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Subspecific designation of the U.S.A. Interior Highlands population of *Argynnis* (*Speyeria*) *diana* (Cramer, 1777) (Nymphalidae: Heliconiinae: Argynnini: Argynnina)

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ABSTRACT. Subspecific designation is designated for the North American Interior Highlands population of *Argynnis diana*, based on four factors: mtDNA haplotype differences from nominotypical *A. diana* of the Appalachian Mountains; wing shape difference in the males between both regions; wing size of the adults; and tendency for females of the Interior Highlands to show tan coloration in the submarginal row of rectangular spots of the subapical region of the dorsal forewings.

Additional key words: Interior Highlands, Ozark Region, Ouachita Mountains, Appalachian Mountains, wing shape, dispersal, range collapse, range contraction.

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INTRODUCTION

The Interior Highlands is a combined physiographic region comprised of several geologic provinces across the states of Missouri, Arkansas and Oklahoma, consisting of the Salem Plateau, St. Francois Mountains, Springfield Plateau, and Boston Mountains, collectively known as the Ozark Plateau or Ozark Region. The Ouachita Mountains, technically south of the Ozarks, form their own geologic province, and together form the Interior Highlands, with floral and faunal links to the Appalachian Mountain region of the eastern United States. Among the butterflies, *Celastrina nigra*, *Celastrina neglectamajor*, *Calephelis borealis* and *Argynnis diana* each share Interior Highlands and Appalachian Mountain affinities, with their distributions concentrated in each of the two regions, and with scant records in the intervening region.

A. diana is the largest member of the North American subgenus *Speyeria*. It is also the most sexually dimorphic species of the subgenus. The historical range of *A. diana* extended broadly from the Atlantic Coastal Plain west to Oklahoma, and from central areas of Georgia, Alabama and Mississippi north to the southern edge of the Great Lakes (**Fig. 9**). There has been some documented contraction of its range, particularly in lowland habitats. It has become extirpated where it was originally discovered in coastal Virginia; and in the Mississippi Valley and lower Ohio River Valley lowland regions. Factors causing this range contraction are believed to be: habitat loss (woodland converted to farmland, widespread logging, changes in land use, residential encroachment into the habitat, wetland draining); habitat fragmentation; floral competition against host *Viola* species; pesticides (specifically aerial application of *Bacillus thuringiensis* for *Lymantria dispar* (Gypsy Moth) control); uncontrolled deer browsing; and fire suppression resulting in profound ecological changes (Rudolph *et al*., 2006). All have negative impacts on *diana* populations in different areas, thus the species is of conservation concern.

Global warming is presented as a predicted factor for continued range contraction in the future (Wells, 2014; Wells & Tonkyn, 2013; Wells *et al*., 2015; Wells & Tonkyn, 2018), as evidenced by the butterfly occupying higher elevation habitats in greater numbers over the studied time period, especially in the southern Appalachians. Interestingly, Wells (2014) and Wells & Tonkyn (2018) noted that populations of *S. diana* in the southern Appalachian Mountains and in Oklahoma and Arkansas have expanded in recent decades. Moran & Baldridge (2002) concluded: "… *A. diana* does not appear to be in immediate risk of extirpation in Arkansas, although monitoring of existing populations is warranted." Habitat restoration efforts, employing prescribed burning of forest habitat in the Ouachita Mountains and in western North Carolina have been documented to help restore the habitat to pre-European conditions by reducing the forest canopy, eliminating mid-story growth, and restoration of dense herbaceous ground cover (Rudolph *et al*., 2006; Campbell, *et. al*., 2007), thus helping to increase *diana* abundance. Presently, *A. diana* is not protected at any local, state or federal level, other than protection within parklands.

However, it begs one to consider that many of the records plotted within the "collapsed" central portion of the species' range during human record keeping were merely historical strays outside of the species' Appalachian and Interior Highlands strongholds. For example, there have been recent strays of unknown origin, reliably reported from places as far north as Chatham, ON. (BAMONA, 2011) and as far east as Jamestown, R.I. (D. Albaugh, pers. corr., 1999). A continuous range across the eastern United States certainly predates the most recent glacial maximum. Wells *et al*. (2015) estimated that the split between Appalachian and Interior Highlands populations occurred at least 20,000 years ago, thus enough time to develop differences in DNA, and long predates human activity. Thus, it is premature to conclude that human activity or global warming are responsible for the perceived collapse of the species' range in the Mississippi and Ohio River Valley regions. Hovanitz (1963) sums this up nicely: "This species…is a relatively rare species due to the limited areas in which it lives. There is no evidence that at any time in the past the species was any less local than it is now" but notes that deforestation [in Virginia] contributed to its demise there. He further states: "The species exists in parts of North America away from the most heavily inhabited regions and therefore collectors have not had as much experience with it…" This would certainly skew the historical record of its distribution and abundance!

Considering that *A. diana* has long occupied mainly the Appalachian and Interior Highlands regions, it has been questioned whether Interior Highlands *A. diana* is represented at subspecies-level, differentiated from its Appalachian counterpart. A recent study by Wells *et al*. (2018) indicated that males of the Interior Highlands and Appalachian populations of *A. diana* differ in forewing shape and the authors posed a hypothesis for this. Females in that study showed a different alignment of wing shape, reflective of high vs. low elevation populations rather than regional. Independent investigation by myself (2016, unpubl.) found no consistent difference in dorsal or ventral wing markings of the males from either region. Individual variation among males overlapped completely, range wide. Likewise, females from both regions displayed no consistent differences with the exception of the color of the postmedian marks in the apical portion of the dorsal forewing, and wing size, that might be considered weakly subspecific.

COMPARISON OF INTERIOR HIGHLANDS AND APPALACHIAN *A. DIANA*

Wells *et al*. (2018) conducted a thorough geometric morphometric analysis of the two *A. diana* regional populations and found significant regional differences in male forewing and hindwing shape, and concluded that wing shape of adults can be used as a character to measure population-level differences. Males from the Appalachian Mountains were determined to have narrower and more angular wings, believed to support high dispersal behavior, vs. Interior Highlands males which have rounder wings, supporting low dispersal behavior. The authors also found significant differences in female forewing shape, not regionally, but between high and low elevation populations, where high elevation females possessed narrower forewings than those from low elevations. Unfortunately, they did not specify in which region(s) this female forewing character occurred or was most prominent [it is my interpretation

that this means that Appalachian Mountain females qualify as “high elevation” vs. “low elevation” females found in the remainder of *diana’s* range, including the Interior Highlands region].

My own detailed analysis of adult morphology from both regions shows virtually no consistent differences in wing marks in the males. The range of variation in both Interior Highlands and Appalachian males, including coloration and extent of all dorsal and ventral markings, appears to fully overlap range wide. Preliminary measurements of my collected series of males from both Arkansas (n=18) and Virginia (n=16) similarly show little difference in wing shape, with both series showing a high degree of variability [certainly not at the scale of investigation of the Wells *et al*. (2018) study, but worthy of note, and supports the argument that large series are often needed to make reliable conclusions]. However, two males were selected, one from each region, each with similar forewing length, and measurements were made, which corroborate the findings of Wells *et al*. (2018). The red-outlined silhouette (ex Needmore, AR) is overlain with the blue-outlined silhouette (ex Longdale Furnace, VA) (**Fig. 1**). Both specimens have identical forewing length (measurement A) at 43 mm. Measurement B (Virginia) is 26 mm, and measurement C (Arkansas) is 29 mm, confirming that Appalachian males have narrower forewings than their Interior Highlands counterparts. The hindwing of the Arkansas specimen is measurably larger than the Virginia specimen, measuring 35 mm (measurement E) along vein Cu_1, whereas the Virginia specimen measures 33 mm (measurement D). A visual representation of the male wing shape difference is shown below (**Fig. 2)** [same specimens measured for Fig. 1]. Difference in forewing shape is most evident. Overall, Arkansas males (n=24) averaged 45.8 mm forewing length, while Appalachian males (n=58) averaged 43.7 mm (2.1 mm smaller). Arkansas females (n=12) averaged 55.2 mm while Appalachian females (n=21) averaged 51.5 mm (3.7 mm smaller). A study by Showalter & Drees (1980), using an unspecified sample size of Appalachian *diana* indicated forewing lengths averaging 44.1 mm for males and 52.3 mm for females, each slightly larger in size than the present sample.

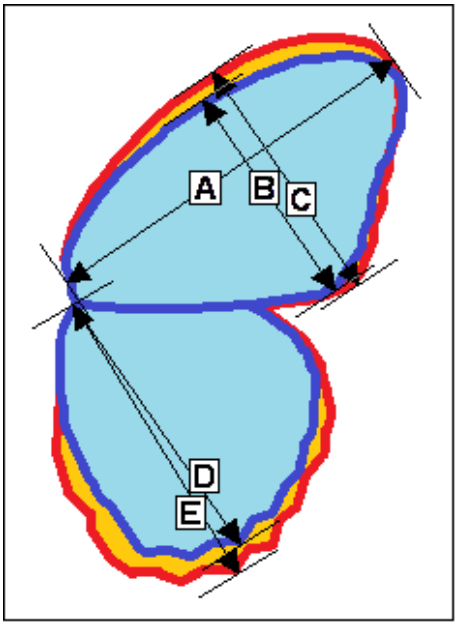

Fig. 1. *A. diana* male wings comparison.

Fig. 2. *A. diana* male, nr. Needmore, Scott Co., AR., 6/12/2016 (left image). *A. diana* male, nr. Longdale Furnace, Alleghany Co., VA 6/28/2017 (right image). Narrower, more elongated forewing in Appalachian male is evident.

While the Wells *et al*. (2018) study found a consistent wing shape difference between males of both regions, they did not study differences in wing markings. Analysis of male wing marks from both regions in the author's personal collection, various printed literature sources (**Table 1**), and a selection of 196 images [clearly-focused perpendicular views of fresh individuals, not sun-backlit and no shadows on wings] posted to the internet via butterfliesandmoths.org, butterfliesofamerica.com, and iNaturalist.org (**Table 2**) corroborates no consistent differences in dorsal or ventral wing marks in males beyond a wide range of individual variation matched in both regions.

Additionally, the Wells *et al*. (2018) study determined that females expressed a different degree of wing shape development based on elevation, where low elevation females have wider forewings than those from high elevations, reflective of dispersal and host-locating habits. The authors also did not identify any differences in wing marks among females from both regions, for their study. However, my own detailed analysis of female wing mark characters, utilizing the same sources listed above (**Table 2**), did find that there is one character that might be considered useful in differentiating some females from both regions. Females from the Appalachian populations generally displayed consistently whitish-blue coloration in the submarginal band of rectangular marks in the subapical area of the forewing (dorsal side), while females from the Interior Highlands populations showed a tendency toward tan to whitish-tan coloration of these rectangular marks. This tendency for tan coloration in the subapical area of the forewing is not seen in all Interior Highlands females examined, but is rarely encountered in Appalachian females. [One problem encountered is the quality of published and web-sourced images. Lighting and focus often distorts the true color of wing marks.]

An earlier study (Dunford, 2007), which constructed a phylogeny of *Speyeria* based on 653 characters of the mitochondrial gene COI, placed Arkansas *diana* separately from West Virginia *diana.* The two sampled Arkansas *diana* were identified with 657 COI base pairs, whereas the two West Virginia *diana* were separately identified with 643 and 657 COI base pairs. Several phylograms of the *Speyeria* (Dunford, 2007: Figures 3-8 through 3-11) were constructed for strict consensus trees, all consistently showing the two Arkansas samples grouping together, separated from the two West Virginia samples.

More recently, the Wells (2014) and Wells *et al*. (2015) studies found significant differences in mtDNA haplotypes between Appalachian and Interior Highlands populations, with eastern populations showing high levels of genetic diversity and Interior Highlands populations with less genetic diversity. Different haplotypes were found to dominate the Appalachian and Interior Highlands populations (Wells, 2014; Wells *et al.*, 2015), with 'haplotype 1' dominating the Interior Highlands population and 'haplotype 2' dominating the Appalachian population. Wells *et al*. (2018) concluded that morphological and mitochondrial DNA differences between the two regional populations "may warrant subspecies designation".

ARGYNNIS (*SPEYERIA*) *DIANA ARKANSANA* – NEW SUBSPECIES

ZooBank registration: urn:lsid:zoobank.org:act:3CDE5E6E-F9F9-4CEB-BEEC-22CAA67D94B2

Description: The primary difference between Interior Highlands and Appalachian populations of *A. diana* is in the rounder shape of the male forewings of the Interior Highlands (Wells *et al*., 2018), whereas Appalachian male forewings were found to be "narrower and more angular" than Interior Highlands males (**Figs. 1 & 2)**. The authors also found that male hindwings from the Appalachian population were narrower than those from the Interior Highlands. Also, there is a tendency for females of the Interior Highlands population (**Fig. 7**) to display tan coloration in the submarginal row of marks in the subapical area of the forewing (dorsal side) rather than the whitish-blue coloration found in Appalachian females (**Fig. 8**). In my analysis, male forewings of the Interior Highlands region averaged 2.1 mm longer than Appalachian males, with a sampled range of 42-48 mm in the Interior Highlands and a range of 39-48 mm

in the Appalachian region. The forewings of Interior Highlands females averaged 3.7 mm longer than Appalachian females, with a sampled range of 54-57 mm in the Interior Highlands and a range of 48-56 mm in the Appalachian region.

Habitat: Carlton & Nobles (1996) compiled information from various sources and listed the habitat choices for the Interior Highlands variously as: hardwood/pine forest (especially edge habitats); second growth pine hardwood forest; even-aged pine stands; mature upland hardwood forest; "a mosaic of severely disturbed pine and second growth mixed forest in various stages of succession with a dense understory of woody vines, shrubs and small trees; and tallgrass prairie/patchy forest with dense undergrowth. *A. diana* was also recorded in prairie habitats in southwest Arkansas, small prairie remnants in mountainous northwest Arkansas, and in wetland habitats in central Arkansas (Moran & Baldridge, 2002). The authors' survey indicated that *diana* was more widespread throughout the mountainous region than previously thought. They also found that *diana* thrived in moderately disturbed habitat such as second growth forest and pastureland and the butterflies thrive where the habitat is frequently burned. In the Interior Highlands region, the butterfly was also reported in pine-dominated forests (Rudolph, *et. al.*, 2006), especially consisting of *Pinus echinata*, with sparse midstories and an understory of *Schizachrium* spp. grasses and abundant nectar sources (**Fig. 3**). They reported the species is also found in *Quercus/Carya*-dominated forest such as found on Mt. Magazine in Arkansas (**Fig. 4**). Spencer (2014) summarizes the habitat in Arkansas as "open moist (mesic) forests, prairies and wetlands".

Fig. 3. Pine-dominated lowland habitat west of Needmore, AR.

Fig. 4. Upland habitat atop Mt. Magazine, Logan County, AR.

Larval hosts: *Viola pedata, Viola riviniana* (Spencer, 2011). Other *Viola* species are suspect, but no others have been recorded in the Interior Highlands. Several *Viola* species recorded in the Appalachians.

Nectar sources: *A. diana* is highly dependent on high-quality nectar sources that can enhance the species' reproductive abilities (Wells & Smith, 2013). Moran & Baldridge (2002) recorded the following: *Cephalanthus occidentalis, Echinacea purpurea, Echinacea pallida, Silphium laciniatum, Satureia arkansana, Pycnanthemum albescens,* and *Rubus* sp. Primary nectar sources recorded by Rudolph *et al.* (2006) added the following: *Asclepias tuberosa, Cirsium carolinianum, Cirsium discolor, Liatris elegans, Monarda fistulosa, Porteranthus stipulatus,* and *Pycnanthemum tenuifolium.* Secondary nectar sources recorded during their study were: *Rhexia* sp., *Scutellaria ovata, Erigeron strigosus, Bidens aristosa,*

Eupatorium fistulosum, Solidago rugosa, Helianthus divaricatus, Vernonia gigantea and *Vernonia baldwinii.* Spencer (2014) listed *Coreopsis* sp., *Vernonia* sp., and garden cultivars such as *Lantana camara, Pentas lanceolata* and *Buddleia* sp. Various internet-sourced images confirmed the following: *Asclepias syriaca, Asclepias exaltata, Daucus carota, Eupatorium perfoliatum* and *Cornus* sp. Recently-emerged adult males were also observed to imbibe from non-nectar sources such as animal feces, regurgitated plant material (animal vomit), carrion, damp soil, dusty road surfaces, even human sweat (Rudolph *et al*., 2006).

Etymology: The subspecies name *arkansana* represents the primarily Arkansas portion of the subspecies range. In 2007, it was designated as the Arkansas State Butterfly.

Holotype, allotype and paratypes: A female originating in the Ouachita Mountains region is selected as the holotype of *Argynnis* (*Speyeria*) *diana arkansana* (**Fig. 5**). The type locality is: County Road 30, 0.64 miles west of U.S. Route 71, Needmore, Scott County, Arkansas. Date is June 12, 2016. The holotype, allotype male (**Fig. 6**) and several paratype males collected at the TL are deposited in the McGuire Center for Lepidoptera and Biodiversity, Gainesville, FL. and a pair is retained by the author.

Fig. 5. Holotype female, 6/12/2016, Needmore, AR. Dorsal view (left), ventral view (right).

Fig. 6. Allotype (paratype) male, 6/12/2016, Needmore, AR. Dorsal view (left), ventral view (right).

Fig. 7. *A. diana arkansana* female displaying tan markings in FW subapical area. Mount Magazine State Park, Logan Co., AR, June 26, 2004. Photo courtesy © Bill Bouton.

Fig. 8. *A. diana diana* female displaying blue markings in FW subapical area. Cleburne Co., AL, August 23, 2021. Photo courtesy © Sara Bright.

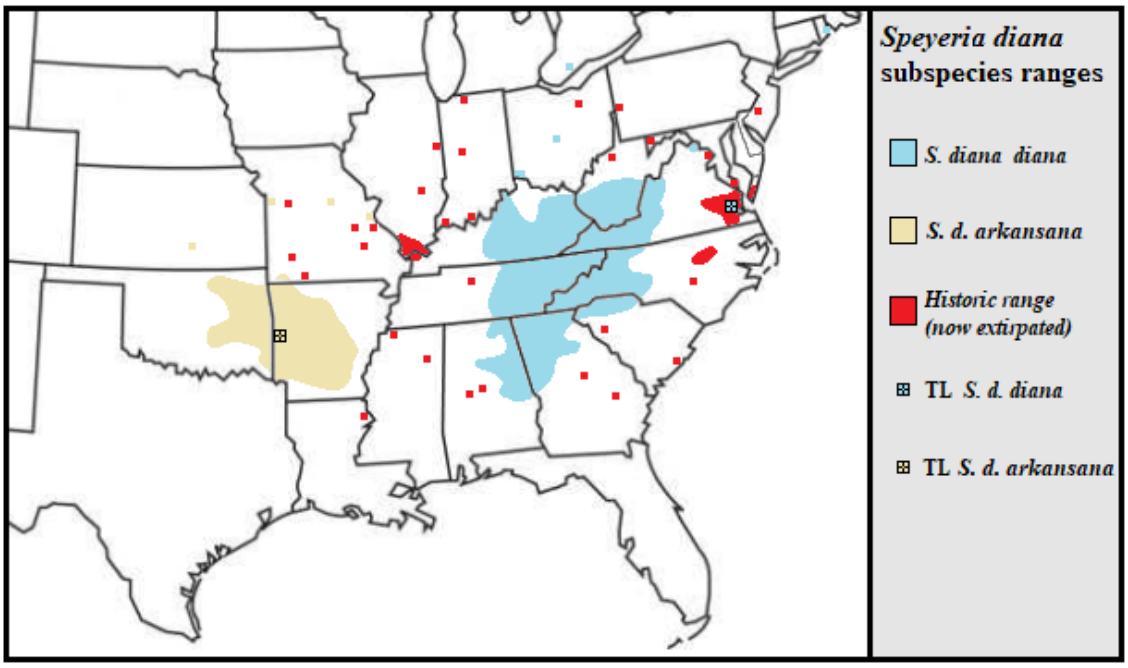

Fig. 9. Extant range of *Argynnis diana*, showing the current range of ssp. *diana* (blue) and ssp. *arkansana* (tan). Historic range, pre-1960 (extirpated and strays) shown in red.

CONCLUSION

The following subspecific arrangement is hereby designated. Alignment under the genus *Argynnis* and subgenus *Speyeria* follows Simonsen (2006), Simonsen, *et. al.* (2006), and Zhang, *et. al.* (2020):

Argynnis (*Speyeria*) *diana diana* (Cramer, 1777), TL: Jamestown, James City County, VA.
Argynnis (*Speyeria*) *diana arkansana* Pavulaan 2021, TL: County Road 30, 0.64 miles west of U.S. Route 71, Needmore, Scott County, AR.

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APPENDIX - SOURCES OF IMAGES

With the presence of the COVID-19 pandemic, institutional collections were closed to the general public, even institutional staff, throughout the compilation of this report. Published imagery in printed literature was sourced (**Table 1)**, when locational information was provided. With the aid of web-based imagery, much visual analysis was able to be accomplished by examining available imagery posted to three major websites: butterfliesandmoths.org, butterfliesofamerica.com, and iNaturalist.org, though exacting measurements were not possible (**Table 2)**. Additional web-sourced imagery was available but not referenced for this study.

Published sources of imagery	Geographic sources of specimen images	Sex and orientation of view
Allen, 1997	W.V., Raleigh Co., Prince	M (D)
	W.V., Raleigh Co., nr. Grandview State Park	M (V)
	W.V., Monroe Co., Jefferson Nat. Forest, Potts Creek	F (D)
	W.V., Wyoming Co., Pinnacle Creek	F (V)
Bouseman & Sternburg, 2001	VA., Montgomery Co.	M (D/V), F (D/V)
Cech & Tudor, 2005	W.V., Boone Co., Fork Creek Recreation Area	M (D/V), F (D/V)
Clark & Clark, 1951	VA., Surry Co., Spring Grove	M (D/V), F (D/V)
Dole, *et al.* , 2004	VA., Montgomery Co.	M (D/V), F (V)
	OK., LeFlore Co., Cucumber Creek	F (D)
Glassberg, 1999	TN., Washington Co., Cherokee Nat. Forest	M (D/V)
	"western N.C."	F (D)
	W.V., Boone Co., Fork Creek Wildlife Management Area	F (V)
Harris, 1972	GA., Fannin Co., Cooper Creek	M (D), F (D)
Heitzman & Heitzman, 1987	"Virginia"	M (D), F (D/V)
Howe, 1975	GA., Fannin Co.	M (D/V)
	N.C., Swain Co., Cherokee Reservation	F (D/V)
Howell & Charney, 2010	AL., Tallapoosa Co., nr. Chatasofka Creek	M (V)
Iftner, *et al.* , 1992	VA., Wise Co.	M (D/V)
	KY., Letcher Co.	F (D/V)
Klots, 1951	AR., Lincoln Co., Tarry	M (D)
	N.C., Transylvania Co., Lake Toxaway	F (D)
Monroe & Wright, 2017	VA., Montgomery Co., Poverty Hollow	M (D/V), F (D/V)
Opler & Krizek, 1984	VA., Bath Co.	M (D/V), F (D/V)
Opler & Malikul, 1998	GA., Fannin Co.	M (D)
	VA., Bath Co.	M (V)
	TN., Carter Co.	F (D)
Shull, 1987	VA., Montgomery Co., Poverty Hollow	M (D/V), F (D/V)
Scott, 1986	VA., Montgomery Co., Poverty Hollow	F (D)
	VA., Montgomery Co., Blacksburg	M (D), F (V)
Smith & Domingue, 2019	N.C., Swain Co., Great Smoky Mountains Nat. Park	M (D), F (D)
Spencer, 2011	AR., Logan Co., Mt. Magazine State Park	M (5D/V), F (3D/V)
Spencer, 2014	AR., Logan Co.	M (D/V), F (D/V)

Table 1. Summary of images examined for this study in published (print) literature.

Online sources of imagery	Image ID	Geographic sources of specimen images	Sex and orientation of view
butterfliesofamerica.com		AR., Hempstead Co., Rick Evans Grandview Prairie WMA	M (D)
butterfliesofamerica.com		AR., Logan Co., Mt. Magazine State Park	M (D/V), F (D/V)
butterfliesofamerica.com		GA., Fanin Co., Cooper Creek	M (D/V), F (D/V)
butterfliesofamerica.com		OK., Cherokee Co., Cherokee WMA	M (D), F (V)
butterfliesofamerica.com		OK., Le Flore Co., Ouachita National Forest	M (V), F (D)
butterfliesofamerica.com		OK., Tulsa Co., Tulsa	M (V)
butterfliesofamerica.com		TN., Blount Co., Townsend	M (D)
butterfliesofamerica.com		VA., Montgomery Co., Poverty Hollow	M (D/V)

Table 2. Summary of online image sources examined for this study (continued below).

Online sources of imagery	Image ID	Geographic sources of specimen images	Sex and orientation of view
butterfliesandmoths.org	535458	AR., Henpstead Co.	M (D)
butterfliesandmoths.org	539374	N.C., Macon Co.	M (D)
butterfliesandmoths.org	613598	TN., Bledsoe Co.	F (D)
butterfliesandmoths.org	614534	TN., Greene Co.	F (D/V)
butterfliesandmoths.org	615306	N.C., Henderson Co.	F (D)
butterfliesandmoths.org	691128	TN., Sevier Co.	F (D)
butterfliesandmoths.org	714401	GA., Coweta Co.	F (D)
butterfliesandmoths.org	714402	GA., Coweta Co.	M (D)
butterfliesandmoths.org	718390	TN., Sequatchie Co.	M (D)
butterfliesandmoths.org	723691	TN., Carter Co.	F (V)
butterfliesandmoths.org	727486	AR., Sebastian Co.	M (D)
butterfliesandmoths.org	741458	GA., Union Co.	M (D)
butterfliesandmoths.org	741460	GA., Union Co.	F (D)
butterfliesandmoths.org	758649	AR., Pope Co.	F (D)
butterfliesandmoths.org	774118	OK., Creek Co.	M (V)
butterfliesandmoths.org	902780	AR., Sebastian Co.	F (V)
butterfliesandmoths.org	903284	AR., Saline Co.	M (D)
butterfliesandmoths.org	928420	AR., Sebastian Co.	F (D/V)
butterfliesandmoths.org	929406	TN., Van Buren Co.	F (V)
butterfliesandmoths.org	978103	TN., Morgan Co.	M (D)
butterfliesandmoths.org	979453	AR., Sebastian Co.	F (V)
butterfliesandmoths.org	982671	TN., Anderson Co.	M (D)
butterfliesandmoths.org	982821	AR., Howard Co.	F (V)
butterfliesandmoths.org	1048427	TN., Blount Co.	M (D/V)
butterfliesandmoths.org	1048821	KY., Pulaski Co.	M (D)
butterfliesandmoths.org	1051311	N.C., Buncombe Co.	M (D)
butterfliesandmoths.org	1086616	AR., Logan Co.	M (D/V)
butterfliesandmoths.org	1096513	TN., Putnam Co.	M (D)
butterfliesandmoths.org	1107574	OK., Wagoner Co.	F (D)
butterfliesandmoths.org	1113388	GA., Stephens Co.	F (D)
butterfliesandmoths.org	1118083	GA., Walker Co.	M (D)
butterfliesandmoths.org	1119277	AR., Sebastian Co.	F (V)
butterfliesandmoths.org	1128365	TN., Cocke Co.	F (D)
butterfliesandmoths.org	1129513	TN., Cocke Co.	M (V)
butterfliesandmoths.org	1134876	GA., Coweta Co.	F (D)
butterfliesandmoths.org	1138739	TN., Marion Co.	F (D)
butterfliesandmoths.org	1141632	VA., Giles Co.	F (D/V)
butterfliesandmoths.org	1143055	AR., Garland Co.	M (D)
butterfliesandmoths.org	1163646	TN., Cocke Co.	M (D)
butterfliesandmoths.org	1163681	AR., Howard Co.	M (V)
butterfliesandmoths.org	1163684	AR., Howard Co.	F (D)
butterfliesandmoths.org	1167684	VA., Dickenson Co.	M (D)
butterfliesandmoths.org	1168376	N.C., Buncombe Co.	M (D)
butterfliesandmoths.org	1178688	TN., Carter Co.	F (D)
butterfliesandmoths.org	1179232	KY., Laurel Co.	F (V)
butterfliesandmoths.org	1181538	S.C., Greenville Co.	M (D)
butterfliesandmoths.org	1182433	TN., Sevier Co.	F (D)
butterfliesandmoths.org	1182581	GA., Polk Co.	F (D)
butterfliesandmoths.org	1187768	VA., Alleghany Co.	M (D)
butterfliesandmoths.org	1200809	TN., Cocke Co.	F (D/V)
butterfliesandmoths.org	1208105	TN., Scott Co.	M (D)
butterfliesandmoths.org	1208746	AL., Cleburne Co.	M (D)
butterfliesandmoths.org	1210776	N.C., Cherokee Co.	M (D)
butterfliesandmoths.org	1212118	VA., Washington Co.	M (D)

Table 2. (cont.)

Online sources of imagery	Image ID	Geographic sources of specimen images	Sex and orientation of view
butterfliesandmoths.org	1212518	TN., Marion Co.	M (V)
butterfliesandmoths.org	1212958	TN., Carter Co.	M (D/V)
butterfliesandmoths.org	1220047	TN., Carter Co.	F (V)
butterfliesandmoths.org	1220950	TN., Blount Co.	M (V)
butterfliesandmoths.org	1233804	TN., Scott Co.	F (D)
butterfliesandmoths.org	1241412	TN., Putnam Co.	M (D/V)
butterfliesandmoths.org	1251655	AR., Franklin Co.	M (V)
butterfliesandmoths.org	1255423	TN., Sevier Co.	M (D)
butterfliesandmoths.org	1255822	TN., Marion Co.	F (D/V)
butterfliesandmoths.org	1255824	TN., Marion Co.	M (D/V)
butterfliesandmoths.org	1258563	VA., Patrick Co.	M (D)
butterfliesandmoths.org	1269386	N.C., Transylvania Co.	M (D)
butterfliesandmoths.org	1271932	W.V., Fayette Co.	M (D)
butterfliesandmoths.org	1286324	TN., Fentress Co.	F (D)
butterfliesandmoths.org	1294758	GA., Union Co.	M (D/V)
butterfliesandmoths.org	1297242	KS., Sedgwick Co.	M (D)
butterfliesandmoths.org	1295236	AR., Pope Co.	M (D/V)
butterfliesandmoths.org	1296563	OK., Pittsburg Co.	M (D)
butterfliesandmoths.org	1298408	N.C., Madison Co.	M (D)
butterfliesandmoths.org	1298409	N.C., Madison Co.	F (D)
butterfliesandmoths.org	1298818	VA., Montgomery Co.	M (D)
butterfliesandmoths.org	1307090	N.C., Transylvania Co.	M (D)
butterfliesandmoths.org	1309779	VA., Craig Co.	F (D)
inaturalist.org	2671123	AR., Montgomery Co., Ouachita National Forest	M (V)
inaturalist.org	6711590	N.C., Madison Co., Pisgah National Forest	M (D/V)
inaturalist.org	9869054	AR., Sebastian Co., Barling	F (V)
inaturalist.org	21577992	AR., Saline Co., Owensville	F (V)
inaturalist.org	26950069	TN., Hamilton Co., Soddy-Daisy	M (D)
inaturalist.org	32177431	TN., Greene Co., Cherokee National Forest	F (D)
inaturalist.org	37397707	TN., Van Buren Co., Fall Creek Falls State Park	M (D)
inaturalist.org	42747475	TN., Fentress Co., Big South Fork National River	F (D)
inaturalist.org	48427528	AL., Cleburne Co., Coleman Lake	M (D)
inaturalist.org	48501855	AR., Franklin Co., Charleston	M (V)
inaturalist.org	49230199	AL., Cleburne Co., Talladega National Forest	M (D)
inaturalist.org	49646447	TN., Bledsoe Co., Pikeville	M (D)
inaturalist.org	49940066	TN., Cocke Co., Cosby	M (D)
inaturalist.org	50336345	N.C., Madison Co., Tom Town	M (D)
inaturalist.org	51192096	TN., Sevier Co., Great Smoky Mountains National Park	M (D)
inaturalist.org	53827533	TN., Grundy Co., South Cumberland State Park	M (D)
inaturalist.org	55061347	N.C., Macon Co., Nantahala National Forest	M (V)
inaturalist.org	55300876	AR., Pulaski Co., Roland	F (D)
inaturalist.org	58889102	AL., Cleburne Co., Talladega National Forest	F (D)
inaturalist.org	59247441	AR., Logan Co., Mt. Magazine State Park	M (D)
inaturalist.org	59369093	TN., Bledsoe Co., Pikeville	F (D)
inaturalist.org	59816190	TN., Carter Co., Cherokee National Forest	F (D)
inaturalist.org	60736812	TN., Carter Co., Elizabethton	M (D)
inaturalist.org	62647956	TN., Sevier Co., Great Smoky Mountains National Park	F (D)
inaturalist.org	64277488	AL., Cleburne Co., Coleman Lake	F (D)
inaturalist.org	67423627	VA., Bath Co., George Washington National Forest	F (D)
inaturalist.org	68882333	TN., Monroe Co., Cherokee National Forest	M (D)
inaturalist.org	69119228	N.C., Haywood Co., Great Smoky Mountains National Park	M (D)
inaturalist.org	69119861	N.C., Haywood Co., Crabtree Bald	F (D)
inaturalist.org	71706836	VA., Bath Co., George Washington National Forest	F (D)
inaturalist.org	78157761	AL., Elmore Co., Burlington	M (D)
inaturalist.org	80413104	AR., Clark Co., Arkadelphia	M (D)

Table 2. (cont.)

Online sources of imagery	Image ID	Geographic sources of specimen images	Sex and orientation of view
inaturalist.org	81364708	AR., Pulaski Co., Fourche Mountains	M (D)
inaturalist.org	82062627	AR., Clark Co., Terre Noire Natural Area	M (D)
inaturalist.org	83401674	TN., Sequatchie Co., Signal Mountain	M (D)
inaturalist.org	83413363	OK., Tulsa Co., Bixby	F (D)
inaturalist.org	83560489	OK., Pawnee Co., Shady Grove	M (V)
inaturalist.org	83603387	OK., Wagoner Co., Leonard	M (D)
inaturalist.org	83670945	N.C., Graham Co., Nantahala National Forest	M (D)
inaturalist.org	83809028	N.C., Buncombe Co., Blue Ridge Parkway	M (D)
inaturalist.org	84229262	N.C., Madison Co., Petersburg	M (D)
inaturalist.org	84383807	N.C., Swain Co., Great Smoky Mountains National Park	M (D)
inaturalist.org	84403956	N.C., Burke Co., Glen Alpine	M (D)
inaturalist.org	84442404	TN., Cocke Co., Cosby	M (D)
inaturalist.org	84619976	TN., Blount Co., Gatlinburg	M (D)
inaturalist.org	84629895	TN., Van Buren Co., Spencer	M (D)
inaturalist.org	84699914	OK., Sequoyah Co., Muldrow	M (D)
inaturalist.org	84770122	AR., Scott Co., Fourche Mountains	M (V)
inaturalist.org	84916356	AR., Conway Co., Morrilton	M (D)
inaturalist.org	85017805	N.C., Graham Co., Nantahala National Forest	M (D)
inaturalist.org	85136888	N.C., Burke Co., Glen Alpine	M (D)
inaturalist.org	85637415	N.C., Macon Co., Nantahala National Forest	M (D)
inaturalist.org	85806894	OK., Tulsa Co., Sand Springs	F (D)
inaturalist.org	85858905	TN., Franklin Co., Sewanee	M (D)
inaturalist.org	86107071	TN., Bledsoe Co., Pikeville	M (D)
inaturalist.org	86115478	W.V., Nicholas Co., Birch River	M (D)
inaturalist.org	86437834	TN., Sevier Co., Great Smoky Mountains National Park	M (D)
inaturalist.org	86897319	N.C., McDowell Co., Green Hill	M (D)
inaturalist.org	87224194	GA., Fannin Co., Chattahoochee-Oconee National Fores	M (D)
inaturalist.org	87615778	TN., Carter Co., Holston Mountain	M (D)
inaturalist.org	87652189	AL., Cleburne Co., Heflin	M (D)
inaturalist.org	88014063	N.C., Transylvania Co., Brevard	M (D)
inaturalist.org	88028727	VA., Tazewell Co., Tiptop	M (D)
inaturalist.org	88240800	VA., Washington Co., Mount Rogers	M (D)
inaturalist.org	88321857	VA., Giles Co., Jefferson National Forest	M (D)
inaturalist.org	89229846	W.V., Mercer Co., Camp Creek State Forest	M (D)
inaturalist.org	89861726	AR., Saline Co., Middle Fork Barrens Natural Area	F (V)
inaturalist.org	89934382	TN., Hamilton Co., Signal Mountain	F (D)
inaturalist.org	89961162	W.V., Nicholas Co., Summersville	M (D)
inaturalist.org	90702769	TN., Sullivan Co., Cherokee National Forest	M (D)
inaturalist.org	91310478	N.C., Transylvania Co., Brevard	M (D)
inaturalist.org	91765520	VA., Craig Co., Jefferson National Forest	F (D)
inaturalist.org	92238969	VA., Montgomery Co., Blacksburg	M (D)
inaturalist.org	92491893	TN., Sevier Co., Great Smoky Mountains National Park	M (V)
inaturalist.org	92521026	KY., McCreary Co., Daniel Boone National Forest	F (V)
inaturalist.org	93309170	TN., Pickett Co., Pall Mall	F (D)
inaturalist.org	93416210	AR., Faulkner Co., Conway	F (D/V)
inaturalist.org	93664247	N.C., Swain Co., Great Smoky Mountains National Park	F (D)
inaturalist.org	94298516	TN., Marion Co., Sequatchie	F (D)
inaturalist.org	94653381	AL., Etowah Co., Gadsden	F (D)
inaturalist.org	94837416	N.C., Alleghany Co., Blue Ridge Parkway	F (D)
inaturalist.org	95824677	VA., Montgomery Co., Jefferson National Forest	M (V)
inaturalist.org	95824711	VA., Montgomery Co., Jefferson National Forest	M (D)
inaturalist.org	96151922	OK., Muskogee Co. , Braggs	F (D)
inaturalist.org	96152611	OK., Muskogee Co. , Braggs	F (D)
inaturalist.org	97258542	TN., Sullivan Co., Bristol	F (D)
inaturalist.org	97364891	TN., Sullivan Co., Bristol	F (D/V)

Table 2. (cont.)

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