



The conservation biology of the Uncompahgre fritillary and the related northern dingy fritillary
by Hugh Bryan Britten

A thesis submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy in
Biological Sciences

Montana State University

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Abstract:

The *Boloria improba* species group consists of a series of populations of a common biennial arctic butterfly, the northern dingy fritillary (*B. improba*), which extends from arctic Canada and Alaska down the Rocky Mountain Cordillera with populations in British Columbia, Alberta, and Wyoming. The closely related Uncompahgre fritillary (*Boloria acrocynema*), known from only two colonies high in the San Juan Mountains of Colorado, occupies the southern end of this distribution. Capture-mark-release (CMR) estimates in 1987 revealed a steep decline in *B. acrocynema* numbers from earlier estimates at one site and the absence of the butterfly at the other.

CMR and transect count estimates in 1988 indicate that both even-year broods consisted of approximately 250 individuals, a decline of about one order of magnitude from estimates made earlier in the decade.

Eight *B. improba* group populations were sampled from the Yukon Territory to Colorado and 20 presumptive allozyme loci were assayed from them. *Boloria titania* were sampled from five *B. improba* group sites and 18 presumptive loci were assayed from each for comparison. The allozyme data suggest within colony structuring and low levels of gene flow between colonies. Significant negative correlations were found between estimates of allozyme variation and latitude, an indicator of geographical isolation in the *B. improba* group, that were not found in *B. titania*. Genetic identity estimates and the geographical distribution of individual alleles suggest that ancestral *B. improba* existed in Alaskan refugia and south of the major glaciers during the last glacial maximum and that central Canadian *B. improba* were derived from northern dispersers when the glaciers receded. Results from *B. titania* concur with this hypothesis.

A principal components analysis of six habitat variables suggests that *B. acrocynema* may have specialized habitat requirements relative to the rest of the group. A phenetic analysis of 12 wing characters and allozyme results indicate that *B. acrocynema* is probably a well differentiated subspecies of *B. improba* rather than a full species. Finally, the results of this study were used to make conservation recommendations for *B. acrocynema* and to draw some general conclusions about the extinction process.

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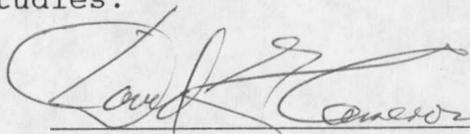
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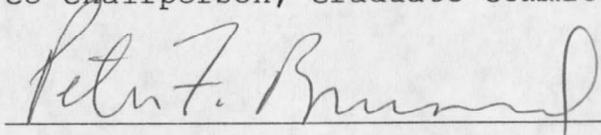
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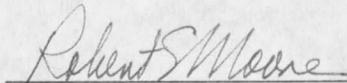

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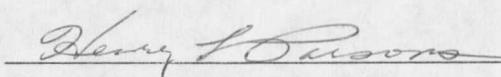
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ABSTRACT

The *Boloria improba* species group consists of a series of populations of a common biennial arctic butterfly, the northern dingy fritillary (*B. improba*), which extends from arctic Canada and Alaska down the Rocky Mountain Cordillera with populations in British Columbia, Alberta, and Wyoming. The closely related Uncompahgre fritillary (*Boloria acrocneuma*), known from only two colonies high in the San Juan Mountains of Colorado, occupies the southern end of this distribution. Capture-mark-release (CMR) estimates in 1987 revealed a steep decline in *B. acrocneuma* numbers from earlier estimates at one site and the absence of the butterfly at the other. CMR and transect count estimates in 1988 indicate that both even-year broods consisted of approximately 250 individuals, a decline of about one order of magnitude from estimates made earlier in the decade.

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INTRODUCTION

The Uncompahgre fritillary (*Boloria acrocneuma*) was discovered on a high alpine meadow near Uncompahgre Peak, Hindsdale Co., CO, in July 1978 (Gall and Sperling, 1980). A second major colony was discovered near Red Cloud Peak, 16 km south of the type locality, in 1982. No other colonies have been located since these initial discoveries; thus *B. acrocneuma* is assumed to have the smallest total range of any North American butterfly (Opler, 1990).

Population estimates carried out in 1979 and 1980 at Uncompahgre Peak (Gall, 1984a) and subsequent anecdotal accounts indicated that populations at both *B. acrocneuma* locations were declining rapidly. Because of its apparently precarious position, the U.S. Fish and Wildlife Service (USFWS) was petitioned to list *B. acrocneuma* under the U.S. Endangered Species Act in 1984. In conjunction with the USFWS, the U.S. Forest Service (USFS), which has jurisdiction over the Uncompahgre Peak *B. acrocneuma* site, and the U.S. Bureau of Land Management (BLM), which manages the Red Cloud Peak colony site, began efforts to determine the causes of the butterfly's decline and to formulate a management plan to mitigate their effects. This effort took two years, 1987 and 1988, and resulted in a comprehensive report that addressed the problem of

declining *B. acrocnema* numbers and made several recommendations for the conservation of the butterfly (Brussard and Britten, 1989)

The plight of *B. acrocnema* provides an opportunity to observe a potential natural extinction as it is occurring. Since very little is known about extinction (Ehrlich, 1983), the study of *B. acrocnema* may provide valuable insights into this process.

Current theories about extinction come from population viability analysis (PVA) which is a subfield of conservation biology concerned with predicting the persistence of populations and species. Two general types of processes are recognized as being important in extinctions: 1) deterministic, and 2) stochastic (Brussard, 1986). Deterministic processes have generally predictable outcomes and operate systematically (Brussard, 1986). These types of extinctions are often caused by human activities; for example, the black-footed ferret (*Mustela nigripes*) was eliminated from most of its historic range because its habitat and food requirements were in conflict with the domestic livestock industry.

Stochastic processes are critical to the survival of small populations, and they operate at two levels (Brussard, 1986; Pimm et al., 1988; and Shaffer, 1987). First, population-wide reproduction and survival can be affected by unpredictable environmental change or

catastrophes. Second, random variations in individual survival and reproduction can affect the persistence of very small populations. In addition, population structure and random genetic processes can play roles in the survival of small populations.

Genetic studies of extinction-prone species have mostly been confined to large mammals (e.g. Bonnell and Selander, 1973; Kilpatrick *et al.*, 1986; and O'Brien *et al.*, 1985). The probability of extinction is thought to be increased by the expression of deleterious alleles brought on by inbreeding (inbreeding depression) and the random loss of alleles through drift (e.g. Brussard, 1986; and O'Brien, 1985). Some species, like the cheetah (*Acinomyx jubatus*; O'Brien *et al.*, 1985) and elephant seal (*Mirounga angustirostris*; Bonnell and Selander, 1973), have recovered from major bottlenecks and persist with very little detectable genetic variability. In contrast, other species, such as the black-footed ferret, are evidently very depauperate genetically (although few loci were assayed) and are near extinction in the wild (Kilpatrick *et al.*, 1986). Thus, the exact nature of the interactions between genetic, demographic, and environmental processes are not known but are thought to be important to species survival (Brussard, 1986; Gilpin and Soule', 1986; and Shaffer, 1987). The general consensus appears to be that environmental and demographic uncertainties can pose

immediate threats to the survival of small populations while genetic factors may be more critical to long-term adaptability and persistence (Bonnell and Selander, 1973; O'Brien et al., 1985; and Shaffer, 1987).

Insect population declines and extinctions have been attributed to several factors including habitat loss and fragmentation, unusual climatic conditions, and random genetic processes (Ehrlich, 1983; Pyle et al., 1981; and Thomas, 1983). Although loss of habitat as a result of human activities is considered an important cause of insect (particularly butterfly) extinctions, other activities e.g., pesticide spraying and collecting are not (Ehrlich et al., 1983; Pyle et al., 1981; and Thomas, 1983). Several butterfly distribution changes and extirpations have been attributed to local climatic change (Ehrlich, 1983; Ehrlich et al., 1980; Gilbert and Singer, 1975; Pyle et al., 1981; and Thomas, 1988). Severe drought probably caused population declines and extirpations in two species of *Euphydryas* in California during the mid-1970's (Ehrlich et al., 1980). Drought apparently had a similar effect on many butterfly species in northwestern Europe in 1976 and 1977 (Thomas, 1988). Gilbert and Singer (1975) and Thomas (1988) provide other examples of butterfly extirpations that were probably induced by unusual weather.

The mechanisms by which climate changes reduce populations are probably species-specific and are not

thoroughly understood, but Gilbert and Singer (1975) note that butterfly fecundity, estimated from daily egg production, is reduced in some species during unusually cold weather. In addition, Ehrlich et al. (1980) found that a drought disrupted the complex phenological balance between *Euphydryas* ssp. populations and their host plants.

Ehrlich (1983) states two tentative conclusions concerning the genetics of butterfly extinctions. First, inbreeding depression seems to have little effect on butterfly population persistence because once populations are small enough for it to be a factor they usually go extinct for demographic reasons (Ehrlich, 1983). Second, butterfly populations appear to be so precisely genetically adapted to their habitats that artificial reintroductions seldom succeed (Ehrlich, 1983). Thus it appears, as is apparently the case in larger bodied species, that demographic and environmental processes are probably most important to short-term species survival and random genetic processes to long-term persistence.

Gall and Sperling (1980) described *B. acrocne* as a sister species of a common arctic butterfly, the northern dingy fritillary (*Boloria improba*). Other authors (e.g. Scott, 1986) consider *B. acrocne* a subspecies of *B. improba*. Although the taxonomic status of *B. acrocne* has not been resolved, its close relationship to *B. improba* is apparent (Gall and Sperling, 1980; Scott, 1986).

Therefore, the entire *B. improba*-*B. acrocneuma* clade will henceforth be referred to as the "*B. improba* group."

The *B. improba* group in North America consists of a differentiated series of populations that extends from the arctic regions of Canada and Alaska down the Rocky Mountain Cordillera with known populations in British Columbia, Alberta, Wyoming, and Colorado (Figure 1). Several subspecies have been described within this group. Scott (1986) recognizes two subspecies from northern North America; *B. improba improba* from the arctic and *B. improba* ssp. from west-central Alberta. Ferris (1984) describes the disjunct Wyoming subspecies, *B. improba harryi*, from the Wind River Range. Finally, the disjunct *B. acrocneuma* is at the southern terminus of the *B. improba* group's distribution in southwestern Colorado (Gall and Sperling, 1980).

Colonies of *B. acrocneuma* are found on patches of its larval food plant, snow willow (*Salix nivalis*), on northeast facing slopes at approximately 4100 m elevation. Colony sites are generally mesic as a result of nearby melting snowfields and have about 15% *S. nivalis* ground cover.

