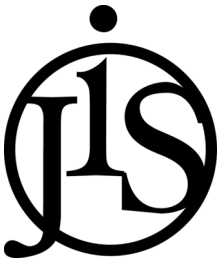
# Preliminary survey of the mayflies (Ephemeroptera) and caddisflies (Trichoptera) of Big Bend Ranch State Park and Big Bend National Park

Authors: Baumgardner, David E., and Bowles, David E.

Source: Journal of Insect Science, 5(28) : 1-13

Published By: Entomological Society of America

URL: https://doi.org/10.1673/1536-2442(2005)5[1:PSOTME]2.0.CO;2



# Preliminary survey of the mayflies (Ephemeroptera) and caddisflies (Trichoptera) of Big Bend Ranch State Park and Big Bend National Park.

**David E. Baumgardner[1*] and David E. Bowles[2, 3]**

[1] Department of Entomology, Texas A&M University, College Station, Texas 77843-2475
[2] National Park Service, Heartland Inventory and Monitoring Network, c/o Department of Biology, Southwest Missouri State University, 901 South National Avenue, Springfield, MO 65804
[3] Field work conducted while employed by the Texas Parks and Wildlife Department, River Studies Program

## Abstract

The mayfly (Insecta: Ephemeroptera) and caddisfly (Insecta: Trichoptera) fauna of Big Bend National Park and Big Bend Ranch State Park are reported based upon numerous records. For mayflies, sixteen species representing four families and twelve genera are reported. By comparison, thirty-five species of caddisflies were collected during this study representing seventeen genera and nine families. Although the Rio Grande supports the greatest diversity of mayflies (n=9) and caddisflies (n=14), numerous spring-fed creeks throughout the park also support a wide variety of species. A general lack of data on the distribution and abundance of invertebrates in Big Bend National and State Park is discussed, along with the importance of continuing this type of research.

Cite this paper as:
Baumgardner DE and Bowles DE. 2005. Preliminary survey of the mayflies (Ephemeroptera) and caddisflies (Trichoptera) of Big Bend Ranch State Park and Big Bend National Park. 13pp. *Journal of Insect Science* 5:28, available online: insectscience.org/5.28

Keywords: Chihuahuan Desert, biodiversity, invertebrate faunas, conservation, inventory
Correspondence: *dbaumgardner@tamu.edu, david_bowles@nps.gov
Received 1 February 2005 | Accepted 16 April 2005 | Published 3 November 2005

## Introduction

The invertebrate faunas of national and state parks historically have been given a low priority by the United States National Park Service, and typically they are ignored unless they become pests (Ginsberg, 1994). Studies have noted that few national parks have initiated systematic inventories of invertebrates and essentially no research has been done towards this end in over half of the National Parks (DeWalt et al., 2005, Flory et al., 2000, Jacobus et al., 2003, Jacobus et al., 2005, Kondratieff et al., 2002, Sharkey, 2001, Stohlgren et al., 1991a, Stohlgren et al., 1991b). Baseline data for aquatic environments in and adjacent to the Rio Grande in western Texas, including those in Big Bend National Park and Big Bend Ranch State Park, are relatively sparse. Indeed, the aquatic invertebrate fauna of these parks is poorly documented having never been comprehensivly surveyed (Bowles, 1997, Bane et al., 1978, Gloyd, 1958, Ross, 1944, Tinkham, 1934).

Such a paucity of information on these systems must be considered in light of the U.S./Mexico Border XXI Program's identification of loss of species diversity in the Rio Grande corridor as an issue of primary concern (United States Environmental Protection Agency 1996). The broad diversity of aquatic habitats in the Big Bend area, including numerous permanent and temporary springs, springs-runs, water tanks, and the Rio Grande, suggests that a rich variety of aquatic invertebrates occur in the Park.

The lack of data on the distribution and abundance of the majority of invertebrate groups in Big Bend National and State Park seriously impedes ecological investigations that could be used to support management decisions in those parks. In particular, those studies concerning fisheries ecology, monitoring for potential or actual introductions of exotic species ( e.g, Asian clam, zebra mussel, various fishes), water quality and monitoring of pollution events, and other anthropogenic disturbances can be severely confounded by a paucity of aquatic invertebrate data. The potential for using invertebrates as indicators of ecosystem disturbance is seen, for example, in the fact that aquatic invertebrates often are used successfully as indicators of ecosystem health. Because of the importance of invertebrates to ecosystem function, detailed surveys of invertebrate faunas are essential for making decisions necessary to effectively manage conservation areas. Such information allows for construction of a comparative framework to evaluate future changes in species composition and distribution that may occur in these systems. The National Park Service has the goal of conducting baseline inventories to support long-term ecological monitoring including biomonitoring to support assessments of non-point sources of pollution (Freet et al., 1999, Nimmo et al., 2002).

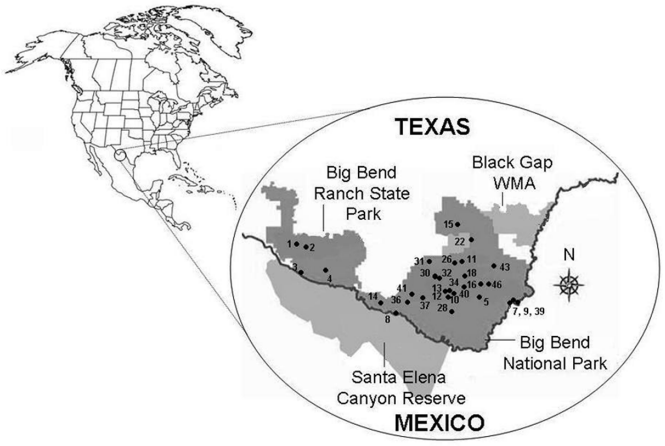
Ginsberg (1994) recommended targeting inventories of selected invertebrate groups for ecological monitoring. The Ephemeroptera, Plecoptera and Trichoptera are the insect orders comprising the Ephemeroptera-Plecoptera-Trichoptera (EPT) index commonly used in assessments of stream water quality and integrity (Barbour et al., 1999). Therefore, a baseline inventory of the mayflies and caddisflies of Big Bend National and State Park is crucial to developing management criteria for protecting aquatic systems in the Parks. There are no known species of Plecoptera (stoneflies) from the Big Bend region. The only known species of Plecoptera known from west Texas, *Isoperla jewetti* Szczytko and Stewart (Szczytko et al., 1977), is a relict population from near El Paso that is likely no longer present.

Big Bend National Park, Big Bend Ranch State Park, Black Gap Wildlife Management Area, and the Santa Elena Canyon Reserve in Mexico are collectively referred to as the "Big Bend Region" and they lie adjacent to each other in the Chihuahuan desert region of far West Texas (Figure 1). Water resources in this region are generally scarce and Black Gap Wildlife Management Area essentially lacks natural surface waters. However, numerous springs and small streams occur throughout the 1.1 million acres of land comprising the national and state parks, and they are bordered by the Rio Grande on the south.

Although there have been numerous surveys of the terrestrial insect fauna within these two parks, little attention has been focused on the aquatic insects. Basic survey work on mayflies and caddisflies in the Big Bend region has been largely neglected. Previously, only cursory attempts have been made to document this fauna. Previous species-level records of mayflies in the Big Bend region are scattered, and include records found in McCafferty and Davis (1992), Henry (1993), and Baumgardner

**Figure 1:** Location of Big Bend National Park and Big Bend Ranch State Park within Texas, with selected collection locations indicated.

Figure 1. Location of Big Bend National Park and Big Bend Ranch State Park within Texas, with selected collection locations indicated.




et al. (1997). Similarly, previous species-level records of caddisflies in this region include those of Bowles and Flint (1997), Moulton and Harris (1997), and Bowles et al. (1999). Bowles (1997) prepared a checklist of the caddisflies of Big Bend National Park, but this list was not published. Moulton and Stewart (1997) presented a checklist of the caddisflies known to occur in Texas at that time, including the Big Bend region, but they did not include specific or regional distributional information. The objectives of this study are to present a preliminary assessment of the diversity and distribution of mayflies (Ephemeroptera) and caddisflies (Trichoptera) in Big Bend National Park and Big Bend Ranch State Park, Texas, and to discuss relevant biological and ecological information related to selected species.

## Materials and Methods

Samples were collected from a wide variety of aquatic habitats from throughout the national and state parks (Table 1, Figure 1). The Black Gap Wildlife Management Area was not sampled because it is essentially devoid of surface water, and the Santa Elena Canyon Reserve was not sampled due to bureaucratic restrictions. Latitude and longitude were collected using hand-held geographic positioning systems (Garmin 45®, Garmin Etrex®, www.garmin.com) , and elevation data was collected with the Garmin Etrex. However, the accuracy of the data was dependent on the conditions under which they were measured at a given time. Elevation was not collected at all sites.

Several collecting methods were used to collect insects in this study, depending on the season and type of habitat sampled. Sampling methods for adult specimens included ultraviolet (UV)-light traps, mercury vapor lights, Malaise traps, emergence traps, sweep netting riparian vegetation, and rearing from immature stages. At some collection localities, more than one method was used. Immature stages were collected directly from the source habitat. Species level identification of most aquatic invertebrates depends chiefly on the morphology of adults because the taxonomic knowledge of immature stages is insufficient. Specimens were preserved in the field with 70% isopropyl alcohol except immature caddisflies which were fixed in Kahle's solution (Wiggins, 1996) for 24 hours prior to be stored in 70% isopropyl.

This report only includes records of species collected during this study or published in the literature. No attempt was made to include records of species collected by other individuals that may be included in data files at Big Bend National Park. Collections in Big Bend National Park were made under the authority of Resource Activity Permit numbers BIBE-95-002-ScRM, BIBE-2001-SCI-0027, BIBE-2002-SCI-0014, BIBE-2004-SCI-0033, and collections in Big Bend

**Table 1:** Collection sites in Big Bend National Park and Big Bend Ranch State Park, Texas.

| Site Number | Collection Site | North Latitude | West Longitude | Elevation |
|---|---|---|---|---|
| **Big Bend Ranch State Park (Presidio County)** | | | | |
| 1 | Ajuga Creek | 29° 30' 0" | 104° 07' 30" | ~1067 |
| 2 | Ojito Adentro | 29° 29' 27" | 104° 03' 50" | ~1097 |
| 3 | Rio Grande, Grassy Banks Access Area | 29° 31' 0" | 104° 17' 30" | ~777 |
| 4 | Fresno Canyon, Madrid Creek | 29° 23' 32.3" | 103° 52' 9.3" | ~1036-1097 |
| **Big Bend National Park (Brewster County)** | | | | |
| 5 | Glenn Spring | 29° 10' 29" | 103° 09' 25" | 727 |
| 6 | Rio Grande (unspecified) | no data | no data | no data |
| 7 | Rio Grande, Rio Grande Village | 29° 10' 46" | 102° 57' 37" | 610 |
| 8 | Rio Grande, Santa Elena Canyon | 29° 09' 55" | 103° 36' 39" | 733 |
| 9 | Rio Grande, nr. Boquillas, Mexico | 29° 11' 45" | 102° 55' 55" | 630 |
| 10 | Upper Juniper Spring | 29° 14' 52.09" | 103° 16' 39.85" | no data |
| 11 | Grapevine Spring | 29° 24' 13.69" | 103° 11' 16.93" | no data |
| 12 | Cattail Falls | 29° 16' 26" | 103° 20' 06" | 1347 |
| 13 | Oak Creek at "The Window" | 29° 16' 47" | 103° 19' 47" | 1467 |
| 14 | Terlingua Creek | 29° 11' 53.52" | 103° 36' 19.10" | no data |
| 15 | Butrill Spring | 29° 32' 36.37" | 103° 16' 22.62" | no data |
| 16 | Dougout Wells | 29° 16' 12.21" | 103° 08' 3.16" | no data |
| 17 | Panther Junction Road | 29° 19' | 103° 12' | no data |
| 18 | Panther Spring | 29° 18' 5.94" | 103° 13' 39.82" | no data |
| 19 | Holly Spring | 29° 10' 9.90" | 103° 10' 39.03" | no data |
| 20 | Melody Spring | 29° 24' 7.95" | 103° 05' 36.13" | no data |
| 21 | Celaya Spring | 29° 24' 45.95" | 103° 12' 12.75" | no data |
| 22 | North Rosillos Mountains, "east spring" | 29° 29' | 103° 10' | 993 |
| 23 | Menagerie Spring | 29° 23' 38.39" | 103° 06' 21.00" | no data |
| 24 | Santa Spring | 29° 07' 18.85" | 103° 24' 26.17" | no data |
| 25 | Tres Spring | 29° 11' 57.12" | 103° 29' 22.88" | no data |
| 26 | Neville Spring | 29° 22' 43.33" | 103° 13' 13.69" | 1029 |
| 27 | Cicada Spring | 29° 14' 25.88" | 103° 07' 54.72" | no data |
| 28 | Tusk Spring | 29° 09' 12.08" | 103° 16' 47.75" | no data |
| 29 | Double Spring | 29° 09' 41.57" | 103° 17' 7.61" | no data |
| 30 | Cottonwood Creek | 29° 17' | 103° 28' | no data |
| 31 | Dripping Spring | 29° 24' 11.21" | 103° 18' 25.81" | no data |
| 32 | Gano Spring | 29° 18' 25.66" | 103° 25' 10.70" | no data |
| 33 | Lorn Spring | 29° 25' 6.57" | 103° 12' 48.38" | no data |
| 34 | Rock Spring | 29° 16' 7.43" | 103° 11' 18.45" | no data |
| 35 | Cottonwood Spring | 29° 17' 20.41" | 103° 22' 32.06" | no data |
| 36 | Bee Spring | 29° 11" 55.97" | 103° 28' 38.84" | no data |
| 37 | Goat Spring | 29° 31' 58.95" | 103° 16' 43.32" | no data |
| 38 | Mano Spring | 29° 08' 56.54" | 103° 18' 7.83" | no data |
| 39 | Rio Grande, "Hot Springs" | 29° 10' 45" | 102° 59' 44" | 700 |
| 40 | Boot Spring | 29° 14' 30" | 103° 17' 49" | 695 |
| 41 | Tinaja Spring [Tule Mountain] | 29° 19' 43.70" | 103° 27' 7.75" | no data |
| 42 | Paloma Spring [Sombrero Peak] | 29° 11' 6.27" | 103° 17' 51.74" | no data |
| 43 | Banta Shut-In [Roy's Peak] | 29° 19' 39.59" | 103° 04' 46.64" | 1202 |
| 44 | Equipaje Spring | 29° 33' 25.13" | 103° 13' 8.60" | no data |
| 45 | Thomas Spring | 29° 22' 1.10" | 103° 22' 33.10" | no data |
| 46 | Hannold Spring | 29° 22' 29.00" | 103° 11' 33.99" | no data |

Ranch State Park were done under the authority of Texas Parks and Wildlife Department Employee Scientific Collecting Permit Number 124.

A synoptic collection of specimens taken during this study are deposited at the Texas A&M University Entomology Collection, College Station, Texas to insure appropriate curation for development of a systematics database, formal systematics research, and establishment of a permanent voucher collection of the material studied.

## Results

Sixteen species of mayflies were collected during this study, representing four families and twelve genera (Table 2). The greatest diversity was found within the families Baetidae and Leptophlebiidae, each with seven (44% of total species) and five species (35% of total), respectively. The specific identity of one species, *Brachycercus* sp. (Caenidae) remains unresolved at this time. Thirty-five species of caddisflies were collected during this study representing 17 genera and 9 families. The greatest diversity was recorded for the microcaddisfly family Hydroptilidae with 18 species, or just over 51% of the total diversity in our samples. The specific identities of some species of caddisflies in our collections remain unknown at this time.

### Ephemeroptera species within Big Bend

### Family Baetidae

*Acentrella ampla* Traver: This species was reported from the Rio Grande at Santa Elena Canyon by McCafferty and Davis (1992). *Acentrella ampla* is also known from the mid-western and eastern United States (McCafferty et al., 1992).

*Baetis magnus* McCafferty and Waltz: *B. magnus* is known from numerous localities throughout the southwestern United States, and occurs throughout much of Central America, south to Panama (McCafferty et al., 1997). Larvae of this species are often found in small spring runs, their apparent preferred habitat.

*Callibaetis montanus* Eaton: The species is known from Arizona, New Mexico and west Texas south to Nicaragua (Lugo-Ortiz et al., 1996). Larvae were found only in the Rio Grande at Santa Elena Canyon, clinging to snag material in an area of the river having low current velocity.

*Callibaetis pictus* (Eaton): *C.pictus* is a widespread species throughout western North America and is known from as far south as Costa Rica (Lugo-Ortiz et al., 1996). Larvae were common and abundant in pools of numerous spring-fed streams and in very small, stagnant pools. Larvae were collected at elevations ranging from 1,500 meters to over 2,200 meters. This was the only species of mayfly collected above 2,200 meters.

Many spring-fed streams in the Big Bend region are reduced to small, isolated, stagnant pools throughout much of the summer. *Callibaetis pictus* larvae commonly occur in these pools where they can be abundant. The larvae varied from those with black wing pads (about to emerge) to early instars. These larvae apparently can survive severe drying conditions, and appear well adapted to the highly variable and often temporary spring runs of the desert region of Big Bend. Mature larvae were collected in late April and early May.

*Camelobaetidius kickapoo* McCafferty: This species was first reported from the Rio Grande at Santa Elena Canyon by McCafferty and Davis (McCafferty et al., 1992) as *Camelobaetidius* sp. 1, and then formally described as *C. kickapoo* by Randolph and McCafferty (2000). *Camelobaetidius kickapoo* is also known from Colorado and Arizona (Randolph et al., 2000).

*Camelobaetidius mexicanus* (Traver and Edmunds): This species is known from throughout much of Texas and Mexico (Lugo-Ortiz et al., 1995), and Idaho (Lester et al., 2002).

**Table 2:** Mayflies (Ephemeroptera) known from Big Bend National Park and Big Bend Ranch State Park. Numbers shown in bold font after species refer to localities within parks found within Table 1 (table1.html) . Literature references refer to previously published records.

**Order Ephemeroptera**

**Family Baetidae**
*Acentrella ampla* Traver: **8** (McCafferty and Davis, 1992)
*Baetis magnus* McCafferty and Waltz: **4** (larvae)
*Callibaetis montanus* Eaton: **8, 39** (larvae, reared adults)
*Callibaetis pictus* (Eaton): **2, 4, 11, 12, 13, 15, 30, 41, 42, 43, 44, 45** (larvae, reared adults)
*Camelobaetidius kickapoo* McCafferty: **8** (McCafferty and Davis, 1992)
*Camelobaetidius mexicanus* (Traver and Edmunds): **39** (larva)
*Fallceon quilleri* (Dodds): **1, 2, 4, 5, 8, 11, 18, 26, 39** (larvae)
**Family Caenidae**
*Brachycercus* sp.: **8, 9, 12, 46** (adults)
*Caenis bajaensis* Allen and Murvosh: **12** (larvae)
**Family Leptohyphidae**
*Tricorythodes explicatus* (Eaton): **39** (larvae)
*Tricorythodes minutus* Traver: **3, 8** (larvae, reared adults)
**Family Leptophlebiidae**
*Choroterpes inornata* Eaton: **12, 13** (larvae, reared adults)
*Farrodes mexicanus* Dominguez: **2, 13** (larvae)
*Neochoroterpes oklahoma* (Traver): **6, 8, 39** (larvae, adults)
*Thraulodes gonzalesi* Traver and Edmunds: **3, 6, 8, 39** (larvae, adults)
*Traverella presidiana* (Traver): **3, 6, 39** (larvae, adults)

*Fallceon quilleri* (Dodds): This is an extremely common and wide-ranging species known from throughout the United States and Central America, south to Costa Rica (Lugo-Ortiz et al., 1994). It was collected at numerous locations in both parks. Habitat of the larvae ranged from small spring-fed creeks to the Rio Grande.

**Family Caenidae**

*Bracycercus* sp.: This is the first record of this genus from the Big Bend region and west Texas. Only adults were collected, making species identification not possible at this point. Considering that no other species of *Brachycercus* are known from west Texas, and the adults do not match any of the described species, this is likely an undescribed species. A formal description is not possible until larvae are associated and its uniqueness confirmed.

*Caenis bajaensis* Allen and Murvosh: *C. bajaensis* is known from throughout the southwestern United States and Mexico (Provonsha, 1990).

**Family Leptohyphidae**

*Tricorythodes fictus* Traver: The larval stage of *T. fictus* was only recently described by Baumgardner et al. (Baumgardner et al., 2003). Larvae are found commonly in many streams throughout Texas, and the species may also occur in Mexico. Big Bend represents the most western known limit of this species.

*Tricorythodes explicatus* (Eaton): Although this species is only known from the extreme southwestern United States and northwestern Mexico (Allen et. al, 1987), *Tricorythodes minutus* Traver is likely a synonym of *T. explicatus*, and it is known from throughout much of the western United States.

**Family Leptophlebiidae**

*Choroterpes inornata* Eaton: This species is distributed throughout the southwestern United States and into northwestern Mexico (McCafferty, 1992). Larvae appear to be restricted to cool, isolated mountain streams and pools (Baumgardner et al., 1997). *Choroterpes inornata* was first reported from Cattail Falls, Big Bend National Park, by Baumgardner et al. (1997). These authors reported on the possibility that this population might represent a new species or subspecies of *C. inornata*, because of their extremely long antennae and caudal filaments that were two to three times the body length. Examination of reared male imagoes and additional larvae indicate that, although this character does appear unusual for the species and might perhaps be an adaptation to life in pools. No other characters have been found to support either species or subspecies status for the Big Bend populations. Larvae were common at Cattail Falls and Oak Creek, both very small, spring-fed creeks. Mature larvae were collected in late April and May.

*Farrodes mexicanus* Dominguez: Although only *F. mexicanus* larvae were collected from the Big Bend Region and *F. mexicanus* is known only from adults, larvae collected from Big Bend were very mature and their abdominal color pattern matched that of *F. mexicanus*, indicating they are probably the undescribed larval stage of this species (W.P. McCafferty, personal communication). Additional collections of larvae and reared adults will be necessary to confirm this suspicion. The apparent presence of *F. mexicanus* in Texas is a new country record for this species in the United States, which was previously known only from southern Mexico. *Farrodes mexicanus* larvae were collected from Ojito Adentro in Big Bend Ranch and from Oak Creek at “The Window” in Big Bend National Park. Both locations are small, permanently flowing, spring-fed creeks. Only a few larvae were found at each location, clinging to the underside of small stones and rocks in regions of the stream with little flow.

*Neochoroterpes oklahoma* (Traver): This is the most widely distributed species of *N. oklahoma*, known from throughout much of Texas, Oklahoma, Colorado, New Mexico, and northern Mexico (Henry, 1993). Larvae live on the underside of rocks in moderate current of medium size streams and rivers (Henry, 1993). As first observed by Baumgardner et al. (1997), larvae collected from the Rio Grande had a very small, untracheated branch of abdominal gill 1, which could be easily confused with *Neochoroterpes nanita*. However, the maxillary and labial palps of *N. oklahoma* have very long setae while those of *N. nanita* do not. In addition, no adults of *N. nanita* have been collected from Big Bend. However, adults of *N. oklahoma* are common there in the late spring and summer.

*Thraulodes gonzalesi* Traver and Edmunds: This is a common species in many of the river drainages of

central Texas and is also known from scattered localities in northeastern Mexico (Allen et al., 1978). Larvae were found commonly at numerous localities in the Rio Grande.

*Traverella presidiana* (Traver): This species is found commonly throughout rivers in Texas and northeastern Mexico. Larvae prefer moderately large to large rivers and can be found clinging to rocks and debris (Allen, 1973). In the Big Bend region, this species has only been found in the Rio Grande.

**Trichoptera species within Big Bend**

**Family Calamoceratidae**
*Phylloicus aeneus* (Hagen): This Neotropical species is widely distributed from throughout central Texas westward into the Big Bend region and southward throughout Central America (Bowles et al., 1997, Prather, 2003). Larvae inhabit small to moderate volume springs and spring-runs. In the Big Bend region, larvae were found living in the cool spring-runs of the Chisos Mountains and from Ojito Adentro on Big Bend Ranch State Park, but they typically are absent from small springs of the lowland desert where trees are few in number or absent, and ambient water temperatures are high.

**Family Glossosomatidae**
*Protoptila alexanderi* Ross: This was the only glossosomatid caddisfly collected during this study, found only from the Rio Grande. This species is primarily distributed in eastern and central Texas, and this record represents a substantial western range extension.

**Family Helicopsychidae**
*Helicopsyche borealis* (Hagen): This species is common and widely distributed in the United States (Wiggins, 1996). The genitalia of specimens we have examined vary somewhat from examples taken elsewhere in Texas, suggesting that the Big Bend population may represent an undescribed species. However, considerable genetic variability may occur among the various populations of *H. borealis* (Jackson et al., 1992) suggesting the genitalic differences may be a phenotypic artifact. We have collected *Helicopsyche mexicana* Banks from elsewhere in western Texas, but not from the Big Bend Region.

**Family Hydropsychidae**
The diversity of hydropsychids in the Big Bend region is low and is likely due to a paucity of flowing water habitat. Only five species of hydropsychids were collected, most from the Rio Grande, and Terlingua Creek, a lowland tributary of the Rio Grande, and from flowing water habitats on Big Bend Ranch State Park. Three species, *Cheumatopsyche campyla* Ross, *Cheumatopsyche lasia* Ross and *Smicridea fasciatella* McLachlan, are common and fairly widespread species (Gordon, 1974, Flint, 1974). Examples of a western species, *Cheumatopsyche arizonensis,* were collected at Ojito Adentro in Big Bend Ranch State Park which appears to be the limit of the eastern distribution of this species. Similarly, *Smicridea signata* (Banks), primarily distributed in the southwestern U.S., Mexico and Central America (Flint, 1974), also appears to have its eastern range limit in Big Bend.

**Family Leptoceridae**
Leptocerids were poorly represented in collections. Only one species was collected from the Big Bend region, *Nectopsyche gracilis* (Banks), from Terlingua Creek in Big Bend National Park. No leptocerids were collected at Big Bend Ranch State Park. Other leptocerids are known from western Texas including *Oecetis avara* (Banks), *Oecetis inconspicua* (Walker) and *Oecetis cinerascens*, but none of these species were collected during this study.

**Family Hydroptilidae**
Eighteen species of hydroptilids were collected from the Big Bend region. Several of these species are common and widely distributed in North America (Blickle, 1979). However, several others are much less common, or their collections in the Big Bend region represent extensions of their respective known eastern ranges.

*Alisotrichia arizonica* (Blickle and Denning): Bowles et al. (1999) described the larva of this unusual microcaddisfly (Hydroptilidae), which occupy madiculous habitats receiving most of their flow from springs. In the Big Bend region, *A. arizonica* is restricted to the mountain springs in the National Park, and a spring-run, Ojito Adentro, in Big Bend State Park. This species also is known from Arizona and Utah, and from an unpublished record from a mountain spring-run in Chihuahua, Mexico (Bowles, personal observation).

*Neotrichia* spp.: Two species in this genus are known from the Big Bend region. The type locality for *Neotrichia sonora* Ross is Neville Spring in Big Bend National Park (Ross, 1944) and only two male paratypes of the type series remain known. The male holotype was accidentally destroyed in a shipping accident several years ago. *Neotrichia sonora* was not collected from the Big Bend region during this study. However, *N. sonora* has been collected from a small spring-run in the mountains near Chihuahua State Mexico (Bowles, unpublished data), not far from Big Bend National Park. The proximity of this collection to the Big Bend region suggests this species likely still occurs in the vicinity of the type locality. *Neotrichia minutisimella* (Chambers), the other species collected during this study, is widely distributed in the central and eastern U.S. (Blickle, 1979).

*Hydroptila* spp.: Four species in this genus were collected during this study. *Hydroptila angusta* Ross is widely distributed and common east of the Rocky Mountains in the U.S. (Blickle, 1979). The three remaining species, *Hydroptila arcti* a Ross, *Hydroptila icona* Mosely, and *Hydroptila protera* Ross, are all widely distributed in the central and southwestern U.S.

*Leucotrichia limpia* Ross has been reported from the southwestern U. S. southward through Central America (Flint 1970). The type locality for this species is Limpia Creek located in the Big Bend region (Ross, 1944).

*Mayatrichia* spp.: Two species in this genus were collected including *Mayatrichia acuna* Ross, and *Mayatrichia ayama* Mosely. The former species is widely distributed in the southwestern U.S., and northern Mexico, while the latter is widely distributed throughout much of North America (Blickle, 1979).

*Ochrotrichia* spp.: Several species of *Ochrotrichia* were collected during this study. *Ochrotrichia boquillas* Moulton and Harris is endemic to the Big Bend region and is known only from Grapevine Spring and the Rio Grande area in the Big Bend National Park (Moulton et al., 1997). *Ochrotrichia capitana* Ross and *Ochrotrichia tarsalis* (Hagen) were collected from the same areas as *O. boquillas*, but both of these species are more widely distributed in central and western Texas. A second group of species including *Ochrotrichia dacytlophora* Flint , *Ochrotrichia rothi* Denning and Blickle, and *Ochrotrichia spinulata* Denning and Blickle were collected only in the Chisos Mountains of Big Bend National Park during this study. The Big Bend region appears to represent the eastern distribution limits for these three Western species.

*Oxyethira* spp.: Two species of *Oxyethira* were collected from the Big Bend region during this study, including *Oxyethira aculea* Ross, and *Oxyethira azteca* (Mosely). Both species are widely distributed in the southwestern U.S. (Blickle, 1979).

**Family Limnephilidae**

*Limnephilus* sp.: Only larvae were collected of this genus during this study, and specific determination could not be made. Five species of *Limnephilus* have been recorded for the western portion of Texas including *L. adapaus* Ross, *L. frijole* Ross, *L. lithus* (Milne), *L. tulatus* Denning, and *L. taloga* Ross (Ruiter, 1995). Specimens were taken exclusively from lowland desert springs in Big Bend National Park.

**Family Odontoceridae**

*Marilia nobsca* Milne: This species was collected from several locations in the Big Bend Region. It also occurs elsewhere in the Southwestern U.S., Mexico and Guatemala (Bueno-Soria et al., 2004).

*Marilia* sp.: Larvae and adults of this unusual species were collected throughout the Big Bend region. The specimens appear closely related to *Marilia flexuosa* Ulmer, but they differ in several respects. The eyes of the male specimens from the Big Bend region are widely separated and are roughly 1.5 times as large as those of the female, but the eyes of male *M. flexuosa* have the eyes nearly touching on the midline and are more than twice the size of the female eyes. Also, the scutellum of the Big Bend specimens is evenly colored and lacks any distinct marks while the scutellum of *M. flexuosa* is distinctly marked with a light pigment bar along the meson. However, no differences in the genitalia of either sex were found between the Big Bend material and typical examples of *M. flexuosa*. The larvae of the two species also can be distinguished on the basis of markings found on the head and thorax. While the Big Bend material clearly appears not to be *M. flexouosa*, it may it represent either an undescribed species, or *Marilia mexicana* (Banks) which is known from Northwestern Mexico. *Marilia mexicana* is known

only from the female holotype (Bueno-Soria et al., 2004), and male and immature stages have not yet been associated. Although the Big Bend specimens may indeed be *M. mexicana*, a formal description of the larvae and adult cannot be accomplished until further research is completed and the female holotype has been examined. *Marilia flexuosa* appears to be absent from the Big Bend region although it commonly occurs elsewhere in Texas and the Southwestern U.S., Mexico and southward to South America (Flint, 1967, Flint, 1991, Bueno-Soria et al., 2004).

**Family Philopotamidae**

Four species of *Chimarra* and a single species of *Wormaldia* are currently known from the Big Bend Region, and all of them are relatively common. *Chimarra* larvae were collected from several locations, but they could not be identified to species. *Chimarra ridleyi* (Denning) and *C. angustipennis* (Banks) are widely distributed throughout the southwestern U.S. and southward through Central America (Armitage, 1991, Blahnik, 1998). *Chimarra adella* Denning and *C. utahensis* (Ross) are known primarily from the southwestern U.S. and northern Mexico (Armitage, 1991, Flint, 1967, Ross, 1951). Western Texas appears to be the eastern boundary of the respective ranges of these two species. Similarly, *Wormaldia arizonensis* (Ling), the only representative of this genus known to occur in western Texas, is primarily distributed in the southwestern U.S. and northern Mexico (Armitage, 1991, Flint, 1967).

**Family Polycentropodidae**

The only polycentropodid collected in the Big Bend region, *Polycentropus halidus* Milne, is primarily distributed in the southwestern U.S. and northern Mexico (Denning et al., 1966, Flint, 1967). Western Texas appears to represent the easternmost boundary of this species distribution.

## Discussion

Sixteen species of mayflies were collected during this study, but the identity of one species, *Brachycercus* sp. (Caenidae), remains unresolved at this time due to the lack of larval specimens. It appears possibly to be new species, but correlation of larval and adult life stages and additional research will be necessary to make this determination. Among collection locations, highest species diversity was observed for the Rio Grande, which accounted for nine of the sixteen species collected. Three species, *C. inornata* Eaton, *F. mexicanus* Dominguez, and *C. pictus* (Eaton) are apparently restricted to small, permanently flowing spring-fed creeks.

The relatively low number of mayfly species within Big Bend is perhaps less than what might be predicted based upon the numerous aquatic habitats. However, this low diversity could be explained by the fact that highest mayfly diversity is often found in highly aerated, rocky, rapidly flowing permanent water bodies (Berner et al., 1988). The vast majority of aquatic habitats in Big Bend are small spring-fed creeks and streams, many of which dry out during much of the year. In addition, many permanent creeks in the Big Bend region are often reduced to stagnant, unconnected pools during much of the year. Even the Rio Grande, the largest aquatic habitat in the region, can become completely dry during the summer months and droughts. This lack of suitable habitat probably explains why the mayfly diversity is so low.

The mayfly fauna of Big Bend has strong Neotropical affinities. The majority of species documented from Big Bend are either wide-ranging species in North and Central America, such as *B. magnus* and *F. quilleri*, or those known principally from the southwestern United States and Central America (*C. bajaensis*, *C. montanus*, *C. pictus, C. inornata*, and *T. explicatus*). A few species (*C. mexicanus, T. presidiana, T. gonzalesi*) are distributed chiefly in the south-central United States, south throughout Central America. *Farrodes mexicanus* was previously known only from southern Mexico.

The caddisfly fauna of Big Bend is quite diverse and most of its components are from southwestern North America and the Neotropics. This was clearly shown in the diverse microcaddisfly family Hydroptilidae. Other families, including the Leptoceridae and Polycentropodidae, are generally common elsewhere in North America, but they are poorly represented in the Big Bend region suggesting a relationship with the paucity of permanent water sources in this area. The identity of some species remains unresolved at this time due to either taxonomic uncertainty (*Marilia* sp.) or the absence of adult specimens in collections (*Chimarra* spp. *Hydroptila* sp., *Limnephilus* sp.).

Big Bend National Park appears to contain a much greater diversity of mayflies and caddisflies than Big Bend Ranch State Park. This is probably due to the greater abundance and diversity of aquatic habitats in Big Bend National Park. Or, it could simply be a collection bias owing to the fact that Big Bend National Park has been more thoroughly surveyed. The high diversity of mayflies (n=9) and caddisflies (n=14) from the Rio Grande is not surprising considering the size of the river and its normal permanent flow. However, undersampling the more than 300 springs occurring on the desert floor also may have contributed to this difference although many of these springs that were sampled contained no mayflies or caddisflies. Among spring-fed creek sites, Cattail Falls (Site 12, Table 3) and Oak Creek at The Window (Site 13, Table 3) support the greatest diversity of mayflies and caddisflies. Both these creeks normally flow throughout the year, but due to extensive regional drought in recent years these systems have been reduced to intermittent pools. Numerous other small springs generally support a smaller diversity of mayflies and caddisflies. However, some springs contain insects that are not found anywhere else in the park, such as the caddisflies *N. sonora* Ross (Family Hydroptilidae), *C. angustipennis* (Banks) and *C. utahensis* (Ross) (Family Philopotamidae).

The results of this study allow for a better understanding of the regional diversity and distribution of mayflies and caddisflies in the Rio Grande drainage basin. Such information will provide a solid basis through which to obtain a better understanding of the structure and functioning of this complex ecosystem. Data collected on mayflies and caddisflies also can be used towards development of rapid bioassessment protocols that are regionally specific and indices used for estimating ecosystem health. Establishment of monitoring criteria for aquatic systems is an important tool for management of fish and wildlife populations, protecting human health, and maintaining quality of life in response to deterioration in water quality and quantity. The information provided here allows for a better understanding of the diversity and distribution of mayflies and caddisflies in the Big Bend region, but additional research is required to fully assess the threats to their existence such as land development, impacts of ground water extraction on the springs, and degraded water quality. Furthermore, research on other groups of aquatic invertebrates also is required to gain a better understanding of the overall structure and function of aquatic ecosystems in this unique region.

## Acknowledgements

We thank Arwin Provonsha and W.P. McCafferty (Purdue University) and Brad Henry (University of Texas Pan American) for taxonomic assistance, and Abigail Baumgardner and Ed Riley (Texas A&M University) for assistance with the field work. Thanks also to Raymond Skiles and Carl Flemming (Big Bend National Park) for assisting with collecting permits and lodging while in Big Bend National Park. Much thanks is due to Dr. Merill Sweet (Texas A&M University) for introducing the senior author to the Big Bend region. Dr. Sweet's enthusiasm and 20 plus years of teaching and research in Big Bend National Park enlightened many students to the wonders of this region. Several dedicated Americorps volunteers assisted with the collection of specimens during this study. They include Stehanie Bartel, Aaron Handzlick, Alexander Hovani, Jeff Marcus, Ellen Kilpatrick, Gina Stropoli, Jennifer Wycoff-McDonough, Kevin McDonough, and Debbie Wong.

**Table 3:** Caddisflies (Trichoptera) known from Big Bend National Park and Big Bend Ranch State Park. Numbers shown in bold font after species refer to localities within parks found in Table 1.

**Order Trichoptera**

**Family Calamoceratidae**
*Phylloicus aeneus* (Hagen): **2, 12, 13**
**Family Glossosomatidae**
*Protoptila alexanderi* Ross: **6,** 7
**Family Helicopsychidae**
*Helicopsyche borealis* (Hagen): **6,** 7**, 13, 14, 23, 24**
*Helicopysche* sp.: **23, 24**
**Family Hydroptilidae**
*Alisotrichia arizonica* (Blickle and Denning): **1, 2, 13**
*Hydroptila angusta* Ross: **14**
*H. arctia* Ross: **13**
*H. icona* Mosely: **6,** 7**, 14**
*H. protera* Ross: **13, 14**
*Hydroptila* sp. (larvae only): **27, 28**
*Leucotrichia limpia* Ross: **1, 2, 5, 6, 15**
*Mayatrichia acuna* Ross: **7, 14, 15, 16, 17, 18**
*M. ayama Mosely*: **6,** 7**, 14, 16**
*Neotrichia minutisimella* (Chambers): **14**
*N. sonora* Ross: **26**
*Ochrotrichia boquillas* Moulton and Harris: **5, 6,** 7
*O. capitana* Ross: **5, 11, 29**
*O. dactylophora* Flint: **13**
*O. spinulata* Denning and Blickle: **13**
*O. tarsalis* (Hagen): **6,** 7
*O. rothi* Denning and Blickle: **13**
*Oxyethira aculea* Ross: **6,** 7**, 19, 20**
*O. azteca* (Mosely): 6, 7
*Oxyethira* sp.: **1, 2, 19, 20**
**Family Hydropsychidae**
*Cheumatopsyche arizonensis* (Ling): **2**
*Cheumatopsyche campyla* Ross: **6,** 7
*Cheumatopsyche lasia* Ross: **2, 6,** 7**, 14**
*Smicridea fasciatella* McLachlan: **6,** 7
*S. signata* (Banks): **6,** 7**, 14**
**Family Leptoceridae**
*Nectopsyche gracilis* (Banks): **14**
**Family Odontoceridae**
*Marilia flexuosa* Ulmer or *M. mexicana* (Banks): **1, 2, 11, 13, 15, 22, 25, 26, 29, 36, 37, 38**
*Marilia nobsca* Milne: **1, 2, 12, 13, 25**
**Family Philopotamidae**
*Chimarra adella* Denning: **2, 5, 6,** 7**, 11, 13, 15**
*C. angustipennis* (Banks): **5**
*C. ridleyi* (Denning): **2, 12, 13, 22**
*C. utahensis* (Ross): **5**
*Chimarra* sp.: **2**
*Wormaldia arizonensis* (Ling): **11, 13, 21**
**Family Polycentropodidae**
*Polycentropus halidus* Milne: **2, 13**

## References


Allen RK. 1973. Generic revisions of mayfly nymphs. 1. *Traverella* in North and Central America (Leptophlebiidae). *Annals of the Entomological Society of America* 66:1287-1295.

Allen RK, Brusca RC. 1978. Generic revisions of Mayfly nymphs II. *Thraulodes* in North and Central America (Leptophlebiidae). *Canadian Entomologist* 110:413-433.

Allen RK, Murvosh CM. 1987. Mayflies (Ephemeroptera: Tricorythidae) of the Southwestern United States and Northern Mexico. *Annals of the Entomological Society of America* 80:35-40.

Armitage BJ. 1991. *Diagnostic atlas of the North American caddisfly adults. I. Philopotamidae*, 2nd edition. The Caddis Press, Athens, Alabama.

Baumgardner DE, Burian SK, Bass D. 2003. Life stage descriptions, taxonomic notes, and new records for the mayfly family Leptohyphidae (Ephemeroptera). *Zootaxa* 332:1-12.

Baumgardner DE, Kennedy JH, Henry BC. 1997. New and additional records of Texas mayflies (Insecta: Ephemeroptera). *Transactions of the American Entomological Society* 123:55-69.

Bane CA, Lind OT. 1978. The benthic invertebrate standing crop and diversity of a small desert stream in the Big Bend National Park, Texas. *Southwestern Naturalis* t 23:215-226.

Barbour MT, Gerritsen J, Snyder BD, Stribling JB. 1999. *Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers: Periphyton, Benthic Macroinvertebrates and Fish*, Second Edition. EPA 841-B-99-002. U.S. Environmental Protection Agency; Office of Water; Washington, D.C.

Berner L, Pescador ML. 1988. *The Mayflies of Florida*, Revised Edition. University Presses of Florida. 415 pp.

Blahnik RJ. 1998. A revision of the Neotropical species of the genus *Chimarra*, subgenus *Chimarra* (Trichoptera: Philopotamidae). *Memoirs of the American Entomological Institute* 59:1-318

Blickle RL. 1979. Hydroptilidae (Trichoptera) of America North of Mexico. *New Hampshire Agricultural Experiment Station Bulletin* 509:1-97.

Bowles DE. 1997. *A Preliminary Assessment of the Caddisfly (Insecta: Trichoptera) Fauna of Big Bend National Park, Texas*. Final Report, Big Bend National Park, Big Bend National Park Resource Activity Permit Number BIBE-93-042.

Bowles DE, Flint OS, Jr. 1997. A review of the genus *Phylloicus* Müller (Trichoptera: Calamoceratidae) in the United States with a redescription of *Phylloicus ornatus* (Banks). Pp. 53-58. In, R. W. Holzenthal and O. S. Flint, Jr. (eds.). *Proceedings of the 8th International Symposium on Trichoptera*. Ohio Biological Survey, Columbus, Ohio.

Bowles DE, Harris SC, Bueno-Soria J. 1999. An assessment of New World Stactobiini (Trichoptera: Hydroptilidae) larvae with new larval descriptions of *Alisotrichia*, *Mejicanotrhica*, and *Scleobotrichia*. Pp. 43-52. In H. Malicky and P. Chantraramongkol [eds.]. *Proceedings of the 9th International Symposium on Trichoptera*. Chiang Mai, Thailand.

Bueno-Soria J, Rojas-Ascendo A. 2004. New species and distributions of the genus *Marilia* Muller (Trichoptera: Odontoceridae) in Mexico and Central America. *Proceedings of the Entomological Society of Washington* 106:679-696.

Denning DG, Sykora J. 1966. New North American Trichoptera. *Canadian Entomologist* 98:1219-1226.

DeWalt RE, Heinold BD. 2005. Summer emerging Ephemeroptera, Plecoptera, and Trichoptera of Abrams Creek, Great Smoky Mountains National Park. *Proceedings of the Entomological Society of Washington* 107:34-48.

Flint OS Jr. 1967. Studies of Neotropical caddis flies, VI: on a collection from Northeastern Mexico. *Proceedings of the Entomological Society of Washington* 69:162-176.

Flint OS Jr. 1970. Studies of Neotropical caddisflies, X: *Leuchotrichia* and related genera from North and Central America (Trichoptera: Hydroptilidae). *Smithsonian Contributions to Zoology* 60:1-64.

Flint OS Jr. 1974. Studies of Neotropical caddisflies, XVII: The genus *Smicridea* from North and Central America (Trichoptera: Hydropsychidae). *Smithsonian Contributions to Zoology* 167:1-65.

Flint OS Jr. 1991. Studies of Neotropical caddisflies, XLV: the taxonomy, phenology, and faunistics of the Trichoptera of Antioquia, Colombia. *Smithsonian Contributions to Zoology* 520:1-113.

Flory EA, Milner AM. 2000. Macroinvertebrate community succession in Wolf Point Creek, Glacier Bay National Park, Alaska. *Freshwater Biology* 44:465-480.

Freet, B., and K. Turner. 1999. Developing a plan for long-term ecological monitoring: a focused workshop approach. Park Science 19:36-38.

Ginsberg HS. 1994. Conservation of invertebrates in U.S. National Parks. *American Entomologist* 40:76-78.

Gloyd LK. 1958. The dragonfly fauna of the Big Bend region of Trans-Pecos Texas. *Occasional Papers of the Museum of Zoology, University of Michigan* 593:1-23.

Gordon AE. 1974. A synopsis and phylogenetic outline of the Neartic members of *Cheumatopsyche*. *Proceedings of the Academy of Natural Sciences of Philadelphia* 126:117-164.

Henry BC, Jr. 1993. A revision of *Neochoroterpes* (Ephemeroptera: Leptophlebiidae) new status. *Transactions of the American Entomological Society* 119: 317-333.

Jackson JK, Resh VH. 1992. Variation in genetic structure among populations of the caddisfly *Helicopsyche borealis* from three streams in northern California, U.S.A. *Freshwater Biology* 27:29:42.

Jacobus LM, McCafferty WP. 2003. An introduction to the Smoky Mountain mayflies (Insecta: Ephemeroptera). *Southeastern Biology* 50:358-360.

Jacobus LM, McCafferty WP. 2005. Mayfly (Ephemeroptera) Diversity in the Great Smoky Mountains. *Southeastern Biology* 52:45-46.

Kondratieff BC, Lechleitner RA. 2002. Stoneflies (Plecoptera) of Mount Rainier National Park, Washington. *Western North American Naturalist* 62:385-404.

Lester GT, McCafferty WP, Edmondson MR. 2002. New mayfly (Ephemeroptera) records from Idaho. *Entomological News* 113:131-136.

Lugo-Ortiz CR, McCafferty WP, Waltz RD. 1994. Contribution to the taxonomy of the Panamerican genus *Fallceon* (Ephemeroptera: Baetidae). *Journal of the New York Entomological Society* 102:460-475.

Lugo-Ortiz CR, McCafferty WP. 1995. Taxonomy of the North and Central American species of *Camelobaetidius* (Ephemeroptera: Baetidae). *Entomological News* 106:178-192.

Lugo-Ortiz CR, McCafferty WP. 1996. Contribution to the Taxonomy of *Callibaetis* (Ephemeroptera: Baetidae) in Southwestern North America and Middle America. *Aquatic Insects* 18:1-9.

McCafferty WP. 1992. New larval descriptions and comparisons of North American *Choroterpes* (Ephemerotpera: Leptophlebiidae). Great Lakes Entomologist 25:25-77.

McCafferty WP, Davis JR. 1992. New and additional records of small minnow mayflies (Ephemeroptera: Baetidae) from Texas. *Entomological News* 103:199-209.

McCafferty WP, Lugo-Ortiz CR, Jacobi GZ. 1997. Mayfly fauna of New Mexico. *Great Basin Naturalist* 57:283-314.

Moulton SR, Harris SC. 1997. New species of southwestern Nearctic microcaddisflies (Trichoptera: Hydroptilidae). *Proceedings of the Entomological Society of Washington* 99:494-50.

Moulton SR II, and Stewart KW. 1997. *A preliminary checklist of the Texas caddisflies (Trichoptera)*. Pp. 349-353. In, R. W. Holzenthal and O. S. Flint, Jr. (eds.). Proceedings of the 8th International Symposium on Trichoptera. Ohio Biological Survey, Columbus, Ohio.

Nimmo DW, Karish J, Bestgen H, Steidl-Pulley T, Willox M, Craig T, Castle . 1992. Assessing nonpoint sources of toxicity, part II: Using biomonitoring techniques. *Park Science* 12:6-8.

Prather A. 2003. Revision of the Neotropical caddisfly genus *Phylloicus* (Trichoptera: Calamoceratidae). *Zootaxa* 275:1-214.

Provonsha AV. 1990. A revision of the genus *Caenis* in North America (Ephemeroptera: Caenidae). *Transactions of the American Entomological Society* 116:801-884.

Randolph RP, McCafferty WP. 2000. Further contributions to the spatulate clawed Baetidae (Ephemeroptera). *Entomological News* 111:259-264.

Ross HH. 1944. The caddis flies, or Trichoptera of Illinois. *Bulletin of the Illinois Natural History Survey* 23:1-326.

Ross HH. 1951. The Trichoptera of Lower California. *Proceedings of the California Academy of Science* 27:65-76.

Ruiter DE. 1995. The adult *Limnephilus* Leach (Trichoptera: Limnephilidae of the New World. *Bulletin of the Ohio Biological Survey* 11:1-200.

Sharkey MJ. 2001. The All Taxa Biological Inventory of the Great Smoky Mountains National Park. *Florida Entomologist* 84:556-564

Stohlgren T, Quinn J. 1991. *Status of natural resources databases in National Parks: Western region*. NPS Resources Study unit, University of California Davis, Technical Report No. 44.

Stohlgren T, Ruggiero M, Quinn J, Wagoner G. 1991. National Park biotic inventories assessed. *Park Science* 11:16-17.

Szczytko SW, Stewart KW. 1977. The stoneflies (Plecoptera) of Texas. *Transactions of the American Entomological Society* 103:327-378.

Tinkham ER. 1934. The dragonfly fauna of Presidio and Jeff Davis counties of the Big Bend region of Trans-Pecos, Texas. *Canadian Entomologist*. 66:213-218.

United States Environmental Protection Agency. 1996. *US/Mexico Border XXI Program, Summary of Domestic Meetings*. EPA Report 160-R-96-001. Washington, D.C.

Wiggins GB. 1996. *Larvae of the North American caddisfly genera (Trichoptera)*, 2nd edition. University of Toronto Press, Toronto, Canada.