CRUSTACEA FROM THE BOLSON OF CUATRO CIENEGAS, COAHUILA, MEXICO

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ABSTRACT

Twelve crustaceans are known from the Cuatro Ciénegas basin. These include: the cirolanid isopods *Speocirolana thermydronis, Sphaerolana interstitialis, Sphaerolana affinis;* one stenasellid isopod *Mexistenasellus coahuila,* the first of the Stenasellidae found in the New World; and two endemic hadzioid (weckeliid) amphipods originally assigned to *Mexiweckelia, M. colei,* and *M. particeps. M. particeps* will be referred to the monotypic new genus *Paramexiweckelia* (Holsinger, in press). These six species were described from the basin and are endemic to it; the genera *Sphaerolana* and *Paramexiweckelia* have no representatives outside the basin. Other crustaceans include: a species of the brine shrimp, *Artemia;* another anostracan, probably a species of *Streptocephalus;* an harpacticoid copepod similar to *Cletocamptus albuquerquensis;* an ostracod referable to *Chlamydotheca;* an amphipod much like *Hyalella azteca,* although designated here simply *Hyalella;* and the decapod *Palaemonetes suttkusi.* The last species, *Chlamydotheca,* and *H. azteca* were described originally from Mexican material. Although crustacean diversity is low in its thermal waters, discovery of more species can be expected in the Cuatro Ciénegas basin.

RESUMEN

Doce crustáceos son conocidos de la cuenca de Cuatro Ciénegas. Estos incluyen: los isópodos cirolánidos *Speocirolana thermydronis, Sphaerolana interstitialis, Sphaerolana affinis;* un isópodo estenasellido *Mexistenasellus coahuila,* el primer Stenasellidae descubierto en el Nuevo Mundo; y dos anfípodos hadziidos (weckeliid) endémicos originalmente asignados a *Mexiweckelia, M. colei* y *M. particeps.* Se referirá a *M. particeps* como un nuevo género monotípico, *Paramexiweckelia* (Holsinger, en prensa). Dichas seis especies fueron descritas de la cuenca donde son endémicas; los géneros *Sphaerolana* y *Paramexiweckelia* no tienen representantes afuera de la cuenca. Otros crustáceos son: una especie de brine shrimp, *Artemia;* un anóstraco probablemente una especie de *Streptocephalus;* un copépodo harpacticoide parecido a *Cletocamptus albuquerquensis;* un ostrácodo referible a *Chlamydotheca;* un anfípodo parecido a *Hyalella azteca,* y designado aqui *Hyalella;* y el decápodo *Palaemonetes suttkusi. Chlamydotheca* y las dos ultimas especies fueron descritas originalmente de muestras mexicanas. Aunque la diversidad de crustáceos sea baja en las aguas termales de la cuenca de Cuatro Ciénegas, se espera el descubrimiento de mas especies locales.

INTRODUCTION.–The history of crustacean studies in Cuatro Ciénegas is largely a saga of serendipity, and lucky "firsts" in what soon became a series of advances in Mexican zoology. Many people contributed their energy and personal talents to the field work, W. L. Minckley being the most avid collector of us all. From the beginning, Dr. Thomas E. Bowman, Division of Crustacea at the Smithsonian Institution, sustained and guided us. His counsel was invaluable, and on two occasions he was the perfect host while I was in Washington examining specimens and literature housed in the U. S. National Museum. Furthermore, he was kind enough to read this manuscript and to criticize it constructively. Other people to whom I am indebted for pertinent information are Drs. Denton Belk, John R. Holsinger and Glenn Longley.

It is the purpose of this paper to tell how and where various new species were found and to detail what happened thereafter. The paper will deal with: three new species of cirolanid isopods and one new genus; one new genus and species of the stenasellid isopods; and two new species of hadziid amphipods belonging to two new genera. All the species and two genera are endemic to the Cuatro Ciénegas basin, and four genera were described originally from Cuatro Ciénegas material. The status of Mexican carcinology in relation to Cuatro Ciénegas will be discussed, and some prophesies about future discoveries will be ventured. Throughout, there may be a more anecdotal style than is usual in modern scientific writing!

CRUSTACEAN DIVERSITY IN CUATRO CIENEGAS.–The impression, perhaps fostered by those who have studied the organisms of Cuatro Ciénegas, is one of exciting diversity. This does not apply to the Crustacea, although there is another side to the coin that will be discussed subsequently. The striking endemism and abundance of new taxa, and the occurrence of several cirolanid isopods, a group that is poorly represented in non-marine settings, may have contributed to the notion of high diversity.

Cole, G. A. 1984. Crustacea from the Bolsón of Cuatro Ciénegas, Coahuila, México. Journal of the Arizona-Nevada Academy of Science 19:3-12.

Actually, the number of crustaceans from the valley of Cuatro Ciénegas is not impressive; only 12 species have been noted. The Amphipoda and Isopoda of the Peracarida are fairly abundant, but other major groups are poorly represented. To date, no mysidacean peracaridans have been found, although at least four troglobitic species are known from México (Bowman 1982c).

Among the Branchiopoda, a population of the brine-shrimp genus *Artemia* Leach 1819, was sampled 20 March 1973 in Laguna Salada by Denton Belk. Also, some immature anostracans have been collected at various times from ephemeral roadside pools; they are probably some species of *Streptocephalus* Baird 1852. No representatives of the Cladocera, however, have been reported from the basin. The Copepoda are represented by an harpacticoid close to, if not conspecific with, *Cletocamptus albuquerquensis* (Herrick) 1895.[1/] Among the other "entomostracans", some species of the ostracod *Chlamydotheca* Saussure 1858 is abundant, serving as a food item for the endemic box turtle, *Terrapene coahuila* Schmidt and Owens 1944. At least five species of *Chlamydotheca* have been noted from México to date.

Amphipods referable to *Hyalella* Smith 1874, designated *H. azteca* (Saussure) 1858 in many papers concerned with Cuatro Ciénegas fauna, are ubiquitous. *Palaemonetes suttkusi* Smalley 1964, a decapod glass or grass shrimp, occurs in some lagunas in the basin. *Chlamydotheca, Hyalella azteca* and *Palaemonetes suttkusi* were described initially from Mexican specimens (Saussure 1858; Smalley 1964). The endemic crustaceans that were described later amount to six species. Thus 75% of the Cuatro Ciénegas Crustacea have Mexican affinities, and 50% are endemic.

The reason for the low crustacean diversity in the thermal and hypogean waters of Cuatro Ciénegas may be rooted in the extreme stability of such habitats. Recently, Ward and Stanford (1983) discussed animal diversity in lotic environments. In two instructive plots (their Fig. 1, p. 349, and Fig. 2, p. 351) the authors showed highest diversity in communities subjected to intermediate levels of disturbing incidents. Lowest diversities occur in thermal springs where constancy prevails, and at the opposite end of the spectrum in extremely disturbed habitats such as those subjected to frequent acid mine discharges or to heavy organic loading.

The thermal, interstitial, and subterranean waters of Cuatro Ciénegas are stable habitats that may account for

[1/]Now is an appropriate time to correct some erroneous statements published previously about the occurrence of this copepod in extremely hypersaline waters in Cuatro Ciénegas. *Cletocamptus* was reported from Laguna Salada " . . . with . . . 309.4 g/liter total dissolved solids." (Minckley and Cole 1968b, p. 429 and Table 2). In Minckley (1969, pp. 25, 26) it is stated that the harpacticoid copepod " . . . was abundant in water that held almost 400 grams per liter total dissolved solids." Summation of the major ions and silica, presented in Minckley and Cole's Table 2 (1968b) gives 99.85 g/liter, a much more credible datum.

Table 1.—Crustacea Known from the Bolsón of Cuatro Ciénegas, Coahuila, México.

- Branchiopoda
  - Anostraca
    - Artemiidae
      - *Artemia* Leach 1819
    - Streptocephalidae
      - *Streptocephalus* Baird 1852
- Copepoda
  - Harpactiocoida
    - Cletodidae
      - *Cletocamptus albuquerquensis* (Herrick) 1895
- Ostracoda
  - Podocopa
    - Cypridae
      - *Chlamydotheca* Saussure 1858
- Malacostraca
  - Peracarida
    - Isopoda
      - Flabellifera
        - Cirolanidae
          - *Speocirolana thermydronis* Cole and Minckley 1966
          - *Sphaerolana interstitialis* Cole and Minckley 1970
          - *Sphaerolana affinis* Cole and Minckley 1970
      - Asellota
        - Stenasellidae
          - *Mexistenasellus coahuila* Cole and Minckley 1972
    - Amphipoda
      - Talitroidea
        - Hyalellidae
          - *Hyalella* Smith 1874
      - Hadzioidea
        - Hadziidae
          - *Mexiweckelia colei* Holsinger and Minckley 1971
          - *Paramexiweckelia particeps* (Holsinger) in Holsinger and Minckley (1971), Holsinger in press.
  - Decapoda
    - Caridea
      - Palaemonidae
        - *Palaemonetes suttkusi* Smalley 1964

(in addition to low diversity) the presence of cirolanid and stenasellid isopods as well as hadziid amphipods. Flabelliferan isopods (including some parasitic families as well as the free-living Cirolanidae and Sphaeromatidae), the Stenasellidae, and amphipods of the family Hadziidae have not been successful in colonizing the common types of epigean freshwater environments. The same can be said for the mysidacean Peracarida, abundant in the seas, but largely troglobitic or halophilic when inland. *Mysis relicta* Lovén 1861, occurring in the deeps of northern oligotrophic lakes, may be an exception to this. The asellid isopods and gammarid amphipods, by contrast, have invaded lakes, springs, and streams far from the sea and have, in some instances, moved directly from epigean freshwaters into caves.

Bowman (1981) concluded that flabelliferan isopods have been excluded from what we consider normal epigean freshwater habitats by the competition of aquatic insects, especially the predaceous species, and their naiads, nymphs, and larvae. Insects occur but rarely in caves and hot springs, the inland habitats where the non-parasitic flabelliferans are found. In the Cuatro Ciénegas basin one small, cold-water laguna contains many benthic mayfly naiads, but no flabelliferan isopods, nor stenasellid isopods, nor hadziid amphipods as far as is known.

Ward and Stanford (1982) discussed the importance of temperature in the ecologic evolution of insects, pointing out that the original home of aquatic insects was in the cool headwaters of streams. From there they moved downstream and spread to warmer waters. Very few species, however, invaded and prospered in thermal waters. Shuster (1981) remarked on the absence of predaceous insects in a hot spring in Socorro, New Mexico, where a population of flabelliferan isopods (Sphaeromatidae in this instance) thrives. He attributed this, however, to intense predation by the omnivorous isopod, *Thermosphaeroma thermophilum* (Richardson) 1897.

After stating that the diversity of crustaceans in the Cuatro Ciénegas environments is low, it is time to point out that it might be much higher than we suspect. First, the difficulty in collecting some of the species leads to the conclusion that there are more microhabitats and new species awaiting discovery. The work of Dickson et al. (1979) implies that hypogean crustaceans have normal levels of genetic variability, comparable to that of epigean forms. Isolating mechanisms, then, could lead to speciation in the various interstitial, subterranean, and thermal habitats of the Cuatro Ciénegas basin. Second, as Frey (1982) emphasized, the notion of cosmopolitanism in the cladoceran Crustacea blinded workers to the host of undescribed species around us in North and South America. This probably applies to the cyclopoid copepods and ostracods also. Diligent searching at shallow margins of lagunas, pozos, and in aquatic weed beds might uncover the presence of some Cladocera, Copepoda, and Ostracoda even though they have not been taken in plankton collections from the bolsón. Careful scrutiny, involving modern techniques, or even old-fashioned methods based on morphology, could well reveal many new and perhaps endemic species.

Another point to consider hinges on the abundance of weckeliid amphipods in various waters of Cuatro Ciénegas (Holsinger and Minckley 1971). Recently, Stock (1982) presented statistical evidence that hadziid amphipods and cyclopoids are mutually exclusive in West Indies habitats. Validating this generality on the basis of the weckeliid members of the Hadziidae would make a worthwhile research project in the basin. The important factor in the relationship seems to be the predatory nature of the amphipods. Moreover, Stock found the thermosbaenacean crustaceans and hadziids rarely co-occur, yet the former and cyclopoids are associated in a normal fashion in West Indies groundwaters. At this time only one thermosbaenacean species is known from the mainland of North America; this is *Monodella texana* Maguire 1965, from the Edwards Plateau, Texas. Suitable hypogean habitats that lack weckeliid amphipods might be the best places to find cyclopoid copepods and, possibly, crustaceans closely related to *Monodella* in the Cuatro Ciénegas valley.

Several accounts of the various habitats in the Cuatro Ciénegas basin have noted the ubiquity of *Hyalella azteca* (Minckley 1969; Cole and Minckley 1970, 1972; Holsinger and Minckley 1971). In the years since those reports at least two new species of *Hyalella* have been described in the American Southwest. These are *H. texana* Stevenson and Peden (1973) and *H. montezuma* Cole and Watkins (1977). The idea of one species, *H. azteca*, ranging from South America to the treeline in North America is on the wane, and it is not accurate to assign a specific name to the Coahuila hyalellids as has been done. The color variation among different populations in the waters of Cuatro Ciénegas is striking, and one unique population, especially, comes to mind: one spring contains snow-white individuals with black eyes! Probably there are many species masquerading as *Hyalella azteca* and some of these may be in the bolsón of Cuatro Ciénegas.

The concept of cosmopolitanism has over-simplified the taxonomy of *Artemia*. Therefore, it is unrealistic to designate animals from North America as *A. salina* (Linnaeus) 1758, described originally from Lymington, Southhampton, England. Clark and Bowen (1976) recommended that the term *A. salina* be dropped for the brine shrimps (found on six continents), except for, perhaps, the type locality. Their paper marked the starting point for a more realistic examination of brine shrimp populations, and presented evidence for far more heterogeneity than had been suspected previously. The *Artemia* from Laguna Salada has yet to acquire a specific name.

Other species of the Anostraca can be anticipated in the Cuatro Ciénegas basin. *Streptocephalus linderi* Moore 1966, *S. mackini* Moore 1966, *Thamnocephalus mexicanus* Linder 1941, and *T. platyurus* Packard 1879 have been reported from Coahuila, although not from Cuatro Ciénegas (see Belk 1975). Five other species of *Streptocephalus* have been reported from Texas, or Mexican states bordering Coahuila. There are, therefore, many possibilities as to what the ultimate taxonomic designation will be when applied to the immature forms from Cuatro Ciénegas.

It is not illogical to assume that more faunal surprises await us as more subterranean habitats are investigated in the Cuatro Ciénegas bolsón. The African shrimp genus, *Potamalpheops*, is represented in North America by a single Mexican species, the troglobitic, white, eyeless *P. stygicola* (Hobbs 1983). This relict decapod recalls the former connection of the present African and American continents and leads to predicting that careful searching or serendipitous good fortune will add to the unique faunal list of Cuatro Ciénegas.

ISOPODA, FLABELLIFERA.—Cirolanidae. The first crustacean described as a new species from the Cuatro Ciénegas basin was the cirolanid isopod, *Speocirolana thermydronis* Cole and Minckley (1966). At that time the genus *Speocirolana* was represented by two other species, both Mexican. Bolívar (1950) reported an isopod from a San Luis Potosí cave, assigning it to the marine genus *Cirolana* Leach 1818, but placing it in a new subgenus, *Speocirolana*, and giving it the specific name *pelazei*. Three years later, Rioja (1953) described a new form, *Cirolana (Speocirolana) bolivari*, collected in a Tamaulipas cave. Bowman (1964) raised Bolívar's subgeneric name *Speocirolana* to full generic rank. Thus, *S. thermydronis* became the third certain species of the genus. It is probable that *Conilera stygia*, described by Packard (1900) on the basis of animals collected in springs near Monterey, Nuevo León, is another species of *Speocirolana*, although it has not been found since Packard's report and, apparently, no types were deposited (T. E. Bowman, pers. comm.). Certainly it is not a member of the marine genus *Conilera* Leach 1818, to which it was assigned by Packard.

The animals referable to *Speocirolana* are much like typical marine cirolanids except for their eyeless condition and lack of pigmentation. They have five obvious pleonites (abdominal segments) anterior to the pleotelson, although the lateral margins of the fourth and fifth are reduced, and the genus represents the third of nine types of pleonal segmentation in order of increased fusion of pleonites (Bowman 1975a, Fig. 4). Its category shows it slightly more modified than *Cirolana* and *Conilera*, both of which show only a slight reduction of the fifth pleonite; they belong to Bowman's second type. The exopod and endopod are well developed on each uropod, forming a typical crustacean biramous appendage. A major character of the genus is that the first three pairs of pereopods are prehensile, followed by ambulatory appendages 4-7. Packard's *Conilera stygia* also has subchelate, prehensile pereopods 1-3, if we are to rely on his words of 1900, "Only the first three pairs of legs are short, with a very thick hand; the four hinder pairs are long and slender."

With the published description of *Speocirolana thermydronis*, only four genera of cirolanid isopods were known from the mainland of North and Middle America. These included: *Cirolanides texensis* Benedict 1896 from caves of the Edwards Plateau of Texas; three species of *Speocirolana*, (perhaps four if *Conilera stygia* can be assigned to that genus); *Creaseriella anops* (Creaser) 1936 from the Yucatán Peninsula; and *Antrolana lira* Bowman 1964 from a Virginian cave. All are troglobitic forms. Nine years later another blind, unpigmented cirolanid, *Mexilana saluposi* Bowman (1975a), was named from a San Luis Potosí cave, raising the total genera to five.

In 1982 Contreras-Balderas and Purata-Velarde published an account of another species, *Speocirolana guerrai*. The description of the new species was based on a study of 48 specimens from a small cave near Linares, Nuevo León. In the same journal, in the paper directly following the description of *S. guerrai*, the fifth and sixth species of *Speocirolana* were named *S. pubens* and *S. endeca* from San Luis Potosí and Tamaulipas, respectively (Bowman 1982a). *Speocirolana endeca* earned its name by being the 11th species of troglobitic Mexican cirolanid to be described (see Bowman 1982a, p. 23).

Bowman's two species of *Speocirolana* nicely fit the distributional pattern formed by the first four species and *Conilera stygia* (Contreras-Balderas and Purata-Velarde 1982, Figs. 28-32). The geographic alignment, from *S. pelazei* and *S. pubens* in San Luis Potosí to the most northern species, *S. thermydronis*, closely follows the Upper Jurassic coastline according to Burckhardt (1930) and Imlay (1943). With reference to the boundaries of marine embayments in México proposed by Axelrod (1979), the *Speocirolana* species are found near the old Paleocene and Eocene shorelines. A pre-Tertiary origin for the genus seems reasonable. The isopods probably moved directly from retreating seas into interstitial and hypogean habitats without an intermediate epigean freshwater stage. The location of Packard's "*Conilera*" within the north-south line formed by the *Speocirolana* species prompted Contreras-Balderas and Purata-Velarde (1982, p. 10) to write ". . . se reafirma la suposcion de que *'Conilera' stygia* Packard debio representar una *Speocirolana* . . ."

Speocirolana thermydronis was described on the basis of one 15-mm female collected in April, 1964, by Mary L. Allesio, a member of a University of Colorado Museum field group. The specimen was sent to us by Clarence J. McCoy. Twenty-nine more animals were collected in August, 1967, and additional distributional and descriptive data resulted from that (Minckley and Cole 1968a). We were apprehensive about describing a new species from a study of only one specimen, but the earlier descriptions of *S. pelazei* and *S. bolivari* were so detailed that we were certain that the Cuatro Ciénegas isopod was different. We were not the first in the annals of hypogean carcinology to describe a new taxon from such scanty material; two more instances will be mentioned in later pages.

Many European and North American zoologists have invaded México to investigate the nation's unique crustacean fauna. It is, therefore, worthy of mention and indeed a happy thought that 50% of the species of *Speocirolana* (if we exclude *Conilera stygia)* were described by Mexican scientists!

The discovery of the new genus *Sphaerolana* Cole and Minckley (1970) was owed to William S. Brown. Brown, then a graduate student at Arizona State University, was studying the box turtle *Terrapene coahuila.* Stomach contents of some preserved *Terrapene* specimens in Tempe contained remains of isopods, which Brown asked me to examine. The isopods were in very poor condition, but obviously were unique. I though they might belong to the flabelliferan family Sphaeromatidae, because many were rolled tightly in a sphere. Brown detailed the location of the pozo from which the turtles had been collected (immediately christened Pozo Tortuga by Cole and Minckley) and the next summer, August 1967, we began searching for isopods in the same pool. A few were found when travertine blocks were broken apart, but the results were generally disappointing. Later we discovered the best way to collect the white, eyeless isopods was to pull up emergent vegetation at pool margins and examine the muddy roots; the crustaceans were abundant there. Soon we had adequate study material and we sent specimens to Dr. Bowman at the Smithsonian Institution. He observed that the mouthparts were typical of a cirolanid isopod rather than a sphaeromatid, and that the isopod could not be referred to any known genus. The two family names were combined to create the new generic name for the isopod, *Sphaerolana* Cole and Minckley 1970. Since then no isopods referable to *Sphaerolana* have been discovered outside the Cuatro Ciénegas basin.

Although two other blind, white cirolanids are capable of rolling into a sphere, they are fundamentally different from *Sphaerolana.* These are *Creaseriella* Rioja 1953 from the Yucatán Peninusula and *Faucheria* Dollfus and Viré 1905 from caves in France. *Creaseriella* resembles *Speocirolana* in having five well-developed pleonites anterior to the pleotelson, the last two having indistinct lateral margins in both genera. *Sphaerolana* has but two abdominal segments cephalad to its pleotelson, and the caudal one has indistinct, covered lateral margins. *Faucheria* reveals four pleonites with well-developed lateral margins, but the transverse sutures are incomplete, representing nearly fused segments. It is the last type in Bowman's (1975a, Fig. 4) nine categories arranged in order of increasing fusion of pleonites. *Sphaerolana* characterizes the eighth category.

The uropodal rami of *Creaseriella* are strong, with large endopods and exopods. Those of *Sphaerolana* are scarcely represented and are inserted in a lateral notch near the end of the protopod. In *Faucheria* the uropodites are represented by subterminal, reduced structures on the protopod. The uropods of *Sphaerolana* have evolved further from the typical cirolanid type. All the pereopods of the Yucatán *Creaseriella* are ambulatory; the first three pairs are subchelate and prehensile in *Faucheria* and *Sphaerolana,* as they are in members of *Speocirolana.* There seems to be no close relationship among the three sphere-forming genera. Probably the ability to roll has developed independently in the cirolanids.

Our early specimens of *Sphaerolana (S. interstitialis)* came from habitats clustered near the northern tip of the Sierra de San Marcos (see Minckley 1969, Fig. 2; Cole and Minckley 1970, Fig. 40; Holsinger and Minckley 1971, Fig. 4). The most remote site was 6 km south of the tip near the eastern slope. Serendipity played a role in the discovery of *W. affinis* in a pozo 12 km southeast of the nearest known *S. interstitialis.* The pit was carpeted with *Chara* except for the central, deepest portion, where water entered; there, clearly visible, were clean, white pebbles. The funnel-shaped pit stirred our imaginations to such an extent that we named it Funnel Poso *[sic],* Pozo Embudo being beyond our collective linguistic talent. Dwight W. Taylor, always on the alert for new mollusc habitats, asked George L. Batchelder to dive down carrying a small sieve and to bring back a sample of the pebbles and, perhaps, associated gastropods. At that time, August 1967, Batchelder was a graduate student and he complied. To our surprise, the sieve contents included some eyeless, white isopods that we immediately recognized as belonging to *Sphaerolana.* We assumed they were conspecific with those taken earlier near the tip of Sierra de San Marcos. Later, when it was possible to dissect and examine them microscopically, several differences emerged, and the small funnel-shaped pozo, about 2 km northeast of Ejido Santa Tecla and about 20 km southeast of the town of Cuatro Ciénegas, became the type-locality for *Sphaerolana affinis* Cole and Minckley 1970. A pattern began to emerge at about that time: the fauna of the eastern part of the basin, and especially the "southeastern lobe", is different from that of the western portion.

Sphaerolana affinis differs from *S. interstitialis* in details of antenna 2, pleopod 1, pleotelson, and the uropod. Of these the most interesting is a small bilobed structure, representing the exopod and endopod of the typical isopod uropod. The two lobes, situated in a shallow pit on the posterolateral border of the protopod, extend slightly beyond the protopod surface. *S. interstitialis* is further modified from the typical cirolanid; its uropodites are reduced even more; they are represented by only a minute marginal mound within the posterolateral pit. The mound bears two or three setae. Only these setae reach and extend past the protopod margin.

At the northern tip of Sierra de San Marcos is a small spring and pool that we christened Taylor's Spring, for reasons now forgotten. The small spring is shown as a half-darkened circle in Cole and Minckley (1970, Fig. 40) and as an open circle in Holsinger and Minckley (1971, Fig. 4). A wide-mouthed quart jar was placed in the spring, its open end tipped upward at an angle of about 35° toward the hole from which the subterranean water entered. Isopods that emerged during the night were trapped in the jar, although we suspect that many individuals of *Speocirolana* were able to swim to their freedom. Members of *Sphaerolana* were unable to crawl up the glassy slope, and most mornings we collected animals that had emerged under the cover of darkness. The *Sphaerolana* individuals were easily separable into two types: one was typically *S. interstitialis;* the other, on the basis of antenna 2, pleopod 1, pleotelson, and uropod, fitted the description of

S. affinis. The latter were 1.6-2.4 X the length of any collected in the southeast-lobe habitats, where they occurred alone, and were much larger than the co-occurring *S. interstitialis* in Taylor's Spring. Furthermore, they were clumsy, elongate, and unable to roll tightly to form a good sphere.

Because the two species were indistinguishable by the unaided eye when sample specimens from allopatric populations were examined, and readily separable where they coexisted in Taylor's Spring, the notion of character displacement came to mind immediately. Only eleven years had passed since Brown and Wilson's important paper (1956) entitled "Character Displacement" and meanwhile workers had been confirming the exaggerated differences between sympatric species when compared with the same characters in allopatric situations. Now, 16 years after the discovery of two kinds of *Sphaerolana* in Taylor's Spring, an alternative explanation seems reasonable. There could be three species of *Sphaerolana* in the Cuatro Ciénegas basin. There might be complete reproductive isolation between the typical *S. affinis* in Funnel Pozo and the elongate, awkward form in Taylor's Spring. Possibly *Speocirolana endeca* (Bowman 1982a) from Tamaulipas should have been *S. dodeca!*

Sphaeromatidae. At this time no sphaeromatid isopods have been found in Cuatro Ciénegas waters, and so only the cirolanids of the Flabellifera are of concern to us here. It should be mentioned, however, that five species of *Thermosphaeroma* Cole and Bane 1978[2/] are found in hot springs of Chihuahua, Texas, and New Mexico. At present, the known species of *Thermosphaeroma* occur in a north-south line that corresponds closely to the western boundary of the Maastrichtian (Upper Cretaceous) embayment (see Bowman 1981, Fig. 11) according to Axelrod (1979). These sphaeromatid sites are all west of Cuatro Ciénegas. Furthermore, they lie west of all the known species of *Speocirolana*, the Mexican stenasellid isopods, and the New World hadziid amphipods, all forms which have relatives in Cuatro Ciénegas. Some thermal bodies of water in the basin, however, seem to be ideal habitats for *Thermosphaeroma.* Possibly a sphaeromatid population will be discovered there some day.

ISOPODA, ASELLOTA—**Stenasellidae.** When the original description of *Mexistenasellus coahuila* was published (Cole and Minckley 1972), we had collected only 10 specimens. The first animals emerged from a small chunk of travertine that Minckley pulled from the wall of the Laguna Juan Santos. Five specimens in that small travertine block were all that were collected in the summer of 1967 despite an intensive search in the laguna and throughout the Cuatro Ciénegas basin. The following year four more specimens were taken singly from four different habitats, and in 1970 a single individual was collected. In each incident the isopod was taken more or less by accident. They were found from 25 cm to 3 m below the water surface in soft organic sediment, spongy travertine, and detritus composed of fibrous plant fragments. The waters that yielded these small isopods were definitely warm; their temperatures were all greater than 30°C, the hottest site being Laguna Escobeda at 34.2°.

Although we never learned how or where to collect the stenasellids in Cuatro Ciénegas waters, we know now, thanks to Magniez's (1978) summary of our knowledge of stenasellids, that we were not unique. The French *Stenasellus virei* Dollfus 1897 was collected in 1896, but despite minutely detailed searching through ensuing years, it was not rediscovered until 1902! Perhaps the stenasellid habit of constructing complex networks of tunnels in compact clay sediments, and occupying other intricate interstitial galleries accounts for the difficulty in collecting them. Parenthetically, Adrian Dollfus described *Stenasellus virei* on the basis of only one individual collected in 1896!

The manuscript describing *Mexistenasellus coahuila* was submitted first to a journal that was having problems. It was neglected for about two years before we withdrew it and submitted it to the *Proceedings of the Biological Society of Washington*, where it was accepted and published in 1972. Later in the same year two more species of *Mexistenasellus* were described from San Lusi Potosí, *M. parzefalli* and *M. wilkensi* (Magniez 1972). We appreciate Magniez's courtesy in delaying his paper until our publication appeared; he was aware of our find and the long period our manuscript had lain without attention. Two years later Argano (1974) published the new *M. magniezi* from Veracruz, and later erected the new genus *Etlastenasellus* to describe *E. mixtecus* from Oaxaca (Argano 1977). Bowman (1982b) described *Mexistenasellus colei* from a cave in Tamaulipas, *M. nulemex* from Nuevo León and *Etlastenasellus confinis,* the second member of that genus from Oaxaca. Thus, there are eight named stenasellid isopods known from the New World, all from México. Certainly they are more widespread. Since 1976, three specimens have been collected from deep wells at San Antonio, Texas. They represent an undescribed species (Glenn Longley, in litt., 11 July 1983). San Antonio is very near the Eocene shoreline shown by Bowman (1981, Fig. 11, from Axelrod 1979), where *M. nulemex, M. colei, M. parzefalli* and *M. wilkensi* occur. *M. magniezi* is farther south on the boundary of the Paleocene marine embayment. The Cuatro Ciénegas location of *M. coahuila* is west of the Paleocene boundary, and the two species of *Etlastenasellus* are south of *M. magniezi* between the Upper Cretaceous and Paleocene shores.

Guy J. Magniez has continued working on the stenasellids and summarizing our knowledge of them. His studies of the west African species led him to conclude that the New World *Mexistenasellus* species are closely related to them, especially *Parastenasellus* (Magniez 1981). The splitting of Gondwana explains this, implying ancient

[2/]*Thermosphaeroma* was a second-choice name for the new genus. We first proposed *Bowmanoma* in honor of Dr. T. E. Bowman, who had reminded one of us that the inland species of *"Exosphaeroma"* differ markedly from the marine members of that genus. Dr. Bowman declined the honor, suggesting that the name sounded like some incurable malady, possibly environmentally induced.

origins of the stenasellids and suggesting that unknown forms close to *Mexistenasellus* are awaiting discovery, especially along the northeastern coast of South America from northern Venezuela to the easternmost tip of Brazil (see Magniez 1981, Fig. 1).

In February 1972, when the description of *Mexistenasellus* was published, about 25 stenasellids were known from Europe, Asia and Africa. Now, throughout the world, extending as far east as the island of Borneo, more than 40 species in at least eight genera are known. Eight species and two genera occur in México alone, and maybe Glenn Longley's Texas wells will add another species at least.

Perhaps *Mexistenasellus coahuila* is the most typical hypogean animal of all that have been found in the thermal waters of Cuatro Ciénegas. From a study of subterranean animals in the springs of northwestern Yugoslavia and from a survey of data in the literature, Sket and Velkovrh (1981) concluded that stenasellid isopods are the most characteristic group of thermophilous hypogean animals, occupying thermal waters even in tropical regions. Moreover, Magniez (1978) used the stenasellids to answer some general questions concerning the biogeography, ecology, and physiology of cavernicolous animals found today in temperate regions. At any rate, our find of small red isopods in the travertine block from Laguna Juan Santos may have been the most significant discovery among the Crustacea of Cuatro Ciénegas: the first record of the Stenasellidae from the New World.

Asellidae in México. The newly collected specimens of what later proved to be *Mexistenasellus coahuila* were puzzling. Although they were obviously asellotes (rather than flabelliferans), we were aware of only one other in the inland waters of México, the so-called *Asellus puebla* Cole and Minckley (1968) from epigean waters in the states of Puebla and México. Each Cuatro Ciénegas asellote had two well-developed pleonites anterior to the pleotelson, a primitive character when compared with the common asellids of the United States and Canada, *Lirceus* and *Asellus;* most of the latter are now referable to *Caecidotea* Packard 1871. The red, eyeless asellotes that emerged from the travertine in Laguna Juan Santos had never been seen in the New World. We were not prepared for them!

It seems opportune at this time to follow up the story of *Asellus puebla* because it pertains to Mexican, if not Cuatro Ciénegas carcinology. Now we believe that *Asellus puebla* is *Caecidotea communis* (Say) 1818, described from streams around Philadelphia, Pennsylvania, and the first of the inland Asellota to be described in North America. Say's description of his *Asellus communis* (1818, pp. 427-428) was inadequate in light of modern work, causing much confusion for the next century and a half. This began to clear up when Williams (1970) examined specimens collected near Say's original sites in tributaries of the Schuylkill River near Philadelpha. Williams' excellent redescription revealed that Cole and Minckley (1968) had busily described a form known for 150 years. How it was introduced to México remains a problem. It was collected about 10° latitude farther south than had been reported for any other member of the genus or closely related genera at that time. Since then, however, other asellids referable to *Caecidotea* have been described from Veracruz (Argano 1972), Chiapas (Bowman 1975*b*), and other southern Mexican and Guatemalan localities (Argano 1977). Suddenly at least five asellids were known to occur far south of *"Asellus puebla"*.

The etymologic history of the North American generic names in the Asellidae was outlined by Bowman (1975b). Briefly, *Asellus* Geoffroy St. Hillaire 1764, an Old World genus, is different, although at least one Alaskan isopod may belong to it. *Caecidotea* was coined by Packard (1871), who believed that a blind, white isopod from Mammoth Cave, Kentucky, belonged to the marine family Idoteidae. The first portion of Packard's genus is from the Latin *caecus,* meaning blind. Bowman (1975b) distinguished the first American *Asellus* of Say (1818) from the Old World genus. This left us with *Caecidotea,* on the basis of priority, as the genus for many of the asellid species this side of the Atlantic. Unfortunately, many *Caecidotea* species are pigmented epigean forms with well-developed eyes. Others are white and eyeless like the Mammoth Cave species, *C. stygia,* that Packard described on the basis of a single, damaged, immature specimen!

AMPHIPODA.—The first specimen of what proved to represent a new genus of amphipod crustacean, *Mexiweckelia* Holsinger and Minckley (1971) was found in Taylor's Spring, shown as a circle in Holsinger and Minckley (1971, Fig. 4) and a half-darkened circle in Cole and Minckley (1970, Fig. 40). One morning in August 1968, while I was showing Dwight W. Taylor the glass-jar trap used to catch nocturnally emerging *Sphaerolana* and *Speocirolana,* he called my attention to a ghostly amphipod trapped on the surface film of the tiny spring pool. The pool turned out to be the type-locality for *Mexiweckelia particeps* Holsinger (in Holsinger and Minckley 1971), where it coexisted with the smaller (ca. 3 mm, rather than 5.5 mm) and more widespread *M. colei,* known also only from the Cuatro Ciénegas basin. The serendipitous observation by Taylor led us to a method of collecting these new amphipods, that we believed were only one species: we vigorously stirred the fibrous plant detritus that lay at the bottom of some small spring-pools and pits, and searched for animals trapped on the water surface. We returned to Tempe at the end of August with more than 40 specimens of the tiny eyeless crustaceans. The aid of Dr. John R. Holsinger was sought in further study of the amphipods, for he had published many papers on subterranean peracaridans, and especially on the amphipods.

The amphipods from Taylor's Spring are related to a group of genera that were considered, at the time of their discovery, to be members of the family Gammaridae. That meant that they were the second freshwater gammarids to be reported from México, and they were the second type of subterranean amphipod known from that nation; *Bogidiella tabascensis* Villalobos-Figueroa 1961 had been described 10 years earlier from a cave in Tabasco. Since then the family Bogidiellidae has been redefined (Bousfield 1977) and is no longer considered synonymous with Gammaridae; Holsinger and Longley (1980) assigned *Mexiweckelia* and related genera to the family Hadziidae. Now the weckeliid genera are distinguished from other members of the Hadziidae on the basis of differences in uropod 3, the lower lip and, to a lesser extent, the female pereopod 2 (gnathopod 2) (Barnard and Barnard 1983). The Cuatro Ciénegas animals belong to the weckeliid group. The freshwater gammarid nearest to México may be some member of the *Gammarus pecos* complex, perhaps *G. hyalelloides* Cole 1976.

Meanwhile, in the dozen years that have passed since the description of the two *Mexiweckelia* species at least nine more species of subterranean amphipods have been named from México, and three or four undescribed forms have been noted (Holsinger 1982). Most of these are bogidiellids from southern México (Ruffo and Vigna Taglianti 1977), but *Mexiweckelia mitchelli* was described by Holsinger (1973) from material collected in a Durango cave. Furthermore, two new hadziids (weckeliid group) have been found in the cenotes of Yucatán, Campeche and the Territory of Quintana Roo, and assigned to a new genus, *Mayaweckelia* Holsinger (1977). Taxonomic changes have added further to the complexity of the Mexican amphipod story.

After the description of the two *Mexiweckelia* species from Cuatro Ciénegas there were discoveries which suggested the genus was rather widespread. Holsinger (1973) described *Mexiweckelia texensis* from an artesian well in San Marcos, Texas, in the same paper that reported *M. mitchelli.* With further study he decided that the Texas species represented a new genus, *Texiweckelia,* and the original species of 1973 was found to be comprised of two species of *Texiweckelia, T. texensis* and *T. insolita,* plus a new genus and species *Alloweckelia hirsuta.* A third species of *Texiweckelia, T. samacos,* was also present in the San Marcos well (Holsinger and Longley 1980). The remarkable congeneric coexistence of three *Texiweckelia* species lost its meaning when Barnard and Karaman (1982) erected the new genus *Texiweckeliopsis* on the basis of *T. insolita,* and changed *T. samacos* to *Holsingerius samacos,* gen. nov. These changes left *Mexiweckelia* restricted to the Cuatro Ciénegas bolsón and Cueva de la Siquita in Durango. The Durango species still belongs to *Mexiweckelia* (Holsinger, in litt. July 1983), diminishing the endemism of Cuatro Ciénegas to the level it was when Holsinger and Minckley (1971) reported the discovery of two species of a new, supposedly endemic genus *Mexiweckelia.* This will be offset when *M. particeps* becomes *Paramexiweckelia particeps,* a new monotypic genus, known only from Taylor's Spring (Holsinger, in press). We often wondered which species, *M. colei* or *M. particeps,* Dr. Taylor spotted on the surface film that day in August 1968; now we can ask, "Which genus did he see?"

All the freshwater hadziids are troglobites or phreatobites; they are found in Eurasia, in North America around the Caribbean, and are associated with the Tethys shores. The bogidiellids are much more widespread, and the discovery of a new species in the East Indian Archipelago by Stock (1983) fulfilled his belief in the antiquity of the family, it having reached a nearly world-wide distribution before the break up of Pangaea. Bousfield (1982) suggests that the Hadziidae and Bogidiellidae are about the same age and fairly young, going back to the Middle Cretaceous. Whatever the case, at least two bogidiellids have been discovered in San Marcos, Texas (Holsinger and Longley 1980, Barnard and Barnard 1983) and the gap between Texas and southern México may be closed some day with bogidiellids, as it is today with species of the weckeliid group of the Hadziidae.

LITERATURE CITED

ARGANO, R. 1972. An asellid of the subterranean waters of Veracruz, Mexico (Crustacea, Isopoda). Quaderni Accademia Nazionale dei Lincei, Problemi Attuali di Scienza e di Cultura 171:35-42.

__________. 1974. *Mexistenasellus magniezi,* n. sp., a blind aquatic isopod from Veracruz, Mexico (Crustacea). Quaderni Accademia Nazionale dei Lincei, Problemi Attuali di Scienza e di Cultura 171:97-103.

__________. 1977. Asellota del Messico meridional e Guatemala (Crustacea, Isopoda). Quaderni Accademia Nazionale dei Lincei, Problemi Attuali di Scienza e di Cultura 171:101-124.

AXELROD, D. I. 1979. Age and origin of Sonoran desert vegetation. Occ. Pap Calif. Acad. Sci. 132:1-74.

BARNARD, J. L. and C. M. BARNARD. 1983. Freshwater Amphipoda of the World: I. Evolutionary Patterns. II. Handbook and Bibliography. Hayfield Assoc., Mount Vernon, VA. i-xix, 1-830.

__________, and G. S. KARAMAN. 1982. Classificatory revisions in gammaridean Amphipoda (Crustacea), Part 2. Proc. Biol. Soc. Wash. 95:167-187.

BELK, D. 1975. Key to the Anostraca (Fairy Shrimps) of North America. Southwest. Nat. 20:91-103.

BOLIVAR y PIELTAIN, C. 1950. Estudio de una *Cirolana* cavernícola nueva de la región de Valles, San Luis Potosí, México. Ciencia, México 10:211-218.

BOUSFIELD, E. L. 1977. A new look at the systematics of gammaroidean amphipods of the world. Crustaceana (suppl.) 4:282-316.

__________. 1982. Amphipoda (Palaeohistory). *In* Yearbook of Science and Technology, pp. 96-100. McGraw-Hill Book Co., New York.

BOWMAN, T. E. 1964. *Antrolana lira,* a new genus and species of troglobitic isopod from Madison Cave, Virginia. Internat. J. Speleol. 1:229-236.

__________. 1975a. A new genus and species of troglobitic cirolanid isopod from San Luis Potosi. Occ. Pap. Mus. Tex. Tech Univ. 27:1-7.

__________. 1975b. Three new troglobitic asellids from western North America (Crustacea: Isopoda: Asellidae). Internat. J. Speleol. 7:339-356.

__________. 1981. *Thermosphaeroma milleri* and *T. smithi,* new sphaeromatid isopod crustaceans from hot springs in Chihuahua, Mexico, with a review of the genus. J. Crust. Biol. 1:105-122.

———. 1982a. *Speocirolana pubens* and *S. endeca,* new troglobitic isopods from Mexico (Flabellifera: Cirolanidae). Assoc. Mexican Cave Stud., Bull. 8:13-23/Bull. Tex. Mem. Mus., 28:13-23.

———. 1982b. Three new stenasellid isopods from Mexico (Crustacea: Asellota). Assoc. Mexican Cave Stud., Bull. 8:25-38/Bull. Tex. Mem. Mus. 28:25-38.

———. 1982c. Mysidacea. *In* S. H. Hurlbert and A. Villalobos-Figueroa, Editors. Aquatic Biota of Mexico, Central America and the West Indies, pp. 201-202. San Diego St. Univ., San Diego.

BROWN, W. L., JR. and E. O. WILSON. 1956. Character displacement. Syst. Zool. 5:49-64.

BURCKHARDT, C. 1930. Étude synthétique sur le Mésozoique mexicain. Mémoires de la Société Paléontologique Suisse. 40:1-280.

CLARK, L. S. and S. T. BOWEN. 1976. The genetics of *Artemia salina.* J. Hered. 67:385-388.

COLE, G. A. and W. L. MINCKLEY. 1966. *Speocirolana thermydronis,* a new species of cirolanid isopod crustacean from central Coahuila, Mexico. Tulane Stud. Zool. 13:17-22.

———. 1968. A new species of squatic isopod crustacean (Genus *Asellus)* from the Puebla Plateau, central Mexico. Proc. Biol. Soc. Wash. 81:755-760.

———. 1970. *Sphaerolana,* a new genus of cirolanid isopod from northern Mexico, with description of two new species. Southwest. Nat. 15:71-81.

———. 1972. Stenasellid isopod crustaceans in the western hemisphere–a new genus and species from Mexico–with a review of other North American freshwater isopod genera. Proc. Biol. Soc. Wash. 84:313-326.

———. and R. L. WATKINS. 1977. *Hyalella montezuma,* a new species (Crustacea: Amphipoda) from Montezuma Well, Arizona. Hydrobiologia 52:175-184.

CONTRERAS-BALDERAS, S. and D. C. PURATA-VELARDE. 1982. *Speocirolana guerrai* sp. nov., cirolanido troglobio anoptalmo de la Cueva de la Chorrera, Linares, Nuevo Leon, Mexico (Crustacea: Isopoda). Assoc. Mexican Cave Stud., Bull. 8:1-12/Bull. Tex. Mem. Mus. 28:1-12.

DICKSON, G. W., J. C. PATTON, J. R. HOLSINGER and J. C. AVISE. 1979. Genetic variation in cave-dwelling and deep-sea organisms, with emphasis on *Crangonyx antennatus* (Crustacea: Amphipoda) in Virginia. Brimleyana 2:119-130.

FREY, D.G. 1982. Questions concerning cosmopolitanism in Cladocera. Arch. Hydrobiologia 93:484-502.

HOBBS, H. H., JR. 1983. The African shrimp genus *Potamalpheops* in Mexico (Decapoda, Alpheidae). Crustaceana 44:221-224.

HOLSINGER, J.R. 1973. Two new species of the subterranean amphipod genus *Mexiweckelia* (Gammaridae) from Mexico and Texas, with notes on the origin and distribution of the genus. Assoc. Mexican Cave Stud., Bull. 5:1-12.

———. 1977. A new genus and two new species of subterranean amphipod crustaceans (Gammaridae s. lat.) from the Yucatan Peninsula in Mexico. Assoc. Mexican Cave Stud., Bull. 6:15-25.

———. 1982. Amphipoda. *In* S. H. Hurlbert and A. Villalobos-Figueroa, Editors, Aquatic Biota of Mexico, Central America and the West Indies, pp. 209-214. San Diego St. Univ., San Diego.

———. In press. *Paramexiweckelia,* a new genus of subterranean amphipod crustacean (Hadziidae) from northern Mexico. Internat. J. Speleol.

———, and G. LONGLEY. 1980. The subterranean amphipod crustacean fauna of an artesian well in Texas. Smithsonian Contrib. Zool. 308:i-iv, 1-62.

———. and W. L. MINCKLEY. 1971. A new genus and two new species of subterranean amphipod crustaceans (Gammaridae) from northern Mexico. Proc. Biol. Soc. Wash. 83:425-444.

IMLAY, R. W. 1943. Jurassic formations of the Gulf region. Bull. Amer. Assoc. Petrol. Geol. 27:1407-1533.

MAGNIEZ, G. 1972. Deux Stenasellidae cavernicoles nouveaux de l'Amérique centrale: *Mexistenasellus parzefalli,* n. sp. et *Mexistenasellus wilkensi* n. sp. (Crustacea Isopoda Asellota). Internat. J. Speleol. 4:19-31.

———. 1978. Quelques problèmes biogeographiques, écologiques et biologiques de la vie souterraine. Bull. Scientifique de Bourgogne 3:21-35.

———. 1981. Biogeographical and paleobiogeographical problems in stenasellids (Crustacea Isopoda Asellota of underground waters). Internat. J. Speleol. 11:71-81.

MINCKLEY, W. L. 1969. Environments of the bolsón of Cuatro Ciénegas, Coahuila, México with special reference to the aquatic biota. Tex. West. Press, Sci. Ser. 2:1-65. Univ. Tex. El Paso, El Paso.

———, and G. A. COLE. 1968a. *Speocirolana thermydronis* (Crustacea:Isopoda) from northeast Mexico, re-discovery *[sic],* habitat, and supplemental description. Tulane Stud. Zool. Bot. 15:2-4.

———. 1968b. Preliminary limnologic information on waters of the Cuatro Cienegas basin, Coahuila, Mexico. Southwest. Nat. 13:421-431.

PACKARD, A. S., JR. 1871. On the crustaceans and insects. *In* A. S. Packard, Jr. and F. W. Putnam, Editors. The Mammoth Cave and its inhabitants, pp. 739-761. Amer. Nat. 5(12).

———. 1900. A new eyeless crustacean from Mexico. Proc. Amer. Assoc. Advan. Sci. 49:228.

RIOJA, E. 1953. Estudios carcinologicos. XXX. Observaciones sobre los cirolánidos cavernícolas de México (Crustáceos, Isópodos). Anales del Instituto de Biologia Mexicana, Universidad Nacional Autónoma de México 24:147-169.

RUFFO, S. and A. VIGNA TAGLIANTI. 1977. Secondo contributo alla conoscenze del genere *Bogidiella* in Messico e Guatemala (Crustacea, Amphipoda, Gammaridae). Quaderni Accademia Nazionale dei Lincei, Problemi Attuali di Scienza e di Cultura 171:125-172.

SAUSSURE, H. 1858. Mémoire sur divers crustacés nouveaux des Antilles et du Mexique. Mémoires de la Société de Physique et d'Histoire Naturelle de Genève 14:417-496.

SAY, T. 1818. An account of the Crustacea of the United States. J. Acad. Nat. Sci. Phila. 1:374-401.

SHUSTER, S. M. 1981. Life history characteristics of *Thermosphaeroma thermophilum*, the Socorro isopod (Crustacea:Peracarida). Biol. Bull. 161:291-302.

SKET, B. and F. VELKOVRH. 1981. Podzemeljske živali v termalnih vodah (Subterranean animals in thermal waters). Bioloski Vestnik 29:91-119.

SMALLEY, A.E. 1964. A new *Palaemonetes* from Mexico. Crustaceana 6:229-232.

STEVENSON, M. M. and A. E. PEDEN. 1973. Description and ecology of *Hyalella texana* n. sp. (Crustacea: Amphipoda) from the Edwards Plateau of Texas. Amer. Midl. Nat. 89:426-436.

STOCK, J. H. 1982. The influence of hadziid Amphipoda on the occurrence and distribution of the Thermosbaenacea and cyclopoid Copepoda in the West Indies. Polskie Archiwum Hydrobiologii 29:275-282.

__________. 1983. Discovery of a bogidiellid amphipod crustacean in inland waters of the East Indian archipelago: *Bogidiella (Medigidiella) sarawacensis* n. sp. Crustaceana 44:198-204.

WARD, J. V. and J. A. STANFORD. 1982. Thermal responses in the evolutionary ecology of aquatic insects. Ann. Rev. Ent. 29:97-117.

__________. 1983. The intermediate-disturbance hypothesis: an explanation for biotic diversity patterns in lotic ecosystems. *In* T. D. Fontaine, III, and S. M. Bartell, Editors. Dynamics of lotic ecosystems, pp. 347-356. Ann Arbor Sci. Publ., Ann Arbor.

WILLIAMS, W. D. 1970. A revision of North American epigean species of *Asellus* (Crustacea: Isopoda). Smithsonian Contrib. Zool. 49:1-80.