower one in autumn, a similar trend as observed with the number of butterfly individuals.

As expected, a clear differentiation between specialist and generalist butterfly species was found (fig. 2 —for the species codes see table 1). The species are clearly divided in two groups, with some species using a considerable higher variety of nectar sources than others. The species deviating from the tendency are listed in table 3. The species considered "generalists" are all very common species in the area, having multiple generations or a long flight period. The "specialist" species can be divided in two groups. Some are species

TABLE 1. Butterfly Species Seen Nectaring During the Field Survey. Species are arranged in order of declining observed abundance. The species code is also provided.

Species	Number observed	code
Syrichtus proto (Esper, 1808)	141	sypr
Pyronia bathseba (Fabricius, 1793	117	pyba
Lycaena phlaeas (Linnaeus, 1761)	113	lyph
Aricia cramera Eschscholtz, 1821	94	arcr
Lasiommata megera (Linnaeus, 1767)	74	lame
Pyronia cecilia (Vallantin, 1894)	68	pyce
Polyommatus bellargus (Rottemburg, 1775)	52	pobe
Cynthia cardui (Linnaeus, 1758)	46	cyca
Pontia daplidice (Linnaeus, 1758)	44	poda
Colias crocea (Geoffroy, 1785)	38	cocr
Polyommatus icarus (Rottemburg, 1775)	34	poic
Euchloe crameri Butler, 1879	31	eucr
Pieris rapae (Linnaeus, 1758)	28	pira
Lampides boeticus (Linnaeus, 1767)	23	
Leptotes pirithous (Linnaeus, 1767)	18	
Satyrium esculi (Hübner, 1806)	16	saes
Satyrium spini (Denis & Schiffermüller, 1775)	13	
Polyommatus thersites (Cantener, 1834)	10	
Hyponephele lupina (Costa, 1836)	9	
Tomares ballus (Fabricius, 1787)	6	
Plebejus hespericus (Rambur, 1839)	6	
Zerynthia rumina (Linnaeus, 1758)	5	
Carcharodus baeticus (Rambur, 1840)	4	
Melitaea phoebe (Denis & Schiffermüller, 1775)	4	
Papilio machaon Linnaeus, 1758	4	
Melanargia lachesis (Hüner, 1790)	4	
Argynnis pandora (Denis & Schiffermüller, 1775)	3	
Issoria lathonia (Linnaeus, 1758)	3	
Vanessa atalanta (Linnaeus, 1758)	2	
Glaucopsyche alexis (Poda, 1761)	2	
Thymelicus sylvestris (Poda, 1761)	2	
Celastrina argiolus (Linnaeus, 1758)	1	
Callophrys rubi (Linnaeus, 1758)	1	
Pieris brassicae (Linnaeus, 1758)	1	
Nymphalis polychloros (Linnaeus, 1758)	1	
Pieris napi (Linnaeus, 1758)	1	
Polyommatus albicans (Gerhard, 1851)	1	
Glaucopsyche melanops (Boisduval, 1828)	1	
Thymelicus lineola (Ochsenheimer, 1808)	1	

with a large secondary generation during autumn or migratory species, which rely on *Dittrichia viscosa* as their most important nectar source. The second group consists out of univoltine "shade" species such as gatekeepers and hairstreaks, which are typical species from open scrublands/woodlands.

To further characterize the observed differences in nectar use, we split the data in 3 distinct time periods: spring, summer and autumn (table 4). Spring is characterized by a low number of butterfly species and individuals, together with a low availability of flowering plants. The summer generation is characterized by a high number of species and individuals, with a high diversity in flowering plants. The autumn generation is characterized by a moderate number of butterfly species but with a high number of individuals, but the amount of flowering plant species is low.

TABLE 2. Plant species that were significantly used by butterflies as a nectar source. Plant species are listed if they were visited by > 10 individuals or > 5 species.

Plant species	Number of butterfly species	Number of butterfly individuals
Dittrichia viscosa	15	372
Eryngium campestre	10	106
Marrubium vulgare	8	86
Allium sphaerocephalon	8	61
Retama sphaerocarpa	11	52
Scabiosa atropurpurea	9	34
Rosmarinus officinalis	12	32
Chondrilla juncea	6	28
Helichrysum stoechas	8	22
Thymus zygis	10	21
Carduus tenuiflorus	13	20
Cephalaria leucantha	5	14
Echium plantagineum	7	13
Biscutella auriculata	6	12
Jasminum fruticans	3	12
Ruta montana	3	11
Coronilla minima	2	11
Teucrium gnaphalodes	1	10
Ecballium elaterium	5	9
Senecio jacobaea	5	8
Phlomis herba-venti	5	6
Teucrium polium	5	5

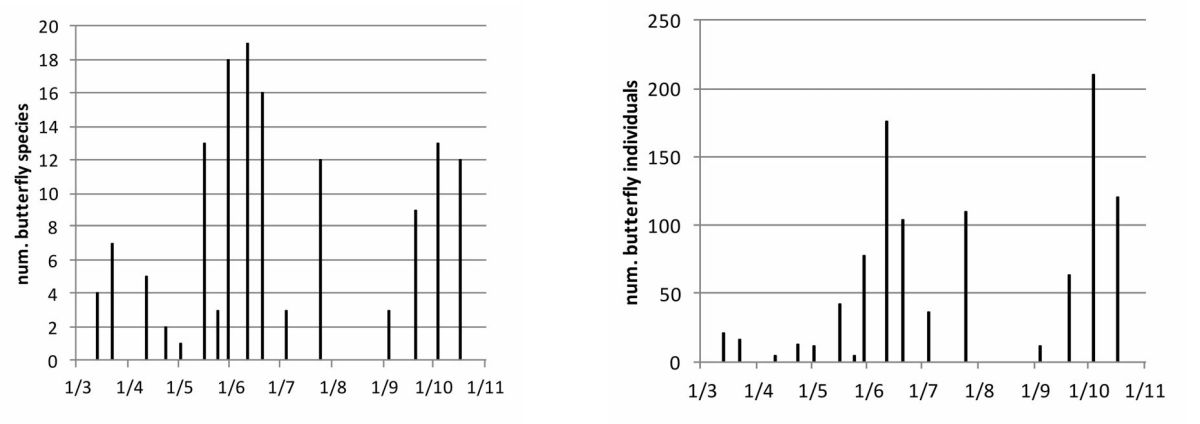

FIG. 1. Number of butterfly species (left) and individuals (right) observed during field surveys.

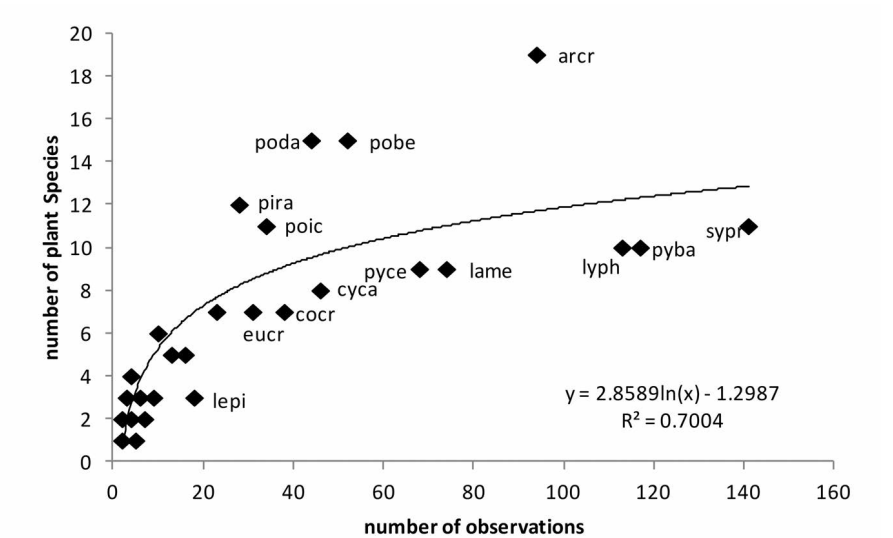

FIG. 2. Number of butterfly observations plotted as a function of the number of plant species visited. The species with only 1 observation were not included.

TABLE 3. Generalists and specialist butterfly species. The main plant species used and % of the main plant species / the total amount of plants used as a nectar source for each specialist species are given.

Generalist	Specialist	Main plant species used	% use of main plant species over total
Polyommatus icarus	*Colias crocea*	*Dittrichia viscosa*	63
Pieris rapae	*Leptotes pirithous*	*Dittrichia viscosa*	61
Pontia daplidice	*Cynthia cardui*	*Dittrichia viscosa*	30
Polyommatus bellargus	*Pyronia cecilia*	*Eryngium campestre*	78
Aricia cramera	*Pyronia bathseba*	*Marrubium vulgare*	56
	Lycaena phlaeas	*Dittrichia viscosa*	49
	Syrichtus proto	*Dittrichia viscosa*	80
	Lasiommata megera	*Dittrichia viscosa*	86
	Euchloe crameri	*Rosmarinus officinalis*	48

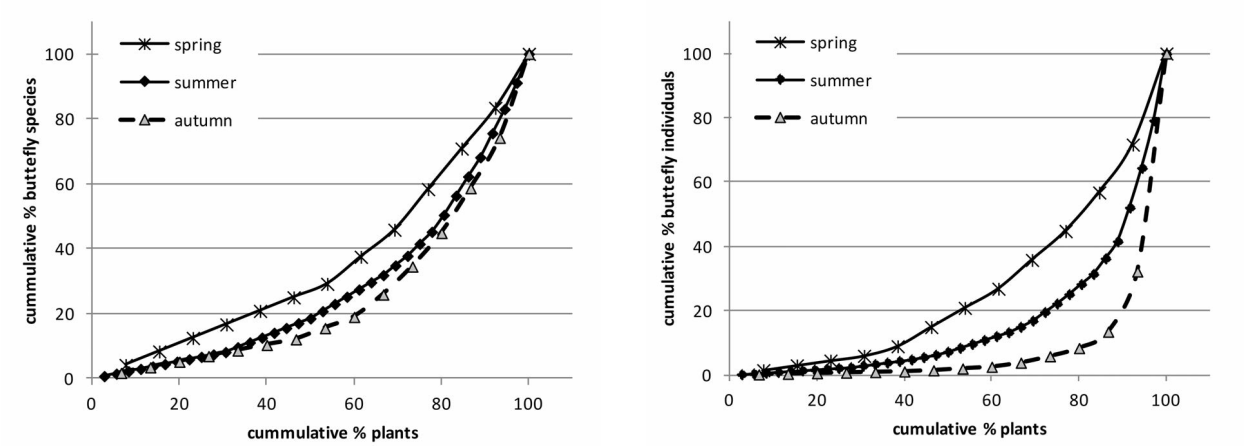

FIG. 3. Cumulative number of butterfly species and individuals per plant species, starting with the plant species with the lowest number, for 3 different time periods.

In Fig 3 we plotted the Lorenz curve, as the cumulative amount of butterfly species observed on each plant species for each season in percentage, starting with the plant species with the lowest number of visits by different butterfly species. The same was done for the number of butterfly individuals on each plant species. A clear tendency over the year can be seen; with a more equalized use of flowering plant species by butterflies in spring, both for species and number of individuals. An increasingly specialized use of certain plant species as nectar source developed over the year. This trend is not related to the sole number of available plant species for each season, as indicated in table 4.

However the results presented in Fig 3 could be influenced by a change in butterfly species present between spring, summer and autumn. Therefore the Shannon's Equitability Index was calculated for individual butterfly species to indicate the variation in number of butterfly visits to the flowering plant species. A value equal to 1 corresponds with a complete evenness in the used nectar sources. This was done for each of the different seasons (table 5). There were almost no butterfly species in large numbers present during both spring and summer, indicating that in this case the specialization trend is correlated with a change in species composition. For the summer and autumn, the same temporal trend was observed as in Fig 3 for almost all species. Furthermore *A. cramera* & *P. bellargus* can easily been recognized as true generalist species, because they both have high index values well into autumn. Other species have high Equitability values during summer but lower ones during autumn, indicating that it is not just the species composition that causes this trend.

To discriminate the other factors possibly influencing the temporal trend found in Fig 3, the Shannon's Equitability Index was calculated for each day of fieldwork separately, indicating the distribution of the number of butterfly individuals over the co-occuring plant species. The Pearson correlation coefficients between the Shannon's Equitability Index and the factors that possibly could influence the temporal trend observed are presented in table 5. The change in Equitability over time is well related with the Julian day, as was observed in Fig 3 at a seasonal scale. However, the number of butterfly species, the number of butterfly individuals and the number of plant species gave lower R^2 results, indicating that they alone are not well related with the temporal trend observed. On the other hand, this trend seems to be related to the relative abundance of butterfly species/numbers over plant species. The Equitability index, the ratio between number of butterfly individuals over number of plant species and the separate number of plant species are plotted over time and presented in figure 4. It can be observed that the number of plant species is not related to the change in the Equitability index, while the ratio follows the inverse trend, with and increasing ratio over the year between numbers of butterfly individuals over plant species.

TABLE 4. Difference in number of plant species, butterfly species and butterfly abundance observed during the different seasons.

	# of nectar plant species	# of butterfly species	# of butterfly individuals
spring	13	12	67
summer	37	32	405
autumn	15	19	551

TABLE 5. Shannon's Equitability index calculated for number of butterfly individuals present on different flowering plant species during 3 time periods. Values given are for separate species and the mean value for all species together ("total").

	Shannon's Equitability index		
	Spring	Summer	Autumn
Total	0.85	0.75	0.41
Eucloe crameri	0.81	0.72	
Pyronia bathseba		0.64	
Syrichtus proto		1.00	0.37
Lycaena phlaeas		0.82	0.51
Aricia cramera		0.72	0.79
Polyommatus bellargus		0.85	0.53
Colias crocea		0.81	0.24
Pyronia cecilia		0.87	0.39

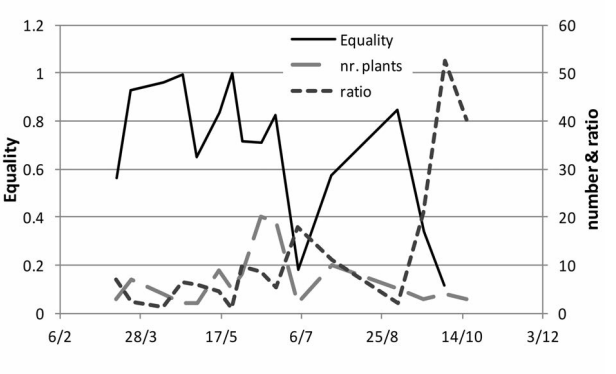

FIG. 4. Trend in Equitability index (left axis), number plants species and the ratio of number of butterfly individuals and number of plant species (right axis) over the year.

DISCUSSION

In this study we characterized the use of different nectar sources over time for a typical Mediterranean butterfly community. The most common species, *Syrichtus proto*, a common skipper in the area, was the most numerous species observed. This is in line with the observation of Tudor et al. (2004) who also observed that skippers are a very active nectaring group of butterflies. However, during spring some of the more common species were not seen nectaring. The reason for this is not clear, although lack of suitable nectar sources could be a possible explanation and should be further investigated.

Although the field survey was only conducted over one year, clear temporal trends could be observed. As expected, butterfly abundance as well as species diversity changed over time in accordance with the available resources, showing peaks in summer and autumn (Fig 1). These two peaks are typical for Mediterranean environments, and also correlate to peaks in vegetation productivity. Species diversity had its peak during May–June, coinciding with the peak of nectar sources available, while the number of individuals observed did not. Abundance reached its highest peak in autumn (table 4). This is a typical trend for species with multiple generations, where the last generation is generally the largest to produce the highest amount of offspring and increase the number of individuals that might survive winter.

As first determined by Tudor et al. (2004), generalist and specialists nectar feeders formed clearly differentiated groups. The specialist species were "shade" species such as gatekeepers. The generalist species were, as expected, the species with multiple generations. This could indicates an adaptation of univoltine species to specialize on common nectar sources during the flight period, while multivoltine species maintain their plasticity to cope with the changing available nectar sources throughout the year.

To our surprise, migratory species were also considered specialist species. Therefore we analyzed the difference in specialization over the year, dividing the data in 3 seasonal groups. The results showed a clear trend to specialization in the use of nectar sources over the season (Fig 3). This trend is partly caused by a

TABLE 6. Coefficients of the Pearson correlation between the Shannon's Equitability index calculated for the number of butterfly individuals present on the different flowering plants for each day separately and the day Julian day of the year, the number of butterfly species recorded, the number of butterfly individuals recorded, the number of plant species recorded and the ratio between number of butterfly individuals over the number of plant species present.

	Julian day	# Butterfly species	# Butterfly individuals	# Plant species	# Butterfly individuals/ plant species	# Butterfly species/ plant species
Slope	-0.003	-0.003	-0.008	0.013	-42.2	-2.54
Intercept	1.12	0.82	0.73	0.58	40.3	3.22
R2	0.41**	0.31*	0.03	0.06	0.69**	0.49**

*p<0.05, **p<0.01

change in butterfly species composition over time, with almost no butterfly species having large broods in both spring and summer. However, this is not the case between summer and autumn. To show that this specialization in autumn is a general trend, not only caused by a change in butterfly species composition over time, the Shannon's Equitability Index was calculated for some of the generalist and specialist species. Although it was observed that some species are true generalists, most species showed an increase in nectar specialization during autumn, coinciding with the previous observations and making it clear that the trend is not only caused by a change in species composition throughout the year.

While the increased specialization in nectaring from spring to summer was expected, the specialization trend in autumn is more related to a lack of flowering plant species compared to the amount of nectaring butterfly species and individuals. This trend can be caused by the numerical dominance of this plant species (*D. viscosa*) or due to the high quality nectar of this nectar source, making it more attractive than other nectar sources. With our dataset it is impossible to separate between the two due to the unavailability of vegetation density measures. The fact that one species is the main nectar source in autumn is an important observation, particularly given that adult food resource distribution plays a key role in determining habitat quality and the suitability of landscapes for butterfly persistence (Erhardt and Mevi-Schütz 2009). This fact also makes the community more vulnerable to temporal and spatial changes and extreme events with negative effects on the occurrence of *D. viscosa*.

One of the reasons for the low number of flowering plants in autumn is the local extinction of typical Mediterranean plant species. Recently, some efforts were undertaken to re-introduce some of these species in our study area. Of these species, *Rosmarinus officinalis* seems especially interesting to use. Although this reintroduced species is only present in very low densities, a high number of different butterfly species used it as a nectar sources during spring (30%) and autumn (42%). This plant species could cover part of the year where low numbers of nectar sources are present. This indicates that for ecosystem restoration of the Mediterranean areas, reintroducing typical plant species can have a positive effect on other species communities, stressing the importance of a "complete" vegetation composition to maintain high butterfly diversity. Further research comparing well conserved and degraded plant communities may further elucidate additional differences.

Currently *D. viscosa* accounts for 70% of the observed butterfly individual's nectaring in our study area. It is a yellow composite, typical for nitrofile and disturbed sites. Our results indicate that different butterfly species could benefit from a high abundance of nectar sources present on small nitrofile zones (e.g. roadsides, field margins) that are present in a nutrient poor environment. Absence of this species in the area would not be a problem for the migratory species, but could negatively affect resident species such as *Syrichtus proto*, *Lycaena phlaeas*, *and Lasiommata megera*.

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BOLORIA BELLONA (FABRICIUS) (NYMPHALIDAE: HELICONIINAE) FROM THE BLUE MOUNTAINS OF THE PACIFIC NORTHWEST

Additional key words: historical records; Meadow Fritillary; peripheral range; threatened species

The Meadow Fritillary, *Boloria bellona* (Fabricius) (Nymphalidae: Heliconiinae), is widely distributed in North America, occurring across the northern USA from the Pacific Northwest to the East Coast, and from eastern British Columbia to Newfoundland in Canada (Holland 1898, Opler 2012). In the eastern USA, *B. bellona* has adapted to disturbed habitats and apparently is expanding its distribution into the southeastern states (Opler 2012). Throughout most of its range *B. bellona* is a common butterfly, ranked G5 by the Natural Heritage Program (demonstrably secure globally and not a conservation concern). In the Pacific Northwest, however, *B. bellona* is on the periphery of its range and is considered local and rare (Warren 2005). It is presently ranked as a species of concern in the states of Washington (S2?; imperiled, but with reservation) and Oregon (S1; critically imperiled). Because all species are locally uncommon or rare at some level of their geographic distribution (Bossart & Carlton 2002), the conservation merit of listing otherwise common species as threatened in regions on the edge of their distribution is open to debate (LaBonte et al. 2001). Studies on these "edge" species, however, can potentially offer important insight into the relative importance of ecological, environmental, and anthropogenic factors that impact population range expansions and declines. Peripheral populations of a species that have been geographically isolated for long periods also may have diverged enough genetically to be recognized as incipient species.

All recent records for *B. bellona* in the state of Washington are from north-central and northeastern regions (Pyle 2002; News of the Lepidopterists' Society Vol. 46, Suppl. S1, 2004 "2003 Season Summary"). Although these specimens are often listed as belonging to the subspecies *B. bellona toddi* (W. Holland) (e.g. LaBonte et al. 2001), Warren (2005) felt that because so few specimens from the Pacific Northwest are available for comparison with other currently recognized subspecies (see Pelham 2008), a trinomial should not be assigned to these individuals.

The southernmost documented distribution of *B. bellona* in the far western USA is in the Blue Mountains of southeastern Washington and northeastern Oregon (Pyle 2002, Warren 2005, Opler et al. 2012). Pyle (2002), however, stated that the species has not been recorded from the Blue Mountains [Washington] since 1952, and mentioned that a single locality in Umatilla County, Oregon was of uncertain status. Warren (2005) provided additional information on the Oregon locality, pointing out that a population at Lehman Springs, Umatilla County (ca. 1325 m elev.) was found in 1982, 1983 and 1984, with small numbers of adults collected in each year (from late May to early July), but that this population has not been seen since. The lack of recent records for *B. bellona* from the Blue Mountains suggests that either it has been extirpated, or alternatively, that remaining colonies are localized and have been overlooked.

Recently, while sorting and cataloguing papered adult specimens I collected in the early 1970s from southeastern Washington, four individuals of *B. bellona* were discovered. The specimens were collected on 21 June 1970 near Big Springs Campground, Umatilla National Forest, Garfield County, Washington. This site is located in the northern Blue Mountains, roughly midway between the northern boundary of Umatilla National Forest and Big Springs Campground, at an elevation of ca. 1400 m (ca. 4600 ft.). Approximate

FIG. 1. *Boloria bellona* (male), Blue Mountains, near Big Springs Campground, Garfield Co. Washington, 21 June 1970. Top (dorsal view); bottom (ventral view). Wing span: 41 mm.

geographic coordinates, estimated from a Google™ Earth satellite photograph, are 46.258° N, 117.516° W. The Big Springs site is approximately 140 km NE of Lehman Springs, and about 10–20 km E of the Blue Mountain locality in southeastern Washington shown on the distribution map for *B. bellona* in Pyle (2002). A further search of my collection now housed in the Santa Barbara Museum of Natural History, Santa Barbara, California, revealed six additional specimens with the same collection data as above. Obtaining ten adults of *B. bellona* after about one hour of collecting suggests that the Big Springs population was relatively healthy at that time. An adult from this sample is shown in Fig. 1. As far as I am aware, specimens from the Blue Mountain populations of *B. bellona* have not been figured previously.

When the Big Springs specimens of *B. bellona* were collected, the significance of the find was not apparent. In the only reference available at that time for Washington State butterflies, Leighton (1946) listed the species for Pullman [Whitman County], located in the Palouse Hills of southeastern Washington, ca. 60 km NE of the Big Springs site. Thus, finding a nearby colony of *B. bellona* in the northern Blue Mountains did not seem unusual. It is now suspected that the previously known colonies of *B. bellona* in the Palouse Hills probably have been extirpated (Pyle 2002).

Additional fieldwork will be required to determine the current status of the populations of *B. bellona* in the Blue Mountains. There seems a reasonable likelihood, however, that the species has not been extirpated there. As mentioned above, the apparently healthy colony found near Big Springs in 1970 is near the site mentioned by Pyle (2002) where the species was last reported in 1952. The reappearance of *B. bellona* in the northern Blue Mountains after an apparent absence of 18 years suggests either that the area was visited infrequently by lepidopterists during those years, or possibly that a recolonization had occurred after a local extirpation. A recolonization, however, would imply the existence of additional source populations in the general area that may still be extant. Examination of satellite images of the Big Springs site, and the northern portion of Umatilla National Forest, suggests that no apparent habitat degradation has occurred there as of September 2011.

Boloria bellona should be sought from late May to early July in riparian habitats (Warren 2005), focusing on elevations corresponding to the most recently documented sites at Lehman Springs and Big Springs (1200–1500 m). Larval host plants in the Blue Mountains populations have not been determined (Warren 2005) but are assumed to be violets, *Viola* spp. (LaBonte et al. 2001; Pyle 2002).

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