

A Systematic Survey of the Dragonflies and Damselflies (Odonata)

Found on Wind Cave National Park (WICA)

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The primary objective of this project was to determine which species of dragonflies and damselflies (odonates) occur on the park as a baseline for the aquatic insect populations found throughout the park. Information collected on each species included the type of wetland habitats preferred, the length or timing of the flight period of the adults, commonality of each species, and any special habitat requirements or behavioral patterns indicative of that species. Both the species checklist created and the life history patterns observed in this survey were compared to previously published reports from South Dakota and the surrounding states. The information was then used to provide a guideline for continued monitoring of odonates by park personnel and management recommendations for maintaining the diversity of odonates dependent upon aquatic habitats in a relatively dry region. This survey is part of a long-term study to document the Odonates of the Black Hills and to determine any geographic variation in life history strategies and physical characteristics specific to this area.

Introduction/Background

Western South Dakota does not have an abundance of water nor a prolonged rainy season. Many species of amphibians, fish, plants, insects, and even mammals have been eradicated or have had their populations severely reduced by abuse of our wetlands. This abuse comes in several forms including, but not limited to, over-grazing, removal of dead vegetation, "cleaning" of ponds and streams, introductions of non-native species, draining the habitat, and complete destruction of a habitat by building new roads and houses. For these reasons, we must guard our aquatic habitats with extreme care if we wish to preserve species diversity and our natural heritage. Unfortunately, in order to protect our aquatic habitats we must first know something about the organisms that occupy these wetlands.

Odonates, dragonflies and damselflies, depend upon aquatic habitats for reproduction and have been studied for years in some areas but they have been virtually ignored in South Dakota. One study surveyed the odonates of the eastern and central part of the state, but avoided the Black Hills because of their unique biological and geological attributes (Fresvik, 1969). Another study mentioned that a dozen species occurred on Cascade Creek in the southern Black Hills, but only one species was discussed (McIntosh, 1928). A third study mentioned that a few specimens of odonates were found at Wind Cave National Park, but the survey was incomplete and only classified insects to the level of family (Walthall, 1962). Only a few other published reports exist for South Dakota and none of the surveys were done on a large scale (Bick and Hornuff, 1972, Bick, et. al., 1977; Provonsha and McCafferty, 1977). The Black Hills and the states in the Great Plains are also unique in that they contain disjunct populations as well as species which are either in their easternmost or westernmost extensions of their ranges (Beckemeyer, 1999; Hummel, 1999; Barber,

1999a). Both range extensions and endemic species can be expected in such a poorly studied and unique biological area as the Black Hills.

Dragonflies and damselflies are one of the oldest orders of insects and as such exhibit a wide array of life history strategies. Differences between species include, but are not limited to, habitat preference, occurrence and timing of diapause, occurrence of territoriality, reproductive behavior, length of larval and adult periods, and timing and duration of the adult flight periods. In addition, many of these traits can vary geographically within a species depending upon such features as temperature (Hawking and New, 1995; Lawson, 1995), photoperiod (Lutz, 1968; Norling, 1984), competition (Gribbon and Thompson, 1990), and predation (Johnson and Crowley, 1980; Johnson, 1991; Rowe and Ludwig, 1991). Physical characteristics such as color pattern (Beckemeyer, 1999; Paulson, 1999) can also display geographic variation whereas other species are thought to hybridize as can be seen when looking at the shape of the males hamules (Barber, 1999b; Carle, 1993). With such a diversity of life history strategies and the factors affecting them and the fact that odonates display geographic variation as well as the ability to hybridize, data should be considered as peculiar to a habitat and not applied liberally to different habitats to geographic regions.

Not only are dragonflies and damselflies an important part of the ecosystem as both prey to vertebrates and voracious predators in both the larval and adult stages, but as such, they can be important indicators of the health of any aquatic habitat. Observations indicate that aquatic habitats containing introduced fish are devoid of many aquatic insects (personal observation; Smith, 1997), and these habitats may be experiencing a loss of species diversity and a decline in habitat quality. Larvae of dragonflies and damselflies develop in aquatic habitats ranging from temporary muddy pools and streams to permanent lakes and rivers. Factors such as competition (Istock, 1973), vegetation preference for oviposition (Westfall and May, 1996), and oxygen deficiency (Gaufin, et.

al., 1974) may prevent larvae from emerging as adults. Many larvae of the Genus *Ophiogomphus* are vulnerable to siltation and pollution and thrive only in undisturbed habitats (Legler, et. al., 1998). Since larvae are susceptible to changes and disturbances in their environment, water quality may be monitored using them as indicator species (Carle, 1979). The body forms of both the adult and larval dragonflies and damselflies are easy to recognize and could be used as an indicator of the health of a habitat. Furthermore, their popularity has grown in recent years and an increasing number of books, magazines articles, videos, and internet web sites has both increased public awareness and interest and made identification of different species easier for most people unfamiliar with entomology. While watching odonates will probably never be as popular as bird-watching, small parks on the east coast have advertised some of the species of dragonflies and damselflies found in their area or added pictures of them to their pamphlets to encourage visitation and enjoyment of these parks.

Study/Collection Sites

Wind Cave National Park (WICA) is located in the southeastern Black Hills in southwestern South Dakota. The Black Hills are a very old uplift which has a unique habitat very different from the surrounding grasslands and has a unique biogeography (Froiland, 1990). The park itself covers 11,449 hectares with elevations ranging from around 1100 m to 1528 m. Habitats range from open prairie to forests of predominantly ponderosa pine. Water resources on the park are sparse. There are three perennial streams with sections turning intermittent during drier periods (Beaver Creek, Cold Spring Creek, and Highland Creek), a number of permanent springs, and several seasonal ponds of varying sizes. The weather of the park is typical of the Black Hills and

consists of a semi-arid continental weather pattern modified by the mountainous terrain (Froiland, 1990). Severe thunderstorms commonly occur and snow and freezing temperatures are possible through the middle of June. The year of this study, 1998, was unusually wet with the last snowfall occurring in the beginning of June after a relatively warm spring. Most intermittent streams and seasonal ponds that normally dried up mid-way through the summer contained water in 1998 for the entire warm season.

Nine sites were visited on a regular basis and are listed below along with a brief description of the areas collected at each site. Since names of some of the sites were unknown, I created names for them and will refer to them throughout this report by these descriptive names. Specimens were collected and/or observed on the way to and from these nine sites to verify their presence or absence on the park and to learn about the feeding habitats used when the individual wasn't breeding. However, these were not considered as a part of the study since the presence of an individual does not mean that it is breeding on the park or that it will stay to do so.

The Route 5 Embankment Pond (GPSed by park staff as DC-34-2) was a stream backed up with a concrete embankment and was located on the eastern side of Route 5 in a deep ravine just off of the road and just south of the junction with Route 6. An intermittent stream flowed into the pond from the northern end, overflowed the embankment and continued southward. I collected at the pond and for a short way along the stream to the north and the south of the pond.

Boland Ridge Spring was located just off of the eastern side of Route 6 a short distance north of its intersection with Route 5. I parked at the trailhead for the Boland Ridge Trail and followed the trail until it came to the spring that was easily recognized by the corrugated metal on its southern side. The spring trickled down a brief slope until it ran into an intermittent stream. The

stream ran by the spring from the west and continued eastward. I collected there and also along the stream for a short way to the east and west of the spring.

Red Valley West Spring was located on the western side of Route 6 a short distance north of the Boland Ridge Trail parking lot. There were two old concrete stock tanks and a shallow, vegetation-filled stream that came from the northwest and ran eastward toward the road. One of the tanks was filled with soil and vegetation but the other contained standing water and lots of damselfly larvae. I collected at the spring and for a short ways up and down the stream.

Blacktail Spring was located on the northern end of Route 6 just before the road leaves the park. It was on the eastern side of the road and was reached by walking eastward across the plains until I came to a stream meandering eastward. I followed the stream until I passed the two old concrete stock tanks and continued on around the bend where the stream widened until it was around 10 feet across. I started collecting east of the widened streambed and continued westward for a short distance west of the stock tanks.

Parker Spring was reached by taking the old fire trail off of Route 5 eastward until it almost ran into the western end of a canyon. There are two old concrete stock tanks at the eastern end of the canyon floor. When it rains water runs into the western side of the western tank, exits from the eastern side of the tank, and winds down toward the eastern tank. I started collecting to the west of the tanks and spent some time collecting at both tanks and around the trees in between them.

The Sanctuary Trail Ponds which included an old stock pond (HD-12-6) and a large pool (HD-12new) just off of the beginning of the Sanctuary Trail. I parked at the trailhead and followed the trail through the trees until it passed a grassy area. I turned east onto the grassy area and followed it lengthwise up to a pass between two ridges. The stock pond was due east of the ridge and could be easily found by following a game trail to it. The western pool was small and shallow

while the eastern pond was approximately 20 feet across and appeared to be several feet deep. Both areas were located at the southern base of rocky outcrops and a shallow, vegetation-filled stream connected them. The stream started to the west of the pool, flowed into the western pool and continued east of the eastern pond. These bodies of water were at the highest elevation of all of the sites and, unlike the others, had direct sunlight most of the day since there were few trees in the immediate vicinity. I started collecting just east of the eastern pond and continued for a short distance west of the pool with more time spent at each body of water.

I entered Reeves Gulch from a parking lot (the Pegmatite Pullout) and collected at two "pond-like" collections of deeper water and the part of the stream between them because I saw more odonates at these ponds than along the whole gulch. The first "pond" was located southeast of the parking lot. I went east of the parking lot until I reached the gulch, climbed down into the gulch, and followed the stream south until I came to the first "pond". This "pond" was surrounded by large rocks and had lots of aquatic vegetation, with the stream entering on the northern corner and leaving on the southern side. I followed the stream south until I reached the second "pond-like" collection of water. This "pond" had large boulders on the southern and western sides, lots of aquatic vegetation, trees shading the area, with the stream entering on the northern part and leaving from the southern section. I started collecting at the northern "pond" and continued until I reached the southern one.

The Beaver Creek/Cold Spring Creek site was a circular hike. I parked at the Centennial Trailhead and followed the path until it crossed Beaver Creek. I followed the creek east well beyond where it intersects Cold Spring Creek. I turned around when the path goes over Beaver Creek and walked through the field (chasing feeding odonates) until I hit the intersection of the creeks and followed Cold Spring Creek until I came to a larger collection of water at the base of a

big hill where dragonflies congregated. Sometimes I would follow the stream for a short ways and then go up the hill and back to the truck, and other times I would follow the stream around the hill and then back to the truck. The route chosen depended upon a lone bison that seemed to like that area and didn't change the number of species observed in the area that day. I started collecting when the trail crossed Beaver Creek the first time and continued until I left Cold Spring Creek. Since Cold Spring Creek was relatively shallow and slow moving while Beaver Creek was much faster and up to a foot deep, I split this collecting trip into two parts and named them after the creek they follow.

The Cold Brook Canyon/Limestone Spring site was a long hike to the sites and back. I followed the Cold Brook Canyon Trail until it turns off at a right angle to the west. Instead of remaining on the trail, I followed the old road southward and down into the canyon. I went south in the canyon to visit three small temporary ponds and then went up a side canyon to Limestone Spring. The first of the three ponds was a small, temporary collection of water under a southwestern-facing rocky outcrop. The second pond was located under a north-facing rocky outcrop, received only small amounts of direct sunlight, and nearly dried up by the end of the summer. The third pond was fairly large and ranged from several inches up to several feet deep in the early part of the season. It was located directly west of the second pond at the foot of a western-facing, shallow but rocky outcrop. Limestone Spring was made up of two old cattle tanks. It was located on the western end of a side canyon near the park's boundary. An intermittent stream started uphill and to the west of Limestone Spring, ran down through the spring, and continued downhill for a short ways. Since each pond and the spring were distinctly different, I split this collecting trip into 4 parts and based my collections around each location. The ponds are numbered

in the order that I reached them with the first being the northern pond and the third being the southern pond.

Methods

Adult damselflies and dragonflies on Wind Cave National Park were surveyed from mid-May when the permit came through until the end of August. By surveying for the entire warm season, this helped determine the probable flight period for each species using the first and last date that adults of that species were observed. This information should be good for the entire Black Hills area although the actual season would depend upon the weather. Only two specimens of each species, one male and one female, were kept to use as voucher specimens for the park. Adult specimens were collected, the species identified, various parameters noted, and the specimen was released if it was a species that already had a reference specimen. Adults were collected with a dark green 18-inch diameter, 38 inch-long net with a 5-foot pole. The large handle, the wide and deep net, and the green coloring were all necessary for collecting dragonflies which are very wary and don't trust anything unusual in their environment.

Surveys of the adults were taken biweekly at each of the nine study sites mentioned in the previous section. By surveying each site regularly, I determined how common a species was on the park and which habitat types it was found most often. An attempt was made to try to cover as many types of aquatic habitats as possible and still be able to visit each site regularly. In order to survey each site every trip and still visit a variety of habitats, study sites were limited to areas that were accessible within a half days walk. In addition, regular surveys were restricted to areas near aquatic habitats since damselflies and dragonflies must return to aquatic habitats to reproduce. At aquatic

sites, males and females were preoccupied with territorial battles, searching for mates, copulating, mate guarding, and laying eggs. Odonates found away from water were feeding and were generally more watchful of their surroundings and cautious in their actions than those individuals trying to breed. This way time was not wasted trying to catch the wary and was efficiently spent catching unwary individuals and those flying in tandem. It was also easier to know the identity of a female when with a male than to try to identify her when caught alone.

An attempt was made to survey the damselfly and dragonfly larvae in order to prove that each species of adult found on the park was actually reproducing and not simply a transient species. Unfortunately, the ground was usually rocky which made it difficult to collect larvae without destroying the habitat. The few specimens collected were difficult to identify to species without killing them. Most of the specimens could be identified to the genus but not the species level. Many of the larval characteristics used in modern keys required that the specimen be placed under a dissecting scope or a microscope which could potentially dry out, harm, or kill the individual. Some of the larvae had obviously barely escaped predators. Body parts such as caudal lamellae, hairs, legs and antennae were often missing, bent, or indented and were required to identify the specimen to species. In addition, some of the characteristics didn't follow the dichotomous keys which may be attributed to geographic variation. Larvae could have been maintained in the lab until they emerged, but many of the adults collected were known to have larvae that dig deep down into the mud and soil and remain there until ready to emerge as adults. Also, with the adverse weather conditions early in the season, enough food for regular feedings was hard to obtain. With all of the problems involved in identifying the larvae, it was decided to concentrate on the adult stage only.

The life history of each species was examined by regularly visiting each site and recording a combination of habitat parameters during each visit. By visiting nine different locations, the habitat preferences on the park of each species could be determined. Information collected about the habitat included atmospheric temperature, amount of sunlight available (sunny versus cloudy), amount of sunlight reaching the water or the amount of shade from trees and rocks, duration of the aquatic habitat if it's a temporary habitat, substrate of aquatic habitat, amount and type of aquatic vegetation, and the presence or absence of fish or other predators. Every time an individual was captured this information was noted along with the scientific name and the behavior of the individual before it was caught.

All life history information collected in this survey was compared to published report of odonates in the surround areas and to species reports to determine if populations on the park display any geographic variation from the surrounding areas.

Results and Discussion

Species checklist and life history patterns:

Most species collected on Wind Cave National Park (WICA) were found throughout the park although there were a few species that were only detected at one or a few locations. Two species of damselflies, *Enallagma civile* (Familiar Bluet) and *Ischnura verticalis* (Eastern Forktail) were found at all locations surveyed on the park. Three dragonflies, the Paddle-tailed Darner (*Aeshna palmata*), *Libellula lydia* (Common Whitetail), *Libellula pulchella* (Twelve-spotted Skimmer) were found at all but one of the locations surveyed although the presence of a territorial male does not mean that they were reproducing at every site. The locations containing the highest

numbers of breeding dragonflies and the most diverse species were the Route 5 Embankment Pond, the Sanctuary Trail Ponds, along Cold Spring Creek, and the ponds in Cold Brook Canyon. Male and female specimens of *Ophiogomphus severus severus* (the Pale Snaketail) were only collected along Beaver Creek which was a relatively fast-flowing creek for the entire flight season. The water was very clear and should be fairly clean since larvae of Snaketails (Genus *Ophiogomphus*) do not survive well in waters polluted with siltation and chemicals (Legler, et. al., 1998). The first temporary pond in Cold Brook Canyon usually dries up mid-way through the summer, but during 1998 it did not although it was reduced to a tiny collection of muddy water by the end of the season. This pond was a haven for the three species of *Lestes* found on the park. All three species were very abundant and were the dominant odonate found at that location. One damselfly, *Archilestes grandis* (Great Spreadwing) was only found at this pond and only males were observed. The reason for the predominance of species in the Family Lestidae at this pond was probably due to the abundance of dead, woody twigs and lots of emergent vegetation in and around the water in which they could lay their eggs. One pair of *Libellula forensis* (Eight-spotted Skimmer) were collected while they were copulating (in the wheel) at Limestone Spring even though they normally prefer ponds. No other individuals of this species were observed on the park.

Usually both males and females of a species were observed or collected although there were a few species represented by only one to several male specimens. Only four male specimens of *Sympetrum danae* (Black Meadowhawk), one male *Aeshna californica* (California Darner), one male *Arigomphus cornutus* (Horned Clubtail), and one male *Leucorrhinia intacta* (Dot-tailed Whiteface) were found on the park although they have been found throughout the Black Hills. Females of any species of damselfly or dragonfly are often difficult to find unless they are breeding so it is possible that they were on the park but were not breeding when I was conducting the survey.

The Black Meadowhawk (*S. danae*) at least can be quite common in some locations of the northern Black Hills. I also saw two dragonflies whose silhouette had black basal wing spots but I was unable to approach them. They could have been either *Libellula luctuosa* (Widow Skimmer) or *Tramea lacerata* (Black Saddlebags). I would see but not be able to approach lots of feeding dragonflies just southeast of the old tanks at Parker Spring and along Cold Brook Canyon. Generally, the damselflies were only found close to water but the dragonflies were often observed feeding far away from water and flying high up in the air. For a checklist of the damselflies and dragonflies found on Wind Cave National Park (WICA) and where they were observed on the park see Appendix 1 of this report.

The life histories of the species found on the park were observed and compared to published reports of conspecifics in other geographic areas (see Appendix 2). Nothing unusual was observed in either the length or timing of the flight period, the habitats preferred, or in their behavioral patterns. There were some slight differences in the commonality of a species when compared to information from states surrounding South Dakota, but those differences can be attributed to a lack of surveys and general knowledge of odonates in South Dakota and the surrounding states. Female damselflies were usually observed before males of the same species appeared while the male dragonflies were usually observed before the females of the species. The absence of male damselflies early in the season may have been caused by the adverse weather conditions during the spring and early summer of 1998 which was unusually wet and cool. Frequent cold spells during May and June included strong winds, snow flurries, and hail. It is likely that adverse weather conditions killed any males that had emerged early. In addition to the adverse weather, the summer was unusually wet and humid and areas that would normally have dried up still contained water and green vegetation late into the summer. All temporary ponds visited and the intermittent streams

contained water throughout the entire flying season although they were greatly reduced in size. Although the perpetuation of water late into the breeding season may have increased the opportunities for breeding and laying eggs, no unusual behavior was observed in 1998. If more eggs were laid in 1998, there should be an increased number of damselflies and dragonflies emerging in 1999 although weather conditions during that time will also play a roll in their eventual fate.

Several species of damselflies and dragonflies collected on the park are thought to be uncommon in South Dakota. However, not enough surveys have been done to tell us all of the species that occur in this state, how far they range, how long the adults are active, nor how common they may be. These questions can only be answered with extensive collecting and surveying although this survey added to our knowledge of which species occur in this state and how far they may range. No previously undescribed species were found on the park although there were many range extensions. The Pacific Forktail damselfly (*Ischnura cervula*) was a new state record. This species had not been previously observed in South Dakota and several breeding pairs were found on Wind Cave National Park. Six species of dragonflies and one species of damselfly were county records. The seven species had been found before in South Dakota, but none of them had been reported in Custer County. The county records for dragonflies were the Blue-eyed Darner (*Aeshna multicolor*), the Variegated Meadowhawk (*Sympetrum corruptum*), the Saffron-winged Meadowhawk (*Sympetrum costiferum*), the Black Meadowhawk (*Sympetrum danae*), the Western Meadowhawk (*Sympetrum occidentale fasciatum*), and the Striped Meadowhawk (*Sympetrum pallipes*). The Emerald Spreadwing (*Lestes dryas*) was the only damselfly found on the park that was a county record. With so many range extensions, whether they are state or county records, we can see the need for further studies of the odonates of the Black Hills.

Field identification of damselflies and dragonflies:

The enclosed key to the adult damselflies and dragonflies found on the park (Appendix 3) will help to identify most specimens while in the field, unfortunately, some problems with this method still exist. The males of some species look identical unless the caudal appendages are examined under a dissecting scope or a microscope. Damselflies such as *Ischnura cervula* (Pacific Forktail) and *I. damula* (Plains Forktail) are one example while *Argia plana* (Springwater Dancer) and *A. vivida* (Vivid Dancer) are another. Three closely related species of dragonflies, *Sympetrum internum* (Cherry-faced Meadowhawk), *S. obtrusum* (White-faced Meadowhawk), and *S. rubicundulum* (Ruby Meadowhawk), have a color pattern and body form that is nearly identical and they are known to hybridize within the Great Plains (Beckemeyer, 1999; Hummel, 1999). Often, these three species cannot be separated visually in the field but instead require a close examination of the paired hamules under the second abdominal segment in the males (Barber, 1999b; Carle, 1993).

Physical similarities in related species are not the only problem with field identification of damselflies and dragonflies. Gender differences aside, females generally do not resemble the males in either behavior or color pattern. Females are not territorial and generally spend most of their time feeding and only arrive at an aquatic habitat in order to breed. Females in the Genus *Aeshna* range from browns to greens and blues or may have a color pattern with a mixture of green and blue while the males range from all blue to blue with some green. Males of the Eastern Forktail damselfly, *Ischnura verticalis*, are green, blue and black while the female is mostly dull brown or gray. It is also difficult to distinguish females of closely related species as they may share many characteristics. Often, the only way to determine the species of a female is to catch her in tandem

with a male. Unfortunately, males may not always grab a female of the same species and his abdomen may be attached to a female of the wrong species although they will not be able to copulate, i.e., form the breeding wheel. Females of many damselflies and some dragonflies may also display more than one color form. For example, many species of damselflies may have a color form matching that of the blue male in addition to a red or gray color form.

Changing color patterns in adult odonates also cause problems with field identification. General, newly emerged or sexually immature, odonates may more closely resemble the females of the species as they may have spots which disappear as the individuals mature. Colors in older individuals may fade from blue to browns and blacks or they colors may darken with age. Some species develop more pruinosity as they mature or their pruinose spots may disappear. The color of many species changes with fluctuations in the temperature, becoming darker during cooler temperatures (Westfall and May, 1996). In addition to these color changes, dried specimens often lose their color patterns as colors fade or darken. Dried specimens often appear mostly dark.

Geographic variation in wide-ranging species also occurs and may hamper field identification. Individuals of a species may have larger sizes in one location than in another. Temperatures and food availability affect the growth and development of a larvae which in turn affects the size of the adult. The color pattern may show geographic variation. Paulson (1999b) shows that individuals of the Striped Meadowhawk (*Sympetrum pallipes*) found in wetter and cooler regions have more black on their abdomen than individuals from dryer and warmer regions. Since physical similarities, hybridization, color patterns, and geographic variation all hamper easy identification of odonates, an attempt was made to include more than one character at each step in the field key without adding too many characters to quickly examine the specimen.

Species management and recommendations:

Binoculars can be used to determine the species of most dragonflies or damselflies and have been used extensively on the East Coast. Binoculars will allow you to see the color pattern, body shape, and distinguishing markings of an odonate without the need to catch the specimens in hand, flush them from vegetation, climb trees and rocks, or disturb their natural behavior. Many odonates can be identified down to species by combining any distinguishing markings or silhouettes with other information such as the time of day, the location (counties within states as well as habitat), and their behavior. While binoculars will not help you identify some individuals down to species, they should be helpful to identify them down to the genus.

I would recommend that the old tank/cement ponds not be cleaned on a regular basis and that adjacent areas not be cleaned in the same year. The muck that collects on the bottom is home to a variety of aquatic insects and odonate larvae have been found in many tanks or surrounding areas from April through August. In addition to not cleaning or rarely cleaning the tanks, care should be taken with the area immediately surrounding the tanks whether the soil has dried out or remains moist. Larvae of most, if not all, species in the Family Gomphidae are known to dig down several feet into soft ground and live there until they are ready to emerge. Also, many species throughout the country have been observed to emerge from spring and summer temporary ponds that were known to have dried out sometime in the fall. How some larvae survive after the pond dries up has not been studied, but it has been observed in a number of odonate Genera that occur on the park, for example the Genus *Sympetrum*.

Fallen tree limbs and dead, rotting, or emergent vegetation found in or around aquatic habitats should not be removed for "aesthetic reasons". The Family Lestidae includes many species, such as *Archilestes grandis* (Great Spreadwing) known to lay their eggs in fallen tree branches and

woody or emergent vegetation in or immediately surrounding aquatic habitats. Instead of removing dead vegetation to make the aquatic habitats look aesthetically pleasing to park visitors, an educational exhibit can be used to explain how many animals use dead or rotting vegetation as their homes.

A public-relations or educational display on the benefits to humans of the predatory nature of dragonflies, damselflies, ladybugs, and various other insects might help to encourage nearby neighbors as well as park visitors that a natural management of our lands and aquatic habitats is preferable to a chemical one. While collecting on WICA, I had the chance to talk to several ranchers from the surrounding area. Most of them had observed adult dragonflies chasing and eating mosquitoes but few of them knew that they had an aquatic larval stage during which they also preyed on aquatic mosquito larvae. Several mentioned admiring anything that would get rid of mosquitoes. Yet, few ranchers knew what a damselfly was, how to distinguish them from dragonflies, or that they also preyed on insects and even fewer knew that the bait they often used to catch fish were dragonfly larvae.

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Appendix 1

Checklist to Adult Damselflies and Dragonflies (Odonata) Found on Wind Cave National Park

ORDER ODONATA

SUBORDER ZYGOPTERA – Damselflies

FAMILY CALOPTERYGIDAE – The Broad-winged Damsels

Genus Calopteryx Leach

Calopteryx maculata (Beauvois, 1805) Ebony Jewelwing

FAMILY LESTIDAE – The Spreadwing Damsels

Genus Archilestes Selys

Archilestes grandis (Rambur, 1842) Great Spreadwing

Genus Lestes Leach

Lestes disjunctus Selys, 1862

Lestes dryas Kirby, 1890

Lestes unguiculatus Hagen, 1861

Common Spreadwing
Emerald Spreadwing
Lyre-tipped Spreadwing

FAMILY COENAGRIONIDAE – The Pond Damsels

Genus Amphiagrion Selys

Amphiagrion sp. Red Damsels

Genus Argia Rambur – The Dancers

Argia alberta Kennedy, 1918

Argia plana Calvert, 1902

Argia vivida Hagen in Selys, 1865

Paiute Dancer
Springwater Dancer
Vivid Dancer

Genus Enallagma Selys – The Bluets

Enallagma anna Williamson, 1900

Enallagma civile (Hagen, 1861)

Enallagma cyathigerum (Charpentier, 1840)

Enallagma praevarum (Hagen, 1861)

River Bluet
Familiar Bluet
Northern Bluet
Arroyo Bluet

Genus Ischnura Charpentier – The Forktails

Ischnura cervula Selys, 1876

Ischnura damula Calvert, 1902

Ischnura perparva Selys, 1876

Ischnura verticalis (Say, 1839)

Pacific Forktail
Plains Forktail
Western Forktail
Eastern Forktail

SUBORDER ANISOPTERA Selys – Dragonflies

FAMILY AESHNIDAE Selys – The Darners

Genus *Aeshna* Fabricius

<i>Aeshna californica</i> Calvert, 1895	California Darner
<i>Aeshna multicolor</i> Hagen, 1861	Blue-eyed Darner
<i>Aeshna palmata</i> Hagen, 1856	Paddle-tailed Darner
<i>Aeshna umbrosa</i> Walker, 1908	Shadow Darner

FAMILY GOMPHIDAE Rambur – The Clubtails

Genus *Arigomphus* Needham

<i>Arigomphus cornutus</i> (Tough, 1900)	Horned Clubtail
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Genus *Ophiogomphus* Selys

<i>Ophiogomphus severus severus</i> Hagen, 1874	Pale Snaketail
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FAMILY LIBELLULIDAE Selys – The Skimmers

Genus *Leucorrhinia* Brittinger

<i>Leucorrhinia intacta</i> (Hagen, 1861)	Dot-tailed Whiteface
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Genus *Libellula* Linnaeus

<i>Libellula forensis</i> Hagen, 1861	Eight-spotted Skimmer
<i>Libellula luctuosa</i> Burmeister, 1839	Widow Skimmer (possible observation)
<i>Libellula lydia</i> Drury, 1773	Common Whitetail
<i>Libellula pulchella</i> Drury, 1773	Twelve-spotted Skimmer

Genus *Sympetrum* Newman

<i>Sympetrum corruptum</i> (Hagen, 1861)	Variegated Meadowhawk
<i>Sympetrum costiferum</i> (Hagen, 1861)	Saffron-winged Meadowhawk
<i>Sympetrum danae</i> (Sulzer, 1776)	Black Meadowhawk
<i>Sympetrum obtrusum</i> (Hagen, 1867)	White-faced Meadowhawk
<i>Sympetrum occidentale fasciatum</i> Walker, 1915	Western Meadowhawk
<i>Sympetrum pallipes</i> (Hagen, 1874)	Striped Meadowhawk
<i>Sympetrum rubicundulum</i> (Say, 1839)	Ruby Meadowhawk

Genus *Tamea* Hagen

<i>Tamea lacerata</i> Hagen, 1861	Black Saddlebags (possible observation)
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Appendix 2

Information on the Life History of the Damselflies and Dragonflies (Odonata) Found on Wind Cave National Park

Information given in this section was obtained by personal observation and through a number of references. These references were consulted frequently for information found in this section and for making the key. To conserve space and make the information more readable, the references will be cited here instead of throughout this section. The references are as follows: Beckemeyer and Huggins, 1997 and 1998; Dunkle, 1989 and 1990; Legler, et. al., 1998; Needham and Westfall, 1954; Paulson, 1998, 1999a, and 1999b; Paulson, and Dunkle, 1996; Walker, 1953 and 1958; Walker and Corbet, 1975; and Westfall and May, 1996.

Scientific Name, Author, Date species was described – Common Name:

commonality, flight period, observed habitat preference, any helpful or distinctive behavioral information, and actual sites collected on Wind Cave National Park (WICA)

- The scientific name consists of the Genus and the species name.
- The author is the person who described the species.
- The date is the date that the species was first described. If the author and date are cited in parenthesis, it means that the species was first described and placed in a different grouping but have since been reclassified and moved into a different group.
- The common name listed is used by most non-scientists to refer to a species and is often descriptive of that species.
- Commonality is determined by observing the number of individuals found in the appropriate habitat for breeding and not just feeding throughout the Park.
- The flight period of a species is the time between the first and last dates that the species is normally observed as adults. It is determined by a combination of information: dates that specimens were collected on Wind Cave National Park, dates that others have collected specimens in South Dakota, and comparisons with flight periods listed for the same species in other parts of the country.
- The preferred habitat is the location and habitat type(s) in which each species is normally observed. Since Odonates have to return to aquatic habitats in order to lay their eggs, more is known of their preference for breeding habitats than is known of their preference for feeding habitats. Generally, odonates emerge from the larval stage and leave the area to search for food. This is the stage when dragonflies are observed miles away from any known aquatic habitats. Some species of dragonflies have been known to migrate great distances in search of new breeding grounds while damselflies are far more sedentary.
- Any behavioral information that may help to distinguish one species from another is given so that some species can be determined without the need for collecting.

- There are many places near aquatic habitats where odonates were collected or observed but the actual sites on which the study was based are abbreviated as follows:

Beaver Creek/Cold Spring Creek sites	BC for Beaver Creek CS for Cold Spring Creek
Boland Ridge Spring	BRS
Blacktail Spring	BS
Cold Brook Canyon/Limestone Spring sites	CB1 for 1 st , northern, pond CB2 for 2 nd , middle, pond CB3 for 3 rd , southern, pond LS for Limestone Spring
Parker Spring	PS
Route 5 Embankment Pond	R5
Reeves Gulch	RG
Red Valley West Spring	RVW
Sanctuary Trail Ponds	ST

ZYGOPTERA, FAMILY CALOPTERYGIDAE – The Broad-winged Damselflies

Calopteryx maculata (Beauvois) – **Ebony Jewelwing**: was uncommon; observed May to August; shaded streams or in the shade of tall emergent vegetation; BC and RG

ZYGOPTERA, FAMILY LESTIDAE – The Spreadwing Damselflies

Archilestes grandis (Rambur) – **Great Spreadwing**: very uncommon; observed July to Oct.; temporary pools and slow streams; oviposits in woody plants overhanging the water; CB1

Lestes disjunctus Selys – **Common Spreadwing**: uncommon; June to September; ponds with emergent vegetation; CB1, CB3

Lestes dryas Kirby – **Emerald Spreadwing**: common; June to September; semi-permanent and temporary water with emergent vegetation; CB1, CB3, and ST

Lestes unguiculatus Hagen – **Lyre-tipped Spreadwing**: very common; June to September; semi-permanent and temporary water with emergent vegetation; BC, BRS, CB1, CB2, CB3, and ST

ZYGOPTERA, FAMILY COENAGRIONIDAE – The Pond Damsels

Amphiagrion sp. Selys – **Red Damsel**: common; May to August; spring seeps and marshes in shelter of grasses and sedges; BC, CS, BRS, BS, PS, R5, RVW, and ST

* Some Odonatologists consider this genus as a single species with a gradual geographic variation from east to west across the US while others consider them as 3 species or even 3 subspecies. As their status is unclear and specimens from the central US are hard to assign to either *A. abbreviatum* or *A. saucium*, they are often designated as *Amphiagrion* sp.

Argia alberta Kennedy, 1918 – **Paiute Dancer**: uncommon; July to August; spring runs, seeps, small spring-fed streams; BRS, CB3, R5, and ST

Argia plana Calvert, 1902 – **Springwater Dancer**: common; June to August; seeps, springs, and streams; BC, CS, BRS, BS, CB1, CB3, PS, R5, RVW, and ST

Argia vivida Hagen in Selys, 1865 – **Vivid Dancer**: common; June to August; seeps, springs, and streams; BC, CS, BRS, BS, CB3, R5, and ST

Enallagma anna Williamson, 1900 – **River Bluet**: common; June to August; ponds, springs, and slow streams; CS, BRS, BS, CB3, PS, R5, RG, and ST

Enallagma civile (Hagen, 1861) – **Familiar Bluet**: very common; May to September; ponds, seeps, springs, and slow streams; tolerates low oxygen levels and organic pollution; BC, CS, BRS, BS, CB1, CB2, CB3, LS, PS, R5, RG, RVW, and ST

Enallagma cyathigerum (Charpentier, 1840) – **Northern Bluet**: common; May to September; ponds, springs, and slow streams; CS, BS, CB3, R5, and ST

Enallagma praevarum (Hagen, 1861) – **Arroyo Bluet**: common; June to September; seeps, springs, and streams; CS, BS, CB3, R5, and ST

Ischnura cervula Selys, 1876 – **Pacific Forktail**: very uncommon; June to August; ponds and springs with ample vegetation; R5 and ST

Ischnura damula Calvert, 1902 – **Plains Forktail**: uncommon; May to August; ponds and springs with ample vegetation; CS and R5

Ischnura perparva Selys, 1876 – **Western Forktail**: rare; April to August; ponds, spring creeks; CS and R5

Ischnura verticalis (Say, 1839) – **Eastern Forktail**: very common; April to September; nearly all still or slow waters; BC, CS, BRS, BS, CB1, CB2, CB3, LS, PS, R5, RG, RVW, and ST

ANISOPTERA, FAMILY AESHNIDAE Selys – The Darners

Aeshna californica Calvert – **California Darner**: very uncommon; June to mid-August; ponds; BRS

Aeshna canadensis Walker – **Canada Darner**: not caught on Wind Cave National Park, but has been observed in the Black Hills; June to September; ponds and slow streams with weedy, marshy borders

Aeshna constricta Say – **Lance-tipped Darner**: not caught on Wind Cave National Park, but has been observed in the Black Hills; July to September; ponds, small lakes, marshes, slow streams, and open areas; often flies at dusk or late evening while a breeding pair flies erratically (very hard to catch) then lands on vegetation to mate

Aeshna interrupta Walker – **Variable Darner**: not caught on Wind Cave National Park, but has been observed in the Black Hills; June to September; ponds, bogs, and slow streams

Aeshna multicolor Hagen – **Blue-eyed Darner**: common; May to mid-August; streams and open areas; often seen patrolling open fields; BC, CB3, R5, PS, and ST

Aeshna palmata Hagen – **Paddle-tailed Darner**: very common; June to September; sunny to partly shaded ponds and streams; BC, CS, BRS, BS, CB2, CB3, LS, PS, R5, RG, RVW, and ST

Aeshna umbrosa Walker – **Shadow Darner**: common; July to September; prefers shaded places near small ponds, streams, and ditches and often active in late afternoon and evening; CS, CB1, CB2, LS, R5, and RG

ANISOPTERA, FAMILY GOMPHIDAE – The Clubtails

Arigomphus cornutus (Tough) – **Horned Clubtail**: very rare; June to July; slow streams and muddy ponds; one specimen found at CB3

***Ophiogomphus severus severus* Hagen – Pale Snaketail:** uncommon; July to August; rivers; larvae are good indicators of fairly undisturbed habitats as they prefer habitats without siltation and pollution; BC

ANISOPTERA, FAMILY LIBELLULIDAE – The Skimmers

***Leucorrhinia intacta* (Hagen) – Dot-tailed Whiteface:** very rare; June to August; spring-fed ponds; R5

***Libellula forensis* Hagen – Eight-spotted Skimmer:** rare; June to September; ponds; one pair found at LS

***Libellula luctuosa* Burmeister – Widow Skimmer:** two specimens may have been observed in June and July; June to September; found in most habitats; maybe observed at CB3 and R5

***Libellula lydia* Drury – Common Whitetail:** very common; May to October; found in most habitats; BC, CS, BRS, BS, CB1, CB2, CB3, LS, PS, R5, RVW, and ST

***Libellula pulchella* Drury – Twelve-spotted Skimmer:** very common; May to September; found in most habitats; BC, CS, BRS, BS, CB1, CB2, CB3, LS, PS, R5, RVW, and ST

***Sympetrum corruptum* (Hagen) – Variegated Meadowhawk:** common; April to June; ponds; very nervous flyers and often hard to approach them as they appear to watch you from different angles; BS, BRS, CB3, R5, and ST

***Sympetrum costiferum* (Hagen) – Saffron-winged Meadowhawk:** uncommon; July to September; weedy ponds and marshes; CB3, R5, and ST

***Sympetrum danae* (Sulzer) – Black Meadowhawk:** rare; June to August; only four male specimens found at a temporary creek running into the western side of the Sanctuary Trail Ponds after rains

***Sympetrum internum* Montgomery – Cherry-faced Meadowhawk:** not caught on Wind Cave National Park, but has been reported in the Black Hills; July to September; weedy ponds

***Sympetrum obtrusum* (Hagen) – White-faced Meadowhawk:** uncommon; August to October; ponds; CB3, R5 and ST

***Sympetrum occidentale fasciatum* Walker – Western Meadowhawk:** very common; June to October; weedy ponds; BC, BRS, BS, CB1, CB3, PS, R5, RVW, and ST

* Two subspecies are recognized: *S. o. occidentale* and *S. o. fasciatum*. The second subspecies generally has more vivid wing markings and is the one found across the plains.

***Sympetrum pallipes* (Hagen) – Striped Meadowhawk:** very common; June to October; weedy ponds; BC, BRS, BS, CB3, PS, R5, and ST

* A noticeable geographic variation has been observed in this species. The abdomens of individuals from wetter, cooler regions appear to be more heavily marked with black than individuals from dryer, warmer regions.

***Sympetrum rubicundulum* (Say) – Ruby Meadowhawk:** uncommon; July to September; ponds; BS, R5, and ST

***Tramea lacerata* Hagen – Black Saddlebags:** two specimens may have been observed in June and July; lentic waters; maybe observed at CB3 and R5

Appendix 3

Key To Adult Odonata (Damselflies and Dragonflies) Found On Wind Cave National Park

This key is for the species collected and observed on Wind Cave National Park during the summer of 1998 although it also includes a few species that were not collected but have been found in nearby areas. An attempt was made to use (mostly) easily visible characteristics so that specimens can be accurately identified to species without the need for catching them. Unfortunately, some pairs of species are hard to differentiate unless you have a specimen on hand to closely examine the differences in the terminal abdominal appendages. The difference can only be seen with adequate magnification such as using a dissecting scope. Often the only way to identify a female is to catch her in tandem with a male. Geographic variation in wide-ranging species, changing color patterns as individuals mature or the temperature changes, physical similarities in related species, and hybridization among related species may all hamper field identification. Therefore, an attempt was made to include more than one character at each step in the field key without adding too many characters to quickly examine.

PART 1: KEY TO THE SUBORDERS OF THE ORDER ODONATA

1. a) Slender-bodied and mostly small; eyes farther apart than their own diameter; wings held together over abdomen when perched (open slightly in one family); front and hind wings similar in shape; usually weak flyers; oviposit in plant tissue Suborder Zygoptera (Damselflies); PART 2
- b) Heavy-bodied and mostly large; eyes closer together than their own diameter (touching in most species); wings held wide open, flat, when perched; hind wings much broader near base than fore wings; usually strong fliers; usually oviposit into water (one family oviposits into plant tissue) ... Suborder Anisoptera (Dragonflies); PART 6

PART 2: KEY TO FAMILIES OF ZYGOPTERA (Damselflies)

1. a) Wings not petiolate (not stalked at base) and partially or wholly black; numerous (10 or more) antenodal cross veins; do not oviposit in tandem Calopterygidae; PART 3
- b) Wings petiolate (stalked at base) and clear except for pterostigma; two antenodal cross veins; oviposit in tandem or alone 2
2. a) Pterostigma equal to diameter of eye; often perches with wings held partially open and abdomen usually held vertically or at an oblique angle; vein M_3 separates from M_{1+2} nearer the arculus than the nodus; usually oviposit in tandem Lestidae; PART 4
- b) Pterostigma not as long as eye; usually perches horizontally with wings closed over abdomen (partially open in some); vein M_3 separates from M_{1+2} nearer the nodus; oviposit in tandem or alone Coenagrionidae; PART 5

PART 3: FAMILY CALOPTERYGIDAE (Broad-winged Damselfs): Genus Calopteryx

This part works for both males and females.

1. a) Wings entirely black (females have a white pterostigma) *Calopteryx maculata* (Ebony Jewelwing)
- b) Outer tip of wings black (females have a white pterostigma) *Calopteryx aequabilis* (River Jewelwing)

PART 4: FAMILY LESTIDAE (Spreadwing Damselfs): Genera Archilestes and Lestes

This part works for both males and females.

1. a) Large (>45mm); diagonal yellow to white stripe on side of thorax; vein M₂ branches from M₁ one cell distal to the nodus *Archilestes grandis* (Great Spreadwing)
- b) Smaller (<45mm); no diagonal stripe on side of thorax; vein M₂ branches from M₁ more than two cells distal to the nodus 2
2. a) Top of thorax metallic green and without longitudinal stripes *Lestes dryas* Kirby (Emerald Spreadwing)
- b) Top of thorax bronzy to black, if green with a pale longitudinal stripe on either side 3
3. a) Rear of head partly pale; pterostigma light to medium brown with pale ends; male inferior caudal appendages (paraprocts) sigmoid in shape, with tips curved outward *Lestes unguiculatus* (Lyre-tipped Spreadwing)
- b) Rear of head entirely dark; pterostigma usually uniformly dark; male inferior caudal appendages (paraprocts) entirely straight *Lestes disjunctus* (Common Spreadwing)

PART 5: FAMILY COENAGRIONIDAE (Pond Damselfly): Genera *Amphiagrion*, *Argia*, *Enallagma*, and *Ischnura*

Males are identified here since they are much easier to reliably identify in the field than females. In some cases the only reliable way to identify male specimens is to examine the differences in the terminal abdominal appendages. Often the only way to identify a female is to catch her in tandem with a male damselfly.

1. a) Mostly bright red with thorax and abdominal segments 8-10 black in males and thorax and abdomen reddish-orange fading to brown with no black pattern in females *Amphiagrion* sp. (Red Damselfly)
- b) Thorax and abdomen not red or reddish, if reddish then thorax has at least a middorsal black stripe 2
2. a) Top of abdomen black with blue tip (segments 8 and 9) Genus *Ischnura*, 3
- b) Abdomen and thorax mostly blue with black markings 6
3. a) Top of thorax black with 4 isolated pale dots 4
- b) Top of thorax black with 2 pale stripes (rarely divided to look like an exclamation mark) 5
4. a) Inferior caudal appendages (paraprocts) with broad tips and shallowly forked when viewed from above or below; top of last abdominal segment protrudes again as high as the segment *Ischnura cervula* (Pacific Forktail)
- b) Paraprocts with tips slender and not forked when viewed from above or below; top of last abdominal segment protrudes only 1/3 again as high as the segment *Ischnura damula* (Plains Forktail)
5. a) Tip of paraprocts deeply divided into 2 forks *Ischnura perparva* (Western Forktail)
- b) Tip of paraprocts deeply divided into 2 forks *Ischnura verticalis* (Eastern Forktail)
6. a) Tibial spurs twice as long as the intervening spaces, at least proximally Genus *Argia*, 7
- b) Tibial spurs at most barely longer than the intervening spaces Genus *Enallagma*, 9
7. a) Abdominal segments 3-6 mostly black when viewed from above with only a blue basal band or a fine blue line per segment *Argia alberta* (Paiute Dancer)
- b) Abdominal segments 3-6 mostly blue when viewed from above, generally with a black band at the end of each segment which may become wider in the more caudal segments, and with a tear-shaped black spot on each side of the front of half of 2 or more of these segments 8
8. a) Tear-shaped spot usually absent on abdominal segment 3; cerci with the downward projection short and toothlike and abruptly narrowed immediately beyond the downward angulation *Argia plana* (Springwater Dancer)
- b) Tear-shaped spot usually present on abdominal segment 3; cerci with the downward projection long and tapered gradually to a point *Argia vivida* (Vivid Dancer)
9. a) Paraprocts longer than the cerci above them *Enallagma cyathigerum* (Northern Bluet)
- b) Paraprocts shorter than or close to the length of the cerci above them 10

10. a) Cerci not broadly and deeply notched *Enallagma civile* (Familiar Bluet) 11
- b) Cerci broadly and deeply notched
11. a) Ventral arm of cerci has a wide tubercle (seen from above and to the side) *Enallagma anna* (River Bluet)
- b) Ventral arm of cerci lacks wide tubercle *Enallagma praevarum* (Arroyo Bluet)

PART 6: KEY TO FAMILIES OF ANISOPTERA (Dragonflies)

1. a) Eyes completely separated 2
- b) Eyes just touching or in contact more broadly 3
2. a) Thorax black with numerous yellow spots; usually perches vertically on tree trunks; oviposits in wet leaves or mud in spring seeps *Petaluridae* (possibly one species)
- b) Thorax colored otherwise; usually perches horizontally on the ground or vegetation; do not swarm or oviposit in tandem *Gomphidae*; PART 7
3. a) Large; abdomen brown or black spotted with blue and yellow; wings clear; oviposit into plant tissue; constant fliers but will perch by hanging vertically from vegetation; triangles in fore and hind wings the same distance from arculus; 2 thickened antenodal cross veins *Aeshnidae*; PART 8
- b) Generally smaller; abdomen not colored as above; often have patterned wings; females oviposit into water either alone or in tandem; perchers that frequently alight on twigs and vegetation; triangle in hind wing closer to arculus than triangle in fore wing; no thickened antenodal cross veins *Libellulidae*; PART 9

PART 7: FAMILY GOMPHIDAE (Clubtails): Genera *Arigomphus* and *Ophiogomphus*

This part works for both males and females.

1. a) End of abdomen not enlarged into a club; male claspers are wide-forked; abdomen mostly dark with pale dorsal and ventral spots on most segments *Arigomphus cornutus* (Horned Clubtail)
- b) End of abdomen enlarged into a club; male claspers not wide-forked; abdomen mostly pale brown with some small dark spots *Ophiogomphus severus severus* (Pale Snaketail)

PART 8: FAMILY AESHNIDAE (darners): Genera *Anax* and *Aeshna*

Males are identified first since they are much easier to reliably identify in the field than females. In some cases the only reliable way to identify male specimens is to examine the differences in the terminal abdominal appendages. Often the only way to identify a female is to catch her in tandem with a male dragonfly, but a separate key for females is often used and has been included here.

1. a) Thorax entirely green *Anax junius* (Common Green Darner) 2
- b) Thorax dark with pale stripes on sides
2. a) The superior appendages of the terminal abdominal appendages are forked at the tip in a side view; eyes, face, and thoracic stripes are bright blue *Aeshna multicolor* (Blue-eyed Darner)
- b) The superior appendages of the terminal abdominal appendages are simple of paddle-shaped; eyes, face, and thoracic stripes are not all bright blue 3
3. a) The superior appendages of the terminal abdominal appendages are paddle-shaped 4
- b) The superior appendages of the terminal abdominal appendages are simple 6
4. a) A black stripe across the fronto-clypeal suture of the face; lateral thoracic stripes parallel-sided, i.e. have no rear-ward projection at the upper end *Aeshna palmata* (Paddle-tailed Darner)
- b) No black stripe across the fronto-clypeal suture of the face; anterior lateral thoracic stripes have a rear-ward

- projection, or hook, at the upper end..... 5
5. a) Abdominal spots small, 15-20% length of each segment; no spots on 10th segment; paired blue spots on underside of abdomen; stripes fairly straight but with a hook at upper end..... *Aeshna umbrosa* (Shadow Darner)
 - b) Abdominal spots larger, 25-33% length of each segment; has spots on 10th segment; no blue spots on underside of abdomen; anterior lateral stripes indented in middle *Aeshna constricta* (Lance-tipped Darner)
* [the first 2 characteristics also work for *Aeshna palmata*]
 6. a) Stripes on front of thorax reduced to fine streaks at midheight; lateral stripes of thorax narrow and straight or reduced to pairs of dots *Aeshna interrupta* (Variable Darner)
 - b) Stripes on front of thorax broader, extending to upper edges, or represented there by isolated dots; later stripes well developed..... 7
 7. a) Small for family ($\leq 65\text{mm}$); a black stripe across the fronto-clypeal suture of the face; anterior lateral thoracic stripe straight *Aeshna californica* (California Darner)
 - b) Normal sized for family ($> 65\text{mm}$); no black stripe across the fronto-clypeal suture of the face; at least one of the lateral stripes indented in middle and often with a hook at upper end *Aeshna canadensis* (Canada Darner)

Females: This may or may not help if you catch one not in tandem with a male.

1. a) Thorax entirely green *Anax junius* (Common Green Darner)
- b) Thorax dark with pale stripes on sides 2
2. a) Small but obvious tubercle (bump) under first abdominal segment 3
- b) No tubercle (bump) under first abdominal segment 4
3. a) Small for family ($\leq 65\text{mm}$); a black stripe across the fronto-clypeal suture *Aeshna californica* (California Darner)
- b) Normal sized for family ($> 65\text{mm}$); no black stripe across the fronto-clypeal suture *Aeshna multicolor* (Blue-eyed Darner)
4. a) Styli (hairlike projections) of ovipositor as long as the 10th abdominal segment; terminal appendages wide ($\geq 2\text{mm}$) *Aeshna constricta* (Lance-tipped Darner)
* [like males, the anterior lateral thoracic stripe indented in middle and usually has a rearward projection (or hook) at the upper end]
- b) Styli shorter than 10th abdominal segment; terminal appendages narrow (1.5mm) and may be missing 5
5. a) Underside of most abdominal segments with light basal spot on each side (paired blue spots)..... 6
- b) Underside of abdomen entirely dark 7
6. a) Lateral thoracic stripes both straight; abdominal spots small, 15-20% length of each segment; no spots on 10th segment *Aeshna umbrosa* (Shadow Darner)
- b) Anterior lateral thoracic stripe indented in middle and usually has a rearward projection (or hook) at the upper end; abdominal spots much larger; has spots on 10th segment *Aeshna canadensis* (Canada Darner)
7. a) Thoracic stripes relatively broad, anterior lateral thoracic stripe indented in middle and usually has a rearward projection (or hook) at the upper end *Aeshna canadensis* (Canada Darner)
- b) Thoracic stripes relatively narrow and straight with no hook at the upper end, may be slightly sinuous, or each represented by a pair of spots 8
8. a) Valves of ovipositor in side view very slightly sinuous (broadest at middle), then slightly narrowed, then slightly expanded at tip *Aeshna palmata* (Paddle-tailed Darner)
- b) Valves of ovipositor straight in side view *Aeshna interrupta* (Variable Darner)
* (difference seen only with adequate magnification)

PART 9: FAMILY LIBELLULIDAE (Skimmers): Genera *Leucorrhinia*, *Libellula*, *Sympetrum*, and *Tramea*

This part works for both males and females. An M is used to designate male specimens and F is used for female specimens.

1. a) At least one pair of wings conspicuously patterned with black or brown spots that cover $\frac{1}{4}$ or more of the wing and sometimes having white spots added..... 2
- b) Wings with yellow to orange patterns in the basal area or mostly clear but with dark basal spots covering less than $\frac{1}{4}$ of the wing area 9
2. a) Wings with a large patch of dark color at the base only, covering $\frac{1}{4}$ to nearly all of basal half of wing: 2 of these individuals were observed but not caught and could be one of two species..... 3
- b) Wings patterned more extensively, with color beyond midlength of wing as well 4
3. a) Both sets of wings have extensive basal spots *Libellula luctuosa* (M; Widow Skimmer)
- b) Only the hind wings have extensive basal spots..... *Tramea lacerata* (M & F; Black Saddlebags)
4. a) Wings with dark patch covering most of basal half and dark spots at the wingtips *Libellula luctuosa* (F; Widow Skimmer)
- b) Wings marked otherwise 5
5. a) Wings with a broad black band beyond midlength, extending more than $\frac{1}{3}$ length of wing and with small oblong basal spots *Libellula lydia* (M; Common Whitetail)
- b) Wings with a spot of narrow band at midlength, extending no more than $\frac{1}{4}$ length of wing 6
6. a) Two black spots on each wing, one at the base and the other at midlength; two white spots on each wing, one between the black spots and the other at the wingtips..... *Libellula forensis* (M & F; Eight-spotted Skimmer)
- b) Three black spots on each wing located at the base, tip, and midlength 7
7. a) Two white spots on each wing, one between each black wing spot..... *Libellula pulchella* (M; Twelve-spotted Skimmer)
- b) No white spots on each wing..... 8
8. a) Abdomen dark and having yellow, rectangular spots along sides *Libellula pulchella* (F; Twelve-spotted Skimmer)
- b) Abdomen dark and having whitish, jagged spots along sides *Libellula lydia* (F; Common Whitetail)
9. a) Thorax and abdomen mostly black or dark brown; wings clear but may have small dark basal spots..... 10
- b) Thorax and abdomen yellow to orange or orange to red; wings anywhere from mostly clear with small yellow to orange basal spots through large yellow to orange spots covering nearly all of basal half of wing 11
10. a) Face entirely or partially dark; abdomen all black in mature specimens although immature specimens may have paired yellow spots on the dorsal view..... *Sympetrum danae* (M; Black Meadowhawk)
- b) Face conspicuously white or at least entirely pale; abdomen with yellow dot on dorsum of 7th segment, immatures may have single yellow spots on the dorsal view of abdominal segments 2-7 *Leucorrhinia intacta* (M & F; Dot-tailed Whiteface)
11. a) Conspicuous yellow to orange wing patch covering nearly all of basal half of wing and usually having a darker line on the distal edge of the wing pattern..... *Sympetrum occidentale fasciatum* (M & F; Western Meadowhawk)
- b) Wings with considerably less conspicuous markings even if they may cover nearly all of basal half of wing..... 12
12. a) Front edge of wings with golden to red veins or membrane in sharp contrast with the rest of the wing..... 13
- b) Front edge of wing the same color as the remainder of wing or at least not in vivid contrast..... 14
13. a) Sides of thorax usually plain; abdomen red to orange in males, yellow to orange in females, may have some black marks on lower part of abdomen; face pale in males..... *Sympetrum costiferum* (M & F; Saffron-winged Meadowhawk)

- b) Sides of thorax with two pale yellow spots (may be almost obscured by red pigment in mature males); abdomen mottled in red and olive/brown/gray in males and mottled orange to yellow, white, and black in females; face red in males *Sympetrum corruptum* (M & F; Variegated Meadowhawk)
- 14. a) Sides of thorax with well-defined pale stripes on each side ... *Sympetrum pallipes* (M & F; Striped Meadowhawk)
- b) Sides of thorax plain or with a complex pattern of black and yellow..... 15
- 15. a) Sides of thorax with a complex pattern of black and yellow..... *Sympetrum danae* (F; Black Meadowhawk)
- b) Sides of thorax plain..... 16
- 16. a) Wing veins dark; face whitish *Sympetrum obtrusum* (M & F; White-faced Meadowhawk)
- b) Wing veins reddish to yellowish; face reddish or yellowish 17
- 17. a) Face reddish..... *Sympetrum internum* (M & F; Cherry-faced Meadowhawk)
- b) Face yellowish..... *Sympetrum rubicundulum* (M & F; Ruby Meadowhawk)

Appendix 4

Checklist to Adult Damselflies and Dragonflies (Odonata) Found at Each of the Survey Locations

Beaver Creek
Cold Spring Creek
Boland Ridge Spring
Blacktail Spring
Cold Brook Canyon, the 1st, northern, pond
Cold Brook Canyon, the 2nd, middle, pond
Cold Brook Canyon, the 3rd, southern, pond
Limestone Spring
Parker Spring
Route 5 Embankment Pond
Reeves Gulch
Red Valley Spring
Sanctuary Trail stock ponds