

## SUMMARY OF AN ONGOING POPULATION STUDY OF *PARNASSIUS CLODIUS* BUTTERFLIES



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### ♦ ABSTRACT

Global and regional climate patterns suggest that future conditions in the western United States will be warmer and drier. Changing climatic conditions are predicted to impact ecosystems on many levels including at a population level. Decreases in population distribution and sizes have the potential to disrupt community and species diversity. Insects are particularly useful organisms to study because of their shorter life spans and sensitivity to changes environmental conditions. We expanded on previous population studies of a butterfly species, *Parnassius clodius*, located in Grand Teton National Park using mark-recapture techniques. We collected data to assess population size and sex ration on one particular population located in the park. Using mark-recapture techniques, we were able to collect data to assess population numbers, total number of males and females, sex rations and number of mated versus unmated females throughout the flight season. Here we compiled information about this population to provide benchmark information for this species and its population dynamics. The combined population data will be further used to study how changing climatic conditions have affected this population throughout the study years. The results will be valuable for understanding the population and also for understanding potential climate-related impacts on butterfly populations in other locations.

### ♦ INTRODUCTION

Global and regional climate patterns suggest that future conditions in the western U.S. will be warmer and drier, and ecosystems at higher altitudes

and latitudes may be subject to larger, more rapid changes (Harte and Shaw 1995; Thuiller et al. 2005). As a result of increasing temperatures and decreasing winter precipitation, it is predicted that the duration of snow cover will decrease (IPCC 2007). Such changes have the potential to impact the dynamic interactions among organisms and their habitat (Bradley *et al.* 1999; Folke et al. 2004). Climatic changes are predicted to alter species distributions, life histories, community composition, and ecosystem function that cascade through the ecosystem because of the complex interplay of organisms (i.e. Kudo 1992; Dunne *et al.* 2003; Parmesan and Yohe 2003; Inouye 2008). In particular, changes in population sizes, as a result of changing climate conditions, have the potential to decrease community and species diversity (Root et al. 2003). Evidence from various studies indicates that range shifting in response to climate warming may lead to population extinctions (i.e. Walther et al. 2002; Parmesan 2006). One particular group of organisms that serves as a useful indicator of climate change effects is insects because they are short-lived ectotherms with wide variation in population size over space and time (Bale et al. 2002; Maclean and Wilson 2010).

Insects have provided clear evidence for ecological responses to climate change. Examination of populations in Europe and North America reveal that butterfly distributions are shifting poleward (Parmesan and Yohe 2003; Parmesan 2006), and phenological events, such as emergence and spring activity, are advancing to earlier spring dates as a result of climate warming (Roy and Sparks 2000; Peñuelas *et al.* 2002; Stefanescu *et al.* 2003). Given the greater availability of both current and historical information on species distributions and population sizes,

Lepidoptera can play a key role in providing evidence and further understanding climate change.

*Parnassius clodius* is a common butterfly in the Greater Yellowstone Ecosystem. However, two related European species, *Parnassius mnemosyne* and *Parnassius apollo* are considered to be vulnerable throughout much of their European range as populations have undergone substantial decline and extinction due primarily to habitat change and climate change (Van Swaay and Warren, 1999; Bergström 2005; Descimon *et al.* 2005; Nakonieczny *et al.* 2007; Ashton *et al.* 2009; Gorbach and Kabanen 2010). Utilizing data obtained from population studies on a common species, we may be able to inform ecologists and land managers as to what factors play a role in population stability.

This study, begun in 2009, was established to provide more information on population dynamics of one of the largest populations of *Parnassius clodius* in Grand Teton National Park by expanding on previous studies from 1999-2001. We collected data using mark-recapture techniques to assess population dynamics, such as population size and sex ratio. Here we compile information obtained from population studies and observations of *P. clodius* from 2009-2012. Our goal is to provide a benchmark of information on this species and its population dynamics for future studies that may utilize the same sites.

## ◆ METHODS

### Study Organism

*P. clodius* are moderately large in size (wingspan of 5 -7 centimeters), predominantly white butterflies found in western Canada and the western United States. Highest densities of *P. clodius* are typically found in dry, gravelly sagebrush meadows (Auckland *et al.* 2004). *P. clodius* adults have one flight per year from mid-June to mid-July. Adult females lay eggs on vegetation near the host plant species, *Dicentra uniflora*. *D. uniflora* is a spring ephemeral that is found growing near the edges of snowmelt (Craighead *et al.* 1998). *P. clodius* larvae feed on the host plant throughout the spring until pupation. Adults display virtually no evidence of courtship behavior. Rather, patrolling males grab females in flight and force them to the ground to copulate (McCorkle and Hammond 1985).

### Study Sites

A mark-recapture-release (MRR) study of a

*P. clodius* population was conducted in a dry, sagebrush meadow with a relatively homogeneous topography at an elevation of ~2100 meters located within Grand Teton National Park, WY. The meadow is approximately 2 x 0.5 km in size (Auckland *et al.* 2004) and located along Pilgrim Creek Road, just south of the University of Wyoming-National Park Service Research Station. Based on previous studies, we concluded that the Pilgrim Creek population is one of the larger populations of *P. clodius* within the Greater Yellowstone Ecosystem. Thus there were sufficient numbers (e.g., hundreds) of butterflies present annually for a mark-recapture-release study (Auckland *et al.* 2004).

### Mark-recapture-release (MRR) study

Adult population size was investigated during the annual flight period in summer months from 2009 – 2012. For each year, MRR studies were initiated immediately after adult emergence and were terminated when less than 5 butterflies were seen summed across all of the plots, signaling population decline. Daily surveys were limited to times between 10:00 and 17:00 hours, and when the temperature was above 21° C, wind was <16kmh<sup>-1</sup>, and the sun was not obscured by clouds. When conditions did not meet the above requirements, MRR surveys were not performed. However, during all four summers, the majority of the days during the flight season were adequate for MRR. Using MRR technique, two investigators walked within 50 x 50 meters plots (located approximately 200 meters apart) for 20 minutes and captured any *P. clodius* individual within the boundary of the plot using a butterfly net. Individuals were then placed in glassine envelopes and held by the investigator in a small box attached to a belt until the end of the survey. At the end of the survey time, surveyors moved off of the plot to a shady location to process the butterflies caught and record data. All unmarked captured individuals were marked with unique numbers, indicating the plot in which they were caught, on the ventral side of each hindwing, using a felt-tip permanent marker. Information for previously marked individuals was recorded, including the plot number where the individual was captured. Males and females were identified based on external morphological differences. Female mating status was determined by the presence or absence of a spermatheca (a waxy structure deposited by the male during mating that prevents future matings). Wing wear of each captured butterfly was recorded for each butterfly. Wing wear classification was as follows: 1) good conditions, no visible damage, 2) slightly damaged wings, small tears, 3) heavily damaged wings or missing wings. Behavior at the time of

sighting (in flight, nectaring (and plant species upon which it was nectaring), or basking/resting (type of surface)) was also recorded. After all the information was recorded for the captured individuals within that plot (~30. min or less), butterflies were released from the center of the plot. It is also important to note that there were generally less than two mortalities per year of all butterflies captured as a result of capture and handling. We randomly surveyed the plots starting with a successive number the following day in order to sample at different times of day for each plot.

◆ **RESULTS**

Initially, six 50 x 50 plots (plots 1 – 6) were surveyed in 2009. Due to a separate but related experiment in the meadow, plot 4 was removed from surveys after the 2009 field season. The original five plots (1 – 3; 5 – 6) were surveyed in 2010. Plot 2 was not surveyed in 2011 due to bear presence. However, two additional plots (7a and 8) were added to the 2011 surveys. In 2012, the original plots (1 – 3; 5 – 6) were surveyed with an additional plot (7b). Table 1 lists the locations (UTM – zone 12N) for each of the plots surveyed and the years in which they were surveyed.

In all years, males were captured more frequently than females (Table 2). Based on the number of plots surveyed, the average number of males that were captured per plot ranged from 141 to 33 individuals, while the average number of females per plot ranged from 35 to 9. The capture sex ratio males/females also varied from year to year with the highest ratio occurring in 2009 with 4 males to 1 female. The lowest sex ratio of males/females occurred in 2012 with 2 males to 1 female.

Annual flight periods varied among years (Table 3). The earliest date of male emergence occurred in 2012 when males emerged on June 13<sup>th</sup>. In 2011, males were not seen until July 6<sup>th</sup>. In general, females emerged after males, ranging from 1 – 7 days after the first males were seen. This resulted in a later peak flight time for females when compared with males. Females also stayed on the wing slightly longer than males.

Average wing-wear condition showed a steady increase as the flight season progressed. Males showed slightly greater wing wear overall when compared with females. Also, as one might expect due to the forceful nature of copulation in this species, mated females had greater wing wear than unmated females.

Table 1. Summary of UTM coordinates for plots surveyed and years surveyed (UTM NAD 1983 zone 12N).

Plot #	Northeast Corner	Southeast Corner	Southwest Corner	Northwest Corner	Years Surveyed
1	E0534108 N4862885	E0534099 N4862833	E0534051 N4862845	E0534059 N4862886	2009 - 2012
2	E0533907 N4862808	E0533902 N4862755	E0533847 N4862765	E0533860 N4862808	2009 - 2010; 2012
3	E0533812 N4862642	E0533801 N4862579	E0533751 N4862602	E0533760 N4862649	2009 - 2012
4	E0533917 N4862535	E0533924 N4862525	E0533872 N4862471	E0533850 N4862503	2009
5	E0533717 N4862409	E0533750 N4862373	E0533704 N4862346	E0533678 N4862387	2009 - 2012
6	E0533629 N4862510	E 0533622 N4862458	E 0533573 N4862465	E05337578 N4862519	2009 - 2012
7a	E0533488 N4862389	E0533421 N4862369	E0533442 N4862415	E0533488 N4862389	2011
7b	E0533614 N4862181	E0533604 N4862131	E0533552 N4862140	E0533561 N4862192	2012
8	E0533582 N4862292	E0533622 N4862254	E0533581 N4862219	E0533547 N4862256	2011

Table 2. Summary of number of plots surveyed per year, average number of males and females per plot by year and ratio of males to females captured.

Year	# of plots surveyed	Ave. # males/plot	Ave. # females/plot	Ratio of male/female
2009	6	141.14	34.83	4.05
2010	5	45.80	12.80	3.58
2011	7	32.71	9.29	3.52
2012	6	56.00	27.00	2.07

Table 3. Summary of emergence dates for males and females by year and last date sampled by year.

Year	Male Emergence Date	Female Emergence Date	Last Date Sampled
2009	24-Jun	25-Jun	12-Jul
2010	4-Jul	6-Jul	15-Jul
2011	6-Jul	7-Jul	18-Jul
2012	13-Jun	20-Jun	3-Jul

## ◆ CONCLUSIONS

Our MRR study has resulted in a large dataset that contains a great deal of information on *Parnassius clodius* butterflies. Throughout the course of data collection, we were able to collect data on many variables that relate to population dynamics in *P. clodius*, such as emergence dates for males and females, peak flight dates for both sexes, wing wear throughout the season, and mating status. Each of these factors varied throughout the years the study was conducted. This report summarizes some of the information obtained from these studies. Future analyses will be performed to uncover potential reasons for variations in population sizes and emergence dates and to correlate these responses to annual weather patterns.

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