Chapter 3

# Cave Biodiversity and Ecology of the Sierra de El Abra Region

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## INTRODUCTION

In this chapter, I discuss the general ecology and biodiversity of fish caves in the Sierra de El Abra region, and describe four important, but very different, caves within the El Abra region.

## BIODIVERSITY

Over 200 caves have been found in the lowland Sierra de El Abra, with hundreds more in the adjacent areas. There are many distinct cave types within this region, including dry, fossil resurgence caves, deep collapse pits, and fissures on the eastern crest of the El Abra, and on the west flank of the El Abra hydrologically dynamic swallet caves, which contain most of the cavefishes. Between those areas a deep fissure cave, Sótano de Soyate, reaches to the base level of the regional aquifer, which drains to the large spring, Nacimiento del Río Choy (see Figures 1.3 and 1.4 in Chapter 1).

These environments contain more than just cavefishes—some are significant bat roosts with up to six species of bats, which contribute guano (droppings) and dead bodies to the cave's basic energy flow. Associated with the bat guano, flood debris, and moist organic films are rich invertebrate communities where new species have been found, including unusual arachnids, such as ricinuleids, schizomids, mites, a blind scorpion, and many insects. Lacking sunlight, cave communities depend upon decomposing organic materials transported in by animals, water, and gravity. These communities have short food chains compared to surface environments, with tiny springtails, thysanurans, mites, and millipedes at the base, and micropredators, such as arachnids and some beetles at the top. The aquatic and amphibious crustacean fauna is also rich in species. Nothing is known to prey on the cavefishes, which is the top predator/scavenger in the ecosystem.

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Forty years ago, 265 species were documented in the caves of the lowland Sierra de El Abra (Reddell and Elliott, 1973a,b), but taxonomic work probably has increased this to nearly 300. Only six fish caves in the region have received thorough biological study: Cueva Chica (60 species identified including 4 troglobites), Sabinos (59 with 9), Tinaja (53 with 2 troglobites), Pachón (42 with 4 troglobites), Yerbaniz (35 with 10 troglobites, including a blind scorpion, Figure 3.1), and Tigre (29 species with 6 troglobites). Easy access on foot to the first four caves allowed teams of biologists to enter many times to collect and observe fauna. Sótano de Yerbaniz and Sótano del Tigre, although vertical, were visited repeatedly for mapping and biological study. Further studies are needed of the other caves. We still do not know exactly which species and energy sources nourish the cavefishes and other species the most, but bat guano appears to be important, which is often true in temperate caves as well.

There are several karstic biogeographic subregions in the area. The Sierra de El Abra subregion contains at least 25 species of troglobites (blind, usually albino, cave-adapted forms): 13 aquatic species and 12 terrestrial species (Reddell and Mitchell, 1971a,b; Reddell and Elliott, 1973a,b; Reddell, 1981), and it shares many species with the Sierra de Guatemala to the north (see the chapter on cave exploration and mapping). The Sierra de Guatemala subregion contains a remarkable assemblage with a higher proportion of troglobites, at least 38 known species, including 10 aquatic and 28 terrestrial species, some of them unique to this subregion. The highlands of the Sierra de Guatemala underwent more climatic changes and isolation of terrestrial species in caves than the tropical lowlands; however, the lowlands had a long history of marine forms invading subterranean habitats along the coast as the freshwater karst developed there, followed by the arrival of freshwater fishes and colonization by ancestral *Astyanax* in stream-capturing caves. The Micos area is another subregion.

**FIGURE 3.1** *Sotanochactas elliotti* (Mitchell), a delicate troglobitic scorpion about 10 mm long from Sótano de Yerbaniz. *By Robert W. Mitchell (with permission of Sharon and Linda Mitchell).*

The nacimientos (large springs) may be considered yet another biogeographic subregion with some similarities to the El Abra and Guatemala caves, but with unique fauna. A tiny blind catfish, *Prietella lundbergi* (Walsh and Gilbert, 1995), inhabits two small nacimientos on the eastern face of the region, Cueva del Nacimiento del Río Frío and Nacimiento de San Rafael de los Castro, along with two new species of *Troglomexicanus* shrimp not found in the *Astyanax* caves (Hendrickson et al., 2001; Villalobos et al., 1999). Cave divers have not found *Astyanax* cavefish in the nacimientos, which receive "type-A waters" from the local ranges, as well as "type-B waters," with hydrogen sulfide and dissolved salts, from deeper circulation (Fish, 1977, 2004); therefore, these zoogeographic patterns suggest that ancestral cavefishes did not invade the karst through springs, but rather were isolated through stream capture.

The intensive stream capture that occurs in the El Abra region contrasts to other karst regions, such as the Yucatán peninsula, where marine-derived fishes, such as the bythitid, *Typhliasina pearsei*, and the synbranchid eel, *Ophisternon infernale*, invaded fresh groundwater in the karst from littoral habitats and perhaps through submarine karst springs (Reddell, 1981).

## GENERAL CAVE ECOLOGY

### Hazards to Cave Visitors

The following is a guide for field researchers or cavers who may want to explore caves in the Sierra de El Abra, or similar caves. Driving and hiking to a cave can be hazardous if one is not prepared with plenty of drinking water, proper clothing, maps, and planning. Heat exhaustion can occur in the humid tropical climate; temperatures in the El Abra region often exceed 40 °C in the spring and summer. Even the easy caves require caving gear: helmets with chin straps, three light sources per person, spare batteries, sturdy clothing, gloves, and good gripping boots. The vertical caves require rigorous training by experienced vertical cavers in single-rope technique and safety rules, such as in a tree or gymnasium, well before descending into a pit. A strong cable ladder with a belay line may be used for short pitches, but prior training is best. For pitches deeper than about 10 m, tough caving rope is much preferred over dynamic climbing rope, and it must be protected from rubbing, cutting, and excessive mud by various methods. Of course one should not enter the swallet caves during the rainy season (September to November), or anytime that rain threatens due to the possibility of flooding. Cave diving is quite dangerous and should not be attempted even for short distances without cave-diving certification. In some caves such as Arroyo, Tinaja, and Venadito, methane bubbles occasionally rise from stream bottoms when disturbed by wading. $CO_2$ at normal atmospheric level is about 0.035%, but it has been measured up to 3.8% in Arroyo, high enough to risk panting and exhaustion, and 0.08-0.10% in Tinaja, which is tolerable for fit people. While it has not been directly measured, it is likely that most of the caves in the Sierra de el Abra have elevated $CO_2$ in the summer and fall.

An additional and commonly encountered danger is histoplasmosis, a serious fungal infection of the lungs, but sometimes the eye, which often hits visitors from Europe, Canada, or the northeastern United States, where it is rare in the environment. It comes from microscopic spores growing on bat guano in caves or bird roosts. Most experienced cavers in Texas and Mexico are somewhat resistant to "histo," but it can result in hospitalization for those who have not been previously exposed. The symptoms are malaise, difficult breathing, and fever, but it can be effectively treated with specific antifungals upon diagnosis. Rabies virus may be found in some bats, and no one should handle bats unless they have been vaccinated and trained in bat study. A rabies infection is nearly always fatal. Bats are ecologically important and should not be unduly disturbed by visitors. Finally, be alert for the large, highly venomous fer-de-lance pit viper, *Bothrops asper*, which cavers have encountered in the bush or, rarely, at the bottom of entrance pits.

## Temperatures

The caves of the region are warm, about 23 °C, approximating the average annual temperature of the region, as do most caves throughout the world. Breder (1942) thought that Cueva Chica had an unusually warm temperature, but follow-up studies found it to be normal for the area. Osorio Tafall (1943) noted that Ciudad Valles' annual average was 26 °C; today's more accurate value is 24.7 °C (Climate-data.org). Cooler temperatures may prevail in rainy season runoff, which has been noted to trigger reproductive behavior in the cavefishes. Pit caves may trap cold, dense air in winter, while air currents and limited evaporation may cool the cave slightly. The author has gleaned water temperatures from 20 measurements in 16 fish caves, from papers by several authors and unpublished cave maps. The mean temperature was 23.1 °C, the standard deviation 2.6 °C. The range was 10.5 °C, from 18.5 °C in winter in the upper pool of Sótano del Molino to 29 °C in summer at Lake 3 in Sótano de Yerbaniz. Probably these differences can be explained by winter versus summer storm runoff that occurred shortly before the temperatures were measured. The water temperatures would equilibrate to that of the bedrock given enough time.

## Cavefish Food

Cavefish food includes bat guano, internal parasites in the guano, crickets, other fishes (cannibalism), and probably flood debris, flies, moths, floating dead bats, guano invertebrates, dead frogs, and perhaps free-swimming crustaceans. The cavefishes are known to be sensitive to disturbances and home in on objects in the water, sometimes schooling or swarming. Some authors have said they are bottom feeders and do not school, but they probably scavenge opportunistically anywhere in the water column, especially on floating objects.

Breder (1942) examined the gut contents of cavefishes in Cueva Chica and said, "Their stomach contents were found to consist of bat droppings and parts of other and smaller cave characins and their eggs. This would suggest that the only regular input of energy into the population for large parts of the year is bat dung. Their ability to thrive and reproduce on the ordinary foods supplied to small aquarium fishes also suggests the lack of any peculiar specialization in dietary requirements." Osorio Tafall (1943) made a thorough study of the invertebrates of Cueva Chica and Cueva de Los Sabinos. He found that the main source of cavefish food is bat guano. Plankton, though diverse and abundant, were not found in the cavefish gut, despite numerous examinations. His team found "murcielaguina" (bat guano), insect parts, and sometimes fragments of other cavefishes. In a 40 mm fish with a distended abdomen, they found a nearly intact gryllid cricket, *Paracophus apterus*. These wingless crickets usually are seen on walls and upside-down on ceilings, and they sometimes fall into the water. Bats and crustaceans are detailed below.

Wilkens and Burns (1972) studied the new population of "Micosfish" in Cueva del Río Subterráneo near Micos. The cave also has surface *Astyanax mexicanus* and *Poecilia sphenops* (Poeciliidae). *Astyanax* and Micosfish feed on bat guano, probably from the bat *Pteronotus parnellii* (field-identified from this cave by Elliott in March 2013), and the Micosfish also feeds on other fishes. The surface fishes appear to be undernourished and the Micosfish probably feeds on them as they succumb from competition in darkness.

## Bats

Bat guano appears to be a critical food source for the cavefishes and other fauna. The richest fauna (highest number of species) occurs in caves with a large number of bat species. Having more species of bats probably indicates that there is more suitable bat roost habitat in that cave, such as many high domes at various temperatures, and therefore more total bat guano. Table 3.1 provides an overview of the known bats of the region. Most of the 29 fish caves occasionally have bats, but only a few have large bat colonies. The common vampire bat is often reported, but in low numbers; its guano often is a recognizable puddle of dark purple liquid with a strong ammonia odor and many flies and their larvae.

## Crustaceans

The cavefishes could prey on several species of groundwater crustaceans: *Speocirolana* isopods, various shrimp, and undiscovered aquatic species. Five species of *Speocirolana* isopods have been found in the greater El Abra region. *Speocirolana bolivari* (Figure 3.2) crawls and swims in deep cave waters and could be a prey of *Astyanax*. The amphibious *S. pelaezi* is not a likely prey for cavefishes, as it inhabits smaller drip pools not usually inhabited by *Astyanax*; it has been identified in 15 caves in the region, three with no *Astyanax*. Amphibious isopods of the genus *Brackenridgia* also probably

**TABLE 3.1** Nine Bat Species in 13 Fish Caves.

| Label | Cave | Atja | Bapl | Dero | Diec | Glso | Mome | Nast | Ptda | Ptpa | Bats | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 6 | Vásquez | | | | | | | | | | 1 | 1 |
| 7 | Pachón | 1 | | 1 | 1 | 1 | | 1 | | 1 | | 6 |
| 8 | Venadito | | | | | | | | | | 1 | 1 |
| 9 | Yerbaniz | | | 1 | | | | | | | | 1 |
| 12 | Tigre | | | | | | | | | | 1 | 1 |
| 14 | Sabinos | 1 | 1 | 1 | 1 | 1 | | | | | | 5 |
| 16 | Tinaja | | | 1 | | | | | | | 1 | 2 |
| 18 | Montecillos | | | 1 | | | | | | | | 1 |
| 21 | Piedras | | | | | | | | | | 1 | 1 |
| 24 | Subterráneo | | | | | | | | | 1 | | 1 |
| 26 | Curva | 1 | | 1 | | | | | | | | 2 |
| 28 | Chica | 1 | | 1 | | | 1 | 1 | 1 | 1 | | 6 |
| 29 | Los Cuates | | | 1 | | | | | | | | 1 |

Five other bat species have been identified in nonfish caves of the region. Most data are from Mollhagen (1971). The identification of *Pteronotus parnellii* in Cueva del Río Subterráneo and some other data are by the author. Vampires usually are few, but are easily identified from their distinctive guano, so they are reported more often than other bats.

Abbreviations are as follows: Atja, *Artibeus jamaicensis*, Jamaican fruit bat; Bapl, *Balantiopteryx plicata*, Gray sac-winged bat; Dero, *Desmodus rotundus*, Common vampire bat; Diec, *Diphylla ecaudata*, Hairy-legged vampire bat; Glso, *Glossophaga soricina*, Common long-tongued bat; Mome, *Mormoops megalophylla*, Ghost-faced bat; Nast, *Natalus stramineus*, Mexican funnel-eared bat; Ptda, *Pteronotus davyi*, Davy's naked-backed bat; Ptpa, *Pteronotus parnellii*, Parnell's mustached bat; Bats, unidentified bats and guano indicated on cave maps.

**FIGURE 3.2** *Speocirolana bolivari* (Rioja), about 20mm long, from Grutas de Quintero. *By William R. Elliott.*

avoid cavefish predators. Swimming *Troglomexicanus* shrimp and mysid shrimp rarely have been seen by wading biologists, so we do not yet know their potential as prey for *Astyanax*.

## ECOLOGY OF FOUR CAVES

### Sótano de Yerbaniz

Sótano de Yerbaniz was discussed in detail by Elliott (2014) and in Chapter 1 as a typical swallet (stream-capture) cave, but with violent flooding. It has the largest catchment basin (area that captures runoff) of all the El Abra caves at 16 $km^2$. Yerbaniz, being a younger swallet than Matapalma, could have already contained cavefishes that arrived via groundwater before stream capture occurred. Surface fishes and hybrids are sometimes found in shallow pools in the cave. As there are few bats, most of the food input is from flood debris and dying surface fishes.

Sótano de Yerbaniz has 35 species with 10 troglobites:

1. *Sphaeromicola cirolanae* Rioja: an ostracod commensal on *Speocirolana pelaezi*
2. *Speocirolana pelaezi* (Bolívar): an amphibious isopod generally found in small pools
3. *Cylindroniscus* sp. nr. *vallesensis* Schultz: an amphibious isopod found on rotten wood
4. *Sotanochactas elliotti* (Mitchell): the world's rarest and most cave-adapted scorpion, about 10 mm long and translucent, known only from Yerbaniz (Figure 3.1)
5. *Agastoschizomus lucifer* Rowland: a small arachnid predator, but the largest species of the Order Schizomida, it is known only from three caves in the Sierra de El Abra

6. *Hoplobunus boneti* (Goodnight and Goodnight): a large harvestman with reduced eyes
7. *Newportia sabina* Chamberlin: a small, slender scolopendrid centipede known from Cueva de Los Sabinos, Sótano de la Tinaja, Sótano de Yerbaniz, and Bee Cave
8. *Anelpistina quinterensis* (Paclt, 1979): a rather large cave silverfish (8.5 cm long, antennae and caudal appendages included), which was first described from Grutas de Quintero near Ciudad Mante, Tamaulipas; when re-describing the species, Espinasa et al. (2007) reported it from Cueva de El Pachón and Yerbaniz
9. *Pseudosinella petrustrinatii* Christiansen: a tiny springtail (collembolan) that feeds on bacteria or fungi on organic material
10. *Astyanax mexicanus*

## La Cueva Chica

La Cueva Chica was the first cave in which Mexican cavefishes were found, and the type locality of Hubbs and Innes' *Anoptichthys jordani* (1936), but it is the least representative of the known fish caves. Its entrance lies about 1 km north of El Pujal and 1.5 km north of the Río Tampaón.

Cueva Chica was originally mapped by Breder in 1940, but somewhat inaccurately (see Chapter 1). Elliott and others remapped the cave from 1971 to 1974 (Figure 3.3), and they surveyed overland to locate pools near the river, and the caves, Los Cuates and Cueva El Mante (Figure 3.4). Cueva Chica's entrance is at about 68 m above mean sea level (msl); its horizontal length is 573 m and its mapped extent is 591 m. The cave is 19 m deep from the entrance floor to the bottom of the sump at Pool 4. The cave follows a joint trend at 192° under a low ridge, which may be a structural fold in the El Abra limestone. The overlying San Felipe shale crops out just above the entrance ledge. The contact between the San Felipe and the El Abra can be seen in high domes in the first half of the cave, as depicted on the map.

A shallow arroyo from the north apparently downcut through the shale and was captured in the joint-controlled cave passage, resurging at risings under the Río Tampaón. As the terrain eroded and the river downcut, the cave was mostly drained, leaving a vadose (partially air-filled) conduit through which groundwater and captured floodwater flows to the sump, then to tinajas (water holes) near the river. The river backfloods into the lower cave pools via these three tinajas at about 48 m msl. The cave's south end is 1230 m from the river, and 970 m from the tinajas. The terminal sump bottom, at −19 m, is at 49 m elevation, about 7 m above the river's typical level of 42 m at the shoreline. Eyed *Astyanax* and even river prawns and crayfishes enter the lower cave system during high water times, fair proof of a connection to the river.

The cave has a succession of pools stepping down from the entrance, with cavefishes in Pool 1. Pools 1 and 2 receive a clear flow of subterranean water

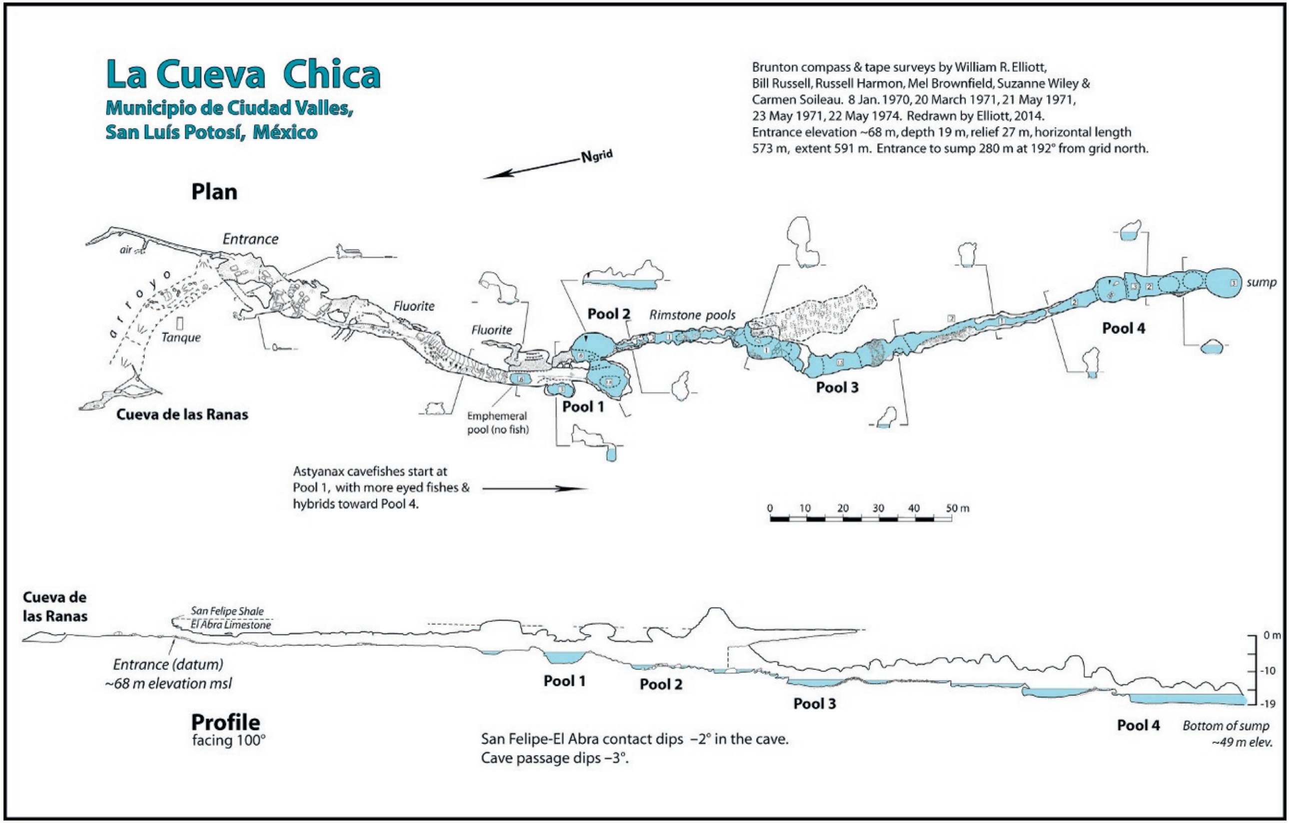


**FIGURE 3.3** La Cueva Chica map, by William R. Elliott. See legend of AMCS cave map symbols in Chapter 1, Figure 1.17. *Copyright © 2015 William R. Elliott. All rights reserved.*

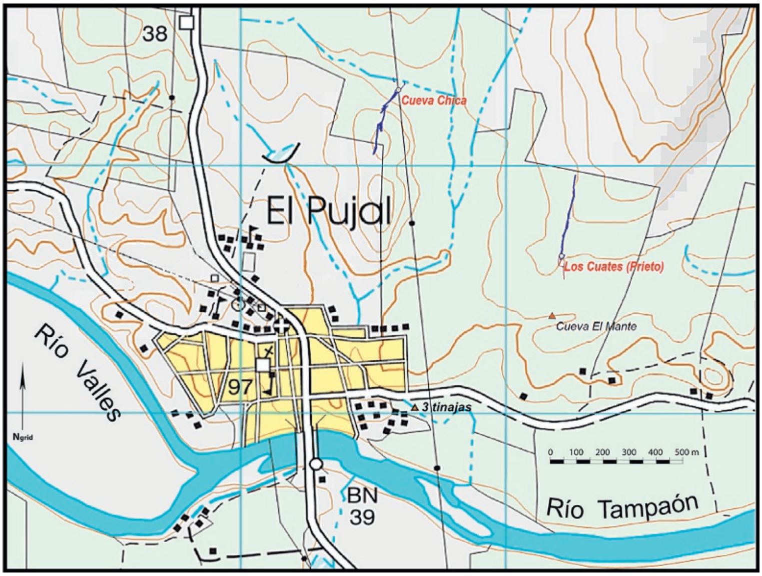


**FIGURE 3.4** Cueva Chica area map. *By William R. Elliott based on INEGI 1:50,000 topographic map and 1974 surveys by the author. Copyright © 2015 William R. Elliott. All rights reserved.*

and, presumably, cavefishes from the regional aquifer to the north (Figure 3.5). There are successively more hybrids with eyed fishes as one travels downstream through cascades to Pools 3 and 4. This situation intrigued biologists for decades, as it was mistaken for a process of evolution from river to cave form within one cave. As more fish caves were found, it became clear that highly troglomorphic (cave-adapted) cavefishes occurred in most sites. A few caves, such as nearby Los Cuates, Sótano de Yerbaniz, Sótano de Matapalma, three Micos caves, Bee Cave, and Sótano del Caballo Moro have intermediate forms (Mitchell et al., 1977).

In the last half of Cueva Chica, most surfaces are covered with guano. Bridges (1940) characterized the last part of the cave as "a nightmare of slime and the stench of bats." The author can confirm Bridges' colorful observation, having swum through Pool 4 with a survey tape while beset with floating dead bats, vampire guano, and leeches.

The cave was known locally, but was "discovered" and its fishes collected in November 1936 by Salvador Coronado, who was employed by the Mexican fisheries agency, Dirección General de Pesca e Industrias Conexas, Secretaria de Marina de México (Mitchell et al., 1977). Specimens were sent to C. Basil Jordan of the Texas Aquaria Fish Company of Dallas, Texas, who soon introduced the cavefishes to the aquarium trade. Specimens were also sent to Carl Hubbs, the famous ichthyologist who described the new species and named it for Jordan (Hubbs and Innes, 1936). The original stock from Cueva Chica then became the common "commercial cavefish" in pet stores, which proved to be hardy and easy to raise. They are of reduced value to scientists because

**FIGURE 3.5** Robert W. Mitchell collecting cavefishes in Cueva Chica, about 1969. *By Francis Abernethy and Robert W. Mitchell.*

of decades of selective breeding for troglomorphic traits, but they are a great educational tool. As far as is known, no additional cavefishes were taken from the cave for the aquarium trade, and it is not a conservation problem to possess commercial Mexican cavefishes.

Cueva Chica was studied in detail by a 1940 expedition of the American Museum of Natural History led by Charles M. Breder (Bridges, 1940; Breder, 1942). They concentrated on the ecology of the cavefish. Breder and his associates contributed greatly to our knowledge of the cavefishes in a series of some two dozen papers dealing with a wide variety of research. By 1946, additional caves were studied: Pachón, Arroyo and Tinaja (Breder and Rasquin, 1947). Overgeneralizations were sometimes made about the region's caves based upon Cueva Chica, which is an atypical sample of the region's fish caves. Cueva Chica probably was not the original site of cavefish evolution in the region. As we now know, most of the caves are not near a river, so surface fishes rarely get in, and if they do, they often perish or become fish food for the cave form; however, sometimes a few hybrids are seen. The dynamics of surface versus cavefish interactions have not been researched well *in situ*, as it is difficult to do (see the story of Suzanne Wiley's study in Yerbaniz in Chapter 1).

Cueva Chica and Cueva de Los Sabinos were also studied by Bibiano Osorio Tafall (1943) and a team of cave scientists from Mexico City's Escuela Nacional de Ciencias Biológicas: Candido Bolívar y Pieltain, Federico Bonet, and Dionisio Peláez, accompanied by three assistants, Cárdenas, Correa, and José Álvarez del Villar, who later described two more *Anoptichthys* (Álvarez, 1946, 1947). Their extensive sampling resulted in identifications of 37 aquatic species from the two caves and a description of a new species of troglobitic copepod. Many terrestrial species, including invertebrates, amphibians and bats, have been identified since then, giving a total of about 60 species (including four troglobites) in Cueva Chica and 59 (with nine troglobites) in Cueva de Los Sabinos. These remain among the richer known cave communities in the region.

Many authors have studied the Cueva Chica fishes, most frequently sampling from Pool 2, and noted that cave and surface fishes were hybridizing there (Breder, 1942, 1943; Sadoglu, 1957; Avise and Selander, 1972; Espinasa and Borowsky, 2001; Strecker et al., 2003; and others). A frequently overlooked study by Romero (1983) found that introgression between surface and cavefish had continued in Pool 2 since the original studies of 1936-1942, as measured using Breder's criteria for eye condition and pigmentation. Romero concluded that introgression (stabilization of backcross types) took place in Pool 2 in about 40 years. By 1983, there were fewer blind and fully eyed types, fewer pigmented types, and more intermediate types there. Strecker et al. (2003), working with microsatellite and mtDNA (mitochondrial DNA), and without knowledge of Romero's study, concluded that the Cueva Chica population evolved recently from a surface population, and subsequently hybridized with a phylogenetically older cave population. I have examined current topographic maps, and besides the connection to the river, it seems possible that nearby stock-watering ponds may be worth investigating as another source of surface fishes entering Cueva Chica via runoff into the cave entrance.

Troglobites in Cueva Chica:

1. *Diaptomus (Microdiaptomus) cokeri* Osorio Tafall: a tiny copepod found in pools of Cueva Chica and Cueva de Los Sabinos
2. *Speocirolana pelaezi* (Bolívar): a blind, albino, amphibious isopod known from 20 caves in the Sierra de El Abra region
3. *Brackenridgia bridgesi* (Van Name): a blind, amphibious isopod that inhabits nine caves in the Sierra de El Abra and one in the Sierra de Guatemala
4. *Astyanax mexicanus*

## Cueva de Los Sabinos

Cueva de Los Sabinos is a classic cavefish cave and type locality of Álvarez's *Anoptichthys hubbsi* (1947). It is a large, complex cave on one level, with a southwesterly flowpath to a sump (submerged passage) connecting to Sótano del Arroyo. It is part of the Sistema de Los Sabinos, comprising Sabinos, Sótano del Arroyo, and Sótano de la Tinaja.[1]

This cave is located about 13 km north-northeast of Ciudad Valles and about 4 km east of the village of Los Sabinos, from which it takes its name.[2]

The entrance of the cave, about 30 m wide and 15.5 m high, is formed on the side of an indistinct branch of the arroyo captured by Sótano del Arroyo. The entrance probably no longer takes much floodwater. Even so, tree trunks and other organic debris make their appearance in the cave. A sump (submerged passage) unites the two caves, and floods from Sótano del Arroyo apparently invade Sabinos. Tinaja approaches close to the south side of Arroyo, and the three caves are hydrologically one unit with semi-isolation among them during dry times.

Sabinos was partly surveyed by the American Museum of Natural History expedition in 1946. About 900 m were surveyed to an indicated depth of 99 m. The resulting map was never published. Bonet (1953) provided a map of the cave apparently done by compass and pace, in which one uses a simple compass and paces off rough distances and directions while making notes. This method is useful for preliminary surveys or small caves only. The cave was resurveyed in 1972 by John Fish, Don Broussard, P. Thompson and others. This map (Fish, 1977, 2004) indicates a total length of 1502 m and a maximum depth of 95.5 at a bottom elevation of 144 m.

From the large entrance room, upper and lower levels trend northeast for 70 m to a large shaft where they rejoin. The lower level continues on for 150 m to the "Guano Room," inhabited by a large bat colony. Also from the entrance room is another passage that trends southeast for about 60 m to a point where a steeply sloping drop of 33 m is encountered. Beyond this drop, the passage enlarges to form a series of rooms extending about 150 m to a sump connecting to Sótano del Arroyo.

About 70 m past the sloping drop is a pool that leads through a small constriction into a large water passage, "Elliott's Swim," explored in 1970 by the author. After 250 m of northeast-trending pools 1 to 2 m in depth, walking passage is encountered, and the passage then continues about 200 m to a sump at the deepest point in the cave.

Troglobites in Cueva de Los Sabinos:

1. *Diaptomus (Microdiaptomus) cokeri* Osorio Tafall
2. *Sphaeromicola cirolanae* Rioja: this commensal ostracod crustacean, known from 15 caves in the El Abra and Sierra de Guatemala, has been taken from both *Speocirolana bolivari* and S. *pelaezi*
3. *Speocirolana pelaezi* (Bolívar): a 20 mm long, white, blind aquatic isopod

1. Maps of these caves may be seen in Fish (1977, 2004) and on the Association for Mexican Cave Studies (AMCS) website.

2. Its first exploration and the first blind-fish collection made in it were on April 3, 1942 by C. Bolívar y Pieltain, F. Bonet, B.F. Osorio Tafall, D. Peláez, M. Correa, and J. Álvarez (Osorio Tafall, 1943; Álvarez, 1946).

4. *Pseudosinella strinatii* Christiansen (det. K. Christiansen): a troglobitic collembolan (springtail) known from nine caves in the Sierra de El Abra
5. *Spherarmadillo cavernicola* Mulaik: an eyeless pillbug (terrestrial isopod crustacean) from the El Abra and Sierra de Guatemala
6. *Brackenridgia bridgesi* (Van Name): a sowbug (different type of isopod) from the El Abra and Sierra de Guatemala
7. *Hoplobunus boneti* (Goodnight and Goodnight): a large harvestman, a spider-like arachnid, with reduced eyes, this abundant species is frequently found on cave walls or silt banks, known from 15 caves
8. *Anelpistina quinterensis* (Paclt): a large, slender thysanuran or silverfish, known from many caves in the Sierra de El Abra and Sierra de Guatemala
9. *Astyanax mexicanus*

## Sótano de Soyate

Sótano de Soyate (Figure 3.6) is the deepest cavefish site in the southern Sierra de El Abra. First explored by William R. Elliott, Jim McIntire, and Don Broussard in 1969, its 195-m entrance pitch leads to two short pitches to a large, clear lake at −234 m. This base level lake rises and falls in synchrony with the Nacimiento del Río Choy (Fish, 1977, 2004). In the lake resides a large population of cavefishes, studied by Elliott (Elliott, 1970; Mitchell et al., 1977), but this population has not been genetically analyzed. Live and preserved specimens were brought to Mitchell's laboratory in 1969, but they did not get into any genetics study. The population may represent an isolated, large, base-level population, or it may have episodic gene flow with the many perched-lake populations in different caves. The cave is oriented at 208° from true north, roughly north-northeast and south-southwest. No flow direction was reported, but the cave likely is a major conduit to the south and eventually to the Río Choy.

Soyate's deep fissure may have captured a shallow arroyo long ago, as there is a short headwall at the north end of the entrance, but there is no distinct arroyo remaining. Fish (1977, 2004) proposed that the cave is a phreatic void, a fissure that was enlarged by groundwater over time, followed by seepage waters depositing calcite on the upper shaft walls.

Troglobites from Sótano de Soyate:

1. *Hoplobunus boneti* (Goodnight and Goodnight): a large harvestman with reduced eyes, this abundant species is frequently found on cave walls or silt banks, known from 15 caves
2. *Anelpistina quinterensis* (Paclt): thysanuran
3. *Astyanax mexicanus*

Soyate has low food input. A few bats were seen by cavers in the upper shaft, but none at the bottom. There is little surface runoff. A few terrestrial invertebrates may fall into the lake. The Soyate cavefishes seemed to congregate at the surface of the deep lake, but they may only have been attracted

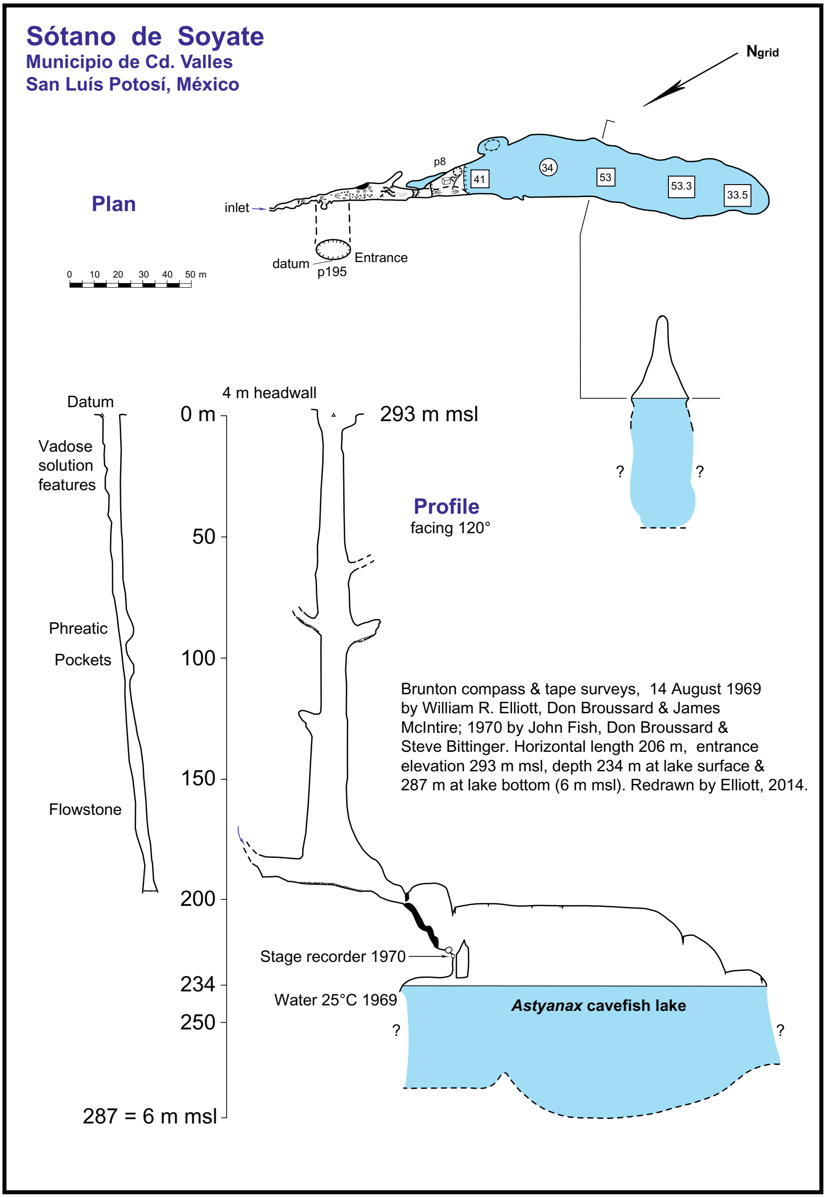


**FIGURE 3.6** Sótano de Soyate map. *By William R. Elliott.* 

to the disturbances caused by the explorers. Further studies of this population would yield information on their use of the water column, prey, and population biology. They may represent a large, base-level population differing from the perched-lake populations with which we are familiar. How such a large population subsists without much apparent food input is a mystery. I suggest that they may have an annual boom/bust cycle, in which the rainy season brings ample organic material into the deep groundwater, then they gorge, gain weight, and reproduce. This may be followed by a starvation period during which they cannibalize other cavefishes. Soyate deserves much more study, and its cavefishes should be sampled for genetic analysis.

## CONCLUSIONS

Soyate and Yerbaniz both have large cavefish populations, but they may have opposite extremes of food input. We must remember, however, that humans can only observe for short periods of time, and not usually during and just after flood events, and therefore a detailed understanding of the ecology within the caves is lacking.

In March 1971, Mel Brownfield and I made cavefish population estimates in Sótano de Yerbaniz and Cueva del Pachón. Using a two-census, mark-recapture method (Lincoln Index), I statistically estimated the Lake 1 population in Yerbaniz at about 8700, with a wide 95% confidence interval of 1810-15,534 owing to the small number recaptured out of 201 marked. Pachón also had a large population, about $9800 \pm 8502$ (Mitchell et al., 1977).

There may be extremely large numbers of cavefishes in the El Abra region at base level, but not in upper pools. The bottom of Sótano de Soyate has a large population of cavefishes not yet estimated. This is interesting to cavefish biologists because of its implications for gene flow among semi-isolated populations. The vertical dimension of the caves must be kept in mind. Small, upper-level populations may sometimes die out, or experience genetic bottlenecking and fixation or loss of some alleles through inbreeding. Large populations could incorporate the results of these genetic drift "experiments," so to speak, when floods reconnect them temporarily to upper-level pools. The large populations could secondarily transmit some of these alleles to other caves through the base-level aquifer. Perhaps this is why some alleles are widespread while others are rare.

Finally, conservation efforts for the Mexican cavefish caves must begin. Land clearing and runoff of sediments, petroleum products, chemicals, and trash could adversely affect the cavefishes and groundwater (Elliott, 2007). The cavefishes are dependent upon bat colonies and other cave fauna for food; therefore, bat colonies should be maintained. A few fish caves already are within the Reserva de la Biósfera El Cielo in the Sierra de Guatemala. Perhaps some of the cave clusters and arroyos could be included as satellites of the Reserva de la Biósfera Sierra de El Abra Tanchipa. Further details and maps of 29 fish caves will be published in an AMCS Bulletin (Elliott, in press).

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