A PRELIMINARY STUDY OF THE BUTTERFLY SPECIES FOUND IN SOUTHERN LEWIS AND CLARK COUNTY, MONTANA

Submitted in Partial Fulfillment of the Requirements for Graduation with Honors to the Department of Natural Sciences at Carroll College, Helena, Montana

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ABSTRACT

The diversity of butterfly species in Lewis and Clark County, Montana was studied. Butterflies were captured, killed, mounted, and identified from eight locations within the county. Collection took place from June 1st to August 15th, 1999. The results were analyzed on the basis of number of species, number of individuals, location and date of capture, and sex of the butterflies. The metamorphosis from larvae to adult was also examined. This investigation demonstrated that the butterflies were mostly male, and that they differed in number of species per location. However, no difference was seen in the number of species observed or first emerging in a time period. The study revealed that the number of individuals increased as summer progressed, and that the species varied in the length of flight period and range of habitat. During the course of the study, 56 species of butterflies were seen. This analysis serves as a basis for comparison to future studies since it is the first of its kind for Lewis and Clark County.
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INTRODUCTION AND LITERATURE REVIEW

The order Lepidoptera consists of butterflies, moths, and skippers. Moths generally fly at night and are distinguished from butterflies by usually having hairier bodies, more muted coloring, wings folded instead of held vertically, and feathery rather than clubbed antennae (Pyle 1992). Skippers fly during the day and are ordinarily considered together with the butterflies. Moths comprise most of the order Lepidoptera, consisting of approximately 185,000 species (Scott 1986). The rest of the 200,000 lepidopterans are butterflies.

Lepidoptera make up one of the largest orders of insects. The variation seen among species is great, while at the same time a few species may be so similar as to make differentiating them nearly impossible. The most distinguishing feature of butterflies is their wings. Evolution has created 14,750 extant species of butterflies, 700 of which are found in North America (Scott 1986). Each of these species varies at least slightly from all others in wing pattern. Butterflies are important in the study of insects, since they are so common and spread throughout numerous habitats. Unlike many other insects, they have the added benefit of not being considered pests. Very few species of butterflies are pests, although some larvae can be numerous enough to do damage to some crops.

All of the species in the order Lepidoptera evolved from a common ancestor. The most profound evolutionary change was the development of wings. Since evolution generally acts to produce traits beneficial for the survival and reproduction of an organism, the leap to flight seems a great one. Each step of wing evolution must have been more beneficial than the previous one. The evolution of wings does not have a universally accepted explanation. One theory (Scott 1986) proposed that wings began as
flap-like outgrowths of gills found in aquatic insect young. These flaps would aid in
swimming and obtaining oxygen from stagnant water. Scott stated that once the adult
insect emerged from the water, the flaps could have been used to glide between trees.
The longer the flight of the insect, the better the mating opportunities, eventually
resulting in the evolution of wings. On the other hand, Douglas (1986) proposed that
thermoregulation guided wing development. The flaps on the sides of the insects would
serve to absorb sunlight, warming the cold-blooded insect. Consequently, the insect
could be active during a wider range of temperatures and times. Growth of the flaps
eventually led to flight. Evidence for this hypothesis is seen in many extant butterflies
that have darkly colored basal wing portions, allowing for greater absorption of sunlight.
The fossil record is not complete enough to show exactly how the flaps evolved into
wings, but these two theories seem plausible.

The numerous species of butterflies have evolved to thrive in many different
habitats. Butterflies are found in almost all habitats in North America. The requirements
for a suitable habitat are varied. Some species can survive in a wide range of habitats,
while others are dependent on certain characteristics in a habitat, the most important of
which is usually the host plant. Butterflies can be found almost any place that plants
grow. Dense forests are one of the few places that are inhospitable to butterflies,
although bogs and open areas within the forest often support butterflies (Scott 1986).
Urban areas can support a considerable variety of species, since they often provide a
large number of different habitats in relative proximity.

The development of each individual butterfly passes through several stages.
Butterflies begin life as eggs, which are deposited on the host plant by the female. The
host plant is chosen for its suitability as a larval food. In order to decrease competition among larvae, eggs are generally not laid next to one another. The presence of eggs on a plant will deter the female from laying more on the same plant. The eggs are generally white, but some species' eggs are colored to camouflage them from predators. The shape of the eggs ranges from spherical to barrel-shaped (Douglas 1986). The shape can also aid in camouflage by blending the eggs into the background. The larvae hatch from the eggs. Larvae are worm-like, being round and segmented. The most advanced region of the larva is the head, which contains complex mouth parts and mechanisms for the spinning of silk. The remainder of the larva is the body. The first three segments contain walking legs. Five of the last ten segments contain prolegs, which are lost during metamorphosis. The legs have hooks that allow them to grasp the plant and the silk webs the larvae build (Douglas 1986). The sole purpose of the larva is to eat. The larva gains weight quickly and molts four to five times to increase the size of the exoskeleton (Ferris & Brown 1981). The exoskeleton is the hard covering of all stages of the butterflies. To molt, the exoskeleton is first softened with enzymes, and the material is absorbed to be reused in the next exoskeleton. Hormones control each molt. Throughout early life, a large amount of juvenile hormone is present with the molting hormone. As the larvae age, the amount of juvenile hormone drops. After several molts the juvenile hormone level is low enough to permit the development of the pupae. The pupae are a sedentary phase during which development into adult structure occurs. The larvae attach themselves to some substrate and pupate. Since they are sedentary, the pupae have no defense against predators except camouflage, often looking like dead leaves. Once metamorphosis is complete, the pupae eclose, or emerge as adults. They then pump
haemolymph into the wing veins and wait for the wings to dry. Adult activity can begin when the wings dry.

The stages of butterfly development can be observed in the rearing of butterflies. In order to raise adult butterflies, an immature form must be collected. If this form is an egg or larva, the correct host plant must be identified in order to feed the organism. It can then simply be kept in a jar that allows air circulation until metamorphosis is complete.

The length of time a butterfly spends in each stage varies. In temperate regions, one of the stages must be able to survive the adverse conditions of winter. This stage is called diapause. Respiration is slowed and the concentrations of glycerol, sorbitol, and colloids increase to lower the freezing temperature of the butterfly (Brown & Ferris 1981). Different butterflies have evolved diapause in different stages. It is possible to get a general idea of which stage undergoes diapause by considering when the species is first seen in the spring or summer. Species that overwinter as adults are the first ones seen in spring, followed by those that diapause as pupae, larvae, or eggs. Diapause is usually controlled by the amount of sunlight. The shortening of days as winter approaches causes the initiation of diapause, and the lengthening of days in spring terminates it. The number of generations in a year is also variable. Most butterflies in the temperate region have only one generation per year. The number of generations is limited because the growing season for host plants is shorter and the weather is colder. In warmer regions, more generations per year are seen since winter is not as harsh. The length of each stage is dependent on the life span of the species of butterfly. Some may complete their entire life cycle in a month, while others may take two years (Scott 1986). The duration of the larval stage is also dependent on the host plant. Species that feed on
flowers and fruit develop quickly since these materials are highly nutritious and contain fewer poisons than leaves (Scott 1986). Adult males, on average, live for about a week, while females live slightly longer (Scott 1986). As discussed above, the longevity of a stage can be greatly increased if the butterfly enters diapause to survive winter.

The ultimate function of the adult butterfly is reproduction. In order to propagate the species, a male butterfly must be able to locate a female of the same species. There are three methods of mate location (Brown & Ferris 1981). Males that use perching behavior sit and wait for females to pass by. The perching site is characteristic to a species, and the males and females are instinctively drawn to these areas. Some males will fly out to investigate anything passing by to see if it is a female of the same species. Other species patrol almost constantly for females. Still others utilize pheromones that attract mates from some distance away. The male butterflies rely on wing pattern and color, occasionally along with odor, to identify females of their species (Scott 1986). In addition to the visible spectrum, butterflies can also see in the ultraviolet range. Ultraviolet light is often useful for distinguishing species since the wings of some species reflect the light. Once the correct female is located, courtship commences. Scott (1986) detailed the mechanisms of courtship. Often, if the female is prepared to mate, the butterflies simply land and breed. Other species may utilize characteristic flight patterns, pheromones, wing fluttering, or tapping antennae as courtship rituals. If the female is receptive, mating occurs. Unreceptive females often have rejection rituals that frequently involve flight. Most commonly, females are unreceptive because they have already mated. During mating, the male transfers a spermatophore to the female. In some species, the male also deposits a substance that blocks the female from mating with other
males (Brown & Ferris 1981). When oviposition commences, the sperm fertilize the eggs as they pass out of the female. The female chooses the correct host plant for larval development when she oviposits. Once laid, the eggs are left alone to begin development.

The majority of a butterfly’s feeding takes place during the larval stage. The larvae eat almost constantly, increasing greatly in size. The larvae of most species of butterflies eat plants. Female butterflies place eggs on the host plant very selectively, and some larvae can only eat that plant. Others can eat from a variety of plants in case their eggs are not laid on the preferred species. Ferris and Brown (1981) explained how butterflies and flowering plants have evolved together for millions of years. The butterflies evolved mechanisms to detect odors given off by their host plants. At the same time, the plants evolved defenses, which include thickened leaves, hairs, spines, toothed leaves, resins, and chemical poisons. Some also have structures that look like eggs to discourage females from ovipositing. In order to combat poisons, butterflies evolved mechanisms to break the poisons down chemically. Not all butterflies are herbivores; some larvae subsist on aphids and ants (Scott 1986). Adult butterflies need food for energy only, since no growth occurs. This energy is obtained from the nectar of flowering plants. Nectar contains sugar, water, and occasionally amino acids (Douglas 1986). Sugar is the most common form of energy storage in butterflies. However, sugar molecules are large relative to the amount of energy they supply, so migratory butterflies such as Danaus plexippus, the Monarch, have evolved the ability to store energy as fat (Douglas 1986). Nectar is transported to the mouth through the proboscis, a tube that coils out from the head when in use. In addition to flowers, male butterflies of many
species congregate around mud puddles. The butterflies obtain sodium and amino acids from the puddles. The sodium is utilized in the spermatophore, and the amino acids are both a source of nitrogen and are incorporated into proteins (Douglas 1986). In addition to flowers and mud puddles, some species feed from animal feces, urine, sweat, tree sap, rotting fruit, and carrion (Douglas 1986).

The majority of an adult butterfly's food intake is used in flight. Flight is an essential part of the butterfly's survival. Flight is necessary to locate mates, find food, escape predators, migrate, and find suitable places for oviposition. The mechanism of flight differs from that in vertebrates since there are no bones on which the flight muscles could attach. Instead, the muscles of butterflies are connected to the exoskeleton. Muscles on the top of the thorax contract, bowing the thorax up and pushing the wings down. Next, muscles pull the thorax together, creating the upstroke (Scott 1986). Alternation of the muscle contraction enables steady flight.

In addition to energy, temperature is an important aspect of flight. Butterflies, like all insects, are cold-blooded. They are dependent on the environment to elevate their body temperature to a point at which activity is possible. Elevating their temperature is achieved by basking in the sun. Butterflies are active during the day because of this dependence. The weather must be sunny and warm for the butterflies to raise their temperature high enough for activity. Flight is possible with air temperatures between 60 and 108° F, but the optimal internal temperature is 82-100° F (Scott 1986). It is possible for a butterfly to raise its internal temperature above the ambient air temperature by basking in the sun. There are two methods of basking, dorsal and lateral. Dorsal basking happens when the butterfly spreads out its wings and exposes the entire area to the sun.
Lateral basking utilizes closed wings with the side of the butterfly exposed to the sun. Location is an important aspect of both basking types. The spot must be protected from winds that would cool the insect while still being exposed to the sun. Basking butterflies are vulnerable to predators, so the spot must be chosen carefully. The structure of the butterfly must also be modified to make basking more efficient. The section of the wing closest to the body is often darkly colored to absorb a greater amount of heat. In addition to absorption, the wings also radiate heat. This heat warms the air around the body. Basking on a warm, darkly colored surface also aids in increasing internal temperatures. Species such as *Nymphalis antiopa*, the Mourning Cloak, warm the flight muscles by shivering (Douglas 1986). Once the butterfly is in flight, however, temperatures can drop quickly. Falling temperatures cause flights to be short on cool days. These various thermoregulatory mechanisms allow butterflies to raise their internal temperatures above the air temperature. Higher temperature allows flight on more days, especially early in spring.

By human standards, butterflies are small. Small individuals do not need large habitats to survive. Some species, however, defy their size and migrate great distances. The most well known example of migration is that of the Monarch. As the colder weather of fall approaches in the temperate regions, the Monarchs move southward for thousands of miles. The Monarchs seem to orient their direction of travel by the sun and possibly by detecting the earth's magnetic field lines with magnetite crystals in their brains (Douglas 1986). They may also be steered by the increasingly cold temperatures. They then spend the winter in Mexico, Florida, California, and Texas, only to return
north as the weather warms in the spring. Once the journey north begins, the butterflies mate and the females oviposit on milkweed as they travel north.

In flight or while basking or resting, brightly colored butterflies make tempting targets for predators. In order to avoid becoming food, butterflies have evolved several defenses. Brown and Ferris (1981) described how a butterfly’s life is in danger from very early on and throughout adulthood. Some wasps and flies lay eggs in or near the butterfly egg, larvae, or pupae. The newly hatched wasps or flies kill and eat the butterfly. Other insects, spiders, lizards, amphibians, mammals, and birds eat larvae, pupae, or adult butterflies. Many captured adults show signs of attack such as torn wings.

One method of avoiding predators is flight. Butterflies are very agile and when startled they avoid the predator and fly away to land somewhere safe and stay absolutely still to avoid detection. Poison is another defense. Some species of butterflies feed on poisonous plants as larvae. They tolerate the poison instead of being harmed by it. When attacked as a larva or adult, the butterfly poisons the predator, which learns to avoid butterflies of that wing pattern. There are also some species that manufacture their own poison and are not dependent on a food plant to get it. The chemical does not even have to be a poison; it can simply have a foul taste or odor that deters predators.

The effectiveness of chemical defense is enhanced by mimicry. In Batesian mimicry, a palatable species resembles an unpalatable one. Therefore, it is afforded protection from predators that have learned to avoid the unpalatable butterfly. Müllerian mimicry occurs when both species of butterfly are poisonous. Due to the similar appearance of the butterflies, predators learn at a faster rate to avoid them. These two types of mimicry evolved because of the advantage of avoiding predators. Individuals
that more closely resemble unpalatable species are avoided by predators and survive to produce more offspring until eventually the mimicry is nearly perfect. The mechanism is the same in Müllerian mimicry; similar appearance results in fewer attacks because the predators have learned to avoid a particular wing pattern. Poisonous butterflies without that wing pattern would be attacked at a greater rate since the predators take longer to learn to avoid a new wing pattern.

The physical structure of a butterfly can also provide defense. Larvae can have hairs or spines, and adults have hard bodies that can survive failed attacks. Although many butterflies are brightly colored, some use their appearance as a defense. One example is the mimicry discussed above. Mimics are often brightly colored to warn predators that they are unpalatable. Other butterflies have coloration on one or both sides of the wings that conceals them from sight. Often they look like dead leaves or blend into the background on which they land. Coloration can also be used to startle predators. Wings or larvae that contain eyespots can fool a predator into thinking the butterfly is a larger animal. When combined with a tail and a rubbing of the wings together, this ruse can fool a predator into thinking the tail end of a butterfly is its head. An attack on this end is more easily survived than one on the head region. Coloration that provides concealment is the only defense for eggs and pupae. All of these mechanisms of defense allow for greater survival of butterflies.

If these defense methods were too effective, the population of butterfly larvae and adults could reach pest levels, although butterflies rarely reach these numbers. Butterflies, however, can reach pest status when diseases, parasites, and predators do not kill enough larvae. The most notable example is *Pieris rapae*, the Cabbage White. This
butterfly is not native to North America but was introduced here in the 1800's from Europe. Since then it has spread throughout the continent and is a pest on all crucifer crops (Brown & Ferris 1981). Several other species sometimes require control methods to stop the destruction of the crops. However, butterfly populations are usually kept under control by natural means.

Complex sense organs have evolved in butterflies. Scott (1986) described the senses of the butterfly, beginning with their compound eye. The eye covers a large portion of the head. A compound eye is composed of hundreds of ommatidia. Each ommatidium has a lens and pigments to detect light. In addition to the visible spectrum seen by humans, butterflies can also see in the ultraviolet range. Butterflies can not see detailed patterns as humans can, but they can see over a much broader area and are more finely tuned to detecting movement. The sense of smell is dependent on nerve cells open to the environment. Often these nerves are concentrated in areas such as olfactory pegs, hairs, or hollows in the exoskeleton. The antennae are the main sites of smell. The taste organs are found on the ends of the legs, allowing the butterfly to tap the substrate upon which it has landed and taste it. Drumming, as this is called, is used to ensure that the female is laying eggs on the correct host plant (Scott 1986). Taste is also used to locate food. Most butterflies can hear only very poorly. Overall, the senses of a butterfly are a combination of finely tuned instruments and rudimentary senses.

Butterflies are an amazingly diverse group of insects. Their beauty, combined with their wide range, makes them enjoyable to study as well as easily accessible. These two attributes draw many people to the study of butterflies, from scientists to children. The wide array of observers results in the gathering of much knowledge that increases
understanding of butterflies and insects in general. In addition, much is learned about the habitats themselves, as well as the many factors, including humans, which impact them.

Although butterflies interest many people, comprehensive studies of populations throughout the United States, as well as the world, are nowhere near complete. Butterflies are currently being researched around the world, for example, in South America, Asia, and the arctic regions. The study of butterflies in Montana is severely lacking; the only other known published data are for Missoula County. This is the first study to be done in Lewis and Clark County. This study, therefore, used the capture of butterflies to study the diversity of species inhabiting the county. The collection of rudimentary data such as the number of butterflies and butterfly species, sex, range of habitat, and flight period will result in the knowledge of the current range and diversity of butterflies. In addition to possible evaluations with other areas such as Missoula County, this study provides a base from which future studies of Lewis and Clark County can track any changes that are occurring.
MATERIALS AND METHODS

Capturing and preserving butterfly specimens is a simple process, requiring little in the way of materials. Once the butterfly is caught, the procedures involved are not difficult, nor are they particularly time consuming.

Butterflies were collected from eight locations of varying geography in the southern part of Lewis and Clark County. The locations were as follows: east side Helena, Spring Meadow Lake, Priest Pass, McDonald Pass, Rimini Road, Magpie Creek, Lincoln, and Holter Lake. Collection took place between June 1st and August 15th, 1999. To avoid unnecessarily depleting populations, an attempt was made to identify the butterflies in the field and release them. At least one member of each species was captured, and a male and female of each species were desired.

In order to capture butterflies, a net and jars were used. Two methods were used to get the butterfly into the net. The best method was to swing the net at a stationary butterfly in a sideways motion and flip the netting over the opening at the end of the stroke to trap the butterfly in the end of the net. Alternatively, if the butterfly was too close to the ground, the stroke was downward and the net held against the ground. The net kept the butterfly trapped. In this case, the end of the net was held vertically so the butterfly could fly up into it off the ground. In either case, the net was then grabbed near the end to restrict the motion of the butterfly. The butterfly must be restricted so the jar could be inserted into the net. The jar was then manipulated until the butterfly entered. The net was held against the jar as a temporary lid until the lid of the jar could be put into place.
Ethyl acetate was used to kill the butterflies. The jar contained a glass tube filled with cotton glued to the lid. The cotton was soaked in ethyl acetate that was replaced periodically as the chemical evaporated. Once caught the butterflies were kept in the jars for 2-3 hr., a sufficient amount of time to kill them.

The butterflies were then set to dry. The positioning must be done soon after they are killed so they do not dry out and become too brittle to manipulate. First, a pin was placed vertically through the thorax. The butterfly was pinned on a setting board. The wings were then drawn into position and held down with index cards to maintain posture. Manipulating the wings was accomplished by pulling them out using another pin, applying pressure directly behind the thick vein on the front edge of the forewing so as not to damage it. The index cards were then set on the wings, and pins were placed in the corners to hold the wings and cards in place. The butterflies were left in this position until they were dry or approximately one week.

The butterflies were stored permanently in a box. The bottom of the box must be covered in some material that the pins can be stuck into, such as soft wood or Styrofoam. Butterflies were identified using books by Scott (1986), Smith and Tilden (1986), and Pyle (1981), and then labeled. The label contained the name of the butterfly, the location and date it was captured, the sex of the butterfly, and the collector’s name. The label was written in waterproof ink to prevent damage. The sex of the butterfly was determined by wing pattern, if possible, and by examination of the genitalia if not. The small size of the genitalia necessitated the use of a microscope. In this study, a microscope of 20X magnification was used.
Larvae, when encountered during the search for butterflies, were captured. A sample of the plant the larvae were found on was also taken. The larvae and plant were placed in a large jar with a loose lid to allow air circulation. New plant material was added as the old dried out. The larvae were observed until metamorphosis was complete.

Once the butterflies were collected, an analysis of the data was necessary. The examination included when, where, and what species and sex were caught. The chi-square test was used in order to determine the statistical significance of the analysis (Kitchens 1998).

Photographs (Fig. 6) were taken in addition to capturing butterflies. Both live butterflies at the search sites and mounted specimens were photographed.
RESULTS

Data on the number of butterflies, number of species, sex, and date of capture were analyzed. The capture of larvae enabled the study of the length of time necessary for development into adulthood.

Butterflies were captured at eight locations of varied habitat in Lewis and Clark County: east side of Helena (ESH), Spring Meadow Lake (SML), Priest Pass (PP), McDonald Pass (MP), Rimini Road (RR), Magpie Creek (MC), Lincoln (L), and Holter Lake (HL) (Fig. 3). The average number of butterflies recorded at each area was 25.9 ± 10.8, while the average number of species was 13.3 ± 6.8 (Fig. 1). The chi-square test was used to evaluate all data, with the null hypothesis that no variation would be seen. For the distribution of individual butterflies throughout the eight locations, a \( \chi^2 \) value of 31.6 was obtained with seven degrees of freedom. This value is high enough to correlate with a p value of less than 0.001. Similarly, the species seen at each location varied, and a total of 56 species was observed. The \( \chi^2 \) value for the number of species in each area is 91.1, again with seven degrees of freedom. This value also gave a p value less than 0.001. Not all of the 56 species caught in Lewis and Clark County are listed for Missoula County. The species not found on the Missoula County list are compiled in Table 1. With only two exceptions, the number of butterflies caught increases in each 10-day period (Fig. 2). These data gave a \( \chi^2 \) value of 31.3 with six degrees of freedom, the p value is less than 0.001. The number of places a species was seen also varied (Fig. 4).

<table>
<thead>
<tr>
<th>Species Name</th>
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<tbody>
<tr>
<td>Agriades franklinii</td>
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<tr>
<td>Cercyonis sthenele</td>
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<tr>
<td>Limenitis weidemeyeri</td>
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<tr>
<td>Phycoides tharos</td>
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<tr>
<td>Polygonia progne</td>
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<td>Speyeria coronis</td>
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Table 1. Butterfly species of Lewis and Clark County not listed for Missoula County.
Fig. 1. Number of butterfly species and individuals caught at each of eight locations in Lewis and Clark County, Montana. Abbreviations are as follows: east side Helena (ESH), Spring Meadow Lake (SML), Priest Pass (PP), McDonald Pass (MP), Rimini Road (RR), Magpie Creek (MC), Lincoln (L), and Holter Lake (HL).

Fig. 2. Number of butterflies recorded in each 10-day time period.

Fig. 2. Number of butterflies recorded in each 10-day time period.
Fig. 3. Search areas in southern Lewis and Clark County, Montana.
Fig. 4. Search areas in Lewis and Clark County, Montana where each butterfly species was found.
Fig. 4. (cont.)
Fig. 4. (cont.)

Western Meadow Fritillary  Zerene Fritillary  Anicia Checkerspot  Pale Crescent

Pearl Crescent  Gray Comma  Green Comma  Milbert's Tortoiseshell

Lorquin's Admiral  Weidemeyer's Admiral  Hayden's Ringlet  Common Ringlet

Ochre Ringlet  Prairie Ringlet  Common Alpine  Common Wood Nymph

21
Great Basin Wood Nymph
Small Wood Nymph
Arctic Skipper
Garita Skipperling
Woodland Skipper
Common Checkered Skipper
Persius Duskywing
Silver-spotted Skipper

Fig. 4. (cont.)

22

Fig. 5. Number of butterfly species first observed in each 10-day time period.
Different species complete metamorphosis at different times of the year. The first time a species was seen was compared to the time period of capture (Fig. 5). The $\chi^2$ value for this data is 11.3 with six degrees of freedom. This value is not high enough to correlate to a p value small enough for the differences in the data to be significant. The flight period, the dates on which adults are seen, also varied among species. The flight periods were compared by charting the time periods during which each species was seen (Table 2). Similarly, the total number of species observed in each time period varied (Table 3). On average, 16.4 ± 5.6 species were observed during the 10-day time periods. Again using the chi-square test, a $\chi^2$ value of only 11.4 was obtained, indicating that the data are random.

Once captured, the butterflies were categorized on the basis of sex. In some species distinguishing the sex was as simple as noting differences in wing pattern, while at other times an examination of the genitalia was necessary. Of the 56 species recorded, both males and females of 15 species were captured. In 25 species, only males were seen, while in 16 species only females were caught. Overall, 87 males and 42 females were observed. The $\chi^2$ value for the number of males and females is 15.7 with one degree of freedom. This number corresponds to a p value of less than 0.001.

Different species of butterflies associate with different species of plants. Host plants are used for both feeding and oviposition. A few times it was possible to determine a connection between a butterfly and a plant by seeing a species on a certain plant several times (Table 4).

Butterflies undergo complete metamorphosis from larvae to adulthood. An attempt was made to study this process. Larvae were captured on two different
occasions. On June 11th a larva was caught in east side Helena on the Wild Prairie Rose (Rosa arkansana). On July 9th it began pupation, and this process was completed on July 27th. Once adulthood was reached, it was apparent that the insect was a moth. Another larva was captured on McDonald Pass on June 16th. It began pupation on June 21st and eclosed on July 5th. It turned out that this insect was also a moth.

Table 2. Flight periods of butterfly species found in southern Lewis and Clark County, Montana.

<table>
<thead>
<tr>
<th>Species</th>
<th>Early June</th>
<th>Mid June</th>
<th>Late June</th>
<th>Early July</th>
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<th>Late July</th>
<th>Early August</th>
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<tr>
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24
Table 3. Total number of butterfly species observed in each time period.

<table>
<thead>
<tr>
<th>Time Period</th>
<th>Number of Species</th>
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<td>Early June</td>
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<tr>
<td>Mid June</td>
<td>17</td>
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<tr>
<td>Late June</td>
<td>19</td>
</tr>
<tr>
<td>Early July</td>
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<td>Mid July</td>
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<tr>
<td>Late July</td>
<td>21</td>
</tr>
<tr>
<td>Early August</td>
<td>21</td>
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</table>

Table 4. Butterflies and associated host plants.

<table>
<thead>
<tr>
<th>Butterfly</th>
<th>Plant</th>
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</thead>
<tbody>
<tr>
<td>Juniper Hairstreak</td>
<td>Pearly Everlasting</td>
</tr>
<tr>
<td>Pearl Crescent</td>
<td>Oxeye Daisy</td>
</tr>
<tr>
<td>Common Sulfur</td>
<td>Dotted Gayfeather</td>
</tr>
</tbody>
</table>
Fig. 6. Butterflies from Lewis and Clark County, Montana. (a-e) Captured butterflies. (f) Phoebus Parnassian (*Parnassius phoebus*). (g) Greenish Blue (*Plebejus saepiolus*). (h) Pearl Crescent (*Phycoides tharos*). (i) Callippe Fritillary (*Speyeria callippe*). (j) Common Wood Nymph (*Cercyonis pegala*). (k) Hayden’s Ringlet (*Coenonympha haydenii*). (l) Common Sulfur (*Colias philodice*).
DISCUSSION

The results can be analyzed in a number of ways. As can be seen in Fig. 1, the numbers of both species and individuals varied greatly in the different locations studied. The chi-square analysis of this data indicates that the variance in the numbers of both species and individuals at the locations is statistically significant, with a certainty of greater than 99.9%. It follows that there is some difference in the sites, and the deviation from the average is not due to random chance. The numbers of species and individuals varied among locations because the habitat is different in each location. Areas that are more open, such as fields, support a wide array of plants that in turn support a wider range of species. Areas that are more densely forested are not as conducive to supporting large numbers of butterflies, since fewer types of plants are supported as a result of the decreased sunlight. No conclusions can be drawn about agricultural areas, since none were included in the search areas. The more species an area supports, the greater the number of individuals seen, simply because each species must have a significant number of individuals to maintain the population. The availability of water plays some role and could contribute to the large numbers of butterflies at the east side of Helena, Spring Meadow Lake, and Magpie Creek. The butterflies need some water, although mud puddles are often enough, but the closeness of water increases the variety of plant species. However, other areas close to water such as Holter Lake and Rimini Road do not support large numbers, while Priest Pass and McDonald Pass contain many butterflies without a major source of water. This discrepancy leads to the conclusion that water is a factor, but is not as important as other factors such as host plant availability. Similarly, increased altitude did not seem to limit the number of butterflies seen in an area. Priest
Pass, McDonald Pass, and Lincoln had the most diversity in butterfly species, even though their altitude is much greater than that of the other areas.

Similarly, the numbers of species and individuals can be analyzed on the basis of the date of capture. For convenience, the months were split into thirds, giving 10 or 11-day periods. The number of individuals increased in almost every successive time period (Fig. 2). As with the data for area, the chi-square analysis indicates that the number of individuals increased from early June to early August, and this increase is not due to chance. On the other hand, the range of emerging species seen in Fig. 5 is not supported statistically. The analysis of these data indicates that the numbers did not vary enough to significantly prove that the variation was not random. At the same time, the total number of species seen in a time period (Table 3) was also found to be random. The differences seen in the numbers of species and individuals in the different time periods is probably related to weather rather than habitat. The fairly steady increase in the number of butterflies seen in each time period directly correlates to an increase in temperature. The increased temperature enables the butterflies to be active for longer periods during the day, increasing the chances of mating and finding food. The greater activity results in both more butterflies seen, since most are seen while in flight, as well as a general increase in number due to increased reproduction. Even though the number of individuals varied by time period, the number of species emerging and total species seen did not. The emergence of species, and therefore the total number of species observed, is controlled in temperate regions by diapause. Butterflies cannot be active during the winter, so they enter a state of reduced activity called diapause. The stage of life that enters diapause can be the egg, larva, pupa, or adult, and varies with the species. Species
that are first seen probably overwintered as adults. Although variation also results from
the length of time spent in each stage, the number of new species emerging in a time
period is statistically constant. Often a species was seen in only one time period, but
some were seen in as many as six of the seven periods (Table 2). Species that first
emerged late in the study were not seen in as many periods, simply because the study
ended. The flight period of species seen only once or twice is impossible to determine,
since they may not have been seen in all time periods that they are active.

Males outnumber females in the study 87 to 42. This difference was found to be
statistically significant. The fact that a greater number of males rather than females was
observed can be explained through behavior. As described above, most butterflies are
encountered in flight. One method that males use to locate females for mating is to fly
out and investigate. Butterflies do not have sight capable of discerning figures from a
distance, so they fly out to investigate anything moving by. As a result, more males than
females are seen. Both males and females are met during the search for food, and
females are seen while they search for a site for oviposition.

The number of locations in which a species was observed also differed among
species. Nearly half (27 out of 56) of the species was seen at only one location. Other
species were observed at as many as six of the eight locations studied. Species that were
found at several of the eight locations, such as the Western Tiger Swallowtail, Northern
Blue, Pearl Crescent, Common Alpine, and Small Wood Nymph, are more widely spread
than other species for several reasons. First, the species may be adapted to a wider range
of habitats. Also, the host plant for a species may be found at more locations than those
of other species. At the same time, there are several explanations for species being found
at only a few areas. This phenomenon was observed in the Pheobus Parnassian, Alfalfa Butterfly, Mariposa Copper, Aphrodite Fritillary, and Lorquin's Admiral. Other areas may be able to support them, but they have simply not dispersed to that area or they may have been driven out of the area. Also, just because this study did not find a species in a certain area does not mean that it is not present.

Finally, an attempt to study metamorphosis was made. Unfortunately, it was not possible to draw any meaningful conclusions from this analysis, since all the larvae found were moths.

Several findings in this study support statements in other works. Scott (1986) stated that the diversity of butterflies is greater in mountainous areas as a result of more varied habitat concentrated in a small area. These habitats include creek bottoms, sunny and shady slopes, and ridges. This observation serves to explain the occurrence of more species of butterflies at Priest Pass, McDonald Pass, and Lincoln. Other works, however, do not support the description of species and associated host plants (Table 4).

Descriptions of the host plants associated with butterfly species in Scott (1986) and Pyle (1981) do not include the associations observed during this study. The plants that butterflies were observed on were therefore most likely a result of the butterfly simply resting on the flower, or feeding on its nectar, rather than the use of the plant as a place for oviposition or as a larval food.

Comparison to other studies is difficult, simply because they have not been done. A list of species found in Missoula County has been compiled (Kerling et al. undated). Several of the species captured in this study are not found on the Missoula County list (Table 1). At the same time, the Missoula County list contains 125 species, while only
56 were found in this study. The significance of this difference, along with the species not found on the Missoula County list, is most likely simply that neither list is comprehensive. This study was conducted over a period of two and a half months, and certainly not all species living in Lewis and Clark County were recorded. Similarly, the Missoula County list most likely does not contain all species found in Missoula County. However, given that 50 of the 56 species found in Lewis and Clark County are also found in Missoula County, it is reasonable to assume that the habitats found in the two counties are similar, and therefore support similar butterfly populations.

In a broader context, this study was able to analyze many different aspects of butterflies with a simple method of study. Conclusions on a wide array of topics were drawn solely from the capture and identification of butterflies. The total number of individuals, the diversity of species, the length of flight period, distribution throughout the county, and the proportion of each sex can all change over time. An important area of research is the decreasing diversity of all species of life from year to year. These changes can have many causes, from yearly environmental fluctuations such as weather to destruction of habitats by humans. This study provides a basis for future comparison concerning how these factors are affecting butterfly populations.
LITERATURE CITED


