

INVENTORY OF AQUATIC INVERTEBRATES

Chaco Culture National Historical Park

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INTRODUCTION

Chaco Culture National Historical Park (CCNHP), formerly known as Chaco Canyon National Monument, was established in 1907 to preserve significant archaeological features found in Chaco Canyon. The park now encompasses one of only two protected areas in the San Juan Basin and thus represents an “island” of protected biodiversity within a region that is otherwise impacted by grazing, mineral extraction, and development.

The headwaters of Chaco Canyon flow from broad plains and rolling hills along the continental divide to the east of the canyon. Surface drainage becomes largely confined in Chaco Wash at the entrance to the canyon near Pueblo Pintado, approximately 13 km upstream from the park boundary. Downstream from the canyon entrance, only local drainage from the canyon walls and mesas enters the wash until it reaches the park boundary, where flows from the relatively large tributary watershed of Fajada Wash and the small tributary watersheds of Sheep Camp Canyon, Gallo Canyon, Mockingbird Canyon, South Gap, and Clys Canyon enter the watershed. At the downstream end of Chaco Canyon within the park, the wash merges with Escavada Wash to form the Chaco “River,” a wide, flat, ephemeral stream with braided channels typical of other drainages within the central San Juan Basin.

The park receives an average annual precipitation of 230 mm. Other than a few small

seeps, sandstone catchments, and small tributary drainages within the side canyons, surface water is limited to ephemeral stream flows in Chaco Wash, the primary drainage feature within Chaco Canyon. A 20 km segment of Chaco Wash flows through the park. Its flows are derived from summer thunderstorms and winter snowmelt within a 2,175 km² watershed (Simons, Li & Associates 1982). Currently the wash is incised into a steep-walled arroyo, with average depth 8.1 m and width 45 to 90 m. There is a well-developed floodplain and a small inner (or “low-flow”) channel on the canyon floor. The low-flow channel typically has flowing or standing water for three to six months of the year. Flows within the wash are somewhat moderated and influenced by a series of check dams and stock tank impoundments in the upper canyon reaches and headwaters of the watershed. Limited records of water wells in park archive files indicate an estimated water table depth of 1.5 to 4.5 m beneath the low-flow channel of Chaco Wash (Paul Whitefield, CCNHP Resource Management, pers. comm.).

A recent analysis of water quality data retrieved from the EPA STORET Database characterized the park watershed as high in suspended and dissolved solids. Surface water samples have relatively high iron concentrations, and more than 10% of the samples exceeded EPA screening parameters for sulfate, arsenic, barium, beryllium, cadmium, chromium, copper, lead, mercury, selenium, and zinc (NPS Water Resources Division 1997, records on file at CCNHP). The absence of large communities and industrial discharges within the watershed implies that poor water quality results from natural processes.

There are few studies of riparian and wetland invertebrates in northwestern New Mexico and no baseline invertebrate data for the park. The purposes of the present study were to inventory and document macroinvertebrate taxa in selected riparian and aquatic habitats within the park and to assess the importance of existing surface waters to the conservation of macroinvertebrate communities. This report is intended to assist park resource managers in mitigation of future impacts to critical surface water resources, in planning riparian restoration projects, and in conservation of biotic resources.

HABITATS AND COLLECTION SITES

During a preliminary visit to the park in February 1999, we identified three potential riparian and aquatic habitat types for invertebrate surveys: (1) arroyo riparian, (2) seeps on upper canyon walls, and (3) temporary pools on mesa tops. A fourth habitat and collection site, emergent wetland (located on state land outside the park), was brought to our attention in September 2000 (Brad Shattuck, CCNHP Resource Management, pers. comm.).

The following collection sites were selected for potential field assessment in the survey (indicated below by • ; locations are shown in Figure 1):

(1) Reaches of Chaco Wash and tributaries (arroyo riparian):

- Chaco Wash south of the Wijiji ruins (Wijiji):

This site is a former oxbow of Chaco Wash now cut off from the main channel. The margin of the present-day pond consists of a thicket of willows (*Salix* spp.) How often this site has held permanent water is not known, but the potential habitat has existed for at least 70 years. It is shown on a 1929 aerial photo (Wells et al. 1983: 240) in its present configuration, with no willows evident.

- Gallo Wash adjacent to the Visitor Center (Gallo):

In this section of Gallo Wash, for approximately 100 m upstream from the bridge and culvert, shallow pools within the channel retain runoff and surface flows. This site appears to be a semi-permanent aquatic habitat, apparently holding water long past the cessation of stream flows in both spring and late summer-early fall (Paul Whitefield, CCNHP Resource Management, pers. comm.)

- Chaco Wash “overbank” channel below Kin Kletso (Kin Kletso):

This site is a former channel of Chaco Wash, now isolated from the main channel. It would probably be more accurately described as an ephemeral side channel, being dry during low-flow intervals. The main channel is lower than the side channel. At peak flows, water fills the side channel during overbank flooding.

We selected the previous sites because of their potential permanence and predictability for aquatic sampling. We did not sample the confluence of Chaco Wash and Escavada Wash (“West Canyon”) because of accessibility and time constraints. Arroyo sites subject to flash flooding (Chaco Wash west of Shabikeschee, Fajada Wash upstream

from its confluence with Chaco Wash, and Clys Canyon drainage at its confluence with Chaco Wash) were not monitored during our field visits.

(2) Seeps located in smaller side canyons along the mesa cliffs. These habitats are the larger “niches” described by Bryan (1928) at Chaco Canyon in the mid-1920’s. They are cave-like openings, with an arched roof, in steeply-sloping rock surfaces or cliffs.

- Clys Canyon (Upper Clys Canyon):

This site includes two seeps with permanent pools of water under overhangs. Bryan’s (1928) description of a large niche in Clys Canyon applies to those we sampled: “This niche has formed in the upper sandstone above a thin shaly lens which crops out in the floor of the cave. Above the shaly bed water seeps out at all seasons along a spring zone about 50 feet long. At places in this zone holes have been dug in which the water collects and is used for watering stock.”

We did not sample seeps in Mockingbird Canyon and in Chacra Mesa west of Wijiji and west of Shabikeschee, because their pools were dry.

(3) Temporary pools in sandstone outcrops:

- Chacra Mesa:

This site includes several small pools and depressions on the mesa surface. Many potential pools occur, but at the time of our surveys only a few retained water.

They had a maximum water depth of 6-8 cm and a diameter of 20-25 cm.

- Lower Clys Canyon:

This site was a relatively large and deep (diameter of 2 m and depth of 1 m at full capacity) runoff pool that held water during our August 1999 field period.

(4) Emergent wetland

- Aggravation Well:

Located outside the park, this site is a shallow wetland consisting of two ponds (diameter 8-10 m, water depth 40-50 cm). The water source is a well that supplies a stock tank. This wetland is an artificial habitat, but it is a permanent source for colonization by aquatic invertebrates. A well-developed stand of *Juncus* (rushes) and *Scirpus* (bulrush) occurs in the wetland.

METHODS

We employed the following collection methods: (1) We used an aquatic D-net (with 0.15 mm mesh bottom) to collect bottom-dwelling (benthic) organisms. A collection or sample consisted of three parallel “pulls” of 1-m length from the interior to the margin of the pool or channel. Each sweep of the net was located outside the zone of disturbance created by the previous one. (2) We used aquatic light traps (BioQuip Products) to attract and capture invertebrates inhabiting the water surface (pleuston) and water column (nekton). We placed a trap at each collection site in late afternoon. After 18 h, we emptied trap contents into a bucket and poured them through a 0.15 mm net. (3) Small dip nets were necessary for the collection of water striders (Gerridae), as the previous two

methods failed to capture these elusive pleustonic insects. Small dip nets were also useful for collecting in small pools. The list of taxa for each collection site (Table 1) includes all methods employed at that site. For example, a sample at an arroyo riparian site consists of a combined D-net, aquatic trap, and dip net collection.

Dates of field visits were 22-27 August and 18-21 September 1999 and 16-19 September 2000. These dates include 3 days of preliminary reconnaissance and 8 days allocated to sampling, collecting, and travel to sites. At arroyo riparian sites (Wijiji, Gallo, Kin Kletso), we collected macroinvertebrates with D-net, aquatic traps, and dip nets in August and September 1999 (sampling effort of 3-4 hours per visit, $n=6$). At the temporary pool in lower Clys Canyon, we used D-net and aquatic-trap methods in August 1999 (sampling effort was 8 hours over 3 days, with one visit per day). The pool was dry in September 1999. Chacra Mesa sites were searched and sampled in September 1999 (sampling effort, 6 hours). The previous sites were dry in September 2000 and re-sampling was not possible. Throughout the park, other potential arroyo riparian sites were also dry. We sampled the seeps in upper Clys Canyon in September 1999 and 2000 (4 hours per site visit, $n = 2$). The Clys Canyon seeps and temporary pools on Chacra Mesa were shallow and susceptible to disturbance, precluding the use of D-net or floating traps. In addition to hand-picking specimens from the bottom substrate and underneath stones, we used dip nets to collect organisms in the water column. We collected at Aggravation Well with the D-net in September 2000 (sampling effort, 2 hours).

Field samples were preserved in 80% ethyl alcohol and transported to the laboratory for sorting. We made identifications to the lowest feasible taxonomic level using keys and descriptions of Belk (1975), Lugo-Ortiz and McCafferty (1996), Merritt and Cummins (1996), Needham et al. (2000), Pennak (1989), Thorp and Covich (1991), and Westfall and May (1996).

In September 2000, we collected soil samples in the streambed of Chaco Wash below Kin Kletso, within the “capillary fringe” zone (15-30 cm depth). These samples were sifted and searched for macroinvertebrates both in the field and subsequently in the laboratory. We found no invertebrates in these soil samples.

RESULTS

Aquatic Insects

In all habitats sampled, 21 taxa of aquatic insects were found (Table 1). Nymphs of the mayfly *Callibaetis montanus* Eaton were abundant at arroyo riparian sites and Aggravation Well. This species is one of four mayfly species in the state occurring no further north than New Mexico and Arizona and extending south through Mexico. In New Mexico, its distribution includes the Gila River drainage, San Juan River, and the southernmost area of the Rio Grande drainage system (McCafferty et al. 1997).

Callibaetis is primarily a lentic genus, with some species occurring in backwaters or quiet margins of running waters.

Larvae of the dragonfly *Sympetrum corruptum* (Hagen) were common at two arroyo riparian sites (early instar larvae, probably members of this genus, were also collected at Aggravation Well). This species has been collected in San Juan and other counties in northwestern New Mexico (Evans 1995). *Sympetrum* larvae are slender sprawlers that inhabit the bottom detritus of lentic habitats and slow streams and are often found in sand-bottomed ponds in arid areas. This late-season species sometimes overwinters as an adult (Needham et al. 2000). Two widespread damselfly genera, *Enallagma* and *Lestes*, each with several species known from northwestern New Mexico (Evans 1995), were also found in arroyo riparian sites. *Enallagma* overwinter as larvae and *Lestes* overwinter in the egg stage, hatching in response to warm spring temperatures (Westfall and May 1996).

Aquatic bugs (Hemiptera) occurred at arroyo riparian and emergent sites. Both notonectids (backswimmers) and corixids (water boatmen) are predators that inhabit the water column. Notonectids frequent quiet water, hanging just beneath the surface film; corixids forage on bottom-dwelling algae, protozoa, and metazoa, and on free-swimming mosquito larvae and other macroinvertebrates. Water striders (Gerridae) were abundant at all arroyo riparian sites and Aggravation Well. These relatively large and non-secretive predaceous bugs are conspicuous inhabitants of the water surface.

Aquatic Coleoptera included three genera of predaceous diving beetles (Dytiscidae): *Hydaticus*, *Laccophilus*, and *Rhantus*; a common and widespread genus of water scavenger beetle (Hydrophilidae): *Berosus*; and *Helophorus* (Helophoridae), a genus and family sometimes included in the Hydrophilidae. *Hydaticus* adults are large, fast-swimming, active predators, and *Laccophilus* adults are collector-gatherers. *Rhantus* larvae are predaceous, commonly occurring in shallow, vegetated ponds but also in almost every conceivable aquatic habitat (Arnett and Thomas 2001). *Rhantus* larvae were found in the broadest range of habitats of any aquatic Coleopterans at CCNHP. *Berosus* larvae are predaceous and adults are collector-gatherers. Adult *Helophorus* are aquatic shredders (Merritt and Cummins 1996), occur in shallow lentic habitats as well as small slow-flowing streams, require abundant organic debris for feeding, and are good fliers (Smetana 1985). The larvae inhabit soil and vegetation near but not in water (Arnett and Thomas 2001).

Dipterans were primarily represented by aquatic larvae of biting midges (Ceratopogonidae), true midges (Chironomidae), and mosquitoes (Culicidae). These three families are common inhabitants of a wide range of aquatic habitats. Adults of five other aquatic or semi-aquatic families were represented by incidental captures (see Table 1).

Gastropods

A few small specimens of a snail in the family Lymnaeidae were collected at one arroyo riparian site (Kin Kletso). Shells of terrestrial and aquatic snails have been collected at Chaco Canyon in two previous surveys of the molluscan fauna. Drake (1948) collected 14 species (including 4 aquatic species) in drift, around ruins, on anthills, and at seeps and springs. Hall (1980) found shells of 9 fossil species (including 2 aquatic species previously collected by Drake) in the valley fill, of which one (*Succinea* sp., a terrestrial genus) occurred on modern surfaces in topographic depressions periodically inundated by runoff. Neither investigator observed living snails. Two lymnaeid genera (*Fossaria* and *Stagnicola*) were part of the aquatic snail fauna collected by the previous authors.

Crustaceans

Three groups of relatively small crustaceans were abundant at all riparian sites and at Aggravation Well: Cladocera (water fleas), Eucopepoda (copepods), and Ostracoda (seed shrimps). We identified none of these groups to a lower taxonomic level. They are common components of southwestern arid-zone wetland habitats. Except for ostracods (a few occurring in upper Clys Canyon), none was found in temporary pools or seeps.

We collected two taxa of larger-bodied crustaceans. Clam shrimps (Conchostraca) were abundant at Gallo Wash and absent at other sites and habitats. We collected a single specimen of the fairy shrimp *Streptocephalus* (Anostraca) at Aggravation Well.

Conchostracans consume detritus from surfaces or collect plankton and are able to feed in soft sediments. Anostracans are free-swimming filter feeders.

The absence of fairy shrimps in arroyo riparian habitats and the presence of conchostracans in Gallo Wash allows some inference about the relative ephemerality of these habitats. Cladocerans, 1-2 mm long at maturity, can produce eggs within 2 days at high temperatures. They can mature in the most temporary of ponds, whereas the larger fairy shrimps (1-2 cm long) and clam shrimps (up to 15 mm) require ponds that retain water long enough to allow completion of their longer life cycle. Anostracans can mature in 3 weeks at 15° C and 45 days at 4-17° C (Dodson and Frey 1991). The presence of these faunal elements suggest that habitats at Gallo Wash and Aggravation Well are less ephemeral than other sites.

DISCUSSION

The earliest written account of Chaco Canyon (Simpson 1849) describes an intermittent channel or succession of scattered pools, with no mention of an arroyo. In 1877, W. H. Jackson (cited in Bryan 1954) described shallow pools of water 250 yards below Pueblo del Arroyo, with grasses, young willows, and cottonwoods extending half a mile up and down stream in the bed of the arroyo, which was 4 to 5 m deep. Bryan (1954) considered 1860 as the tentative date for the initiation of arroyo formation in Chaco Wash, a date that was based on Jackson's observations and the recollections of two Navajos who grew up in the area. The beginning of channel erosion in the late 1800s has been attributed to a combination of climatic changes and the switch in land use from pastoral sheep and goat herding by Navajo

inhabitants to the movement of large herds of livestock through the region by ranchers. In the 1930s, extensive erosion control projects were implemented within the park to prevent lateral erosion and loss of archeological sites on the canyon floor. These efforts included extensive planting of cottonwood, willow, and tamarisk saplings along the base of the arroyo walls.

A combination of photographs and channel measurements made from 1896 through the early 1980s document the history of the arroyo (Simons, Li & Associates 1982). From 1896 until about 1930, the arroyo was actively degrading and had little vegetation and a broad, flat, braided stream bottom that undercut the arroyo walls. In 1925, it was 9.1 m deep at Pueblo del Arroyo (Bryan 1954). By the late 1930s, point bars were forming along the margins. By the 1960s, an inner floodplain of aggraded sediment had developed, and a stable, inner “low-flow” channel was evident. In 1982, the inner floodplain was 5.2 m deep at Pueblo del Arroyo and the total depth to the bottom of the inner channel was 7.1 m. No measurements have been recorded since 1982.

The ephemeral nature of desert riparian habitats is well documented, both at a contemporary ecological scale (Fisher 1986, Stanley et al. 1997) and at a historical scale, exemplified in the preceding history of Chaco Wash. Riparian habitats suitable for invertebrates have occurred in Chaco Canyon as long as Chaco Wash has existed. Recent changes in the canyon floor, such as arroyo formation and associated lowering of the water table, would have eliminated some of the more extensive riparian habitat. Smaller areas, such as oxbows

and braided-channel remnants, would have persisted. The net result has been a more fragmented or patchy mosaic of intermittent pools and former channels. Temporary pools on mesa tops and the sandstone seeps are intrinsic geological features of Chaco Canyon. Our very limited collections at Aggravation Well demonstrate overlap in taxa between the arroyo riparian and surrounding aquatic habitats created by humans. This suggests that new and more permanent water sources, such as stock tanks and other impoundments, both within and outside the park, provide a source for many invertebrate taxa that rely on dispersal to colonize ephemeral aquatic habitats.

The effects of flash floods on the invertebrate faunas of lowland Sonoran Desert streams have been well documented (Fisher et al. 1982, Grimm and Fisher 1989). Little has been published on the impact of flash floods on aquatic invertebrates of intermittent streams in the Great Basin or Colorado Plateau (Myers and Resh 1999, Ward et al. 1986). Chaco Wash and the Chaco River have probably never been constantly flowing streams (Bryan 1954). During flash floods, the Chaco River has been (and continues to be) a major source of sediment for the San Juan River. Large sediment loads, extreme fluctuations in discharge, and high current velocities have undoubtedly prevented development of a diverse and abundant benthic fauna in Chaco Wash. If a well-adapted invertebrate fauna existed in Chaco Canyon, it has been extirpated by human modification of the riparian zone within historical time. By comparison, a rapid change occurred in the benthic fauna of the San Juan River after the completion of Navajo Dam in 1963. The pre-dam river was a relatively warm and turbid environment with a diverse benthic fauna, including at

least 13 species of mayflies, more than six species of stoneflies and caddisflies, and numerous dipterans. In 1969, the resulting tailwater trout fishery, with seasonal temperatures of 5-9° C two km below the dam, had a benthic fauna composed primarily of chironomids and baetid mayflies (Ward et al. 1986).

Recent studies of temporary rock pools in the Colorado Plateau (Baron et al. 1998, Dodson 1987) have provided new information about invertebrate assemblages in these habitats. These investigators have emphasized the rarity, unique characteristics, and sparse knowledge of these habitats. Our limited samples of a few temporary pools and seeps at CCNHP precludes quantitative comparisons, but we note that a majority of taxa that we collected have also been reported in the previous studies. These taxa include the beetle genera *Rhantus* and *Berosus* and the dipteran families Ceratopogonidae, Chironomidae, and Culicidae. A similar management and monitoring opportunity was recognized for tinajas (water-filled bedrock depressions) and hanging garden habitats in Capitol Reef National Park. Investigations of the floristics and plant communities of these habitats has resulted in additional biological studies of their importance to vertebrates and invertebrates (Spence and Henderson 1993).

There are several reasons to consider monitoring aquatic invertebrates at CCNHP. If the macroinvertebrate fauna at Chaco is representative of temporary rock pools in the area, as this study suggests, CCNHP populations may be contributing to the maintenance of regional biodiversity of this faunal group. Few studies exist of temporary wetland

macroinvertebrates in the San Juan Basin. Therefore, it is not possible to assess adequately the importance of the populations at CCHNP. More data are necessary before it would be reasonable to conclude that aquatic invertebrates at Chaco are not an important biological resource. Finally, if regular monitoring of the invertebrate fauna is not feasible, it is important to at least monitor their habitats. By virtue of their rarity in the San Juan Basin, these aquatic habitats are reservoirs of a relatively uncommon segment of the invertebrate biodiversity of the area.

Future monitoring of aquatic insects at CCHNP should focus on species or guilds that can be easily detected or sampled throughout the year. Odonata (dragonflies and damselflies) would be a potentially useful group to monitor. Adults are relatively easy to identify by both amateurs and professional biologists and the aquatic larvae can be collected quantitatively by simple methods. The absence of fish in Chaco Canyon aquatic habitats removes the confounding influence of predation when assessing abundances of odonates in a biomonitoring program. Mayflies (Ephemeroptera) would also be potential candidates for bioassessment, as they are useful indicators of pollution and heavy metal contamination under some conditions. The intent of this study was not to estimate population sizes, but rather to survey for the range of taxa and habitats present. For effective future monitoring, baseline quantitative studies should be conducted, followed by periodic assessment of species richness and numbers.

Future management of riparian habitat at CCNHP may include control and removal of saltcedar (J. Ramakka, CCNHP Resource Management, pers. comm.). Saltcedar leaves decompose faster than those of *Populus* and *Salix* spp., providing a diminished resource for aquatic invertebrates dependent on leaf litter as a food source. Bailey et al. (2001) found that faster decomposition of saltcedar litter, relative to native Fremont cottonwood, was associated with a two-fold decrease in richness and a four-fold decrease in overall abundance of aquatic macroinvertebrates. These results provide justification to recommend the planting of native cottonwoods and willows in wetland or riparian areas, whether or not saltcedar removal is planned. From National Park Service perspective, there may be more compelling justifications for avoiding large-scale saltcedar removal without replacement planting; i.e., losses of avian stopover habitat (B. H. Smith, pers. Comm.) and erosion threats to cultural resources.

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Table 1. Aquatic insects collected August-September 1999 and September 2000 in Chaco Culture National Historical Park. Developmental stages are identified as n, nymphs; l, larvae; p, pupae; a, adults. Qualitative estimates of abundance are indicated as --, absent; +, present in low numbers in one or more samples; ++, common in most samples; +++, abundant in most samples; ~, not sampled.

			Habitat Type and Collection Sites						
Order			Arroyo Riparian			Emergent	Temporary Pool		Seep
Family			Kin			Aggravation	Lower	Chacra	Upper
Genus/Species	Stage		Wijiji	Kletso	Gallo	Well	Clys Canyon	Mesa	Clys Canyon
Ephemeroptera									
Baetidae									
<i>Callibaetis montanus</i> Eaton	n		+++	+++	++	+++	+	--	--
Odonata									
Libellulidae									
<i>Sympetrum corruptum</i> (Hagen)	l		++	++	--		--	--	--
Coenagrionidae									
<i>Enallagma</i> sp.	l		++	++	--		--	--	--
Lestidae									
<i>Lestes</i> sp.	l		--	+	--	--	--	--	--
Hemiptera									
Corixidae									
<i>Corisella</i> sp.	n, a		+	+	+	++	--	--	--
Gerridae									
<i>Gerris</i> sp.	n, a		+++	+++	+++	+++	--	--	--
Notonectidae									
<i>Notonecta</i> sp. A	a		--	--	+	+	--	--	--
<i>Notonecta</i> sp. B	n, a		+	+	+	--	--	--	--
Coleoptera									
Dytiscidae									
<i>Hydaticus</i> sp.	a		--	+	--	--	--	+	--
<i>Laccophilus</i> sp.	a		+	++	+	--	--	--	--
<i>Rhantus</i> sp.	l		--	++	++	++	+	+	--
Hydrophilidae									
<i>Berosus</i> sp.	l, a		--	++	++	++	a +	--	--
Helophoridae									
<i>Helophorus</i> sp.	a		--	+	++	--	--	--	--
Diptera									
Ceratopogonidae	l		--	+	--	p +	+	+	--
Chironomidae	l		++	+	--	++	--	--	+
Culicidae	l		--	++	++	+++	++	+	+
Dolichopodidae	a		+	--	~	~	--	~	~
Muscidae	a		+	+	~	~	--	~	~
Sciaridae	a		--	--	~	~	+	~	~
Sciomyzidae	a		+	+	~	~	--	~	~
Tipulidae	a		+	+	~	~	+	~	~

Figure 1. Map of Chaco Canyon Natural Heritage Park, showing invertebrate collection sites.

