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NOTES ON CERTAIN SPECIES OF *COLIAS* (LEPIDOPTERA: PIERIDAE) FOUND IN WYOMING AND ASSOCIATED REGIONS[1]

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INTRODUCTION

There has been some confusion in the literature concerning three species of *Colias* found in Wyoming. The taxa involved are *Colias meadii* Edwards, *Colias alexandra* Edwards, and *Colias gigantea* Strecker. Subspecies of *alexandra* and *gigantea* have been described from the state.

The purpose of this paper is to examine the distributions of these three species of *Colias* in Wyoming with respect to range and subspecies. Intergrades within a given species are discussed and possible hybridization with another *Colias* group is examined. As necessary, populations from other geographic regions are treated.

Colias meadii Edwards

There are various literature references to *Colias meadii elis* Strecker from Wyoming although I have yet to see typical specimens from the state. There is a question in some workers' minds whether *elis* and *meadii* should be separated at the subspecific level or considered simply as clinal forms. Several workers have proposed separation at the species level. After examining large series (in the hundreds) of *C. meadii* from Colorado, Wyoming, and Alberta, and a limited number of specimens from Montana and Utah, I would tend to make the separation into two subspecific taxa on the basis of habitat and differences in facies.

Generally *C. m. meadii* in Colorado and Wyoming inhabits the windswept tundra-like regions above the timberline (above 10,000') where the females are reported to oviposit upon the alpine clover *Trifolium dasphyllum* Torr.

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and Gray (Shields, *et al.*, 1969). The butterfly is wary and possessed of swift flight, usually quite close to the ground. Capture is not easy while the insect is on the wing, and equally difficult when the butterfly alights because of the protective green coloring of the under side which blends with the alpine flora. Although basically a high mountain butterfly in the two states, I have taken *meadii* in lush meadows below timberline in both Colorado (San Juan Co.) and Wyoming (vicinity of Green River Lakes, Sublette Co., and near Brooks Lake, Fremont Co.).

As we move north in latitude, *meadii* flies lower in elevation. During July, 1970, I collected extensively in Alberta from the Montana border to just south of Jasper. In this region *C. m. elis* was found flying in meadows at quite low elevation (on the order of 6000′) and well below timberline. Specimens were taken in suitable meadows along most of the length of the Kananaskis Forest Trunk Road between Coleman and Seebee, on Plateau Mountain (elevation 8200′), and *elis* was literally swarming in mid-July in the valley through which Nigel Creek flows in Banff National Park. Flight patterns and habits were quite different from Colorado and Wyoming *meadii*. In Canada, *elis* flew relatively slowly, appeared rather unwary, and frequently nectared upon flowers where it was easily netted. Considerable collecting on the ridges above timberline (here only 6500′-7000′ north of Banff) failed to produce very many *elis* although other alpine species were taken, including *C. nastes streckeri* Grum-Grschimaïlo. From my experiences, I must infer that *meadii* is a high alpine species generally, while *elis* prefers lush meadow areas generally below timberline. One must also consider the change in latitude with respect to the two subspecies.

The males in a given population of *meadii* are rather uniform in facies. The females show considerable variation in the amount of dark color which composes the wing borders dorsally. With increasing altitude, *m. meadii* tends to become smaller, the under side darker, and the upper side more dusted in aspect. In northern Wyoming, a few females from any *meadii* population will approach *elis*. Fig. 58 shows a typical female *meadii* and an extreme light female (Fig. 59) is shown from Wyoming. A dark female (Fig. 62) and an extreme light female *elis* (Fig. 63) are also shown.

Canadian *elis* is a larger insect than the American *meadii* (length of costal margin of female forewing, 2.5 cm. for *elis* and 2.1 cm. for *meadii*, Alberta and Wyoming specimens) and the females show considerably less black and more yellow than any *meadii* which I have seen. Both sexes are quite pale on the under side when compared with the nominate subspecies.

Colorado and Wyoming populations produce albinic females (form "*medi*" Gunder). A Wyoming specimen is illustrated (Fig. 60). Although originally described from Colorado, female form "*medi*" is not common in that state. White females are recorded from Fremont, Park, and Sublette Counties in Wyoming. Specimens have also been taken in Carbon Co., Montana on the Beartooth Plateau which extends into Park Co., Wyoming. One population in Park Co., based upon limited study, may run as high as 25 per cent albino females.

C. meadii elis appears to produce albinistic females only rarely. Letters from Dr. T. N. Freeman and Dr. A. B. Klots indicated that neither the Canadian National Collection nor the collection of the American Museum of Natural History contains white females of *elis*. Dufrane (1947) named a white female form, presumably of *elis*, as "*lambillioni*". No precise type locality is stated, only that the type specimen was from Canada "*sans nom de localité précise.*" A white female *Colias* (Fig. 64) was taken by the author on Plateau Mountain in Alberta in 1970. Photographic reproduction fails to do justice to detail. The specimen appears possibly to be an albino *elis*. It may

well be an atypical *streckeri* or as remote possibility *elis* x *streckeri.* In the meadow where it was collected, both species were flying. The specimen is quite distinct from any of the females in the series of *streckeri* which was taken concurrently.

The type localities and dates of publication for the *meadii* group are listed below:

Colias meadii meadii Edwards, 1871 [T. L. Mosquito Pass, Park/Lake Co., Colorado].
♀ form *"medi"* (Gunder), 1934 [T. L. Breckenridge Peak, Empire Co., Colorado].
Colias meadii elis Strecker, 1885 [T. L. vicinity of Kicking Horse Pass, 10,000', Rocky Mtns., British Columbia, Canada].
♀ form *"lambillioni"* Dufrane, 1947 [T. L. Canada].

Based upon my experience with *meadii*, I would conclude that *meadii* and *elis* should be retained as separate subspecific taxa; *elis, per se,* does not occur Wyoming; intergrades between *meadii* and *elis* occur to a limited extent in northern Wyoming.

The **Colias alexandra** Complex

Three forms of *C. alexandra* are found in Wyoming. Before undertaking a study of this taxon in the state, it is first necessary to devote some discussion to a confusion which has developed over the years between two distinct taxa. Both taxa, *C. astraea* and *C. harroweri,* were originally described from Wyoming. Their principal species associations are noted below.

Colias alexandra astraea Edwards

In recent years, *astraea* has been placed with the *C. scudderii* complex (dos Passos, 1964), most probably as a result of a paper by Klots (1937). In this paper, Klots recorded a collecting trip made in 1935 through New Mexico, Colorado, and Wyoming. On page 321 he notes: "A considerable number of *C. astraea* were seen, and a small series taken, in the valley of Clear Creek just below the 'Natural Bridge', near the head of the lower Green River Lake on August 3." This location is in the Bridger Wilderness in Sublette Co., Wyoming. Klots subsequently realized that this butterfly was not *astraea* and he named it *harroweri* (1940). In the 1937 paper, reference was made to *Salix* as the possible food plant for *"astraea"* (= *harroweri*). This reference has probably aided in the misapplication of *astraea* to the *scudderii* complex.

William Henry Edwards described *C. astraea* in March, 1872 based on a single male taken by the Hayden Expedition of 1872 (Figs. 83-84). The type locality is Yellowstone Lake, (Yellowstone National Park) Wyoming. Edwards noted at the end of his description: "On the under side this species is nearest *Alexandra*; on the upper side of a different shade of color from any of our species."

Two key points of Edwards' description are the following excerpts: "Upper side pale ochraceous, very little tinted with orange on the disks of secondaries from cell to marginal border and from base to hind margin of secondaries below the cell, this color being not decided but only a tint; . . . . discal spot of primaries a short black streak; on secondaries wanting."

"Under side of primaries yellow nearly as above, without orange; of secondaries yellow densely covered with black scales so as to obscure the whole surface; discal spot of primaries very narrow, black, enclosing a few yellow scales, of secondaries white, as in *Alexandra,* without a ring; . . . ."

The specimen which Edwards had before him would appear to be not quite typical of the insect which flies in northern Wyoming thence to Alberta. Specimens fitting the description occur sparingly and I have in my collection one from Wyoming and one from Alberta. When a series of "typical" *astraea* is examined, one notes a distinct discal spot on the upper surface of the secondaries. There are two extremes in dorsal color of the wings from heavily orange tinted to nearly pure yellow. In the former case, the discal spot on the upper side of the hind wing is obscured by the ground color (probably the situation in the type specimen). In the latter case, it appears as a pale but distinct orange spot. On the under side of the hind wing, the discal spot is usually finely ringed with pink scales. This is quite different from the situation in *harroweri* described below.

In other respects, *astraea* resembles *alexandra* in the ventral color and the sharp apices of the primaries. The females are white. Ventrally they are similar to the males except for lighter ground color. The secondaries exhibit a greenish overscaling. Dorsally, the margins are lightly black bordered in a pattern suggesting *eurytheme*, but much more lightly scaled. In some examples, the dark scaling is virtually absent. The secondaries may or may not show dark border scaling. The discal spot varies from white to pale pink-orange to orange.

Colias gigantea harroweri Klots

This taxon was originally placed by Klots in the combination shown. Based upon food plant association, habitat similarity, and other considerations, various workers have adopted *scudderii* as the species. Some discussion of this point will be found in a later section of this paper.

In his description of *harroweri*, Klots (1940) recognized the *astraea-gigantea* confusion, as noted in his opening statement: "For many years this, as well as other yellow *Colias* from western North America, has been passing under the name *Colias christina* [now *C. alexandra christina*] form *astraea* Edwards." He then continues: "A small series taken by the author in 1935 (now a part of the present type lot) was thus tentatively named (Journ. N. Y. Ent. Soc., 1937, XLV, p. 321)." Here Klots corrected the earlier misidentification of *harroweri* as *astraea*. The description of *harroweri* is quite detailed and needs no embellishment. The key points are as follows: Males - Apices of primaries definitely rounded; dorsal ground color clear lemon yellow with greenish tinge on secondaries; discal spot of secondaries "shows through" from under side as a pale orange spot; ventral ground color similar to above but lighter with some dark overscaling along costa of primaries and lightly on disc of secondaries; secondary discal spot large and distinct, usually with satellite and frequently with full double spot; spot or spots pearly, heavily ringed with dark pink-brown scales which frequently invade the spot center; satellite spot often totally dark. Females - Dorsal ground color bright yellow with orange tinting toward body; black border absent or present only as a trace; discal spot of secondaries bold, double, and orange; ventrally the nature of the coloring resembles that of the males, but with the base color of the females. White females are occasionally found in Wyoming, and become more common in regions north of the state.

C. alexandra astraea and *C. gigantea harroweri* are quite distinct from one another. In some areas, the two species are sympatric and synchronic (vicinity of Slide Falls and Clear Creek, Bridger Wilderness, Sublette Co., Wyoming) which perhaps has caused some of the confusion. This area is the type locality for *harroweri*. The term sympatric is used here in the general sense, as *harroweri* is a denizen of the wettest portions of sphagnum

bogs in which its food plant (*Salix*) grows (occasionally a female is found nectaring at the bog edge), while *astraea* is found on dry land in grassy clearings in the forest, frequently in association with sagebrush and its suspected food plants in the family Leguminosae, *Astragalus* and *Lupinus*.

The specimens of *C. astraea* figured as types by Holland in the Butterfly Book (Plate LXVIII, Figs. 26, 27, 1931 Edition) and illustrated in Figs. 81, 82, 85, 86, are not the types and at best represent atypical *astraea*. Klots referred to this situation in his 1940 paper. The male specimen which Holland figured shows "*eurytheme*" spotting on the under side of the secondaries and a partial satellite discal spot which is not characteristic of *astraea*. The type specimen of *astraea* (Figs. 83, 84) does not exhibit "*eurytheme*" spots.

I have seen specimens of *C. alexandra astraea* from Wyoming, Utah, Idaho, Montana, and southern Alberta. *C. gigantea harroweri* is recorded from Wyoming, Montana, Idaho, and southern portions of Manitoba, British Columbia, and Alberta. Sorensen (unpublished) has shown that specimens from southern Manitoba are distinct *harroweri* as has Masters (1970a). The Chermocks (1940) applied the name *mayi* to the Riding Mountains, Manitoba population. Sorensen's work indicates that *mayi*, if a synonym, should be considered synonymous with *gigantea* rather than *harroweri* as listed by dos Passos (1964). Masters has chosen to consider *mayi* a valid taxon. Northern Canadian specimens are referred to *C. g. gigantea* as is the Alaska population. The ranges of the various forms of *gigantea* overlap considerably and appear to represent a clinal situation. It remains to be seen whether only the end points of the cline should carry subspecific names, or if additional subspecific names should be applied. The ranges of *C. alexandra* and *C. gigantea* overlap considerably, but these species are distinct in their morphology and their food plant associations. Their habitats are different in that *gigantea* is a bog species and *alexandra* a dry land species. Positive separation can be achieved by ultraviolet photography of doubtful individuals. Under ultraviolet illumination, *C. alexandra* males exhibit a luminous patch (actually an interference pattern) on the dorsal surface of the secondaries; *C. gigantea* shows no luminosity. For several years a series of *Colias* from southern British Columbia and northern Idaho has resided in the author's collection as "*gigantea*". These are large insects and generally resemble *gigantea* except that they were collected in forest clearings rather than in bogs. Ultraviolet photography has shown them to be *alexandra*. Detailed studies will be published in the near future.

Both Klots (1940) and McDunnough (1922, 1928) have called attention to the differences between the *alexandra-astraea-christina* (*alexandra*) complex and the *gigantea-scudderii* complex. Apparently these works have been overlooked in recent years by some workers.

To understand the *alexandra* populations found in Wyoming, it is necessary to examine superficially the entire *alexandra* complex as it is presently known. Three population divisions can be made with respect to dorsal coloration in the males: entirely yellow, entirely orange, mixed yellow and orange. The taxa associated with these color divisions, their type localities, and dates of publication are:

Yellow Populations

Colias alexandra alexandra Edwards, 1863 [T. L. Front Range, West of Denver, Colorado].

Colias alexandra edwardsii Edwards, 1870 [T. L. Virginia City, Storey Co., Nevada].

Colias alexandra emilia Edwards, 1870 [T. L. Oregon].

Colias alexandra ssp. Arizona - New Mexico segregate.

Orange Populations

(?) *Colias alexandra alberta* Bowman, 1942 [T. L. Wembley, Alberta, Canada]. See discussion which follows below concerning placement of *alberta*.

Colias alexandra krauthii Klots, 1935 [T. L. Black Hills, 12 miles west of Custer Co., South Dakota].

Colias alexandra ssp. Manitoba segregate. Beulah, Manitoba and other areas. Orange population perhaps referable to *krauthii* (?).

Yellow-Orange Populations

Colias alexandra astraea Edwards, 1872 [T. L. Yellowstone Lake, Wyoming].

Colias alexandra christina Edwards, 1863 [T. L. Slave River Crossing, N. W. T., Canada].

The yellow populations of *alexandra* range from the Pacific Northwest (Oregon) south through California and east across the Great Basin and into Arizona, New Mexico, and Colorado. Apparently undiluted yellow forms are found in western Nebraska, and in the southern portions of Utah and Wyoming. Generally speaking, *emilia* is associated with the Pacific Northwest, *edwardsii* with eastern California and the Great Basin, and *alexandra* with Colorado and the Front Range into Wyoming. The Arizona - New Mexico segregate from the Mogollon Rim through the White Mountains in Arizona and into the Mogollon Mountains in New Mexico is interesting. It appears to be distinct from the named subspecies. The insects are quite large and the females very pale in color. This segregate appears closest to *edwardsii*. This is true also of some southern Utah specimens.

The orange form *krauthii* occurs in western South Dakota and northeastern Wyoming (Black Hills region). Another orange form, *alberta*, was described by Bowman from Canada. This taxon is the subject of a separate discussion in a later section of this paper.

The geographic region defined by the Pacific Northwest into northern Utah and Wyoming on the south, through Montana and Idaho into Alberta and east to Manitoba encompasses the range of the yellow-orange populations of *alexandra*.

When we examine the yellow-orange populations, it is frequently difficult to attach the name *astraea* or *christina* to given specimens. Wyoming material from Sheridan Co. west to Yellowstone National Park generally fits Edwards' description of *astraea* with reference to the males. Based upon specimens which I have seen and taken in Wyoming, I would arbitrarily assign females which exhibit an untinted white dorsal ground color to this taxon.

Northern Utah specimens (Salt Lake, Summit, Tooele, Wasatch Cos.) tend toward both *astraea* (in the males) and *christina* (in the females). The females frequently show an overwashed orange coloration. Idaho and Montana specimens represent both forms. Material from southern Alberta south of Banff National Park exhibits the complete range from pure yellow *alexandra*-like specimens to pure orange *krauthii*-like specimens in the males. Females from this region range from pure white dorsally to pale orange-yellow as in *christina*. I have not seen specimens with as dark an orange as in *krauthii* females from the Black Hills. The name *christina* has been applied to specimens taken from the Northwest Territories to the Riding Mtns. in Manitoba.

There appears to be one characteristic in the males of the *alexandra* complex which can be used reliably to separate the populations. This is the dorsal discal spot on the secondaries. The original descriptions of the taxa associated with the yellow populations note that this spot is absent (hence concolorous with the yellow of the wings). In the orange and the yellow-orange populations, this spot is orange, although sometimes masked by the orange color of the wing. Extreme examples of *astraea*, although appearing pure yellow, will show the orange discal spot and may thus be separated from *alexandra alexandra* and other yellow populations.

It would appear that "*emilia*" from north-central Washington (Okanogan Co.) intergrades with the yellow-orange populations to the east. I have seen specimens which fit the original description of *emilia* in all respects save that the discal spot is orange. Specimens of *alexandra* from southern British Columbia and northern Idaho, alluded to previously, are quite large and show an orange discal spot in the males. They are quite distinct from *astraea*. F. M. Brown is currently preparing a paper which treats "*emilia*" and *edwardsii*, as part of his continuing work on the Edwards types. The *alexandra* complex will be treated in detail in a subsequent paper.

Females of the *alexandra* complex are quite variable and range from white through yellow to orange. The quantity of dorsal dark bordering varies from lacking to prominent. The discal spot separation technique is not reliable with this sex. Normally members of the yellow populations have the spot absent or appearing lighter than the wing color. Occasionally the spot is *pale* orange. Females of the orange and yellow-orange populations normally exhibit an orange spot, if the females are yellow or orange, but the spot may be almost white (or sometimes a very pale pink) in white females.

The ventral surface of the males and to a lesser extent in the females is usually diagnostic. Members of the yellow populations exhibit a cold gray-greenish color on the secondaries. This is produced by a heavy dusting of dark scales over the yellow base color. In the orange and yellow-orange races, the secondaries generally show a warm orange overtone, although heavy dark dusting may be present. Ultraviolet photography is diagnostic for males of *alexandra*.

In western Wyoming and northern Utah, a diminutive *alexandra* is found. It is not clear whether this is an altitudinal form or genetically related. The specimens are considerably smaller than normal *alexandra alexandra* and the dorsal black borders of the males are very narrow (as in *emilia*). The discal spot is concolorous with the yellow of the wings.

C. alexandra is usually associated with relatively open areas, either sagebrush zones (frequently in aspen-pine zone clearings) or forest clearings. The food plant is generally thought to be the Leguminosae (*Lupinus* and *Astragalus*) and has been proved in certain instances (McDunnough, 1922; Shields, *et al.*, 1969). The larvae of the yellow-orange population in Utah pupate at the bases of sagebrush plants, generally in the debris at ground level (Tidwell, 1970).

Colias alberta Bowman

Bowman, when he described *C. alberta*, placed the taxon with *C. eurytheme* in the combination *Colias eurytheme alberta* Bowman (1942). Hovanitz (1943) in a brief discussion assigned *alberta* to *alexandra* and dos Passos (1964) followed. The position and validity of this taxon has been in question ever since. Some workers have stated that Bowman simply re-described *C. alexandra christina*; others feel that *C. eurytheme* was re-described. Recently, Masters (1970b), based upon examination of a single paratype, has unequivo-

cally stated that *alberta* is *C. alexandra christina*. The author has not been able to ascertain what specimens Hovanitz examined in preparation for his 1943 paper.

According to the *International Code of Zoological Nomenclature* (Articles 72 and 73), when a holotype is designated, as Bowman did, that specimen is the reference for the taxon. Thus one runs a risk in making pronouncements based upon examination of paratypes or single specimens within the type series.

Recently I was able to locate the type specimens of *alberta* in the entomological collection of the University of Alberta at Edmonton. These are figured on the color plate. In addition, seven paratypes from the original series were examined as well as the holotype and one paratype of the female form *"pallidissima"* Bowman. Photographs of additional paratype material from the Los Angeles County Museum of Natural History were also examined. The type specimens have been placed in the Canadian National Collection. The seven paratypes of *alberta* and the holotype and paratype of *"pallidissima"* are figured (Figs. 7-24.)

Based upon careful examination of this material and comparison of it with populations of *C. eurytheme* and *C. alexandra*, it would appear that *alberta* represents a hybrid situation and is not really a valid taxon.

The maculation of the upper surface is characteristic of *C. eurytheme* Boisduval in the following respects: males- ground color, width and dentation of dark margin (margin about half again as wide as in *alexandra*), size, shape and color of both primary and secondary discal spots. Based upon examination of the upper surfaces only, one would place *alberta* with *eurytheme* as Bowman did. The white female forms, *pallidissima*, are not unlike the white females of *C. philodice vitabunda* Hovanitz; they bear little resemblance to the white female forms in the *alexandra* complex.

The facies of the under surface of *alberta* are generally characteristic of *eurytheme*, but with some exceptions, as shown in Figs. 3-24. Figures 3-6 illustrate typical *eurytheme* from the Rocky Mountain regions. These two specimens were selected for their similarity to the holotype and allotype (dorsal surface) of *alberta*. The overall coloring of the under sides of *alberta* specimens is lighter than *eurytheme* from the Middle Atlantic Region and the spotting is not so strongly defined. Three characteristics of *eurytheme* are present. These are submarginal spots on either the primaries or secondaries, or both, or satellite discal spot to main discal spot on the secondaries. The *"eurytheme"* spots are generally present to some degree, although very pale to the point of being almost absent in some of the material examined, especially in the holotype and allotype. The discal spot on the secondaries is light and pearly or almost silvery as in *eurytheme*. The submarginal row of spots on the secondaries, although generally light, is typical in its form to *eurytheme*. The pink fringes on the wings are again more typical of *eurytheme* than *alexandra*.

Actually the specimens are not very different from the forms of *eurytheme* taken at higher elevations in Colorado and Wyoming. Wyoming material, in particular, is frequently pale on the under surfaces with spotting almost obsolete. If we equate altitude to latitude, as can sometimes be done with respect to maculation, we would expect lighter spotting in northern populations of *eurytheme*.

The specimens shown in Figs. 7-14 have been photographed also under ultraviolet illumination. The interference patches which occur are closer in form to those produced by *eurytheme* than those produced by *alexandra*. Patches occur on both the primaries and secondaries as is the case with the orange races of *alexandra*.

In view of the preceding discussion, I feel that *alberta* represents a hybrid situation and th ename should be suppressed rather than sunk in synonymy with another taxon. The hybrid would appear to be *C. alexandra christina* x *C. eurytheme*, and possible backcross generations. Populations of *C. philodice eriphyle* Edwards are sympatric with *christina*, but it is felt that this is not the hybridizing species. The *philodice* group does not exhibit ultraviolet interference patterns while *eurytheme* does. This situation would also indicate that *philodice* and *eurytheme* are separate species, although hybridization does appear to occur naturally. These problems are currently being studied by O. R. Taylor, J. T. Sorensen, and R. Silberglied. P. A. Opler (unpublished) has placed *eurytheme* as a subspecies of *philodice*.

There is considerable evidence for natural hybridizing between *eurytheme* and members of the *alexandra* complex. Some discussion is presented in subsequent portions of this paper. Dr. S. A. Ae (Japan) has done studies on laboratory hybrids between *C. eurytheme* and *C. interior*, *C. philodice* and *C. alexandra*.

The **Colias scudderii-gigantea** Complex

The exact relationships of the members of this complex is not completely clear. The Wyoming taxa involved are *Colias gigantea harroweri* Klots, *Colias pelidne skinneri* Barnes, and *Colias s. scudderii* Reakirt. Klots (*in* Ehrlich and Ehrlich, 1961) provisionally combined the taxa *pelidne* and *scudderii* and indicated that these may be conspecific with *gigantea*. dos Passos (1964) lists *gigantea* and *scudderii* as conspecific and *pelidne* separately. It has been demonstrated that the larvae of all three feed upon *Salix* (Klots *in* Ehrlich and Ehrlich, 1961 ; Klots 1937, 1940 ; Shields, *et al.*, 1969). I do not feel that a common food plant genus is sufficient evidence for conspecificity. *C. pelidne skinneri* and *C. gigantea harroweri* are sympatic in Wyoming. The range of *C. s. scudderii* does not appear to overlap the ranges of the other two species.

My inclination is to treat *pelidne* as a species distinct from *gigantea* and *scudderii*. Based upon one seemingly consistent character, I would also separate *gigantea* and *scudderii*, although they appear very closely related. This character is the discal spot on the ventral surface of the secondaries. Only very rarely in *scudderii* does this show a suggestion of a satellite spot. In *gigantea*, this spot invariably shows a trace of a satellite spot (except in a very few far northern specimens) and generally the spot is distinctly double, as shown in Figs. 73-78, 87, 88.

There is one habit difference between *gigantea* and *scudderii* in Wyoming: *gigantea harroweri* is distinctly a deep bog species and seldom strays very far from the center of its habitat; *scudderii* on the other hand may range quite far from willow bogs. Both *s. scudderii* and *pelidne skinneri* may be found along forest roads and frequenting open grassy meadows, although these two species inhabit different areas of the state.

In Wyoming, the females of all three species are dimorphic, being either yellow or white. The dominant female form for *scudderii* is white, for *harroweri* yellow, and about equally divided between yellow and white for *skinneri*. In northern Canada, *gigantea* females tend toward white rather than yellow.

Based upon the previous discussion, I would be inclined to group these *Salix* feeders as follows:

Colias scudderii scudderii Reakirt, 1865 [T. L. probably near Empire, Clear Creek Co., Colorado].

Colias scudderii ruckesi Klots, 1937 [T. L. Windsor Creek Canyon, west

of Cowles, San Miguel Co., New Mexico].

Colias gigantea gigantea Strcker, 1900 [T. L. west coast of Hudson Bay above Ft. York, now taken as Churchill, Manitoba, Canada. For the present, *mayi* is lumped here.

Colias gigantea harroweri Klots, 1940 [T. L. vicinity Clear Creek and Slide Falls, Sublette Co., Wyoming].

Colias pelidne group. Four subspecies listed by dos Passos 1964.

Colias pelidne skinneri Barnes, 1897 [T. L. Yellowstone National Park, Wyoming].

Dr. A. B. Klots has raised a question that the Alaska population of *gigantea* might be quite different from the Churchill, Manitoba (type locality) population. Compare the specimen shown in Figs. 73-74 with the specimen shown in Figs. 87-88. Note the double discal spot on the underside of the Alaskan specimen.

Further research may well show that the taxa *gigantea, pelidne,* and *scudderii* should all be grouped under *pelidne* which bears publication priority. Morphology would incline me to separate *gigantea* at least from the other two taxa as was suggested by Klots (*in* Ehrlich and Ehrlich, 1961).

Possible Hybridization

Genitalic studies and chromosome examination (Kodo and Remington, 1960) indicate that from a structural standpoint, hybrids are possible between various species of *Colias*. Field collected specimens tend to bear this out. Several specimens which appear to be hybrids are figured in the plates. Various subspecies of *alexandra* consistently show "*eurytheme*" spots (submarginal row) ventrally on the secondaries and occasionally a satellite spot to the discal spot. This is especially true in populations of *astraea, christina,* and *krauthii*: the orange and yellow-orange populations. *C. alberta* has been treated previously. It is interesting to note that the *alexandra* complex and *C. eurytheme* have members of the Leguminosae as larval foodplants. *C. eurytheme* is an aggressive species and one might expect mating attempts with other species. Studies are being conducted by O. R. Taylor, S. A. Ae and others.

The author has undertaken extensive ultraviolet photographic studies of the genus *Colias* to determine which species have similar appearance under ultraviolet illumination. These studies will be published subsequently. Several species do appear similar under ultraviolet illumination which does give support to hybridization attempts.

The possible hybrid situations for Wyoming species are presented. Fig. 46 shows a male *C. alexandra krauthii* with typical under side "eurytheme" spots. Fig. 48 shows a probable *krauthii* x *eurytheme* specimen. The under side of this female is typical of *alexandra,* but the upper side resembles *eurytheme.* Figs. 79-80 show a probable cross between *meadii* and *pelidne skinneri.* The dark border and general facies resemble *pelidne,* but the color of the dorsal surface is orange as in *meadii.*

Distribution in Wyoming

Figure 1 shows the probable general distribution of the *alexandra* complex with designations for the various color populations. The distribution will be treated in greater depth in a subsequent paper. Figure 2 illustrates the distributions in Wyoming for the various species mentioned in this paper.

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Additional material used in this study was drawn from the literature. The various papers examined will be found in the "Literature Cited". The author would like to express his appreciation to Dr. Lee D. Miller and Mr. A. C. Allyn for making publication of this paper possible.

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Color plate. *Colias "alberta"* Bowman; Holotype ♂ (upper figures) and Allotype ♀ (lower figures). Both specimens are from Wembley, ALBERTA, CANADA. These specimens are now placed in the Canadian National Collection. Color transparencies by George Lewis.

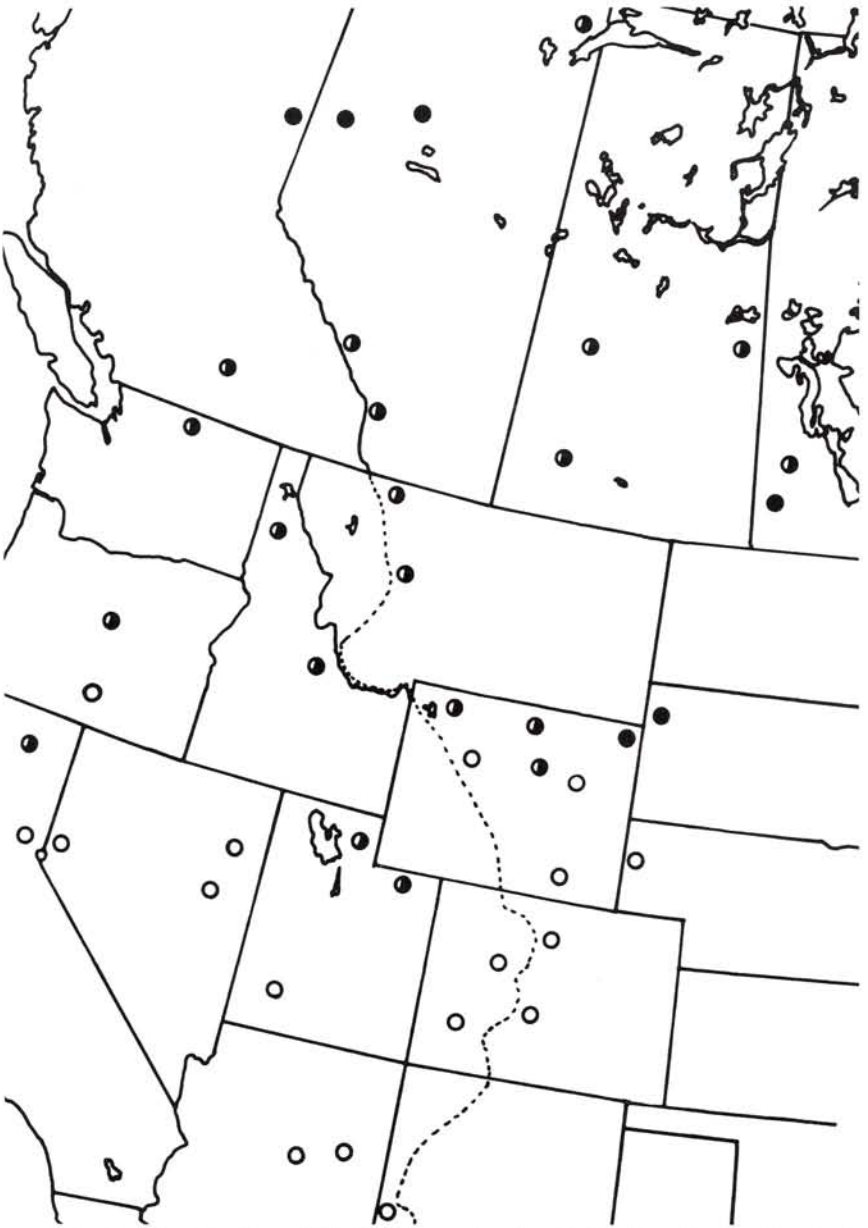


Fig. 1. Distribution of *Colias alexandra* in North America south of the 60th parallel. Open circles = yellow populations, solid dots = orange populations and half-open circles = yellow-orange populations. Dotted line is Continental Divide. Solid dots in Alberta and British Columbia refer to *C. alberta* (see discussion in text). Only subspecies of *C. alexandra* as listed in dos Passos (1964) are indicated. Compare with Hovanitz (1950a: fig. 6).

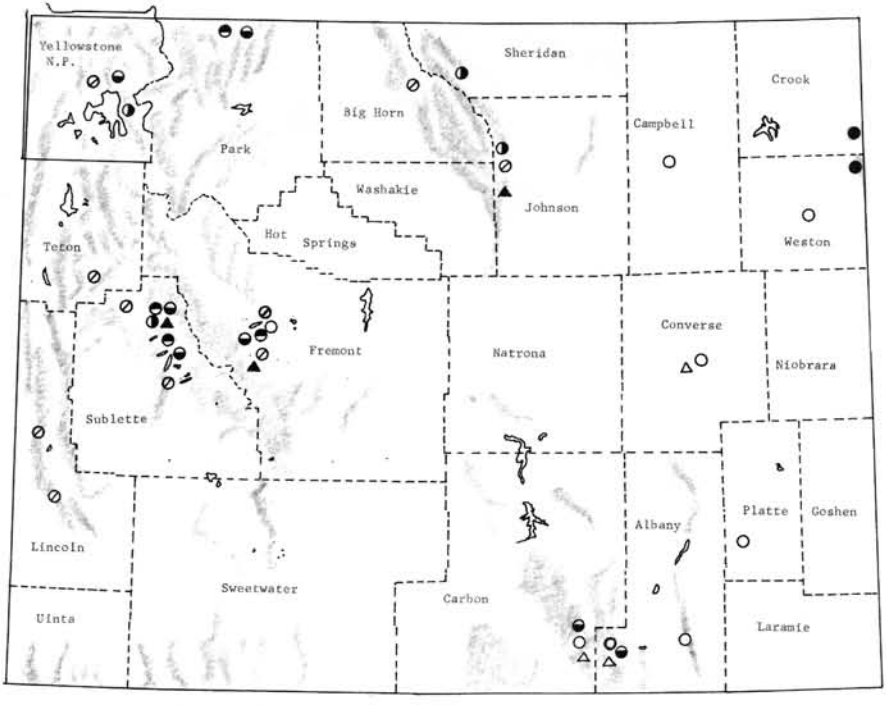
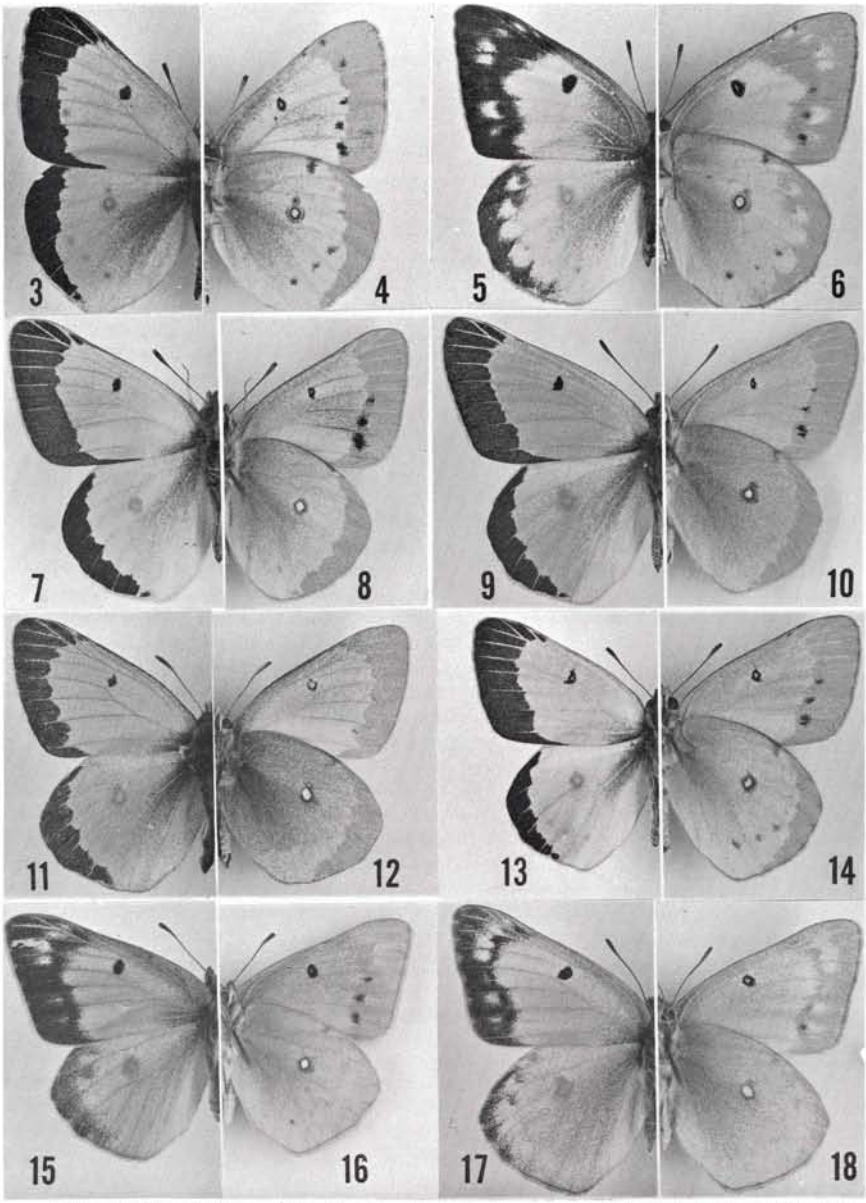
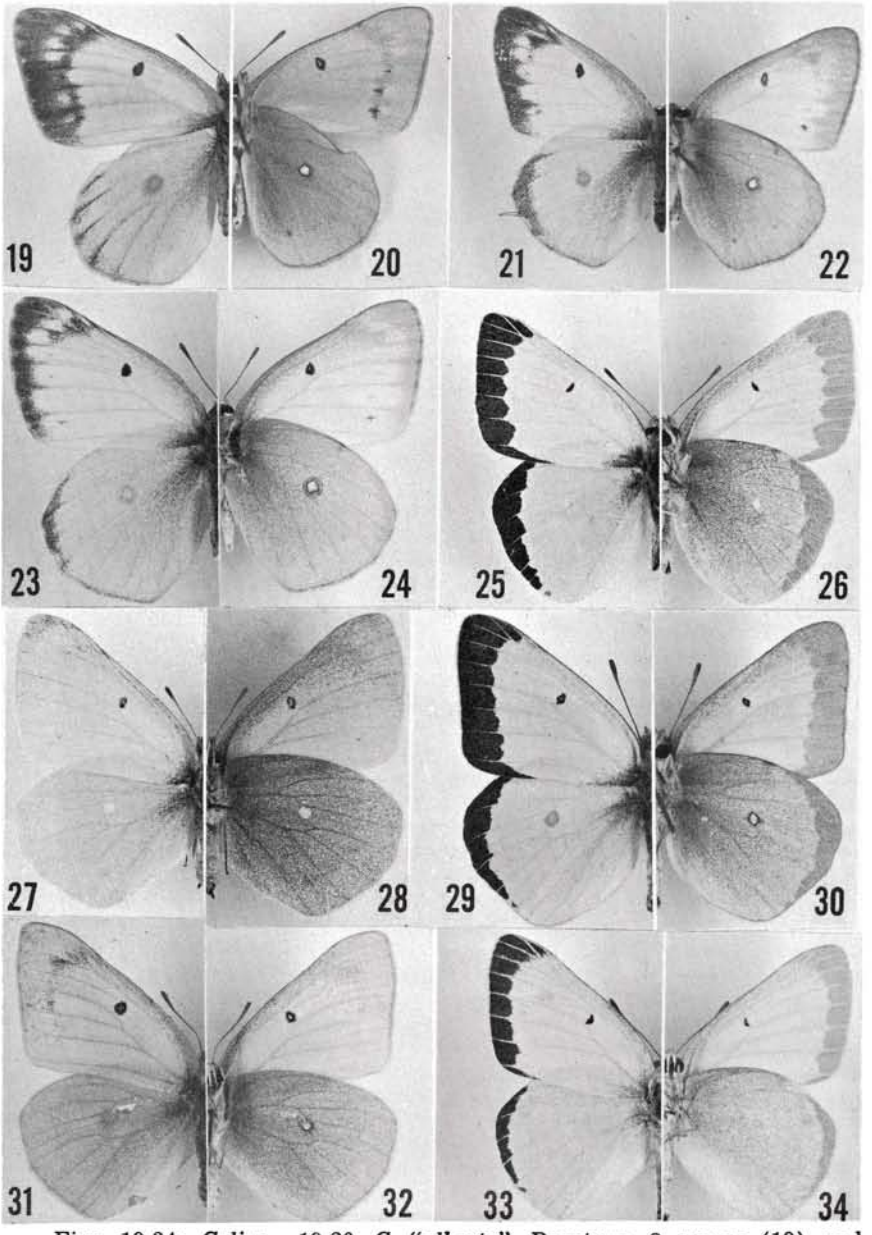


Fig. 2. Distribution of certain *Colias* species in Wyoming. Solid dots = *C. a. alexandra*, open circles = *C. alexandra krauthii*, vertical half-open circles = *C. alexandra astraea*, horizontal half-open circles with solid bottom = *C. m. meadii*, horizontal half-open circles with solid top = *C. m. meadii* ♀ form *medi*, open circles with diagonal line = *C. pelidne skinneri*, open triangles = *C. s. scudderii* and solid triangles = *C. gigantea harroweri*. All county records to date are indicated; individual collection sites within a county are not shown.

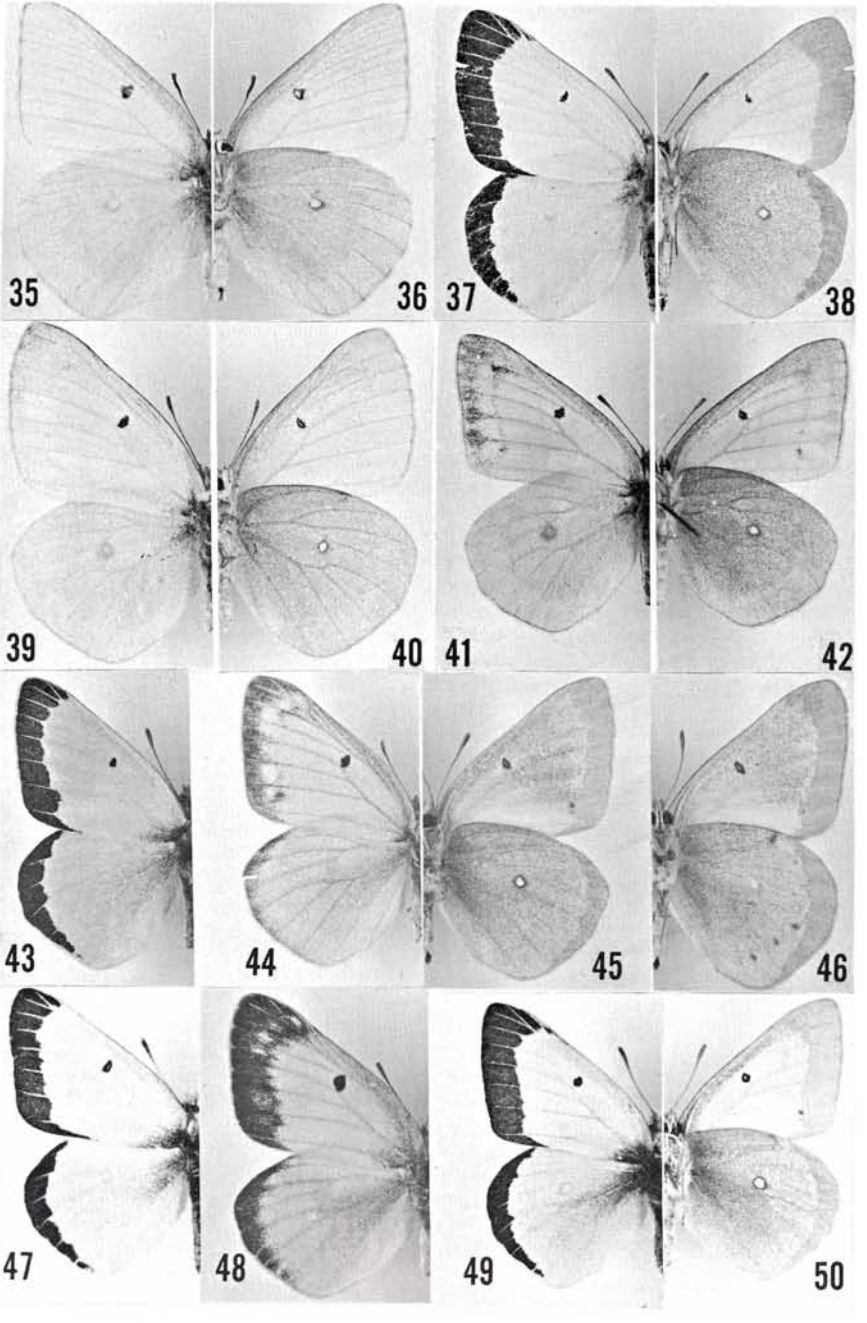


Figs. 3-18: *Colias*. 3-4, *C. eurytheme*, ♂ upper (3) and under (4) surfaces; MONTANA: Sanders Co. 5-6, Same, ♀ upper (5) and under (6) surfaces; NEW MEXICO: Grant Co. 7-8, *C. "alberta"*, Paratype ♂ upper (7) and under (8) surfaces; ALBERTA: Wembley. 9-10, Same, Paratype ♂ upper (9) and under (10) surfaces; ALBERTA: Wembley. 11-12, Same, Paratype ♂ upper (11) and under (12) surfaces; ALBERTA: Fort Vermilion. 13-14, Same, Paratype ♂, upper (13) and under (14) surfaces; ALBERTA: Beaverlodge. 15-16, Same, Paratype ♀, upper (15) and under (16) surfaces; ALBERTA: Wembley. 17-18, Same, Paratype ♀, upper (17) and under (18) surfaces; ALBERTA: Wembley.



Figs. 19-34: *Colias*. 19-20, *C. "alberta"*, Paratype ♀ upper (19) and under (20) surfaces; ALBERTA: Beaverlodge. 21-22, *C. "pallidissima"*, Paratype ♀ upper (21) and under (22) surfaces; ALBERTA: Fort Vermilion. 23-24, Same, Holotype ♀ upper (23) and under (24) surfaces; ALBERTA: Fort Vermilion. 25-26, *C. a. alexandra*, ♂ upper (25) and under (26) surfaces; WYOMING: Albany Co. 27-28, Same, ♀ upper (27) and under (28) surfaces; WYOMING: Albany Co. 29-30, *C. alexandra christina*, ♂ upper (29) and under (30) surfaces; ALBERTA: Bow River Forest. 31-32, Same, ♀ upper (31) and under (32) surfaces; ALBERTA: Bow River Forest. 33-34, *C. alexandra* ssp., ♂ upper (33) and under (34) surfaces; UTAH: Tooele Co.

Figs. 35-50: *Colias*. 35-36, *C. alexandra* ssp., ♀ upper (35) and under (36) surfaces; UTAH: Wasatch Co. 37-38, *C. alexandra* ssp. (yellow form with orange discal spot), ♂ upper (37) and under (38) surfaces: BRITISH COLUMBIA: nr. Golden. 39-40, Same, ♀ upper (39) and under (40) surfaces; BRITISH COLUMBIA: nr. Golden. 41-42, *C. alexandra christina*, ♀ with "*eurytheme*" under surface spots, upper (41) and under (42) surfaces; ALBERTA: Bow River Forest. 43, *C. alexandra krauthii*, ♂ upper surface; SOUTH DAKOTA: Lawrence Co. 44, Same, ♀ upper surface; SOUTH DAKOTA: Lawrence Co. 45-46, Same, under surfaces of two ♂♂; SOUTH DAKOTA: Lawrence Co. 47, *C. alexandra astraea*, ♂ upper surface; WYOMING: Sheridan Co. 48, *C. alexandra krauthii* x *C. eurytheme* hybrid (?), ♀ upper surface; SOUTH DAKOTA: Lawrence Co. 49-50, *C. alexandra astraea*, ♂ upper (49) and under (50) surfaces; WYOMING: Sublette Co.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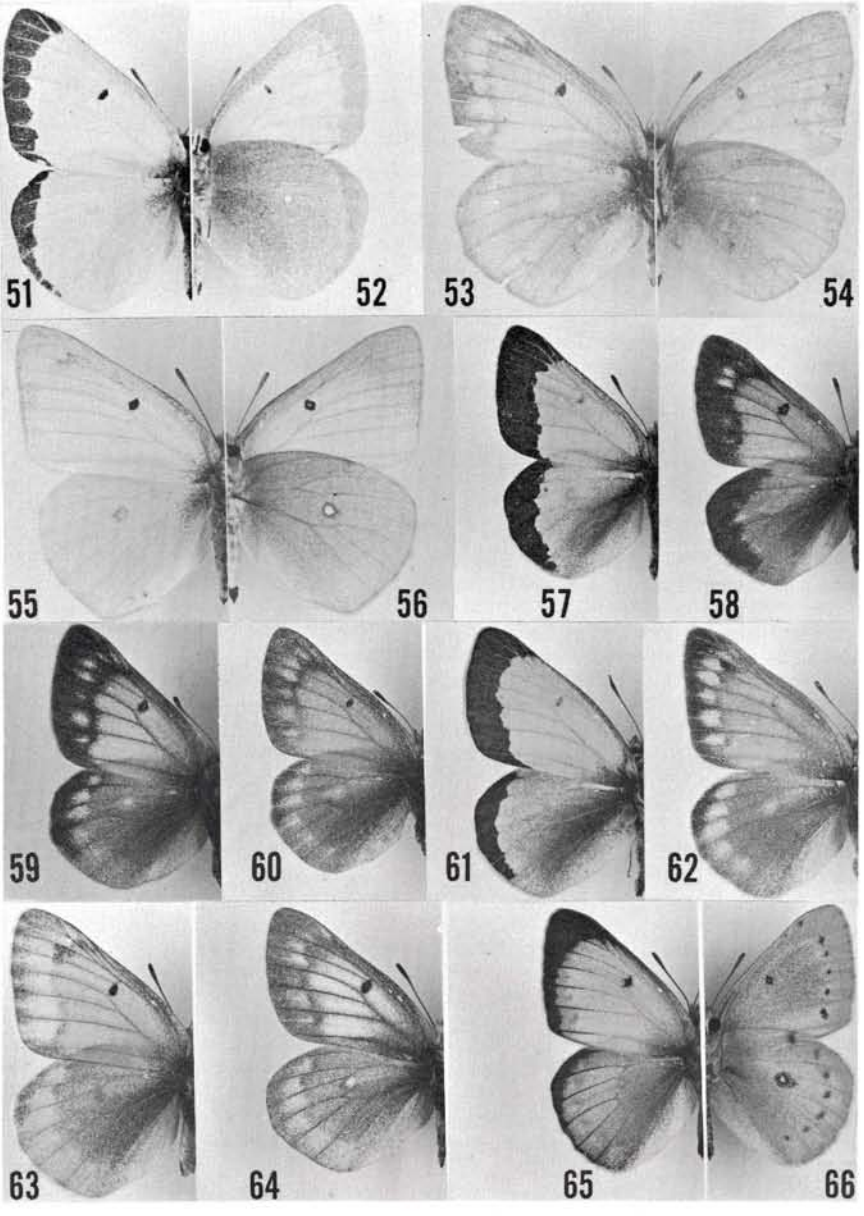
Figs. 51-66: *Colias*. 51-52, *C. alexandra astraea*, ♂ upper (51) and under (52) surfaces; ALBERTA: Bow River Forest. 53-54, Same, ♀ upper (53) and under (54) surfaces; WYOMING: Johnson Co. 55-56, Same, ♀ upper (55) and under (56) surfaces; ALBERTA: Bow River Forest. 57, *C. m. meadii*, ♂ upper surface; WYOMING: Albany Co. 58, Same, ♀ upper surface; WYOMING: Albany Co. 59, Same, ♀ upper surface; WYOMING: Fremont Co. 60. Same, form "*medi*", ? upper surface; WYOMING: Fremont Co. 61. *C. meadii elis*, ♂ upper surface; ALBERTA: Plateau Mtn. 62, Same, ♀ upper surface; ALBERTA: Plateau Mtn. 63, Same, ♀ upper surface; ALBERTA: Plateau Mtn. (light form). 64, Same, possibly form "*lambillioni*", ♀ upper surface; ALBERTA: Plateau Mtn. 65-66, *C. cunninghami* Butler, ♂ upper (65) and under (66) surfaces; erroneously labelled "Vic Estes Park, Larimer Co., COLORADO"; probably from either Ecuador or Peru.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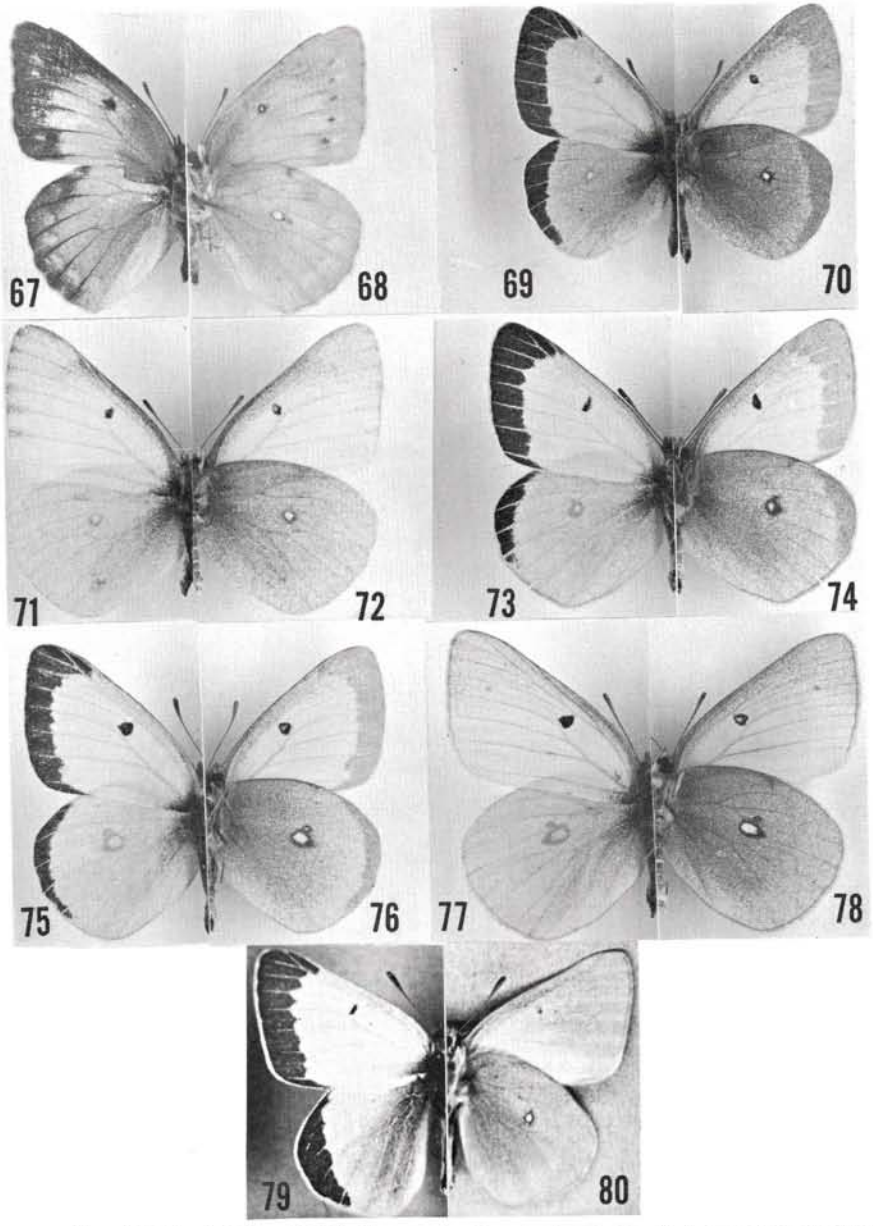
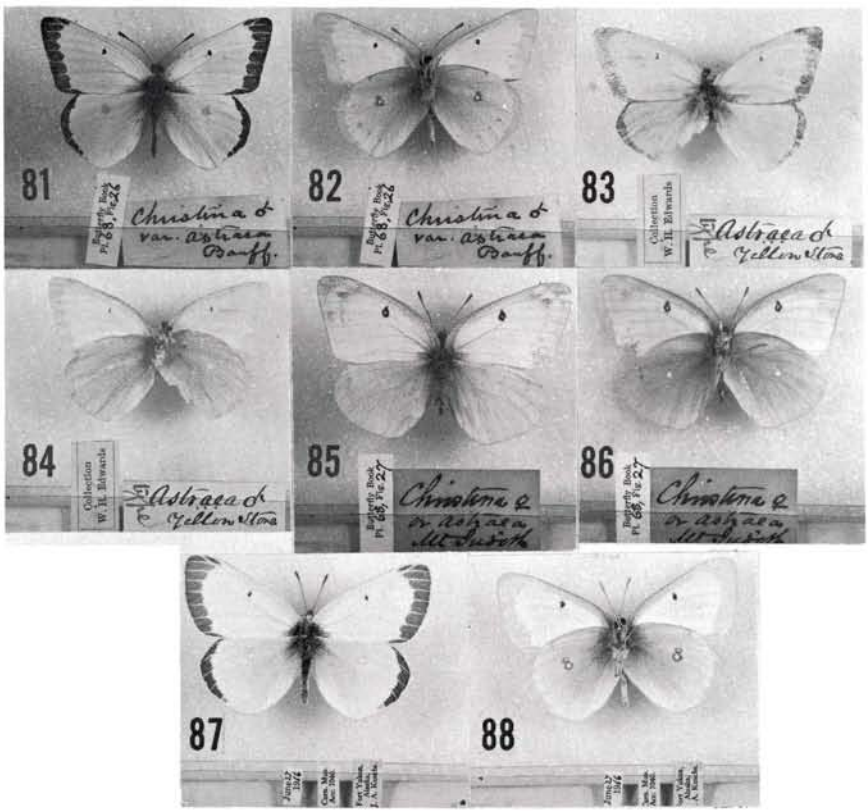


Figs. 67-80: *Colias*. 67-68, *C. cunninghami*, ♀ upper (67) and under (68) surfaces; data as in Figs. 65-66. 69-70, *C. s. scudderii*, ♂ upper (69) and under (70) surfaces; WYOMING: Albany Co. 71-72, Same, ♀ upper (71) and under (72) surfaces; WYOMING: Carbon Co. 73-74, *C. g. gigantea*, ♂ upper (73) and under (74) surfaces; MANITOBA: Churchill. 75-76, *C. gigantea harroweri*, topotypic ♂ upper (75) and under (76) surfaces; WYOMING: Sublette Co. 77-78, Same topotypic ♀ upper (77) and under (78) surfaces WYOMING: Sublette Co. 79-80, *C. m. meadii* x *C. pelidne skinneri* hybrid (?), ♂ upper (79) and under (80) surfaces; WYOMING: Sublette Co.



Figs. 81-88: *Colias*. 81-82, *C. alexandra astraea*, the Holland "type" ♂ upper (81) and under (82) surfaces; ALBERTA. 83-84, same, the Edwards type ♂ upper (83) and under (84) surfaces; WYOMING: Yellowstone Lake. 85-86, *C. alexandra astraea*, the Holland "type" ♀ upper (85) and under (86) surfaces; MONTANA: Judith Mtns. 87-88, *C. g. gigantea*, ♂ upper (87) and under (88) surfaces; ALASKA. Photographs by F. M. Brown.