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REVISION OF SEVERAL NORTH AMERICAN LEGUMINOSAE — FEEDING *COLIAS* SPECIES, WITH DESCRIPTION OF A NEW SUBSPECIES (PIERIDAE: COLIADINAE)¹

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INTRODUCTION

The author has discussed some of the Leguminosae-feeding of *Colias* in several prior papers (Ferris 1972; 1973; 1981; 1982; 1985; Curtis & Ferris, 1985). Some of this work is reviewed and revised in the current paper, and additional species are examined. The taxa treated are: *Colias alexandra* W.H. Edwards, *hecla* Lefebvre (s.l.), and *occidentalis* Scudder. One new name is proposed in *Colias alexandra* and a change in status is proposed for a member of the *Colias hecla* complex. No discussion is included here of either *Colias eurytheme* Boisduval (a UV-reflective species) or *Colias philodice* Godart (a non-UV-reflective species).

Members of this *Colias* group can be divided into two categories; those which reflect ultraviolet light and those which do not. Species in the former group possess specialized wing scales which produce strong UV reflectance in the 300-400 nm wavelength range. In North America, only legume-feeding *Colias* manifest UV reflectance. In this paper, the UV-reflective species are examined first and then the non-reflective species are discussed. In keeping with the I.C.Z.N. Code [Arts. 31a (ii), 32c (i)] regarding the endings -i, -ii the spelling has been modified from the original since the use of -ii for modern personal names contravenes Arts. 27-31. The designation "Var." appears in much of the early literature. This is treated herein as synonymous with subspecies.

Unless noted to the contrary, all specimens illustrated are from the author's collection.

UV-REFLECTIVE SPECIES

Colias alexandra Complex

As shown in an earlier paper (Ferris, 1973), this complex can be divided into three categories based upon the nature of the UV reflectance from the dorsal surfaces of the FW: 1. narrow marginal band; 2. post-discal reflective area; 3. all but basal and marginal

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portions of wing reflective. Typical examples are shown in Figures 3, 11, 12, 13, 28. Although wing color (pigment) *per se* has no bearing upon the amount of UV reflectance, generally it does correlate in this *Colias* group. On the average, pure yellow species exhibit minimal FW UV reflectance, yellow-orange species modest reflectance, and orange species maximum UV reflectance. These reflectance patterns tend to remain fairly constant in those races in which wing color varies from nearly pure yellow to pure orange (for example, *C. alexandra astraea* W.H. Edwards). It is quite possible that several sibling species comprise the *alexandra* complex, but this remains to be elucidated. The existence of blend-zone areas where all phenotypes can be collected in the same meadow (such as the Kananaskis Forest region south of Banff, Alberta, and the northern Laramie Mts. in eastern Wyoming) suggests a single but polymorphic species. This is the approach adopted herein. In certain areas of Idaho, however, the yellow and orange *alexandra* phenotypes appear to behave as separate species. Nomenclature in the group is historically confused. For this reason, synonymies are shown immediately below for all of the recognized species and subspecies (Miller & Brown, 1981 and emended) even though no additional detailed discussion may be provided. For convenience, the arrangement is in historical chronological order for the present discussion, and has no phylogenetic significance. Intraspecific names, if preoccupied, are not included (see Miller and Brown, 1981 for particulars). In general, the MONA Check List (Hodges, *et al.*, 1983) is not cited in the synonymies because the butterfly section represents an earlier version of Miller and Brown (1981), despite the disparity in publication dates.

***Colias alexandra alexandra* W. H. Edwards 1863**

Colias alexandra W. H. Edwards, 1863, Proc. ent. Soc. Philadelphia, 2: 14-15. TL — "Pike's Peak", restricted to foothills W. of Denver, Colorado by F.M. Brown, 1973. Trans. American ent. Soc., 99:60. LT in CMNH, designated by F.M. Brown, 1973. Trans. American ent. Soc., 99:62.

- = *Colias alexandra* W. H. Edwards; Strecker, 1878:81.
- = *Colias alexandra alexandra* W. H. Edwards; Skinner, 1898:69.
- = *Eurymus alexandra alexandra* (W. H. Edwards); Dyar, 1902:10.
- = *Eurymus alexandra alexandra* (W. H. Edwards); Barnes and Benjamin, 1926a:8.
- = *Colias alexandra alexandra* W. H. Edwards; McDunnough, 1938:8.
- = *Colias alexandra* W. H. Edwards; Holland, 1949:249.
- = *Colias occidentalis alexandra* W. H. Edwards; McHenry, 1963:210;215.
- = *Colias alexandra alexandra* W. H. Edwards; dos Passos, 1964:43.
- = *Colias alexandra alexandra* W. H. Edwards; Brown, 1973:57;59.
- = *Colias alexandra alexandra* W. H. Edwards; Ferris, 1973:71.
- = *Colias alexandra alexandra* W. H. Edwards; Miller and Brown, 1981:81.

DISCUSSION

Over most of its geographic range, *Colias alexandra* is univoltine. In Sioux Co., Nebraska, however, there is a bivoltine population of the nominate subspecies. Specimens have been taken in both Monroe and Sowbelly Canyons from 4.vi-1.vii, and again from 1-16.viii in 1983 and 1984. This colony occurs at low elevation (4100-4400') for this species and in a warm environment, which may account for the observed voltinism. Johnson (1975:221, fig. 2;226), however, implies that *C. a. krauthi* Klots is bivoltine and that south of the Black Hills (South Dakota) there occurs a yellow population of "unclear voltinism". I know of no data to support the bivoltinism of *krauthi*. Ellis (1974) has discussed the biology and larval hosts of this species in some detail. He reports a bivoltine colony of *a. alexandra* (discovered by M. S. Fisher) from near Parker, Douglas Co., CO. The flight periods for the two generations are respectively: 15.v-22.vi; 25.vii-19.viii. Hayes (1980) has reported various aspects of the early stages of this species.

***Colias alexandra christina* W. H. Edwards 1863**

- Colias christina* W. H. Edwards, 1863. Proc. ent. Soc. Philadelphia, 2:79-80. TL — "portage of the Slave River", N.W.T. Lectotype — CMNH, designated by F. M. Brown, 1973; Trans. Amer. ent. Soc., 99:63. Male and female "types" (pseudotypes) illustrated by Holland (1949: pl. 68, figs. 14-15). See Brown (1973:73-74) for discussion of the type.
- = *Colias pelidne christina* W. H. Edwards; Strecker, 1872-1900:133.
 - = *Colias pelidne christina* W. H. Edwards; Strecker, 1878:81.
 - = *Colias christina christina* W. H. Edwards; Skinner, 1898:69.
 - = *Eurymus christina* (W. H. Edwards); Dyar, 1902:10.
 - = *Eurymus christina* (W. H. Edwards); Barnes and Benjamin, 1926a:8.
 - = *Colias christina* W. H. Edwards; McDunnough, 1938:8.
 - = *Colias christina* W. H. Edwards; Holland, 1949:296.
 - = *Colias christina* W. H. Edwards; Jones, 1951:4.
 - = *Colias occidentalis christina* W. H. Edwards; McHenry, 1963:210;215.
 - = *Colias alexandra christina* W. H. Edwards; dos Passos, 1964:43.
 - = *Colias alexandra christina* W. H. Edwards; Brown, 1973:57;62.
 - = *Colias alexandra christina* W. H. Edwards; Ferris, 1973:60;71.
 - = *Colias alexandra christina* W. H. Edwards; Miller and Brown, 1981:81.

DISCUSSION

This subspecies is somewhat variable in phenotype. In the "classical" form, the wings of the males dorsally are basally yellow and distally orange. The color transition is abrupt and gives the appearance that the wings have been over-painted with an orange band. Dorsally the wings of the females are generally yellow with an orange blush. Considerable color variation occurs in both sexes, with some males being completely orange, and some females of the white "alba" form. Examples from the northernmost limits of this species' geographic range tend to be paler than specimens from the Riding Mtns. of Manitoba. Masters (1975) commented upon the polymorphism of this subspecies. Walter Krivda of The Pas, Manitoba has reared *christina* on *Hedysarum* sp. (Hooper, 1973:77).

***Colias alexandra edwardsii* W. H. Edwards 1870**

- Colias edwardsii* W. H. Edwards, 1870. Trans. Amer. ent. Soc., 3:11. TL — vic. Virginia City, Nevada. LT — CMNH, designated by F.M. Brown, 1973; Trans. Amer. ent. Soc., 99:67. Male and female "types" illustrated by Holland (1949: pl. 68, figs. 24-25). The male (fig. 24) is the lectotype designated by Brown (1973:65-66).
- = *Colias emilia* W. H. Edwards, 1870. Trans. Amer. ent. Soc., 3:12. TL — "Oregon", restricted to Crump Lake, Lake Co., Oregon, and neotype designated by F.M. Brown, 1973; Trans. Amer. ent. Soc., 99:68-72. NT in CMNH. See also Ferris (1973:68) for additional discussion.
 - = *Colias edwardsii* W. H. Edwards; Strecker, 1878:82.
 - = *Colias emilia* W. H. Edwards; Strecker, 1878:82.
 - = *Colias alexandra edwardsii* Behr; Skinner, 1898:69.
 - = *Colias alexandra emilia* W. H. Edwards; Skinner, 1898:69.
 - = *Eurymus alexandra edwardsii* (W. H. Edwards); Dyar, 1902:10.
 - = *Eurymus alexandra emilia* (W. H. Edwards); Dyar, 1902:10.
 - = *Eurymus alexandra edwardsii* (W. H. Edwards); Barnes and Benjamin, 1926a:8.
 - = *Eurymus alexandra emilia* (W. H. Edwards); Barnes and Benjamin, 1926a:8.
 - = *Colias alexandra edwardsii* W. H. Edwards; McDunnough, 1938:8.
 - = *Colias alexandra emilia* W. H. Edwards; McDunnough, 1938:8.
 - = *Colias emilia* W. H. Edwards; Holland, 1949:295.
 - = *Colias occidentalis edwardsii* W. H. Edwards; McHenry, 1963:210;215.
 - = *Colias occidentalis emilia* W. H. Edwards; McHenry, 1963:210;216.
 - = *Colias alexandra edwardsii* W. H. Edwards; dos Passos, 1964:43.

- = *Colias alexandra emilia* W. H. Edwards; dos Passos, 1964:43.
- = *Colias alexandra edwardsii* W. H. Edwards; Brown, 1973:57;65.
- = *Colias alexandra edwardsii* W. H. Edwards; Ferris, 1973:60;71.
- = *Colias alexandra edwardsii* W. H. Edwards; Miller and Brown, 1981:81.

Infrasubspecific Names

Eurymus alexandra edwardsii ♀ f. "hatui" Barnes and Benjamin, 1926b:89. TL — Stockton, Utah. HT in NMNH. This name applies to a nearly "alba" female form from a clinal population between the subspecies *alexandra* and *edwardsii*.

DISCUSSION

The geographic range of *C. alexandra edwardsii* includes the Great Basin region of central and southern Nevada with an extension into the adjoining eastern slopes of the Sierra Madre in California, and xeric regions of southern Oregon. This subspecies penetrates into Mohave Co., Arizona north of the Colorado River, where it has more than one generation per year and is associated with *Astragalus* sp. (fide K. Roever). These butterflies are recognized by their large size and bright lemon-yellow color. The wing fringes contain pink hairs, especially toward the FW apical area. The dorsal dark borders in the males tend to be narrower than in other subspecies of *alexandra*. The females are clear yellow, sometimes with a very slight orange flush, and there is a suggestion of dark apical dusting on the DFW which occasionally produces a partial border. To the north in California through the Sierra-Cascade divide region and into Oregon, typical *edwardsii* is replaced by a population that clines from *edwardsii* into *columbiensis*. Females from this region are variable in color ranging from yellow into creamy-white and often flushed with orange. Males may manifest orange DHW discal spots as opposed to yellow spots as in *edwardsii*. Similar clinal forms occur in the Snake River Valley and the more arid areas of central Washington. These populations are frequently erroneously cited in the literature as *edwardsii*. Additional comments appear in the discussion of *columbiensis* below. Reported larval hosts are *Astragalus*, *Medicago*, *Thermopsis*, and *Trifolium*.

Colias alexandra astraea W. H. Edwards 1872

Colias astraea W. H. Edwards, 1872. Trans. Amer. ent. Soc., 4:61. TL — Yellowstone Lake, Yellowstone Natl. Park. HT in CMNH. Male and female "types" illustrated by Holland (1949: pl. 68, figs. 26-27). What Holland illustrated are not types. This taxon was described from a single male, and not the one shown by Holland. See Brown (1973:73-74) for a complete discussion. Additional description, including the female appears in Edwards, 1884, *Papilio*, 4:30-34.

- = *Colias astraea* W. H. Edwards; Strecker, 1878:83.
- = *Colias christina astraea* W. H. Edwards; Skinner, 1898:69.
- = *Eurymus christina* syn. *astraea* (W. H. Edwards); Dyar, 1902:10
- = *Eurymus christina* f. "astraea" (W. H. Edwards); Barnes and Benjamin, 1926a:8.
- = *Colias christina* f. "astraea" W. H. Edwards; McDunnough, 1938:8.
- = *Colias astraea* W. H. Edwards; Holland, 1949:297.
- = *Colias occidentalis astraea* W. H. Edwards; McHenry, 1963:210;215.
- = *Colias scudderii astraea* W. H. Edwards; dos Passos, 1964:43.
- = *Colias alexandra astraea* W. H. Edwards; Brown, 1973:57;72.
- = *Colias alexandra astraea* W. H. Edwards; Ferris, 1973:60;71.
- = *Colias alexandra astraea* W. H. Edwards; Miller and Brown, 1981:81.

DISCUSSION

The name *astraea* applies to a variable-phenotype subspecies. The moderately uniform females are generally white, sometimes flushed with yellow-orange, and manifest varying

degrees of dorsal dark wing bordering. The males, however, may vary dorsally from nearly pure yellow to orange. Their UV reflectance pattern remains fairly constant. This phenotype occurs in southern Alberta (in the foothills west of Calgary and north to the Banff region), Idaho, Utah, and northern Wyoming. Edwards (1884) expanded substantially upon his original comments concerning *astraea*.

***Colias alexandra harfordi* Hy. Edwards 1877**

- Colias harfordii* Hy. Edwards, 1877. Pac. Coast Lepid., (24):9. TL — Havilah, Kern Co., California. HT in AMNH. Male and female "types" illustrated by Holland (1949: pl. 68, figs. 20-21).
- = *Colias barbara* Hy. Edwards, 1877. Pac. Coast Lepid., (24):7-8. TL — Santa Barbara, California. HT in AMNH. Male and female "types" illustrated by Holland (1949: pl. 68, figs. 18-19).
- = *Colias barbara* Hy. Edwards; Strecker, 1878:82.
- = *Colias chrysotheme* ab. f. "harfordii" Hy. Edwards; Strecker, 1878:83.
- = *Colias harfordii harfordii* Hy. Edwards; Skinner, 1898:69.
- = *Colias harfordii barbara* Hy. Edwards; Skinner, 1898:69.
- = *Eurymus hartfordii* [sic] (Hy. Edwards); Dyar, 1902:10.
- = *Eurymus hartfordii* [sic] syn. *barbara* (Hy. Edwards); Dyar, 1902:10.
- = *Eurymus harfordii* (Hy. Edwards); Barnes and Benjamin, 1926a:8.
- = *Eurymus occidentalis barbara* (Hy. Edwards); Barnes and Benjamin, 1926a:8.
- = *Colias occidentalis barbara* Hy. Edwards; Comstock, 1927:52.
- = *Colias harfordii* Hy. Edwards; McDunnough, 1938:8.
- = *Colias occidentalis barbara* Hy. Edwards; McDunnough, 1938:8.
- = *Colias barbara* Hy. Edwards; Holland, 1949:294.
- = *Colias harfordii* Hy. Edwards; Holland, 1949:294.
- = *Colias occidentalis barbara* Hy. Edwards; McHenry, 1963:210;215.
- = *Colias occidentalis harfordii* Hy. Edwards; McHenry, 1963:210;216.
- = *Colias barbara* Hy. Edwards; dos Passos, 1964:42.
- = *Colias harfordii* Hy. Edwards; dos Passos, 1964:42.
- = *Colias alexandra barbara* Hy. Edwards; Ferris, 1973:68;71.
- = *Colias alexandra harfordii* Hy. Edwards; Ferris: 1973:68;71.
- = *Colias alexandra harfordii* Hy. Edwards; Orsak, 1978:82.
- = *Colias harfordii* Hy. Edwards; Miller and Brown, 1981:80.
- = *Colias harfordii* syn. *barbara* Hy. Edwards; Miller and Brown, 1981:80.

Infrasubspecific Names

Eurymus hartfordii [sic] ab. "weaverae" Gunder, 1924:156. TL — Warner Springs, San Diego Co., California. HT (not allotype as stated) in AMNH. Miller and Brown (1981:80) suggested that this butterfly may represent a hybrid with *eurytheme*. Gunder addressed the hybrid possibility and rejected it. After examining the color plate accompanying the original description of this taxon, I feel that it represents a varietal form of *harfordii* in which the orange gene is partially expressed. This situation occurs fairly commonly in normally yellow *alexandra* populations.

Eurymus barbara ♀ ab. "martini" Gunder, 1931:45. TL — S. side Arrowhead Lake, San Bernardino Co., California. HT In AMNH. This name applies to the "alba" female form, which is apparently rare.

DISCUSSION

As indicated by the synonymy provided above, considerable confusion has existed about the names *harfordii* and *barbara*. Many specimens so labeled that I have examined in museum collections were neither insect, but rather specimens of either *Colias philodice eriphyle* W.H. Edwards or *Colias eurytheme* Boisduval. The latter species was confused

with or considered to be synonymous with the Old World *chrysotheme* Esper. Males of *C. alexandra harfordi* produce a UV reflectance pattern typical of the yellow group in the *alexandra* complex. Photos were shown by Ferris in 1973 (Fig. 5, j.l). Males of both *occidentalis* and *philodice* are easily separated from the *alexandra* complex because they are not UV-reflective. Short-photoperiod males of *eurytheme* which exhibit very reduced orange coloration have been confused with *harfordi*. Again UV photography may be used to separate these two species. Males of *C. eurytheme* strongly reflect UV light from both the FW and HW, and the DHW has a submarginal row of spots characteristic of this species. Priestaf (1974) described a putative hybrid *eurytheme x harfordi*.

As noted by Ferris (1976), the range of *harfordi* extends from southern California into northern Baja California (Sierra San Pedro Martir). Comstock (1927) indicated a range for the species (*barbara* = *harfordi*) from San Diego Co. northwards to Contra Costa and Sonoma Cos. Klots (*in* Howe, 1975:357) also cited Contra Costa Co. as the northern limit to the range of *harfordi*. Either the range of this species has contracted southwards in contemporary times, or Comstock confused *harfordi* with forms of *eurytheme* and *philodice*. The Emmels (1973:19) cite Santa Barbara and Kern Cos. as the northern limits to this butterfly's range, with one occurrence in Ventura Co. (J. F. Emmel, *in litt.*). Comstock placed *barbara* as a subspecies of *occidentalis* Scudder. Hovanitz (1950) placed *harfordi* in the *alexandra* complex, but he also placed *occidentalis* with *alexandra*. The larval hosts are *Astragalus* sp., including *A. antiselli* (R. Priestaff, *in litt.*), and *Lotus crassifolius* (J.F. Emmel, *in litt.*). There are two generations per year; one in early spring, and the second one normally in late June and July. Davenport (1983:58) cites a record for 9.x81. This record may represent an ectopic emergency or a possible third generation, assuming that a misidentification did not occur.

***Colias alexandra krauthi* Klots 1935**

Colias christina krauthi Klots, 1935. Amer. Mus. Novitates, (767):1-2. TL — Black Hills, 12 mi. W. of Custer, Custer Co., South Dakota. HT in AMNH.

- = *Colias christina krauthi* Klots; McDunnough, 1938:8.
- = *Colias occidentalis krauthi* Klots; McHenry, 1963:210;216.
- = *Colias alexandra krauthi* Klots; dos Passos, 1964:43.
- = *Colias alexandra krauthi* Klots; Brown, 1973:57.
- = *Colias alexandra krauthi* Klots; Ferris, 1973:60;71.
- = *Colias alexandra krauthi* Klots; Miller and Brown, 1981:81.

***Colias alexandra columbiensis* Ferris 1973**

Colias alexandra columbiensis Ferris, 1973. J. Lepid. Soc., 27(1):68-71. TL — Anderson Lake, D'Arcy, British Columbia. HT in CNC.

- = *Colias alexandra alexandra* W. H. Edwards; Jones, 1951:5.
- = *Colias alexandra edwardsii* W. H. Edwards; Jones, 1951:5.
- = *Colias alexandra emilia* W. H. Edwards; Jones, 1951:5.
- = *Colias alexandra columbiensis* Ferris; Miller and Brown, 1981:81.

DISCUSSION

An enigmatic colony of *alexandra* occurs in the general vicinity of Moyie Springs in Boundary Co., Idaho. Specimens are illustrated in Figures 1-3. This is not typical *columbiensis*, whose range extends from NW Montana across northern Washington and into British Columbia, but in many respects it is closer to *edwardsi*. The width of the D dark wing borders in the males is on the whole slightly wider than in typical *edwardsi*. Only rarely does a male show orange color in the DHW discal spot. The UV reflectance pattern produced by the males, however, is typical of *columbiensis*. All female specimens collected to date are large and bright lemon-yellow. As in *edwardsi*, the amount of dark apical dusting varies from virtually none to the suggestion of a border. The specimen

shown in Figure 2 is an extreme example in this respect. These butterflies normally appear in early July, but in late-season years (such as 1986) they may not emerge until the third week. They frequent open clearings in the forest, road cuts and railroad rights-of-way. This population perhaps represents a spur of the *columbiensis-edwardsi* cline (mentioned above in the *edwardsi* discussion) in which the *edwardsi* phenotype is strongly expressed.

***Colias alexandra kluanensis* Ferris 1981**

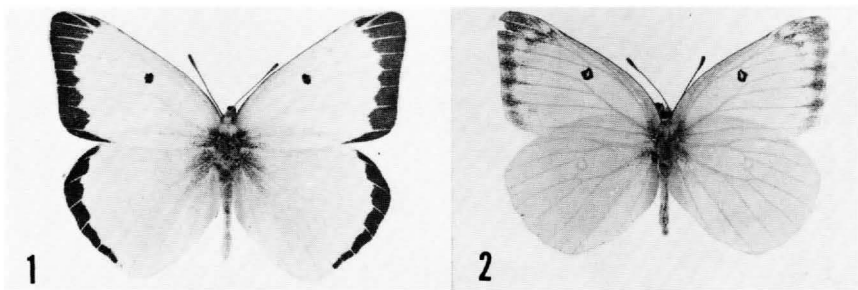
Colias alexandra kluanensis Ferris, 1981. Bull. Allyn Mus., (63):1-4. TL — Haines Junction, Yukon Territory. HT in AME/FSM.

DISCUSSION

This subspecies was fully discussed in Ferris, 1981. No new or additional data have been received.

Description of a New Subspecies

Since the publication in 1973 of my original revisionary paper on the *Colias alexandra* complex, additional colonies of this species have been discovered in various localities including SW New Mexico, Idaho, and the Yukon Territory. In the 1973 paper, an Arizona-New Mexico segregate was discussed briefly, but not described as a new subspecies. A description is provided below:



Figures 1-2. *Colias alexandra* clinal form from vic. Moyie Spgs., Boundary Co., ID, 18-19.vii.86. ♂ D (1); ♀ D (2).

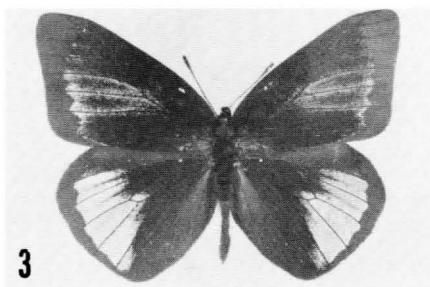
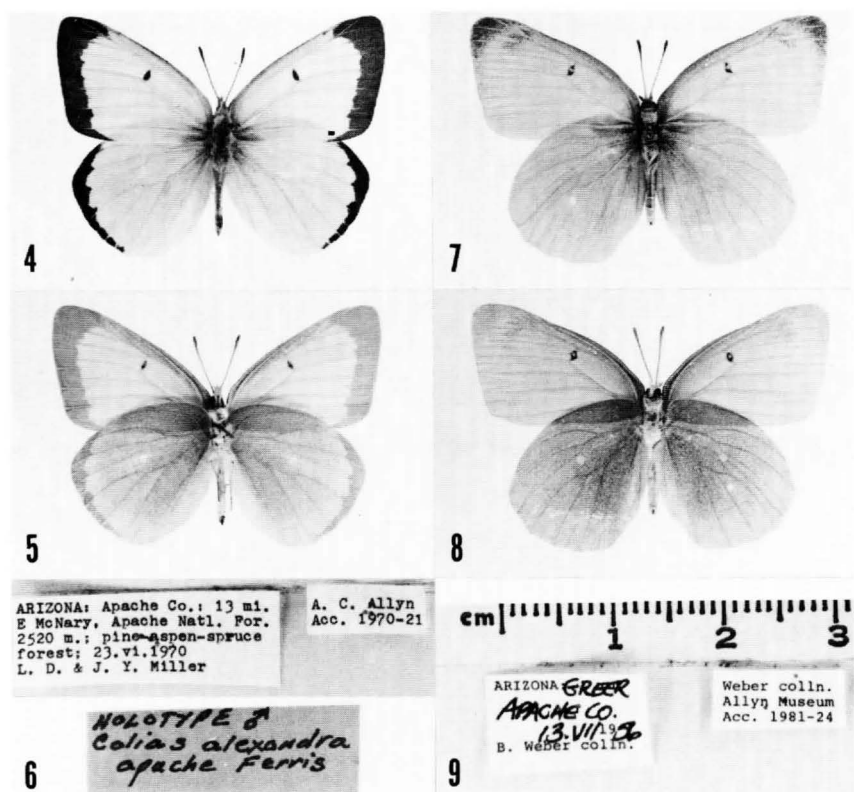


Figure 3. UV photograph of specimen shown in Fig. 1.

***Colias alexandra apache* New Subspecies**

Types and Location: This subspecies is described from 25 ♂♂ and 13 ♀♀ collected in Arizona and New Mexico. The male holotype (Figures 4-6) was collected by L.D. and J.Y. Miller, 13 mi. E. of McNary, 2520 m., Apache Co., Arizona on 23.vi.70, and it is placed in the Allyn Museum of Entomology/Florida State Museum, Sarasota, Florida. A female paratype (Figures 4-5) collected by B. Weber at Greer, Apache Co., AZ, 13.vii.56 is also in the AME/FSM collection. Other paratypes are in the C.D. Ferris collection as follows: **Arizona.** Apache Co.: Ditch Camp, 8.vii.67, 1 ♂; 16.viii.68, 1 ♂; 9.vii.76, 1 ♂; 1.viii.80, 1 ♂; Gila Co.: Promontory Point Lookout, Mogollon Rim, 2.viii.67, 2 ♀♀. **New Mexico.** Catron Co.: Willow Ck., Gila Nat. For., 15.viii.75, 1 ♂; S.R. 78 at Silver Ck., Gila Nat. For., 23.viii.68, 1 ♀ Grant Co.: Signal Peak, 8200', Gila Nat. For., 7.vii.79, 1 ♂; 7900', 19.vi.84, 1 ♂; Sierra Co.: S.R. 90, mi. 83-85, Black Range, 29.vi.77, 1 ♂, 3 ♀♀. Additional specimens examined (11 ♂♂, 4 ♀♀), but not designated paratypes as follows: **Arizona:** Coconino Co.: Oak Creek Canyon. Greenlee Co.: Hannagan Meadow. "White Mts.", no county stated. **New Mexico:** Sandoval Co.: T19N, R1E, S15-16, Santa Fe Nat. For., 8600', 28.vi.77, 1 ♂. Taos Co.: Cabresto Canyon, NE of Questa, Carson Nat. For., 10,600', 10.vii.76, 1 ♀; 8500', 27.vii.86, 1 ♂. Torrance Co.: Capilla Peak, 9200', 2.vii.67, 1 pr., leg. M. E. Toliver, Holland (1974:43) reported this subspecies as common in the Manzano Mtns. in Torrance Co. Two additional specimens in the Canadian National



Figures 4-9. *Colias alexandra apache* Ferris, new subspecies. Holotype ♂ D (4), V (5), specimen labels (6). Paratype ♀ D (7), V (8), specimen labels (9). Specimens in AME.

Collection from the vicinity of Alpine, Apache Co. were examined. This butterfly has also been recorded by R. A. Bailowitz (*in litt.*) from B.S. Gap, San Carlos Indian Reservation, Graham Co., Arizona on 15.vii.83. Holland (1984:229) lists a questionable record from Buffalo Gap in the Chuska Mts., Apache Co., AZ. This record is not plotted in Figure 10.

Diagnosis and Description: Among other features, this subspecies is characterized by its alpine habitat, large size, and absence (in all specimens examined) of any pink color in the cilia of the wings.

Male holotype: FW costa 24 mm. Wing width measured from thorax to margin at vein Cu_1 = 21 mm. WINGS. Dorsal ground color bright lemon yellow (no Smithe equivalent, paler than Spectrum Yellow #55). Borders narrow and black but heavily suffused with yellow dusting and veins clearly outlined in bright yellow. Width of FW border measured at vein Cu_1 = 3 mm (= 14% of wing width at that point). DFW cell spot prominent, black, and irregularly ellipsoidal. DHW color just basad of the marginal band is more saturated than color of wing elsewhere. The discal spot is pale and prominent (but does not reproduce clearly with b/w photography). The ventral ground color is similar to that of the dorsal surfaces, but has a greenish aspect because of black over-scaling. The dorsal dark margins "print through" ventrally. Both the FW and HW cell spots are prominent. The pupil of the VHW cell spot is pearly-white. The wing fringes (cilia) are yellow and devoid of pink hairs. HEAD. Antenna approx. 9 mm (= 37.5% of FW costa length); shaft dorsally "dusty-rose" D, more dark tan V with some elongate darker spots on the club; tip of club paler, bald, and squared-off. Frons hairs pale yellow; palpi with interspersed pale yellow and blackish hairs D, with distinct D white patch, white and blackish V. Eyes smooth and brown. THORAX. Black and adorned with long pale yellow hairs. ABDOMEN. Black and covered with pale yellow scales and hairs. LEGS. Dark tan, covered with nearly-white scales and hairs; no pinkish color evident as with other *Colias* species, and *alexandra* subspecies.

Variation in the Males: Variation is slight in this subspecies. Wing width measured from the thorax to the margin at vein Cu_1 varies from 21 to 25 mm. Width of the FW black border measured at vein Cu_1 varies from 3 to 6 mm. The size and shape of the FW black cell spot vary slightly.

Description of and Variation in the Females: The females exhibit more variability than the males. The basic ground color of the wings is similar to that of the males, but somewhat paler ventrally and frequently with a very slight orange flush dorsally. The DFW cell spot is large, generally elliptical and contains a yellow pupil. Otherwise the dorsal surface varies from immaculate to suggestions of a typical *Colias*—female dark marginal border on the FW. In specimens of the latter group, there may be some dark dusting at the HW outer angle. In other respects, the color in the females resembles that of the males. I have not taken the "alba" form in the females. Wing width measured from the thorax to wing margin at vein Cu_1 varies from 25 to 29 mm.

Flight Period: Mid-June to late August depending upon locality and onset of the summer rains. This subspecies may be bivoltine.

Distribution: Figure 10 is a distribution map for this subspecies. It normally occurs in montane regions above 8000' (2400 m). It is widely distributed, but I have never found it to be common. I have taken it in clearings, open wet meadows, and along roads. In Navajo Co., AZ, *apache* occurs in the extreme southern portion along the White River and its forks. The specimens noted above from Taos and Sandoval Cos., New Mexico as phenotypic *apache*, but they probably represent examples from a cline into nominate *alexandra*. Toliver (*in litt.*) has reported specimens of this new subspecies from McKinley Co., New Mexico, but I have not seen specimens. Material from the Spanish Peaks, Huerfano Co., in southern Colorado is fairly typical *alexandra*, although some ♂♂ tend to be large and exhibit narrow dark DFW borders.

Biology: Toliver (*in litt.*) has reported oviposition on *Astragalus* sp. in the Manzano Mtns., Torrance Co., New Mexico. In the White Mts. of Arizona, it is associated with *Thermopsis* sp. (*vide* K. Roever).

Comparison with Other Subspecies: This subspecies belongs to the yellow group of the *alexandra* complex, as demonstrated by Figure 11. Both sexes are devoid of pink coloring

on the body parts and wing cilia, normally associated with other members of this species. The cilia of nominate *alexandra* are frequently pure yellow, but there is pink vestiture on the head, thorax and legs. *C. alexandra apache* is characterized by its large size, and its closest relative appears to be *C. alexandra edwardsi*.

Etymology: The subspecific epithet is a noun in apposition descriptive of the Apache Indian race to whom the region where the butterfly occurs once belonged.

Species Grouping for the *Colias alexandra* Complex

The grouping shown below is based upon a combination of visible-light characteristics

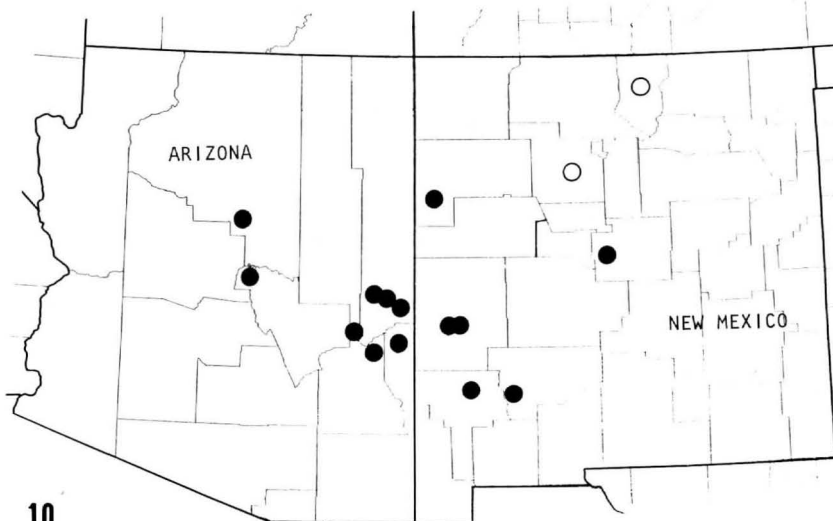


Figure 10. Map showing distribution of *Colias alexandra apache*. Open circles denote probable clinal populations with *C. alexandra alexandra*.

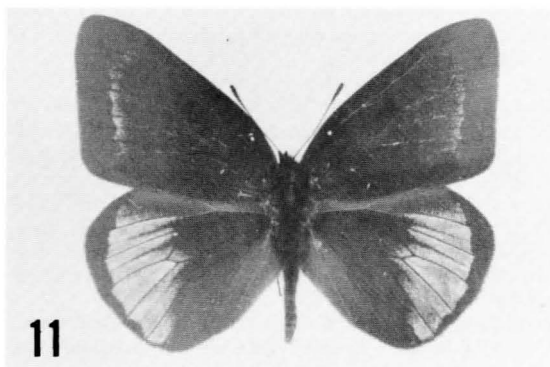


Figure 11. Dorsal UV photograph of typical male of *Colias alexandra apache* from Ditch Camp, Apache Co., AZ, 9.vii.76.

and UV-reflectance patterns in the males. Typical UV dorsal reflectance patterns are shown in Figures 3, 11, 12, 13 and 28.

The *alexandra* Group

Figure 1

Colias alexandra alexandra W. H. Edwards

Colias alexandra edwardsi W. H. Edwards

Colias alexandra apache Ferris

Colias alexandra harfordi Hy. Edwards

The *astrea* Group

Figures 3, 12

Colias alexandra columbiensis Ferris

Colias alexandra astraes W. H. Edwards

Colias alexandra christina W. H. Edwards

The *krauthi* Group*

Figures 13, 28

Colias alexandra krauthi Klots

Colias alexandra kluanensis Ferris

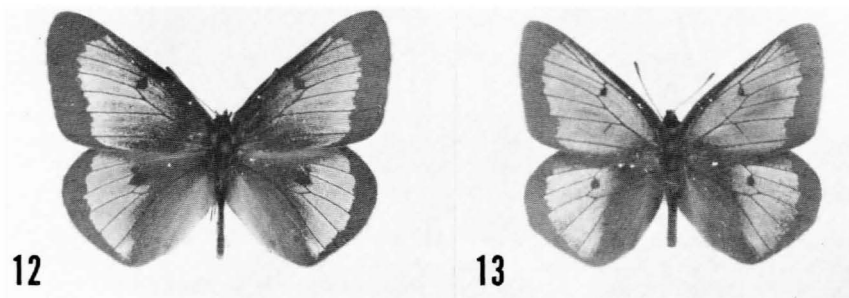
* Included here are several orange clinal populations found in Idaho and Utah that various authors (*in litt.*) have placed with *Colias occidentalis* Scudder.

Distribution of *Colias alexandra*

Collecting in northwestern North America since publication of my original paper (1973) has uncovered many new colonies of *Colias alexandra* and has extended the known range of this butterfly. Figure 14 illustrates the present situation. To date, *Colias alexandra* has not been confirmed from Alaska (*vide* K.W. Philip). There are also distribution gaps in Arizona, Utah and Wyoming. The map shown in Ferris (1973:59) is based upon incorrect data. Both Scott (1986:195) and Tilden and Smith (1968:134) have repeated these errors. There are also vague references to the occurrence of *alexandra* in Russia (Korshunov 1972:90). I suspect that such records refer to misidentifications of *C. marcopolo* Grum-Grshmailo.

Colias hecla Complex

Colias hecla Lefèbvre has been treated in some detail in several recent papers (Ferris, 1981; 1982; 1985). My field studies in the western arctic in 1985-1987 require some



Figures 12-13. Dorsal UV photographs of two males of *Colias alexandra* ssp. *C. alexandra christina*, ca. 5 mi. E. of Mayo, Y.T., Can., 13.vii.86 (12). *C. alexandra krauthi*, Tinton Ck. Can., Lawrence Co., SD, 2.vii.69 (13).

adjustments in the conclusions drawn in these earlier papers. No general synonymy (as given above for *alexandra*) is required, since compilers of checklists have always maintained *hecla* as a distinct species. In keeping with his times, Dyar (1902:9) placed *hecla* in genus *Eurymus*. The taxon that requires revision is *Colias hecla canadensis* Ferris, 1982.

***Colias canadensis* Ferris 1982 New Status**

Figure 15-25

Colias hecla canadensis Ferris, 1982. Bull Allyn Mus., (71):11-14. TL — Mile 208 Alaska Highway, British Columbia. HT in AME/FSM.

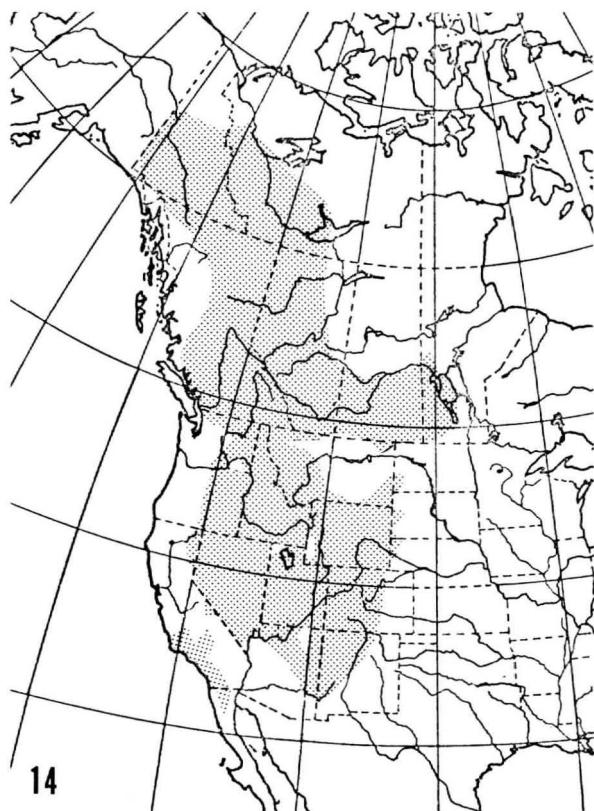
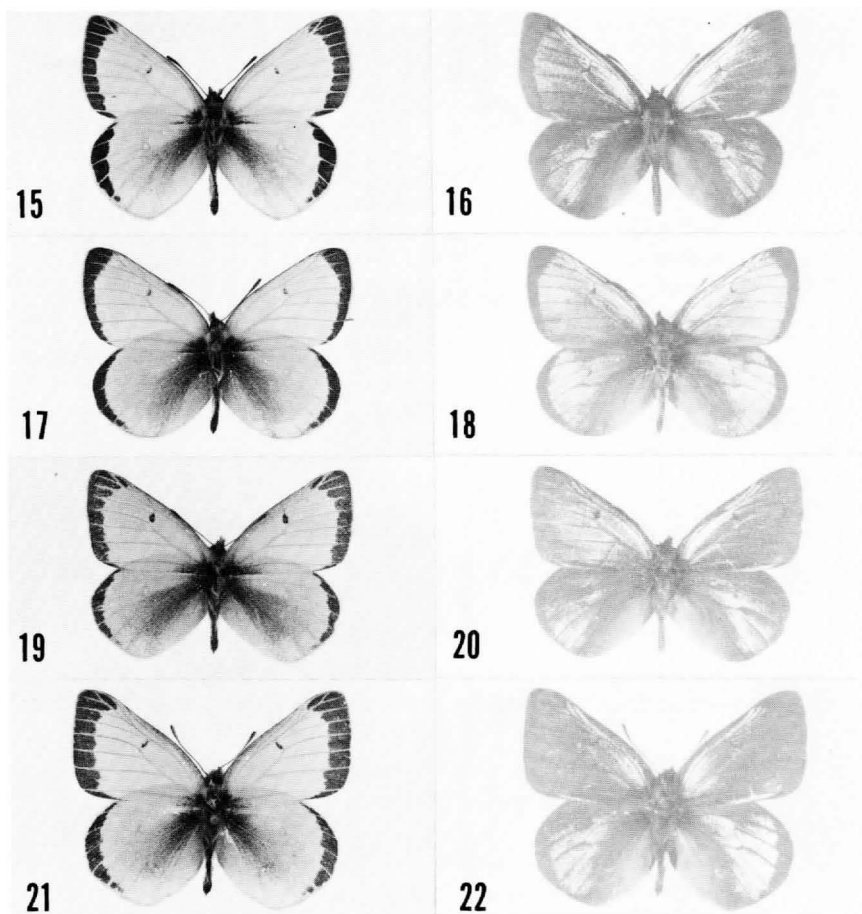


Figure 14. Map showing distribution of *Colias alexandra* in North America.

- = *Colias hecla* Lefèbvre; Jones, 1951:3 [partim].
 = *Colias christina* W. H. Edwards; Jones, 1951:4 [partim].
 = *Colias hecla canadensis* Ferris, 1982:11-14.

Discussion

It is with some reluctance that this change in status is made, but field evidence and morphometric data (Tables 1 & 2) lead me to believe that *canadensis* is a sister species of *hecla*. The major basis for now separating *hecla* and *canadensis* is the phenology and color of individuals from colonies of the latter that occur in central Alaska on the summit (ca. 3000') of Murphy Dome and just below the summit (ca. 2700-2900') of Wickersham Dome. Both areas are short distances north of Fairbanks. I have now examined 359



Figures 15-22. Dorsal photographs of 4 males of *Colias canadensis*. (15) Pink Mtn. rd., B.C., Can., 29.vi.84, (16) same, UV photo; (17) km. 176 Dempster Hwy., Y.T., Can., 10.vi.85, (18) same, UV photo; (19) Richardson Mtns., Y.T., Can., 5.vi.85, (20) same, UV photo; (21) Murphy Dome N. of Fairbanks, AK, 14.vi.86, (22) same, UV photo.

specimens from these two localities, of which 54 are in my personal collection (53 collected in 1986 and an additional white female collected in 1971); the remainder is in the K.W. Philip Collection in Fairbanks, Alaska. Specimens from these localities differ from typical *hecla* in several respects: 1. Adults emerge 2-3 weeks earlier than *hecla*. Regardless of latitude, adults generally appear in early June. J.S. Nordin took adults near Nordegg, Alberta on 3.vii.74, but this was an exceptionally delayed-season year. Other Nordegg records are from 4-16.vi (Ferris, 1982:11). 2. The white female form predominates (of 109 females, 70 = 64% are white; 12 = 11% are yellowish-white; 27 = 25% are yellow-orange). Females of typical *hecla* are very rarely white, and when so, their ground color is a dead white, while the "alba" form of *canadensis* is always a slightly greenish- or yellowish-white. 3. Males often exhibit yellow suffusion on the DHW and just basad of the DFW

Table 1. Morphometric Data for Males of *Colias canadensis* and *Colias hecla*

	<i>canadensis</i> ¹	<i>hecla</i> ²
N	50	50
W _{min} (mm) ³	17.5	18.0
W _{max} (mm)	22.0	22.0
W _{av} (mm)	20.0	19.6
B _{min} (mm) ⁴	1.5	3.0
B _{max} (mm)	5.0	5.5
B _{av} (mm)	2.96	4.17
R _{min} (%) ⁵	7.89	15.8
R _{max} (%)	23.8	26.3
R _{av} (%)	14.7	21.2
SE ⁶	0.00498	0.00385
SD ⁷	0.0352	0.0273
VAR ⁸	0.00124	0.000743
CV (%) ⁹	23.9	12.8
SK ¹⁰	0.0349	-0.0189
K ¹¹	0.0345	-0.0238

NOTES:

1. Specimens from Alaska, British Columbia, Yukon Territory.
2. Specimens from Alaska, Greenland, Manitoba, Northwest Territories, Yukon Territory.
3. W = FW width measured from thorax to outer margin at middle of cell Cu₁.
4. B = Width of border measured at middle of cell Cu₁.
5. R = B/W x 100.
6. SE = Standard Error for R = B/W.
7. SD = Standard Deviation for R = B/W.
8. VAR = Variance for R = B/W.
9. CV = Coefficient of Variation for R = B/W.
10. SK = Skewness for R = B/W.
11. K = Kurtosis for R = B/W.

dark marginal border. This border is frequently very narrow in *canadensis*, while seldom so in *hecla*. Data are presented in Table 1. Where the veins transect the dorsal dark wing borders in the males, they are generally clearly outlined in yellow or yellow-orange in *canadensis*, while marginally-to-slightly visible in most specimens of *hecla*. 4. The dorsal ground color in females of *canadensis* is much paler than is found in *hecla*. The D dark wing borders are not nearly so suffused with black scales as are those of *hecla*. Analysis of the FW width-to-border ratio (R) data shown in Table 1, using Student's t-test, indicates virtually no statistical relation between these two species ($p < < < < 0.01$).

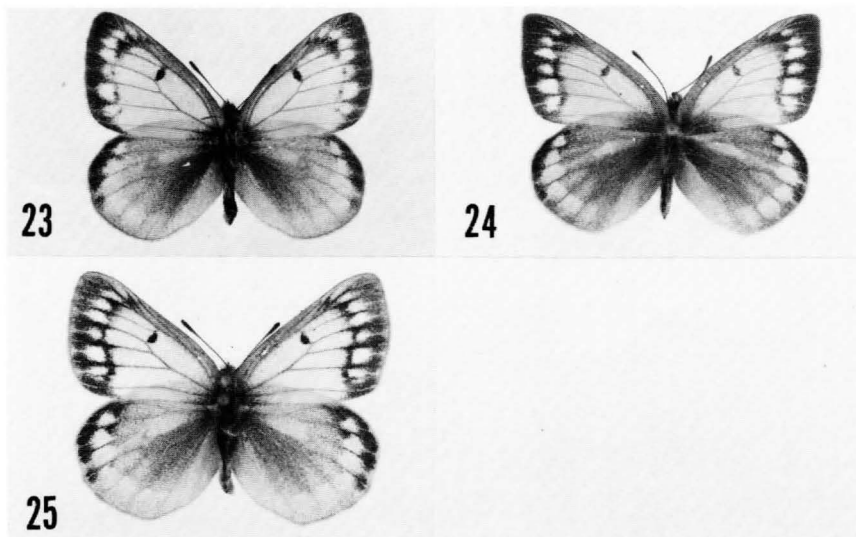
Although E.M. Pike (*in litt.*) obtained oviposition (45 ova) on *Salix* sp. by a single female *canadensis* collected at Pink Mt., B.C., I am sure that the normal oviposition substrates and larval hosts are members of the Leguminosae. Ectopic ovipositions on willows by other

Table 2. Significance of R (Mean Value)¹ Differences — Student's t Statistic

Mean	0.147	0.212
SD	0.00349	0.00270
N	50	50
n (deg. of freedom)	98	
t-statistic	10.3	
Significance (p)	1.86×10^{-8}	

$p < 0.01$ is deemed highly significant.

NOTE: 1. Measurements in mm.



Figures 23-25. Dorsal photographs of 3 females of *Colias canadensis*. (23) yellow form, Pink Mtn. rd., B.C., Can., 29.vi.84; (24) orange form, Wickersham Dome N. of Fairbanks, AK, 15.vi.86; white form, Murphy Dome N. of Fairbanks, AK, 14.vi.86.

legume-feeding *Colis* have been observed and the larvae typically die during the second or early third instar, which was the case with Pike's larvae. At Pink Mt., I have always observed *canadensis* females in association with *Hedysarum* sp. While males have been observed patrolling over willow bogs, I have generally collected them as they flew over open areas where *Hedysarum* was in bloom. In the Richardson Mts., Yukon Territory, I have observed female *canadensis* exhibiting oviposition behavior about the emerging sprouts of an undetermined legume; however, I was not able to find ova. Regarding *C. hecla*, I can find no reports in the European literature of larval hosts other than legumes. *Astragalus alpinus* L. is the host normally listed. Oliver, *et al.* (1964), however, asserted that *C. hecla* is perhaps specific to *Salix arctica* Pall. This statement is contrary to other reports (excepting anecdotal ones) and no definitive data were presented.

The UV reflectance pattern produced by *canadensis* males is somewhat variable (Figures 16, 18, 20, 22), but similar to that produced by *hecla*. This is not surprising considering

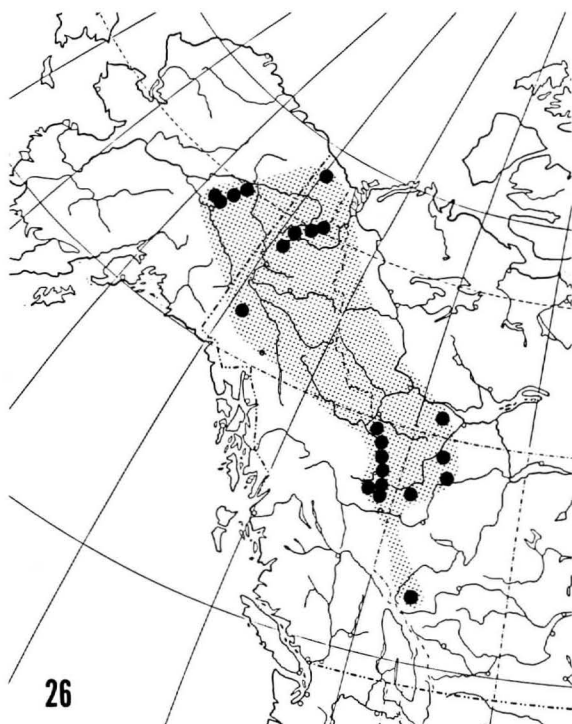


Figure 26. Map showing distribution of *Colias canadensis*. Shaded area indicates potential distribution of this species.

the general similarity between these two species. In *canadensis*, the DHW cell spot frequently reflects as strongly as the rest of the wing surface, while in *hecla* this spot often appears in UV photographs as a non-reflective dark dot.

Because *C. canadensis* is easily confused with *C. hecla*, the extent of the geographic range of *canadensis* is unclear. A tentative distribution map is provided in Figure 26 based upon material in my collection and museum specimens previously determined to be *canadensis*. Based upon 1987 field studies, this species occurs sparingly in the northern Richardson Mts., Yukon Territory, and north to Inuvik, Northwest Territories.

The relationship of *Colias canadensis* to the putative hybrids *C. boothi* Curtis = *C. thula* Hovanitz (Ferris, 1985) has yet to be resolved. It is perhaps one of the parent species. It has been suggested by one experienced arctic collector (J. Troubridge, *in litt.*) that *canadensis* and *boothi* (= *thula*) represent different forms of the same insect. In this case, the name *boothi* would assume publication priority. The UV reflectance patterns recorded from the dorsal wing surfaces of *boothi* are very different from the patterns produced by *canadensis*, as are also the densities of the specialized UV-reflecting scales, as shown in Ferris, 1985. Based upon my field experience and the phenotypes of *canadensis* that occur on Murphy and Wickersham Domes in interior Alaska, I feel that these two entities are not conspecific. This matter will be resolved only by careful breeding and rearing studies as suggested in my 1985 paper.

NON-UV-REFLECTIVE SPECIES

Colias occidentalis Scudder 1862

Colias occidentalis Scudder, 1862. Proc. Boston Soc. Nat. Hist., 9:109-110. TL — "Gulf of Georgia" [British Columbia]. LT, designated herein, in MCZ (Type no. 16603). Two cotypes bear the same MCZ type number label. The ♀, however, is an "alba" form of *C. eurytheme* Boisduval. Male and female "types" illustrated by Holland (1949: pl. 68, figures 16-17). In no way can the specimens illustrated by Holland be construed as types. See discussion below.

- = *Colias philodice occidentalis* Scudder; Strecker, 1878:82.
- = *Colias occidentalis occidentalis* Scudder; Skinner, 1898:69.
- = *Eurymus occidentalis* (Scudder); Dyar, 1902:10.
- = *Eurymus occidentalis* (Scudder); Barnes and Benjamin, 1926a:8.
- = *Colias occidentalis* Scudder; McDunnough, 1938:8.
- = *Colias occidentalis* Scudder; Holland, 1949:293.
- = *Colias occidentalis* Scudder; Jones, 1951:4.
- = *Colias occidentalis* Scudder; McHenry, 1963:210; 215.
- = *Colias occidentalis* Scudder; dos Passos, 1964:42.
- = *Colias occidentalis* Scudder; Miller and Brown, 1981:80.

Discussion

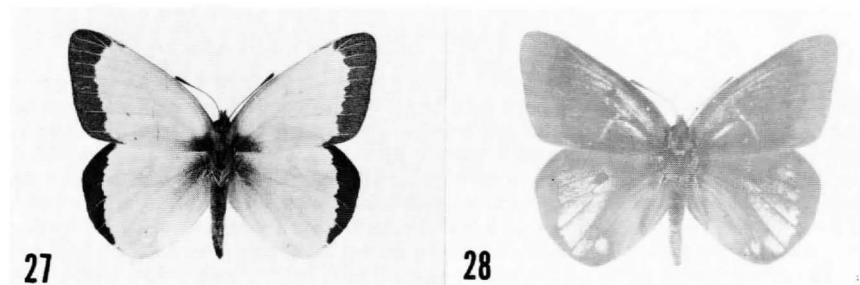
Two problems surround this species. The first is associated with its assignment to *philodice* Godart by Strecker, although subsequent authors correctly placed it as a separate species. While superficially similar to *philodice*, *occidentalis* is clearly distinct from it. The original confusion probably arose from the fact that Scudder selected a female "alba" form of *eurytheme* Boisduval as the allotype of *occidentalis*. Early workers often confused *philodice* with *eurytheme*, and it is sometimes difficult to separate the "alba" female forms of these two species. Even as late as his 1951 Check List, Jones treated *philodice* as a subspecies (*eriphyle* W. H. Edwards) of *eurytheme*. dos Passos too, in his List (1964), placed *Colias philodice eriphyle* as a subspecies of *eurytheme*. In the Rocky Mts., *philodice* is a resident species, while *eurytheme* occurs as a migrant since it is apparently unable to withstand the normal low winter temperatures of this region. While *C. philodice* in several phenotypes ranges over virtually all of British Columbia, *eurytheme* is restricted to the southern tier with occasional penetrations in favorable years into the Peace River District.

Whether or not *C. eurytheme* regularly over-winters in British Columbia and northern Washington has yet to be ascertained.

The second problem relates to the persistent confusion of *occidentalis* with *alexandra*. This first occurred in the Barnes and Benjamin Check List (1926a) with the entry *Eurymus occidentalis barbara*. McDunnough followed suit in his 1938 Check List. Hovanitz (1950) placed *occidentalis* in the *alexandra-christina* complex. It was McHenry (1963), however, who placed under *occidentalis* all of the *alexandra* names, one name belonging to *interior* Scudder, and several names variously associated with *philodice* and *eurytheme*. The reasons for this action are not explained in the paper cited.

dos Passos (1964) managed to rectify many, but not all, of the incorrect McHenry placements. The remaining errors were laid to rest by Brown (1973), Ferris (1973), and Miller and Brown (1981). These publications, notwithstanding, Gillette (1983) resurrected some of the McHenry misconceptions. McHenry can perhaps be partially forgiven for his actions since UV photographic techniques were not widely used in his day. Gillette, however, by his own statement (p. 28) dismisses the value of UV reflectance as a taxonomic tool, and his associated statements imply a misreading on his part of existing publications. My reason for mentioning this unpublished thesis relates to Gillette's description of a race of "*occidentalis*" from Utah. What he has provided is a redescription, in essence, of *Colias alexandra astra* W. H. Edwards, or of a clinal population of *alexandra* in which there is an orange-color expression. Similar *alexandra* populations occur in Idaho (Boise, Elmore, Nez Perce Cos.) and have been incorrectly placed as *occidentalis* by some collectors. The males in these populations are strongly UV-reflective, and the wing-shape and ventral maculation are typical of *alexandra*. A specimen from Elmore Co., Idaho is shown in Figures 27-28.

I suspect that much of the confusion and lack of recognition of these two separate species stems from the fact that they occupy the same geographic regions, although *alexandra* has a much wider distribution than *occidentalis*, which is restricted to California and the Pacific-Northwest. Generally the two species can be separated by differences in wing shape, pattern, and the ventral color. The outer wing borders of *occidentalis* are rounded, while those of *alexandra* terminate in an acute angle at the apex. Ventrally the color in *alexandra* is not so saturated as in *occidentalis* (described by one author as "bright burnt golden") and there is often a greenish cast to the HW produced by melanic over-scaling. Males of *occidentalis* possess wide black wing borders, while those of *alexandra* tend to be narrower and transected along the veins by yellow lines. Questionable male specimens are immediately separated by UV photography (Figures 31, 45). As confirmed by SEM examination (photographs not included herein), males of *occidentalis* lack entirely the specialized UV-reflecting scales found in *alexandra*. While pallid females of *occidentalis* are recorded, I have yet to see a true "alba" form. The "alba" form does occur in the Pacific-Northwest populations of *alexandra*.



Figures 27-28. Dorsal photographs of a male specimen of *Colias alexandra* nr. *astra* from W. of Paradise, Elmore Co., ID, 5.vi.79, leg. N.S. Curtis. (27) visible light photo; (28) UV photo.

Figures 29-32 illustrate the male type of *occidentalis*. Since two specimens bear the same MCZ type number label, I hereby designate the male shown in Figures 29-32 as the lectotype of *Colias occidentalis* Scudder. The Scudder-designated female type of *C. occidentalis*, actually a specimen of *C. eurytheme* f. "alba", is shown in Figures 33-35. I do not know who authored the comment label shown in Figure 35 (left). I have attached an additional comment label as shown in Figure 35 (right). Typical *occidentalis* specimens are shown in Figures 36-39. Figure 40 is a distribution map for this species. Based upon the disjunct distribution of this species as a whole, it appears that *occidentalis* may have specific and restrictive habitat requirements. Reported larval hosts include *Vicia*, *Melilotis*, "legumes", and several suspected genera including *Astragalus*, *Lathyrus*, and *Lupinus*.

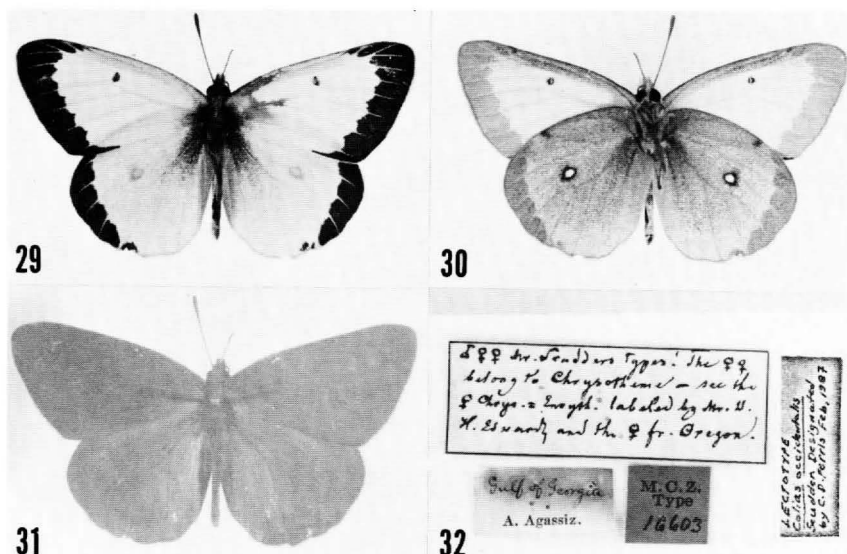
***Colias occidentalis chrysomelas* Hy. Edwards 1877**

Colias chrysomelas Hy. Edwards, 1877. Pac. Coast Lepid., (24):8-9. TL — Napa Co., California. HT in AMNH.

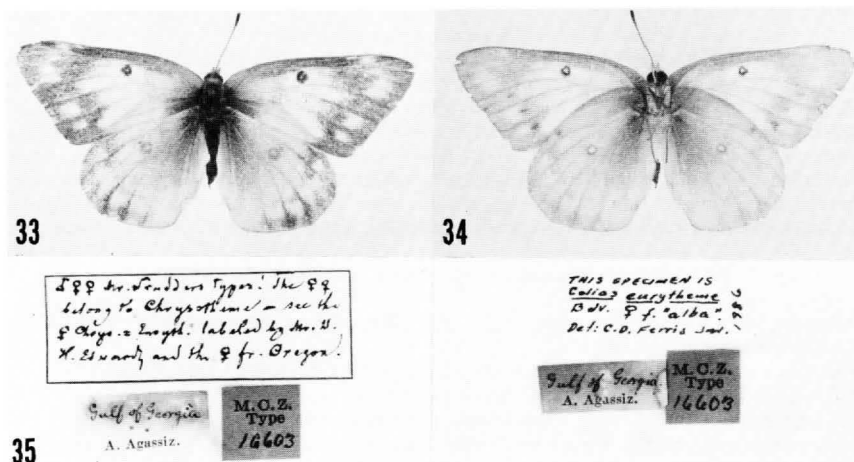
- = *Colias occidentalis* syn. *chrysomelas* Hy. Edwards; Strecker, 1878:82.
- = *Colias occidentalis chrysomelas* Hy. Edwards; Skinner, 1898:69.
- = *Eurymus occidentalis* syn. *chrysomelas* (Hy. Edwards); Dyar, 1902:10.
- = *Eurymus occidentalis chrysomelas* (Hy. Edwards); Barnes and Benjamin, 1926a:8.
- = *Colias occidentalis chrysomelas* Hy. Edwards; McDunnough, 1938:8.
- = *Colias chrysomelas* Hy. Edwards; Holland, 1949:293.
- = *Colias occidentalis chrysomelas* Hy. Edwards; McHenry, 1963:210;215.
- = *Colias occidentalis chrysomelas* Hy. Edwards; dos Passos, 1964:42.
- = *Colias occidentalis chrysomelas* Hy. Edwards; Miller and Brown, 1981:80.
- = *Colias occidentalis chrysomelaena* Hy. Edwards; Miller and Brown in Hodges, et al., 1983:52.

Infrasubspecific Names

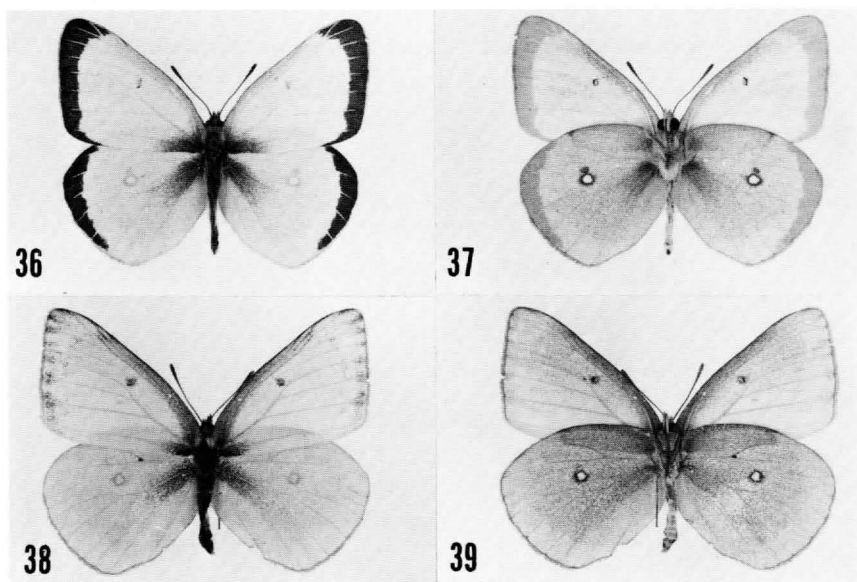
Eurymus occidentalis chrysomelas ♀ f. "shastae" Barnes and Benjamin, 1926b:88. TL



Figures 29-32. Lectotype male of *Colias occidentalis* Scudder. D (29), V (30), D, UV photo (31), specimen labels (32). Specimen in MCZ.



Figures 33-35. Specimen of *Colias eurytheme* f. "alba" designated by Scudder as the female type of *Colias occidentalis*, D (33), V (34), specimen labels (35).



Figures 36-39. Photographs of typical specimens of *Colias o. occidentalis*. ♂ D (36). Satus Pass Ski Area, Klickitat Co., WN, 16.vi.62, leg. R. E. Woodley; same, V (37); ♀ D (38), Wellington, Vancouver Is., B.C., Can., 6.vii.72, leg. R. Guppy; same, V (39).

— Shasta Retreat, Siskiyou Co., California. HT in NMNH. Described as a male.

Discussion

This subspecies in its pure form occurs only in California. Dornfeld (1980) recorded only nominate *occidentalis* from Oregon. Several characters separate *chrysomelas* from *occidentalis*. In *chrysomelas*, the dorsal black wing border is wider and more intense (especially in the males) than in *occidentalis*, and the ventral ground color in the males is a darker golden-yellow than is found in the nominate subspecies. Typical specimens are illustrated in Figures 41-44. A dorsal UV photograph is shown in Figure 45. The name *chrysomelas* was apparently incorrectly emended to *chrysomelaena* by an unknown editor of the MONA Check List (Hodges, *et al.*, 1983). Based upon the original description of this taxon, such an emendation does not appear to be valid under the I.C.Z.N. Code (Art. 31). Shapiro, *et al.* (1979:117) have discussed habitat and host plant associations for this subspecies. The Santa Cruz Co. locality record may be in error. Apparently certain early

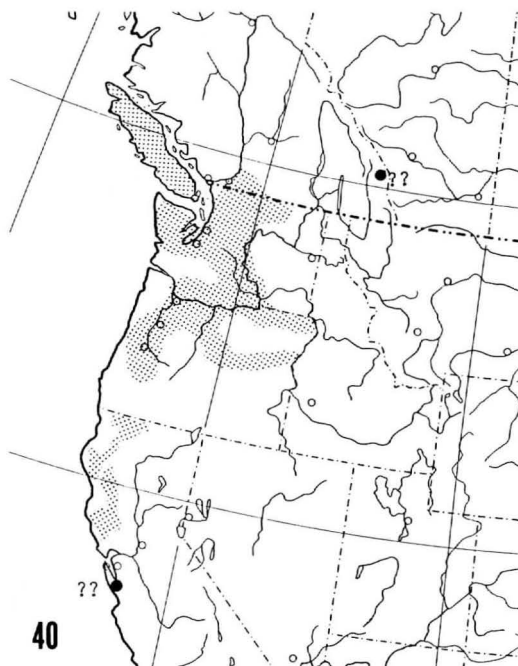
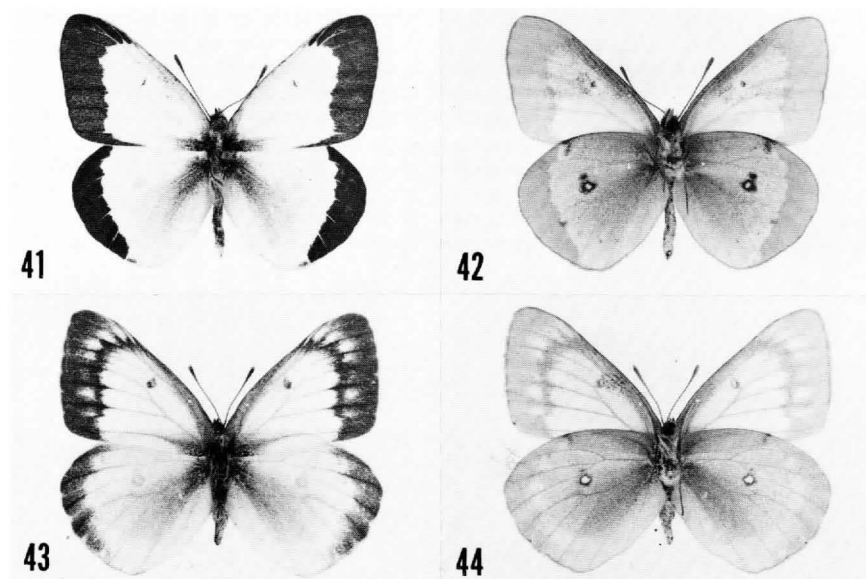


Figure 40. Map showing distribution of *Colias occidentalis*. Records for Field, B.C. and Santa Cruz, CA (indicated by black dots) most probably represent mislabeled specimens.

collectors labeled material "Santa Cruz" when it was actually collected elsewhere in California (*vide* J.F. Emmel). Adult records are from May to July.

A Note about *Colias nastes* Boisduval

In my 1985 paper, I referred in the text (p. 32;35) to two lectotypes designated by F.M. Brown, and figured their corresponding labels (Figures 111, 122). The subspecies involved are *Colias nastes moina* Strecker and *Colias nastes streckeri* Grum-Grschimaïlo. Brown



Figures 41-44. Photographs of typical specimens of *Colias o. chrysomelas*. ♂ D (41) Camp Ellendale, Glenn Co., CA, 5.v.73, leg. J. R. Mori; same, V (42); ♀ D (43), same data; same, V (44).

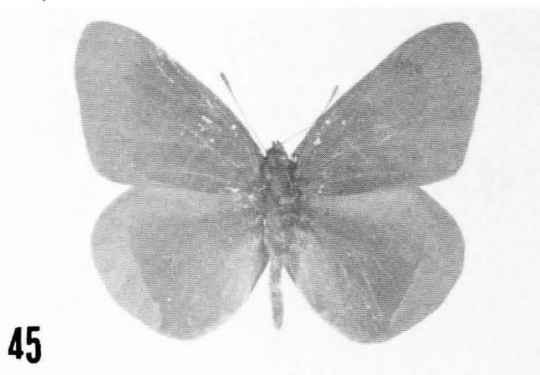


Figure 45. Dorsal UV photograph of male *C. o. chrysomelas* specimen shown in Fig. (41).

intended to, but never published these lectotype designations. Thus they must be credited to Ferris, 1985. New labels, as shown in Figure 46 have been attached to the specimen pins.

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Dr. Scott Shaw of the MCZ, Cambridge, MA kindly permitted me to borrow the type specimens of *Colias occidentalis* for examination and photography. His assistance is much appreciated. Dr. K.W. Philip, Fairbanks, AK guided me to collection localities for *Colias canadensis* and graciously opened his collection to me for study of his arctic *Colias* holdings. Prof. N.S. Curtis, Moscow, ID provided material for study, as did J. Troubridge, Cayuga, Ont., Canada. Dr. J.D. Lafontaine, Biosystematics Research Institute, Ottawa, Ont., Canada made it possible for me to examine material in the Canadian National Collection. J.H. Shepard, Nelson, B.C. kindly provided British Columbia records; R.A. Bailowitz, Tucson, AZ and K. Roever, Phoenix, AZ, records from Arizona; J.F. Emmel, Hemet, CA, records from California; M.E. Toliver, Eureka, IL, records from New Mexico; P.J. and S.F. Savage, St. George, UT, records from Utah; J.P. Pelham, Seattle, WN, records from Washington; R.L. Hardesty, Kalispell, MT, records from WY.

Guy Martin, Village Land Manager, Bering Straits Native Corporation, Nome, Alaska kindly arranged for collecting permits for native lands in the Nome area (a joint enterprise with K.W. Philip and J. and L. Troubridge).

As always, special thanks are due Lee and Jackie Miller for making possible publication of this paper, supplying SEM photos and photographic negatives of specimens in the AME/FSM collection, and for their many kindnesses during my visits to the Allyn Museum of Entomology/Florida State Museum and while a guest in their home.

Prior to submission, this paper was reviewed by Drs. J.C. Burne and R.E. Pfadt of the Department of Entomology, University of Wyoming, and their helpful comments are appreciated.

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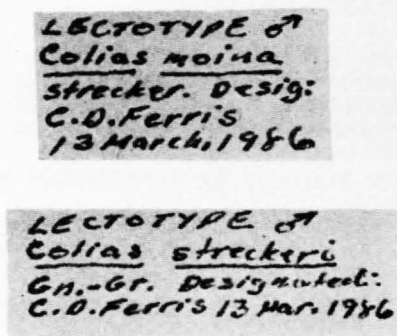


Figure 46. Lectotype labels (black ink on red paper) for *Colias moina* Strecker and *Colias streckeri* Grum-Grschimaïlo.

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APPENDIX

Collection Records and Material Studied

The records cited below are, for the most part, in addition to those listed in my previous publications (1973, 1976, 1981, 1982, 1985). To conserve space, names of collectors and dates of collection are omitted. In addition to material in the author's collection, specimens

from the following collections were examined: Allyn Museum of Entomology/Florida State Museum; Canadian National Collection; Nelson S. Curtis; J.S. Nordin; K. W. Philip. Many hundreds of specimens of *Colias alexandra* in the Canadian National Collection (CNC) were examined and, with few exceptions, an exact count was not recorded.

Colias alexandra alexandra (23 specimens). **NEBRASKA**. Sioux Co.: Monroe and Sowbelly Canyons.

Colias alexandra apache (38 specimens). **ARIZONA**. Apache Co.: 3-5 mi. SE Alpine; Crow Polson [Poison?] Ck. nr. Alpine; ditch Camp; Greer; vic. McNary. Coconino Co.: Oak Creek Canyon. Gila Co.: Promontary Point Lookout, Mogollon Rim. Greenlee Co.: Hannagan Meadow. **NEW MEXICO**. Catron Co.: Willow Ck., Gila Nat. For.; S.R. 78 at Silver Ck., Gila Nat. For. Grant Co.: Signal Peak, 7900-8200; Sandoval Co.: T19N, R1E, S15-16, 8600'. Sierra Co.: S.R. 90, mi. 83-85. Taos Co.: Cabresto Canyon, NE of Questa, 8500-10,600'. Torrance Co.: Capilla Peak, 9200'.

Colias alexandra astraea [or near *astraea*] (479 specimens). **ALBERTA**. Banff Park; Calgary; 82 mi. N. Grimshaw; Highwood Pass; Sunwupta Pass; nr. Waterton. **UTAH**: Summit Co.: N. Fork Provo River.

Colias alexandra christina (CNC plus 473 specimens). **ALBERTA**. Bluesky; Calgary; Laggan [Lake Louise]; Lethbridge; Mayberries; Prospect Mtn., Sexsmith; Waterton Lakes. **BRITISH COLUMBIA**. Alaska Hwy. mi. 147, 163, 220, 275, 384, 399, 415, Racing River; Dawson Creek; Stikine River; vic. Pink Mtn. and Halfway River; Summit Lake; **MANITOBA**. Minnota; Pine River; Riding Mtns.; The Pas. **SASKATCHEWAN**. Candle Lake, Cypress Hills, Fairholme, Harlan; Lloydminster; Nipawin Prov. Forest; Pedvers; Roche Percee. **NORTHWEST TERRITORIES**. Ft. Simpson; Ft. Smith; Hay River; Norman Wells; Salt River 20 mi. S. Ft. Smith; Yellowknife. **YUKON TERRITORY**. Dawson; W. of Mayo.

Colias alexandra columbiensis (CNC plus 49 specimens). **BRITISH COLUMBIA**. Anderson Lake; D'Arcy; Canim Lake; Clinton; Jesmond; Lac La Hache; Williams Lake; 100 Mile House. **WASHINGTON**. Ferry Co.: W. of Kettle Falls; vic. Liberty; vic. Republic. Okanogan Co.: Salmon Meadows. Yakima Co.

Colias alexandra edwardsi (17 specimens). **NEVADA**. Elko Co.: Lemoille Canyon. White Pine Co.: Austin Summit; Kingston Canyon; Mahogany Canyon.

Colias alexandra harfordi (15 specimens). **CALIFORNIA**. Los Angeles Co.: Eaton Canyon above Pasadena, 1000'. Kern Co.: Frazier Park, Tehachapi Mtns.; Tehachapi. San Bernardino Co.: Forest Home; Mill Creek. San Diego Co.: Garnet Peak, 6000'; Laguna Mtns.; Tecate Peak, 3890'. Santa Barbara Co.: El Camino Cielo, Santa Ynez Mtns.

Colias alexandra clinal populations (206 specimens). **CALIFORNIA**. Lassen Co.: Blue Lake, Warner Mtns. Modoc Co.: Blue Lake, S. Warner Mtns. **IDAHO**. Boise Co.: 5 mi. W. of Lowman (*astraea* phenotype); Boundary Co.: Vic. Moyie Springs (near *edwardsi*); Elmore Co.: W. of Paradise (*astraea* phenotype); Lemhi Co., Lemhi Range W. of Gilmore; Owyhee Co.: 10 mi. S. Bruneau; Shoshone Co.: 4 mi. SW of Clarkia. **NEVADA**. Nye Co.: Jett Canyon, Toiyabe Range. **OREGON**. Crook Co.: Hwy. 26 nr. summit of Ochoco Mtns. Harney Co.: Steens Mtns. Lake Co.: Abert Lake; vic. Lakeview. **UTAH**. Tooele Co.: Willow Creek, Stansbury Mtns. Summit Co.: Kamas; Shingle Creek. Wasatch Co.: S. Fk. Provo River.

Colias canadensis (522 specimens). **ALASKA**. Eagle Summit (below treeline); Fairbanks area (Murphy Dome, Wickersham Dome); Ft. Yukon; Index Lake; Yukon Valley nr. Central. **ALBERTA**. Ft. Vermillion; 27 mi. N. Meikle River; Nordegg region; Steen River. **BRITISH COLUMBIA**. Alaska Hwy. mi. 126, 140, 146, 148, 160, 163, 174, 200, 206.5, 211, 222, 226, 228, 371, 409; Pink Mtn. region. **NORTHWEST TERRITORIES**. Dempster Hwy., km 36; Chuk Park, Inuvik; Victoria Falls. **YUKON TERRITORY**. Dempster Hwy. km. 176.5 and 207.5, Ogilvie Mtns., km 373 at Eagle River xing.; km. 406-2 km. E., Richardson Mtns.; 411-1 km. N., Richardson Mtns.; Mt. Decoeli.

Colias occidentalis occidentalis (289 specimens). **BRITISH COLUMBIA**. Vic. Aspen Grove; Field (an unusual locality, perhaps a mislabeled specimen); Mt. Donald; Goldstream; Princeton and vicinity; Quamichan Lake; Tzohalem, Vancouver Is.: Bevan; Bowser; Courtenay; Duncans; Fowl Bay, Victoria; Malahat; Mt. Benson; Mt. Prevost; Nanaimo

Lake; Pt. Holmes, Comox; Royal Oak; Saratoga Beach, Oyster River; Shawnigan Lake; Spectacle Lake; Tod Inlet; Victoria; Wellington. **OREGON.** Crook Co.; Ochoco Mtns. (various locations). **WASHINGTON.** Chelan Co.: Tumwater Canyon nr. Leavenworth. Clallam Co.: Hurricane Ridge. Klickitat Co.: Bear Canyon; Satus Creek; Satus Pass. Mason Co.: Belfair; Stinson Creek, Okanogan Co. Thurston Co.: Tumwater. Yakima Co.: Satus Creek.

Colias occidentalis chrysomelas (64 specimens). **CALIFORNIA.** Glenn Co.: Camp Ellendale; W. of Stonyford. Humboldt Co.: Hoopa Ind. Resvn.; Orleans. Lake Co.: E. of Loch Lomond; Kelseyville; Mt. Cobb. Napa Co.: Napa; Spring Mtn. Napa-Sonoma Co. line; Mt. Vidar [sic], presumed to be Mt. Veeder. Santa Cruz Co.: Santa Cruz. Shasta Co.: Castella. Siskiyou Co.: Mt. Shasta. Sonoma Co.: Lokoya Lodge. [**COLORADO**]: There are specimens in museum collections which bear Osler labels showing Gunnison, Colorado. Osler was a commercial dealer who often provided no locality data with specimens that he sold. At one time, he operated from Gunnison, Colorado, and it is presumed that these labels were simply his business-address labels. The specimens examined were typical *chrysomelas*.

Species-Only Localities by State and County or Province

Colias alexandra. **CANADA: ALBERTA.** Virtually all of province in suitable habitats. **BRITISH COLUMBIA.** Southern, eastern to central and north to Yukon Territory. **MANITOBA.** Western in Riding Mtns. and contiguous regions. **NORTHWEST TERRITORIES:** Southern and western, N. to Norman Wells and Ft. Good Hope. **SASKATCHEWAN.** Southern and central, N. to Hudson Bay, Candle Lake and Harlan. **YUKON TERRITORY:** Southeastern to Dawson City. **MEXICO: BAJA CALIFORNIA.** Sierra San Pedro Martir. **UNITED STATES: ARIZONA.** Apache, Coconino, Gila, Graham, Greenlee, Mohave, Navajo. **CALIFORNIA.** Kern, Lassen, Los Angeles, Modoc, Mono, Orange, San Diego, Santa Barbara (includes Santa Cruz Is.), Tulare, Ventura. **COLORADO:** Arapahoe, Archuleta, Boulder, Chaffee, Clear Creek, Conejos, Costilla, Custer, Delta, Denver, Dolores, Douglas, Eagle, Elbert, El Paso, Fremont, Garfield, Gilpin, Grand, Gunnison, Hinsdale, Huerfano, Jackson, Jefferson, Lake, La Plata, Larimer, Las Animas, Mesa, Moffat, Montezuma, Montrose, Ouray, Park, Pitkin, Pueblo, Rio Blanco, Routt, Saguache, San Juan, San Miguel, Summit, Teller, Weld. **IDAHO.** Ada, Bingham, Blaine, Boise, Bonner, Boundary, Butte, Camas, Canyon, Cassia, Clark, Custer, Elmore, Franklin, Fremont, Idaho, Jefferson, Kootenai, Latah, Lemhi, Nez Perce, Oneida, Owyhee, Shoshone, Twin Falls. **MONTANA.** Beaverhead, Carbon, Carter, Cascade, Daniels, Fergus, Flathead, Gallatin, Glacier, Golden Valley, Jefferson, Judith Basin, Lake, Lewis and Clark, Liberty, Lincoln, Madison, Meagher, Mineral, Missoula, Park, Powder River, Powell, Ravalli, Silver Bow, Sanders, Stillwater, Sweet Grass, Teton, Toole, Yellowstone. **NEBRASKA.** Box Butte, Dawes, Scotts Bluff, Sioux. **NEVADA.** Carson City, Churchill, Clark, Douglas, Elko, Esmeralda, Eureka, Humboldt, Lander, Lincoln, Lyon, Mineral, Nye, Pershing, Storey, Washoe, White Pine. **NEW MEXICO.** Catron, Colfax, Grant, Los Alamos, McKinley, Rio Arriba, Sandoval, San Miguel, Santa Fe, Sierra, Taos, Torrance. **NORTH DAKOTA.** Slope. **OREGON.** Baker, Crook, Deschutes, Gilliam, Grant, Harney, Jefferson, Klamath, Lake, Malheur, Morrow, Sherman, Wallowa, Wheeler, Wasco. **SOUTH DAKOTA.** Custer, Jackson, Lawrence, Meade, Pennington. **UTAH.** Beaver, Cache, Carbon, Davis, Emery, Garfield, Grand, Iron, Juab, Morgan, Piute, Rich, Salt Lake, San Juan, San Pete, Sevier, Summit, Tooele, Uintah, Utah, Wasatch, Washington, Wayne. **WASHINGTON.** Asotin, Benton, Columbia, Douglas, Ferry, Franklin, Garfield, Grant, Kittitas, Klickitat, Lincoln, Okanogan, Pend Oreille, Spokane, Stevens, Whatcom, Whitman, Yakima. **WYOMING.** Albany, Big Horn, Campbell, Carbon, Converse, Crook, Fremont, Johnson, Laramie, Natrona, Niobrara, Park, Platte, Sheridan, Sublette, Sweetwater, Teton, Uinta, Weston, Yellowstone N.P.

Colias canadensis. **CANADA: ALBERTA.** SW in Nordegg area; extreme NW. **BRITISH COLUMBIA.** NE along Alaska Hwy. corridor from mi. 126-371 (and probably to Yukon Territory border); Pink Mtn. region. **NORTHWEST TERRITORIES.** From border with

Yukon Terr. N. to Inuvik. **YUKON TERRITORY**. SE along Alaska Hwy. and central along Dempster Hwy. N. to Richardson and British Mtns. **UNITED STATES: ALASKA**. Central interior region in suitable habitats.

Colias occidentalis. **CANADA: BRITISH COLUMBIA**. South-central mainland and Vancouver Is. **UNITED STATES: CALIFORNIA**. Glenn, Humboldt, Lake, Napa, Santa Cruz (probably erroneous, *fide* J. F. Emmel), Shasta, Siskiyou, Sonoma, Trinity (Shapiro, *et al.*, 1978). **OREGON**. Baker, Clackamas, Crook, Douglas, Grant, Jefferson, Lane, Marion, Umatilla, Wallowa, Wasco, Yamhill. **WASHINGTON**. Chelan, Clallam, Clark, Jefferson, Kittitas, Klickitat, Mason, Okanogan, Pierce, Skagit, Skamania, Whatcom, Yakima.

General distribution records for the range maps were taken from Hovanitz (1950) and Stanford (1985).

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