

## SULPHUR BUTTERFLIES OF THE *Colias alexandra* COMPLEX IN ALBERTA

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The *Colias alexandra* complex consists of butterfly populations that are widely distributed in western North America (see Ferris or Scott for a range map).<sup>23,53</sup> A substantial literature has developed on this insect and the various taxa that have been treated as part of this complex in the contemporary literature have been the subject of "taxonomic football."

Ferris provides a synonymy.<sup>23</sup> The purpose of this paper is to review what has been published about this complex in Alberta, describe the situation that actually exists in Alberta, and present an argument for recognizing *Colias alexandra* (Queen Alexandra Sulphur) and *Colias christina* (Christina Sulphur) as distinct species.

The name *Colias alexandra* is used here in the qualified sense of Kondla as the best name available.<sup>36</sup>

**Historical Taxonomy Summary** The taxa relevant to Alberta were described by W. H. Edwards in 1863 and 1872, Klots in 1935, and Bowman in 1942.<sup>7,13,14,15,34</sup> In 1863, the taxon *alexandra*<sup>14</sup> was described from material collected in the region

west of Denver, Colorado.<sup>9</sup> Later that year, *Colias christina* was described as a new species with type material from "the portage of the Slave River."<sup>14</sup> Kondla (in press) has clarified this type locality as being the vicinity of Mountain Rapids, Slave River, Alberta. Edwards introduced the name *astraea* as a new species

based on a single male collected near Yellowstone Lake.<sup>15</sup>

Klots added the name *krauthii* to the literature as a subspecies of *christina*.<sup>34</sup>

The taxon *alberta* was described as a subspecies of *eurytheme*.<sup>7</sup> Ferris viewed it as a hybrid situation, while Miller and Brown treated it as a synonym for *eurytheme*.<sup>21,45</sup> I side with Hovanitz and Masters in treating it as a synonym for *C.*

**"one would be successful if they attached the name alexandra to a yellow male, flipped a coin and called a yellow/orange or mostly orange male astraea, christina or krauthii, and threw a planning dart at a female and called it a Colias species unknown."**

*christina*.<sup>30,39,41</sup>

Except for a listing as a subspecies of *C. occidentalis*, the name *alexandra* has survived the attention of various writers essentially unmolested.<sup>44</sup> The synonymy provided by Ferris shows that fate was not kind to the other taxa.<sup>23</sup> It did not take long for Stecker to align *christina* with *pepidne*. In 1878, Skinner moved

*christina* back to species status, where it remained until the early 1960s. At this time, McHenry associated it with *C. occidentalis* and Dos Passos shifted *christina* to a subspecies of *alexandra*.<sup>12</sup> *Astraea* survived as a species in the literature until 1898 when Skinner placed it as a subspecies of *christina*. In 1949, Holland reverted to species status for *astraea*. Again, in the 1960s strange things happened. *Astraea* was variously placed as a subspecies of *occidentalis*, *scudderi* and *alexandra*. *Krauthii* has a somewhat cleaner history. It was not tinkered with for some 20 years, when it was moved to a subspecies of *occidentalis* and then *alexandra*.

The mass migration of *christina*, *astraea* and *krauthii* to their status as subspecies of *alexandra* appears to originate from the treatment of Ehrlich.<sup>17</sup> Dos Passos made these assignments explicit.<sup>12</sup> I have been unable to find any published arguments or data to support this arrangement.

This chapter of the story therefore leaves us in a situation where the conventional wisdom as reflected in the literature places taxa relevant to Alberta in the species *Colias alexandra*.

**Characteristics of the Taxa** Additional murkiness and confusion confront naturalists and lepidopterists when attempting to do something as apparently simple as using the literature to identify and attach some names to Alberta specimens. In random order, here is a smattering of what one finds when trying to attach descriptions to the names *alexandra*, *christina* and *astraea*:

#### *alexandra*

- Ferris - yellow (concolorous with

the ground colour) dorsal spots on the dorsal surface of the secondaries in the males;<sup>22</sup>

- Pyle - some northern populations are orange; forewing yellow fringed; brighter yellow spot in hindwing cell; narrow black forewing and hindwing border; unrimmed cell spot on ventral hindwing; female yellow or white; refers to Alberta populations as "yellow populations"; wingspan 3.8-4.8 cm;<sup>51</sup>
- Royer - ventral hindwing with much reduced discal spot (always poorly outlined); narrow dorsal borders; females usually have no dorsal hindwing border at all; white females occur; 4-5.5 cm wingspan;<sup>52</sup>
- Brown - pale yellow upperside and cool, pale greyish green on ventral hindwing; albino females are rare; female black borders vague but rarely absent; straight outer margin of forewing; yellow wing fringes;<sup>8</sup>
- Ferris and Brown - male bright lemon yellow and female warmer yellow; ventral hindwing dusted with greenish grey scales; ventral hindwing discal spot unrimmed and usually quite small; white females occur in some colonies;<sup>24</sup>
- Howe - light bright yellow above, deepening to a warmer yellow outward to the dark border, especially of the hindwing; fringes yellow; no orange discal spot above; ventral hindwing grey-green to slaty grey with no rim on discal spot;<sup>33</sup>
- Scott - ventral hindwing is greyish with a silver spot lacking a rim; fringes yellow; wings yellow;<sup>53</sup>
- Tilden and Smith - referring generally to yellow subspecies: dorsal

bright yellow in male, paler near wing bases; black border narrow, crossed by yellow veins; dorsal forewing cell spot usually small; dorsal hindwing discal spot inconspicuous but present; female yellow, occasionally white; ventral: hindwing greenish grey in both sexes; discal spot white with no ring; wing edge yellow, seldom pink.<sup>56</sup>

### *christina*

- Howe - presumably all orange but cannot be sure;<sup>33</sup>
- Scott - orange on outer half of dorsal hindwing and outer 2/3 of dorsal forewing; ventral hindwing often has submarginal spots and rarely a central satellite spot;<sup>53</sup>
- Hooper - females more yellow and some of them albinistic, their hindwings almost or entirely lacking black margins; males orange above with a wide band of sulphur yellow across the base of each wing; silver spot in middle of hindwing beneath;<sup>29</sup>
- Ferris - somewhat variable in phenotype, considerable colour variation occurs in both sexes; some males completely orange and some females white form; dorsal wings of 'classical' male basally yellow and distally orange, colour transition abrupt; dorsal female wings generally yellow with an orange blush;<sup>23</sup>
- Masters - males extremely regular in appearance while females are extremely variable; 36 females from near the type locality were roughly 1/3 orange, 1/3 yellow, 1/3 white; female black bands absent to complete.<sup>42</sup>

### *astraea*

- Ferris and Brown - males vary from warm yellow through orange and yellow to orange with a small amount of yellow basally; orange dorsal hindwing discal spot; females vary from pure white to overwashed with pink and orange;<sup>24</sup>
- Howe - variously mixed yellow to orange populations; yellow individuals, often predominant locally, have an orange discal spot on the dorsal hindwing;<sup>33</sup>
- McDunnough - white females; ventral hindwing discal spot not entirely constant, can be single or double;<sup>43</sup>
- Gerould - extreme variability in females; "most bewildering variety of colours," "wonderfully variable species";<sup>27</sup>
- Hovanitz - variation ranging from full yellow to bright orange in Waterton area;<sup>32</sup>
- Hovanitz - frequency of white females about 70%;<sup>30</sup>
- Scott - the description given under *christina* is applied to Alberta in total;<sup>53</sup>
- Tilden and Smith - usually a blend of orange and yellow; referring generally to orange subspecies; dorsal: "Male distinctively two-toned, orange with yellow at wing bases and costa. Female duller orange, usually heavily marked with dark borders and dark veins"; ventral: "dull orange to greenish grey in both sexes; often much dark overscaling. HW discal spot usually ringed."<sup>56</sup>

**Table 1. WHITE VS. YELLOW/ORANGE FEMALES FROM VARIOUS ALBERTA LOCALITIES**

Location	yellow/ orange	white	total	% white
Ft. Smith-Fitzgerald	73	0	73	0
Pocahontas, 1948	8	21	29	72.4
Pocahontas, 1947	18	24	42	57.1
Mountains (unspecified)	3	13	16	81.3
Banff	66	39	105	37.1
Calgary	25	20	45	44.4
Calgary, 1948	1	1	2	
Macleod Junction		1	1	
Didsbury	14	12	26	46.2
Waterton Lakes	4	2	6	33.3
Laggan [Lake Louise]	23	13	36	36.1

For specific Alberta locations, here is what has been written:

- Masters - "A series of 36 males and 36 females of topotypical northern Alberta *Colias christina* (at Carnegie Museum) displayed slightly smaller size. Alberta males had a median forewing length of 24 mm, with the average slightly more than 24 mm; the range was between 22 and 27 mm. Alberta females had a median forewing length of 26 mm, with the average being slightly less than 26 mm; the range was between 19 and 29 mm; of the Alberta sample of nominate *christina*, only 27.8% of 36 females were orange, while 30.6% were yellow and 41.8% were white; ... the Alberta sample of 36 females contained 19.4% with immaculate wings, 44.4% with apex bands only, 22.2% with outer bands only and 13.4% with complete bands";<sup>42</sup>
- Hovanitz - provided data on the prevalence of white vs. yellow/orange females in samples from various Alberta localities (Table 1);<sup>30</sup>
- Ferris - map assigning most of eastern 2/3 of province to *christina* with a minor intrusion of *astraea* on

the prairies and the rest of the province to intergrade forms: "Southern Alberta appears to represent a complex blend zone region. In the area from Calgary to Banff and east of the Rocky Mountains, specimens can be taken which represent *alexandra*, *astraea*, *christina* and *krauthii*. It is frequently possible to collect two or three good 'subspecies' at the same locality"; "Pure orange races of *alexandra* have been reported from the area near ... Pocahontas, Alberta. ... the Alberta specimens superficially resemble *krauthii* but are considerably smaller";<sup>22</sup>

- Ferris - "blend zone areas where all phenotypes can be collected in the same meadow (such as the Kananaskis Forest region south of Banff"; referring to *astraea*, "This phenotype occurs in southern Alberta (in the foothills west of Calgary and north to the Banff region)"; includes a map showing *alexandra* complex as being absent from much of northeastern Alberta (including the type locality of *christina*);<sup>23</sup>
- Hovanitz - in reference to waterways and areas to the north, "Toward the middle of July, *C.*

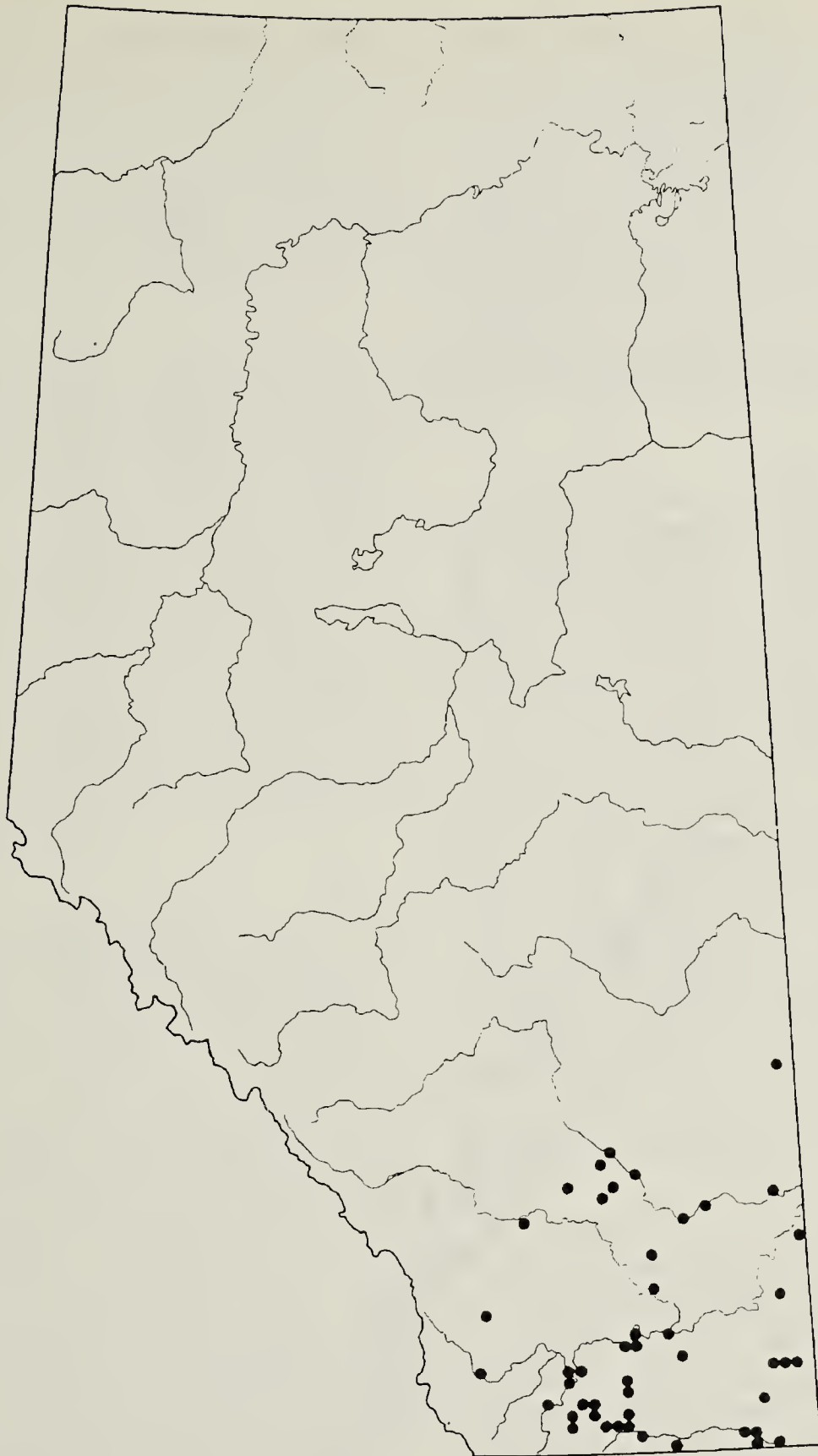


Figure 1. DISTRIBUTION OF *Colias alexandra* IN ALBERTA.

- *gigantea* adults are replaced largely by those of *C. christina*"; in reference to Jasper and vicinity, "*Colias christina* occurs only below 5,000 feet in elevation and is most common in late July";<sup>31</sup>
- Hovanitz - "Populations ... from the north and east of [Waterton Lakes area] are generally orange or orange-yellow in the male";<sup>32</sup>
- Wolley Dod - "The females show most extraordinary variation. It is hard to find two alike";<sup>58</sup>
- Wolley Dod - referring to the area around Calgary, "scarcely any two (series of 30) even nearly alike in either colour or markings, much variation in male border."<sup>59</sup>

As well the following papers report

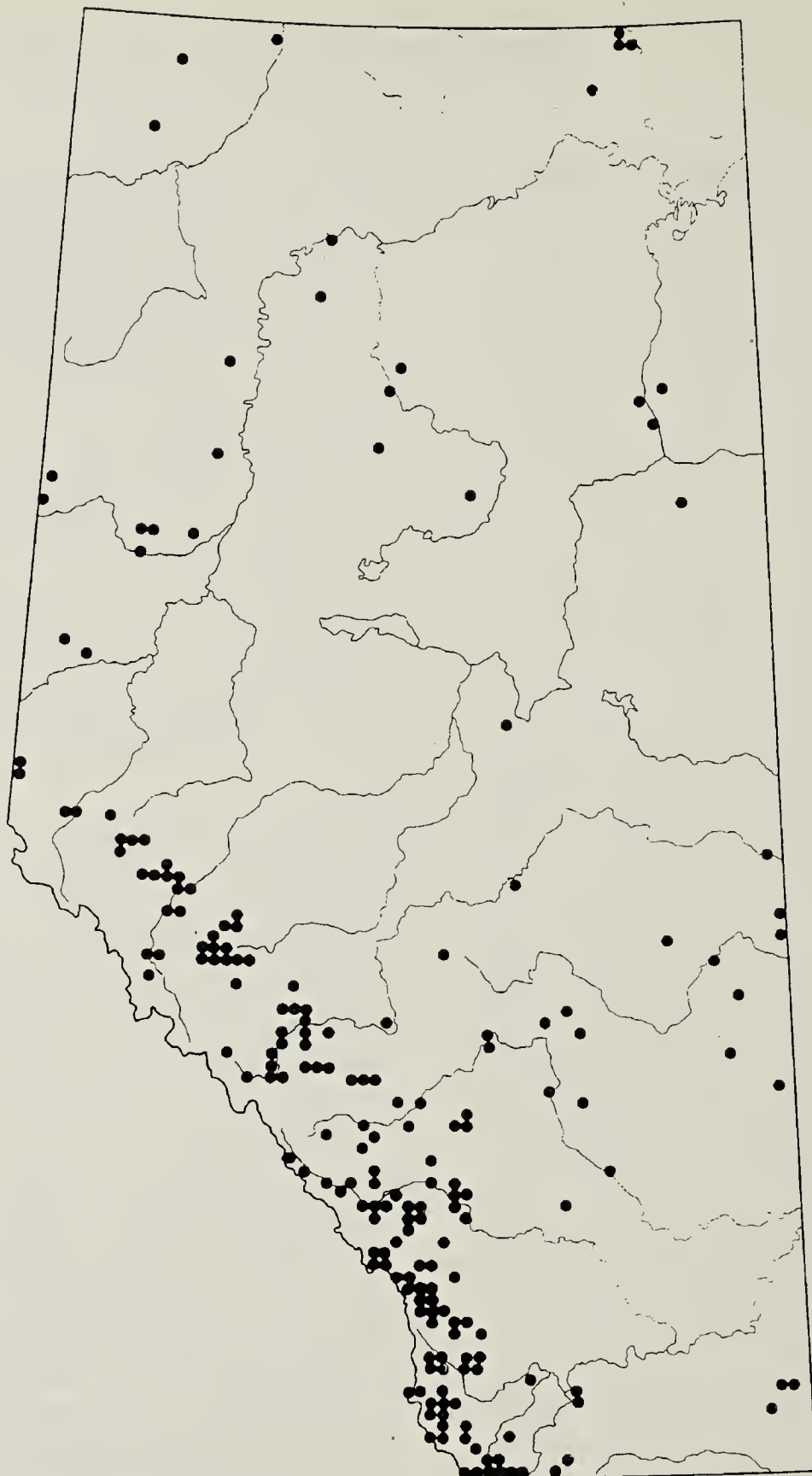


Figure 2. DISTRIBUTION OF *Colias christina* IN ALBERTA.

the occurrence of *christina* and *alexandra* at various Alberta locations: Anderson<sup>1</sup>; Bird<sup>2</sup>; Bird *et al.*<sup>3</sup>; Bowman<sup>4,5,6,7</sup>; Cary<sup>10</sup>; Case and Bird<sup>11</sup>; Eff<sup>16,17,18,19,20</sup>; Ferris<sup>21,22,23</sup>; Geddes<sup>25,26</sup>; Hovanitz<sup>30</sup>; Klots<sup>34</sup>; Kondla<sup>35,36,37,38,39</sup>; McDunnough<sup>43</sup>; Nicholl<sup>46</sup>; Pinel<sup>47,48,49</sup>; Pinel and Kondla<sup>50</sup>; Thormin, Kondla and Bird<sup>55</sup>; Whitehouse<sup>57</sup>; and Wolley Dod.<sup>58,59,60</sup>

Most reasonable people would look at such inconsistent and contradictory descriptive material (along with the supporting illustrations) and derive, for example, the following conclusions: males are yellow or orange or something in between; females are white or yellow or orange or some combination thereof; the black wing borders are narrow or wide; populations are variable in ap-

pearance or they are not; the hindwing underside may or may not have submarginal spots; the ventral hindwing dorsal spot may be orange or it may not; the ventral hindwing discal spot maybe silver or white and it may or may not have a satellite spot, etc.

Curious indeed. One could suppose that various authors are describing different species rather than a single species. Using the existing literature on what appearance (phenotype) is associated with various names, one would be successful if they attached the name *alexandra* to a yellow male, flipped a coin and called a yellow/orange or mostly orange male *astraea*, *christina* or *krauthii*, and threw a planning dart at a female and called it a *Colias* species unknown.

Fortunately all is not lost. Both species and subspecies names usually have a spatial (geographical) dimension and a phenotypic dimension. That is to say, by knowing where you caught, photographed or saw a critter, you can eliminate names that have a traditional geographic definition remote from the record under consideration. For example, a bug that looks like *krauthii* caught in southwestern Alberta obviously is not *krauthii* since this name is spatially defined as referring to bugs in the Black Hills of South Dakota. You can feel safe in knowing that a *Colias* from southwestern Alberta with at least some orange on it is probably *astraea* — unless of course it is *eurytheme* or *canadensis* or *meadii*.

Confused or misled? Of course! This statement is not a reflection on the work of many people who have researched the *alexandra* complex. It is an example of biological and taxonomic research at work. Field work;

measurements; descriptions; publication of data; publication of opinions and speculation to foster more data collection; interpretation based on differing concepts and researcher backgrounds; conflicting interpretation based on differing data sets, analytical techniques, and spotty data sets, etc.; the list of reasons for disparate statements goes on and on.

### **A Local View of the Alberta Situation**

I became suspicious about the reported status of the *Colias alexandra* complex in 1978 when I caught a specimen of that species near Standard.<sup>35</sup> At that time *alexandra* was unreported in the literature for any specific Alberta location. The authoritative treatment of the day (Ferris) clearly indicated that I should have caught *christina* but that I could expect specimens that would be equally at home under the names *astraea*, *alexandra* or *krauthii*.<sup>22</sup> With a bit of additional field research around the province it soon became obvious that reality was in fact not as reported in the literature.

My personal work in Alberta over a 20 year period was supplemented by an exhaustive literature search that has yielded close to 400 references on Alberta butterflies and also by data collected by others. Particularly significant data have been provided by C.D. Bird, G. Hilchie, E.M. Pike, H. Pinel, S. Shigematsu and F.A.H. Sperling. The complete data base from which information was used represents contributions from nearly 300 individuals.

Regardless of which names will be shown to be correct by further research, there definitely appear to be two distinct species in the province. Figure 1 shows the distribution I have been able to document for *C.*

*alexandra* and Figure 2 shows the situation for *C. christina*.

By comparing these distribution maps with a map of ecoregions it is immediately clear that *alexandra* is essentially a prairie grassland insect and that *christina* is essentially a woodland insect. From a distribution and geographic perspective this reality suggests (and field work confirms) that there is in fact no broad band of intergradation, zone of intergradation or blend zone region as reported in the literature. This macro-scale forest and grassland distinction also holds up on a site basis. Most of the prairie occurrences of *christina* and *astraea* phenotypes are places where forest and grassland habitats are in juxtaposition.

The phenology (time of adult flight) of these two species is very interesting. The data set was examined from the perspective of stations and abundance. A station is defined as a report of butterfly occurrence at a single place on a single day. Abundance is synonymous with specimen count. Both station frequency and total abundance were plotted against phenology units for each month of the flight season. A phenology unit is defined as early, mid-, or late month as follows: early - days 1-10; mid - days 11-20; late - days 21-31. Since butterfly phenology is known to vary with latitude and altitude, the data set for *christina* was stratified according to the following scheme to account for regional differences: prairies, aspen parkland, boreal forest, southern mountains, and northern mountains. The Bow River valley was used as the northern terminus of the southern mountains region.

*Colias alexandra* extreme flight dates are 13 May and 1 September. The data show a very pronounced

bimodal pattern consistent with a bivoltine (two brooded) butterfly. In fact, the break between broods is more substantial than illustrated by graphed data. No records of this species are available between 3 July and 23 July.

In contrast, the smaller *christina* data set shows a clear unimodal pattern consistent with a univoltine (single brooded) butterfly. Individuals of these taxa peak during the time window (mid-July) when *alexandra* is not known to fly. The small boreal forest *christina* data set also indicates a univoltine situation but with a peak flight in early July. The much more substantive aspen parkland sample again indicates a univoltine creature with a pronounced flight in mid-July.

The very substantial samples from the southern mountains and the northern mountains are congruent and show that *christina* is univoltine here as well. Peak flights are in mid-July. The abundance data also suggest that the butterfly is more abundant (where it occurs) in the northern mountains than it is in the southern mountains. This is in agreement with my own qualitative field observations. Extreme early and late flights for *christina* in the province are 10 May and 26 September.

Table 2 presents the readily observable differences between the taxa *alexandra* and *christina* (including *astraea*-like phenotypes) in Alberta. It does not include less observable differences requiring equipment for scrutiny nor differences in immature stages.

These differences are more dramatic than the differences between, for example, *C. pelidne* and *C. philodice*. Given the distributional,



**Table 2. COMPARISON OF *Colias christina* AND *Colias alexandra* IN ALBERTA.**

<i>Colias christina</i>	<i>Colias alexandra</i>
males variable but usually extensive orange areas on dorsal surface in at least 99% of individuals	males with no orange areas on dorsal surface, yellow except for black forewing discal spot and marginal band
male dorsal yellow areas of a lemon hue	males with dorsal cold yellow hue
male ventral hindwing mostly yellow in boreal region, mostly greenish elsewhere	male ventral hindwing greyish green
ventral hindwing discal spot larger and with red rim, frequent satellite spot in north	ventral hindwing discal spot smaller and does not have a red rim, no satellite spot
frequent ventral submarginal spots in boreal populations (especially in males)	no ventral submarginal spots
dorsal hindwing with large orange discal spot	dorsal hindwing without a discal spot, appearance of small pale spot is optical illusion due to ventral hindwing spot
wing fringes mostly pink	wing fringes yellow
males larger, FW length mostly 25-27 mm	male dorsal FW length mostly 22-23 mm
male dorsal FW black border wider, generally 3.5 mm	males smaller, FW black border generally narrower, 2 mm
females extremely variable in size, colour (yellow, orange, white or any combination thereof), amount of black dorsal marginal scaling	females consistent in size, 99% white, minimal black dorsal marginal scaling
antennae pink	antennae pale buff
dorsal forewing black band with yellow-orange overscaling; makes band look grey in fresh individuals	dorsal forewing black band without coloured overscaling
univoltine	bivoltine
found in boreal forest, mountains and some fescue prairie areas	found in prairie grasslands and some dry foothills grasslands

phenotypic, ecological, and phenological differences between these taxa, it is reasonable to conclude that they are in fact separate and distinct species. Both taxa were originally described as distinct species and various literature that treats them as one species does not provide solid support for such treatment. The highly variable *C. christina* populations of the southern mountains seem to have been misinterpreted by various researchers as evidence of intergradation between the taxa.

In Alberta *C. alexandra* is a remarkably consistent species. Specimens differ from the nominate subspecies in the following characteristics: smaller size, narrower forewing black borders, darker greyish green ventral hindwing, and almost all females white. These differences

are more substantial than the differences between the nominate subspecies and subspecies *apache* which was described by Ferris.<sup>23</sup> Consequently these "prairie" populations which are known from the plains of Alberta, Saskatchewan, Montana, and North Dakota should be described as a new subspecies. Until such time as transitional populations to *C. alexandra alexandra* are documented, the possibility of separate species status for these prairie populations should not be categorically ruled out. Alberta populations of *C. alexandra* completely lack any dorsal hindwing discal spots which some literature deems to be a consistent characteristic of all *Colias* species. North American literature has traditionally claimed that this discal spot is concolorous with the ground colour but close examination

shows that in fact there is no discal spot.

The variability, within and between populations, of *C. christina* makes general characterization over the whole province a real challenge. Some regional trends in Alberta are: boreal forest populations tend to be smaller, have a yellow ventral hindwing, frequently have ventral hindwing satellite spots and submarginal spots, and have a larger proportion of yellow and orange females; parkland populations are larger, have a pale greenish ventral hindwing; southern mountain populations are larger, have a greenish ventral hindwing and most females are white; the Mountain Park area in the northern mountains supports distinctive populations that are smaller, dark green on the ventral hindwing, frequently have substantial dark scaling on the basal portion of the dorsal hindwing, and most females are white. Many male specimens from the Mountain Park area resemble *C. christina kluanensis* (a Yukon subspecies) more than any other named subspecies.

The archtypal phenotype of nominate male *C. christina* is that of a dorsal surface with a sharply divided, deep, bright orange outer half and a bright yellow basal portion (e.g., Gillette<sup>28</sup>). Such individuals do occur in all sampled populations of *C. christina* in Alberta, except the Mountain Park populations where the bright yellow basal portion of the dorsal hindwing is mostly replaced with melanic scaling. These archtypal phenotypes are however a minority in sampled populations. Examination of a long series shows that variation runs from occasional individuals that are all yellow to those that are almost all orange. The most frequent male phenotype is a butter-

fly that is roughly one-half orange and one-half yellow on the dorsal surface with the orange of a paler hue and with an ill-defined transition from yellow to orange in comparison to the archtypal phenotype.

There remains then the problem of suitable names to attach to Alberta material. For the purpose of communicating the general appearance of individuals there is no problem. The existing names (*alexandra*, *astraea*, *krauthii*, and *christina*) can be used as convenient "handles" to communicate that the specimen at hand is consistent in phenotype with the characteristics normally associated with the name.

Attaching names in a true taxonomic sense is an unresolved problem at the time of writing. There are no published data to support lumping of the yellow prairie insect with nominate *C. alexandra*. Information presented herein suggests it is at least a distinct subspecies that should be formally described and given a name. The appropriateness of using the name *astraea* to refer to the southern mountain populations also needs to be critically reviewed. Again no published data exist to support lumping of Alberta material with populations from the vicinity of the type locality, at least not at the subspecies level. Ferris attributes *astraea* to Alberta but does not provide data to refute the equally unsubstantiated and contradictory opinion of Masters who states that southern Alberta and Alberta mountain populations are "statistically at least distinct from typical *astraea* from Wyoming."<sup>21,23,41</sup> At this time only the name *christina* can be confidently used as a species and subspecies name to reference the yellow/orange and mostly orange populations of the boreal forest.

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On butterfly migration: "On September 25, 1981, I observed approximately 6,000 Monarchs, 4,000 Red Admirals, 4,000 Question Marks, and 2,000 Mourning Cloaks moving south through a 10-foot wide path adjacent to the beach at Riis Park, Brooklyn, New York." *Jeffrey Glassberg, Butterflying Through Binoculars.*



Spiders are the major predators of butterflies. *R.M. Pyle. 1984. Audubon Society handbook for butterfly watchers. Scribner's, New York.*