



Observations on *Anthocharis julia browningi* and *Anthocharis thoosa thoosa* Including Tension Zones near Nephi, Juab County, Utah

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ABSTRACT: Two visibly distinct taxa of the sara orangetip fly sympatrically and synchronically in a zone northeast of Nephi, Juab County, Utah. This paper discusses how these two taxa interact based upon six character sets—adult phenotype, adult male behavior, distribution, habitat, larval coloration, and pupal shape.

Introduction

There currently are different schools of thought regarding how many species there are in the *Anthocharis sara* complex (sara orangetip.) The purpose of this report is to discuss a small piece of that puzzle by sharing observations in the distribution, habitat, behavior, adults, and immature stages of *Anthocharis julia browningi* and *Anthocharis thoosa thoosa* (Fig. 1.) More importantly, this report will also provide a historical account of tension zones between these two taxa in Northern Utah as well as present a closer in-depth study carried out during the spring of 2009 near Nephi, Juab County.

Because of my research in progress on much of the *Anthocharis sara* complex, *browningi* is currently treated as a subspecies of the southern rocky mountain orangetip (*Anthocharis julia*) based upon larval and pupal characters as well as adult blend zones amongst this and other races of *A. julia*. At the same time, the southwestern orangetip (*Anthocharis thoosa*) is treated as a distinct species consistent with Opler (1999), because of adult, larval, and distributional differences with *A. sara*.



Fig 1. Adult reared series of *A. julia browningi* (left) and *A. thoosa thoosa* (right) from Northern Utah.

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Anthocharis julia browningi in Utah

General:

The Type Locality of *Anthocharis julia browningi* is City Creek Canyon, Salt Lake County, Utah; Skinner, 1905. Topotypical *A. j. browningi* is phenotypically very similar to other Wasatch Front populations of this butterfly. In both sexes, the dark markings are reduced or washed out as compared to *A. julia stella* and *A. julia julia*. The background color in males is off white with a slight yellowish tint that can be more pronounced in some individuals in Cache County populations. The background color in females is a light yellow. The discal cell bar is narrow, offset, and frequently disconnected with the bottom black apical border. This subspecies has been recognized as being a race of *A. sara*. However, consistent larval differences between this and other races of *A. sara* and *A. thoosa* coupled with consistent larval similarities with ssp. *julia*, *sulfuris*, *stella*, *flora*, and *alaskensis*, place *browningi* as a subspecies of *julia*.

Utah Distribution and Habitat:

In Utah, *browningi* flies throughout most of the Wasatch Range from Box Elder to Juab County as well as the Bear River Range found in the extreme northeastern corner of the state. Intermediates between *browningi* and nominotypical *julia* have been taken by Alan Myrup in the Uinta Mountains. *A. j. browningi* also flies in the San Pitch Mountains of Juab County and in Carbon County in Price Canyon.

Bionomics:

Host plants for *browningi* include many rock cresses including *Arabis sparsiflora* var. *subvillosa*, *Arabis perennans*, *Arabis microphylla*, *Arabis drummondii*, and *Descurainia pinnata* (tansy mustard.) Oviposition has also been observed on *Arabidopsis thaliana*. Larvae will readily accept *Isatis tinctoria* (dyars woad) in the lab. With the exception of dyars woad, most of these larval host plants can be found either between rocks (*Arabis* spp.) or taking refuge under trees (*Descurainia pinnata*.)

The ova are white turning orange after 24 hours; hatching in about 4-5 days. First instar larvae are cannibalistic and will consume other pierid ova if it finds them. The young first instar larva is light colored with a dark head. Second and third instar larvae of *browningi* are greenish. The fifth instar larva is light green and is pictured below (Fig. 2) and darkens as it approaches pupation. Hibernation is as pupa.



Fig 2. Last instar larva of *Anthocharis julia browningi* from the Type Locality located at City Creek Canyon, Salt Lake City, Salt Lake County, Utah.

Anthocharis thoosa thoosa in Utah

General:

The Type Locality of *Anthocharis thoosa thoosa* is Mokiak Pass, Mojave County, Arizona; Scudder, 1878. The amount of dorsal yellow coloration in females seems to be greater with southern Utah populations as compared to northern ones. This butterfly is at home in great basin pinyon-juniper habitat where males patrol up and down ravines or dry washes occasionally leaving the gully to investigate nearby *Juniperus osteosperma* trees in search of females. Females can be found flying in association with Juniper trees either resting or ovipositing on one of its larval host plants, *Descurainia pinnata*, which take refuge under or near the same Juniper trees. Females also oviposit on rock cresses from the genus *Arabis*.

Utah Distribution and Habitat:

The general distribution of *thoosa* in Utah ironically forms a general U shape surrounding and circumventing the Wasatch Range and the distribution of *browningi*. In the northwestern part of the state, *A. thoosa* flies in Utah's Great Basin and West Desert Ranges south to Utah's Dixie located in the southwestern corner of the state. Populations then extend east towards the four corners region of the state and then north again towards the East and West Tavaputs Plateau. Eastern Utah populations are designated as *Anthocharis thoosa colorado*. See Scott and Fisher (2008).

Current studies of adults, larvae, and pupae of topotypical *colorado* from McElmo Creek, Montezuma County, Colorado, may place it as a junior synonym to nominotypical *thoosa*. To date, my furthest documented northeastern population of *thoosa* is Slaughter Canyon, near Sunnyside, Carbon County, Utah. As you head north, populations of this butterfly from Eastern Utah are replaced by *Anthocharis julia* in the Uinta Range in Summit and Daggett counties in the NE section of the state.

Bionomics:

Host plants for *A. t. thoosa* include *Descurainia pinnata*, *Arabis perennans*, *Arabis holboelli*, and other species of *Arabis*. The young first instar larva is light orange colored with a dark head. Second and third instar larvae of *A. thoosa* are greenish. The fifth instar larva is green and is pictured below (Fig 3). Hibernation is as pupa. Because the butterfly flies in more or less xeric habitat, most pupae will bypass emergence after one year and will emerge during the second, third, or fourth year of diapause.



Fig 3. Last instar larva of *Anthocharis thoosa thoosa* from the Type Locality located at Mokiak Pass, Mohave County, Arizona.

Differences in Immatures

Larvae:

Because last instar caterpillars of many species of the pierid tribe Euchloini change color as they advance through their last instar, it is imperative that any larval coloration comparisons between taxa be made from the same timeframe after a fourth instar larva molts to fifth instar. For my larval comparison studies, I compare larvae that have been fifth instars for 54 - 60 hours because this interval demonstrates the most visible, consistent differences to the naked eye.

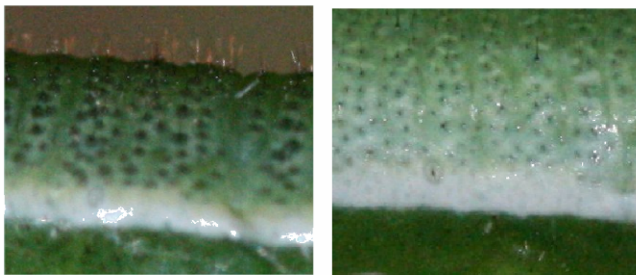
Fifth instar *browningi* larvae have a broader white lateral stripe and the ground color is lighter green as compared to *thoosa* (Fig. 4.) At the same time, to the naked eye, the transitional color change from the white lateral strip to the green base color of a *browningi* larva is much more subtle as compared to *thoosa* larvae. *A. t. thoosa* larvae show larger green pinacula surrounding the setae or tubercle giving the larva the appearance of being a much darker green to the naked eye. The pinacula of *browningi* fifth instar larvae also enlarge and darken as the larva progresses towards pupation; but do so 12 to 24 hours later.

These consistent differences between last instar caterpillars of these two taxa are also applicable when comparing other subspecies of *A. thoosa* to *A. julia*. (This is not just a consistent phenomenon in comparing *thoosa* to *browningi*.) Interestingly, coloration of fifth instar larvae of topotypical *A. sara sara* and topotypical *A. sara pseudothoosa* are consistently a much darker green above the white lateral stripe than those of *A. julia* or *A. thoosa*; irrespective of the darkening of the pinacula surrounding the setae.

Pupae:

The shape of *browningi* pupae are consistently different to those of *thoosa* even though color differences, whether green or tan are not reliably consistent. The main difference is that the *browningi* pupal cone bends back whereas those of *thoosa* are erect and upright (Fig. 4.) These pupal differences are only consistent on a population or subspecific level; but, not necessarily a specific level. For example, pupae of *A. julia sulfuris* and *A. julia flora* tend to have pupal cones that bend back and are longer than those of *A. julia julia*, *A. julia browningi*, and *A. julia stella*. (Pupal cones of *A. julia alaskensis* are erect; similar to *A. thoosa*.) At the same time, pupal cones of *A. thoosa inghami* are similar in shape to those of *A. thoosa thoosa*; but, the cone is slightly longer and sometimes slightly tilted back.

Cross section Comparison of Fifth Instar Larvae



A. thoosa thoosa

A. julia browningi

Comparison of Pupae



A. julia browningi

A. thoosa thoosa

Fig. 4. Comparison of the mid segments of same-age fifth instar larvae (left) and pupae (right) of *A. t. thoosa* and *A. j. browningi*. Oddly enough, color larval differences appear more noticeable to the naked eye or when you squint your eyes—which is how I noticed their differences in the first place.

Differences in Adult Characters

There are a few contact or tension zones of different taxa within the *Anthocharis sara* complex including but not limited to *A. sara* and *A. julia stella* near Fresno Dome, Madera County, California (Ken Davenport, personal communication), *A. sara sara* and *A. julia stella* in Northern California—see Geiger and Shapiro (1986), *A. sara* Siskiyou segregate and *A. julia* nr. *stella* at Klamath River Canyon, Klamath County, Oregon (Andy Warren, personal communication), as well as *A. julia* and *A. thoosa colorado* near the Four Corners Region—see Scott and Fisher (2008). Scott also references several other contact zones in California, Colorado, and New Mexico.

The best opportunity to visibly note possible intermediates between two sympatric taxa was to select those that visibly looked the most distinct from each other. *A. julia browningi* and *A. thoosa thoosa* seemed to fit these criteria. (See table and Figure 5 below.)

Distinguishing Adult Characters	<i>Anthocharis julia browningi</i>	<i>Anthocharis thoosa thoosa</i>	<i>A. julia browningi</i> x <i>A. thoosa thoosa</i>
Ground Color in Males	Off White	White	White
Ground Color in Females	Light Yellow	White with some Yellow	Unknown
Thickness of Discal Cell Bar	Narrow	Wide	Intermediate
Coloration of Orange Tip	Bright orange	Brighter Orange	Intermediate
Ventral Hindwing Mottling	Medium Green	Dark Green/Gray	Intermediate
Dorsal Forewing Apical Black Borders	Somewhat faded	Dark	Dark
Alignment of Orange Tip to Discal Cell bar	Offset	Slightly Offset (but hard to tell based upon thickness of bottom black margin)	Offset
Connecting of Bottom Black Margin to Discal Cell Bar	Usually Disconnected	Usually Connected	Barely connects / Intermediate

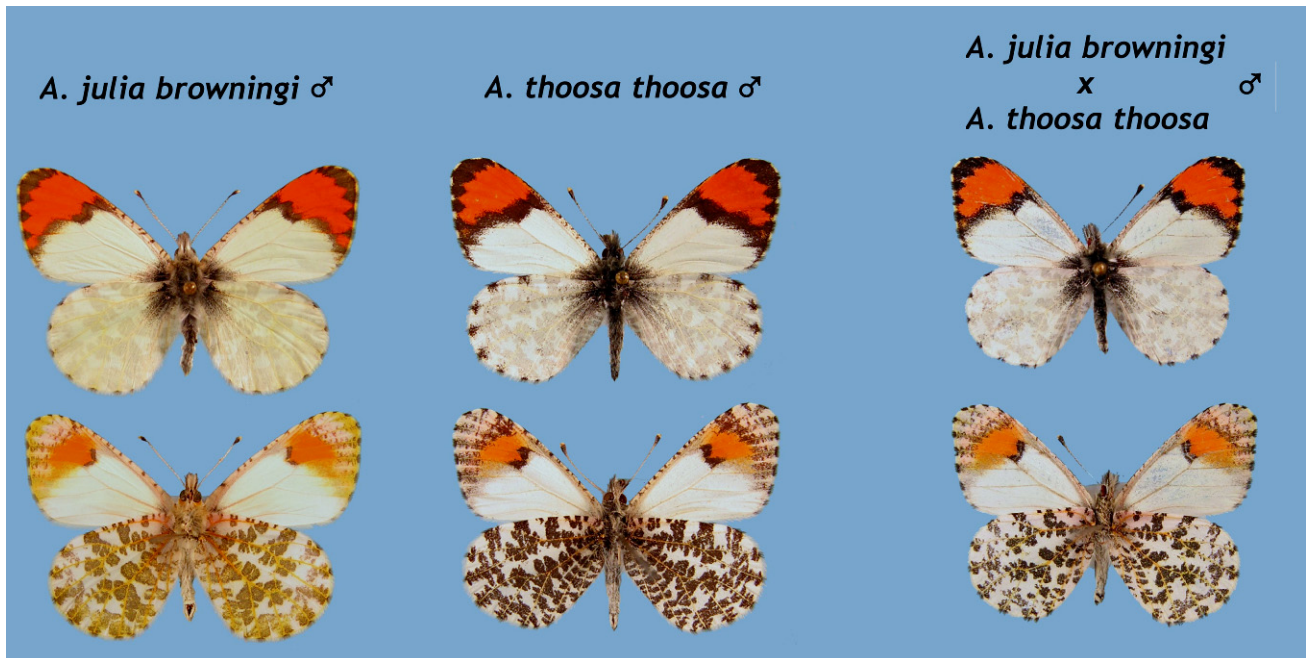


Fig 5. Dorsal and ventral examples of an *Anthocharis julia browningi* male (left), *Anthocharis thoosa thoosa* male (middle) and hybrid male (right) from 2009 study area in Juab County, Utah.

Previous Northern Utah Contact Zones

Willow Creek; 3.0 miles ESE of Mona, Juab County

My personal interest in discovering contact zones of *A. j. browningi* and *A. t. thoosa* was piqued on 7 May 1997, when Bob Hardbarger discovered both taxa flying together at Willow Creek; 3.0 miles east of Mona, Juab County, Utah. Three days later, Bob, Steve Sommerfeld and I returned to Willow Creek and confirmed Bob's finding when I vouchered several *Anthocharis* males—some of those were *thoosa* and the rest were *browningi*. (I do not have exact numbers as those specimens were later sent to Paul Opler for research and study.) However, we did not locate any apparent intermediates or hybrids on that day.

Subsequent trips to Willow Creek in 2006, 2007, and 2008 were somewhat frustrating as the dominant taxon was *A. j. browningi*. All males and females collected during this timeframe were *browningi*. However, I also collected and reared several eggs and caterpillars to adult—all *browningi*; except two were *thoosa*. I obtained no intermediates from reared material.

Deep Creek Canyon; 3.6 miles South of Levan, Juab County

On 27 May 1999, Steve Spomer, Jim Reiser, and I found mostly *A. t. thoosa* and a few *browningi* flying together at Deep Creek Canyon, Juab County. Of the males I collected that day, one appeared to have intermediate characters between *thoosa* and *browningi* (Fig. 6.) The rest were parentals. We also found a population further up the canyon where patrolling males were *browningi*.



Fig 6. Male of an apparent hybrid of *Anthocharis thoosa thoosa* x *Anthocharis julia browningi* taken on 27 May 1999 at Deep Creek Canyon, Juab County, Utah.

Gardner Creek; 2.7 miles NNE of Nephi, Juab County

Because *A. j. browningi* was the dominant taxon at Willow Creek in 2007, I decided to investigate Gardner Canyon—which was typical “*thoosa*” habitat located 2.5 miles south of Willow Creek and 2.7 miles NNE of Nephi. On 14 Apr 2007, because it was a relatively dry year for that region, I only collected two *thoosa* males, 1 *thoosa* female, six ova on *Descurainia pinnata* (which were reared to adult and turned out to be *thoosa*) and one apparent hybrid (Fig 7); but did not observe or collect any parental *browningi*.

In a tension zone, the key to finding *thoosa* and *browningi* flying sympatrically may have a lot to do with habitat. The mouth of this canyon, even though officially part of the Wasatch Mountains, was typical Great Basin habitat ubiquitous with *Artemisia tridentata*, *Juniperus osteosperma* and *Purshia mexicana*.



Fig 7. Male of a possible hybrid of *Anthocharis thoosa thoosa* x *Anthocharis julia browningi* taken on 14 Apr 2007; Gardner Canyon; 2.7 miles NNE of Nephi, Juab County, Utah.

Rock Canyon; 2 miles East of Provo, Utah County

On 17 April 2004, after a Utah Bug Club meeting held at the Monte L. Bean Life Science Museum at BYU, I took students on a field trip and collected several males of *A. j. browningi* as well as 2 males of *A. t. thoosa* flying in what was previously considered to be a “*browningi*-only” population in Rock Canyon, just east of BYU in Provo, Utah County, Utah. These two *thoosa* males were examined and appeared to be pure parental *thoosa* without any visible evidence of gene exchange with *browningi*.

2009 Study Area

During the winter of 2009, because I located two study areas within 2.5 miles of each other where either one taxa or the other dominated in northeastern Juab County, I decided to take a closer look at other canyons, draws, and/or gullies between these two areas where I might find both taxa flying sympatrically and synchronically.

I decided to study three small accessible canyons—Birch Creek, Little Birch Creek, and an unnamed draw several hundred feet south of Little Birch Creek. These study areas (Fig. 11) were almost nestled between Willow Creek to the north (where *browningi* dominates) and Gardner Creek to the south (where *thoosa* dominates.)

Birch Creek; 3.7 miles SSE Mona; 4.0 miles North of Nephi, Juab County

On 20-21 Apr 2009, I visited Birch Creek and found several *A. t. thoosa* males patrolling along the base of the canyon flying in typical *Juniperus osteosperma* habitat at an elevation of 5400 feet (Fig. 11.) As I hiked about 1,000 feet to the east up Birch Creek to an elevation of 5585 feet, I noted the subtle difference in habitat change where oaks and maples replaced Juniper trees. It was here where I collected three patrolling *browningi* males and one apparent hybrid male.

About fifty feet away from where the males were flying, I collected a female (Fig. 8.) My initial impression was that she was a hybrid based upon her proximity to *browningi* males, smaller discal cell bar than typical *thoosa*, faded dark markings (which turned out to be the result of age), and weak flight. However, of the 25 eggs she laid; 16 were reared to pupae where larvae and pupae conformed to *thoosa*; without showing any noticeable *browningi* characters.

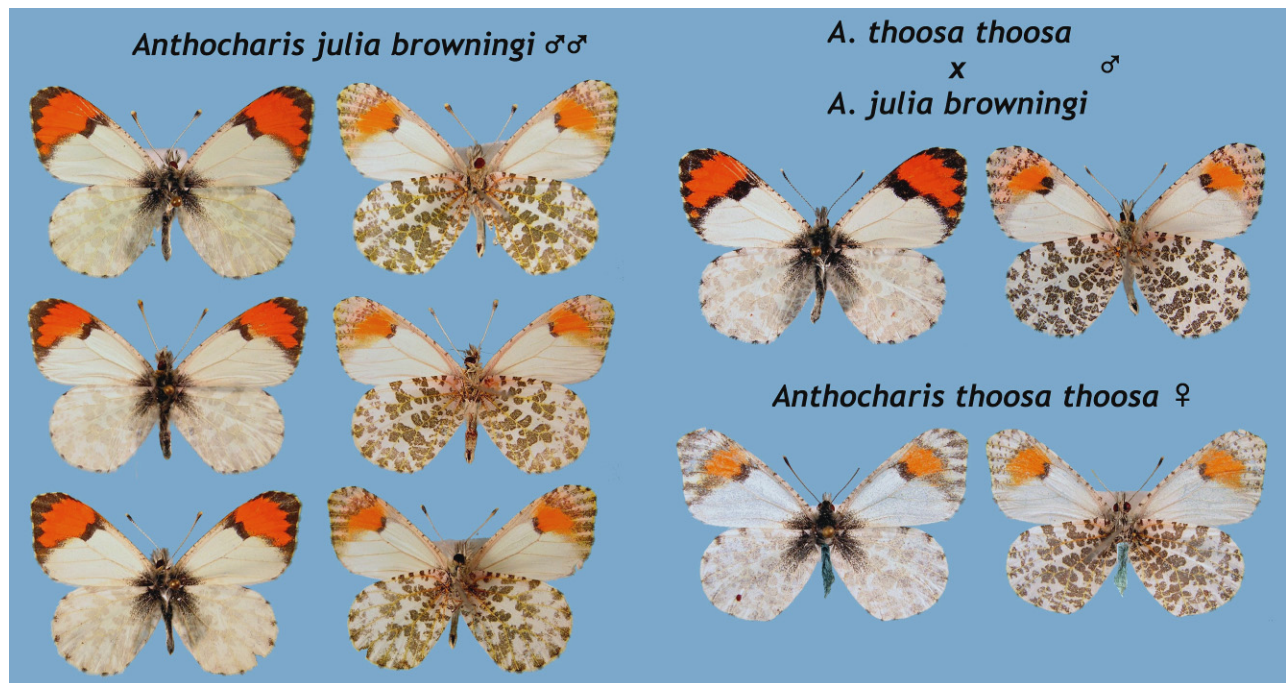


Fig 8. Three *A. j. browningi* males (left); one hybrid male and one faded/worn female *A. thoosa thoosa* (right) collected at Birch Creek on 20 Apr 2009.

Little Birch Creek; 4.2 miles SSE Mona; 3.6 miles North of Nephi, Juab County

Although I was unable to locate *A. t. thoosa* and *A. j. browningi* flying in the exact same spot at Birch Creek, I was able to collect 4 male *browningi*, 9 male *thoosa*, and 4 apparent male hybrids patrolling sympatrically and synchronically at Little Birch Creek at an elevation of 5400 feet (Fig. 9.) This might have been the case because this ravine was so narrow that it didn't really separate *browningi* from *thoosa* habitat.

It was interesting to note the behavioral differences in the patrolling males at Little Birch Creek. *A. j. browningi* males tended to fly much slower than *A. t. thoosa* males. Also, *thoosa* males left the ravine from time to time to investigate nearby Juniper trees in search of females; before scampering back to the ravine to patrol. Oddly enough, it seemed to me that the behavior of the hybrid males was either slow and deliberate (*browningi*) or fast and scampering (*thoosa*.)

Approximately 250 feet below the ravine, I collected two female *thoosa* flying amongst the Juniper trees which laid eggs in the lab on native host *Descurainia pinnata*. Both the larvae and pupae of those immatures were analyzed as *thoosa* without any visible evidence of *browningi* immature traits.

I had hoped to find ova on several plants of *Arabis perennans* growing in the outcroppings near the ravine where the males of both species were flying; but didn't find any pierid immatures on them; including those of *Pontia sisymbri nigravenosa*.

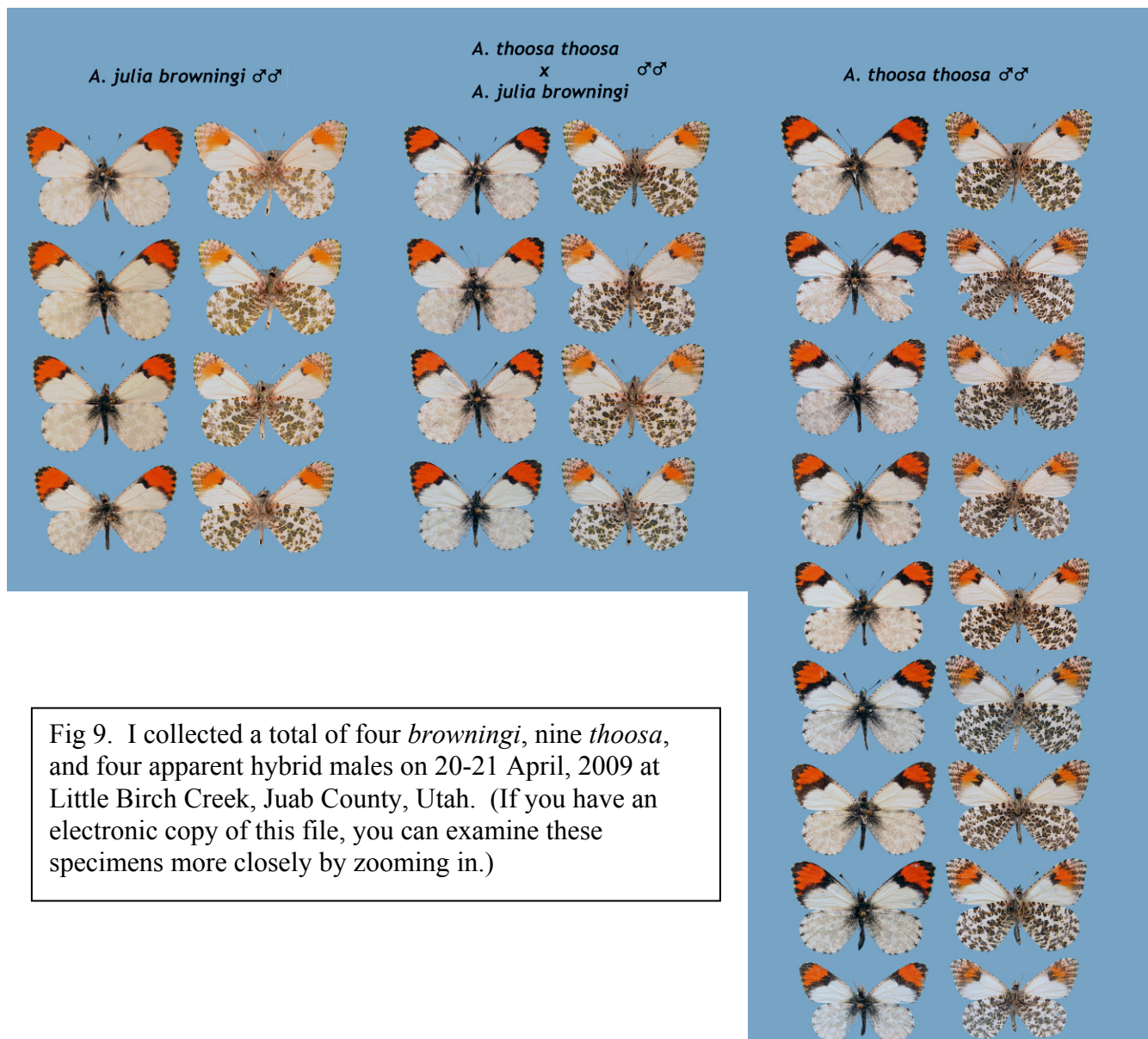


Fig 9. I collected a total of four *browningi*, nine *thoosa*, and four apparent hybrid males on 20-21 April, 2009 at Little Birch Creek, Juab County, Utah. (If you have an electronic copy of this file, you can examine these specimens more closely by zooming in.)

Unnamed Draw; 4.3 miles SSE Mona; 3.4 miles North of Nephi, Juab County

I didn't spend as much time in the draw located roughly 0.1 miles south of Little Birch Creek; but, I was able to collect 1 male *A. thoosa thoosa* and 1 male *A. julia browningi* flying there (Fig 10.)

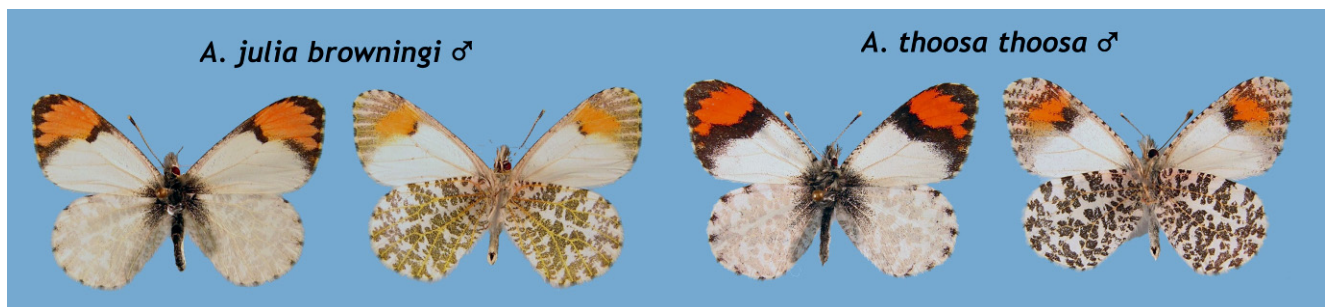


Fig.10. Male *browningi* and *thoosa* collected at the unnamed draw located 0.1 miles south of Little Birch Creek

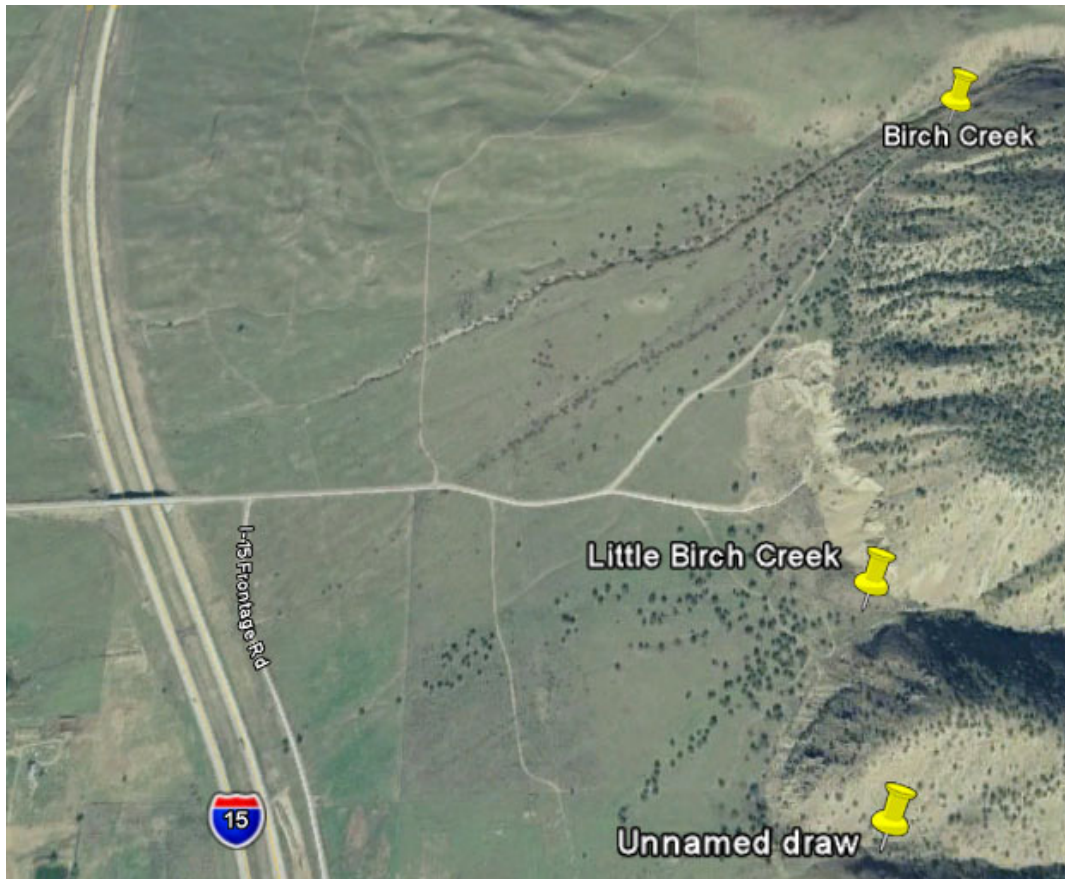


Fig. 11. Aerial view of 2009 research area including Birch Creek, Little Birch Creek, and an unnamed draw; all located ENE of Nephi, Juab County, Utah.

Review

During my 2009 study of contact zones of *Anthocharis julia browningi* and *Anthocharis thoosa thoosa* between Mona and Nephi, Juab County, Utah, I noted that of the 23 collected males, 43.5 percent were parental *A. t. thoosa*, 34.8 percent were parental *A. j. browningi*, and 21.7 percent showed apparent intermediate traits. I also collected three females who were parental *thoosa* where all offspring and emerged adults showed notable *thoosa* characters; although at press time, these have not yet been spread.

The fact that the percentage of hybrids in this study area is roughly 22 percent with the rest showing parental traits coupled with a narrow overlap in distribution, consistent differences in habitat preference, male adult flying behavior, larval coloration characters and pupal shape characters, suggest that subspecies *thoosa* and *browningi* belong to different species.

Also, outside of noticeable adult characters, there may be other factors that might show a higher percentage of gene exchange using better available technologies such as electrophoresis (Geiger & Shapiro, 1986), or nuclear dna studies.

Acknowledgments

Special thanks are given to Jon Pelham, Dr. Andy Warren, Paul Opler, and Harry Pavulaan for reviewing this paper and to Norbert Kondla for his help with plates. Also, because of information shared with James A. Scott in *Papilio* #18, I did not reference Scott who was referencing me regarding larval studies; but have referenced original material from James A. Scott. Acknowledgment also goes to COL. Clyde F. Gillette, who has proven records of either *browningi* or *thoosa* in every county in Utah.

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