

## The Edwards Aquifer: Earth's Most Diverse Groundwater Ecosystem?

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### SUMMARY

Recent studies on the Edwards Aquifer, a karstic formed cavernous system in Texas, indicate an extremely diverse community of aquatic troglobites. Sampling of wells and springs is providing new insight into the dynamics of this fascinating system, which is possibly the most diverse subterranean aquatic ecosystem known in the world today.

The Edwards Aquifer is found in association with the Balcones Escarpment in central Texas. The Balcones Escarpment and Fault Zone is the dominant structural feature in the area, and the major faults occur as a series of closely spaced step faults that trend eastward in Kinney County to Bexar County area then northeastward from Bexar County to Hays County. The Edwards Aquifer is a porous, honeycombed, cavernous limestone that consists of fine grained carbonate rocks between the base of the Del Rio Clay and the top of the Glen Rose Formation. The thickness of the porous beds of Edwards limestone varies between 122 and 152 m (Puente, 1976). The aquifer is about 282 km long, from 8 to 64 km wide, and has two major features: the recharge area and the artesian area (Fig. 1). The water entering the aquifer moves first southward from the Edwards Plateau then eastward and northeastward toward large natural outlets at Comal Springs in New Braunfels and San Marcos Springs in San Marcos. Other discharges from the aquifer are Leona Springs in Uvalde, San Antonio and San Pedro Springs in San Antonio, and Hueco Springs north of New Braunfels. An illustration of the possible structure of the cavernous Edwards is given in Figure 2. This indicates the possible relationship between flow and the top of the piezometric surface (Arnou, 1959). Many wells have been drilled into the artesian part of the aquifer, and many of them in the San Antonio area flow at ground level. The fauna occurring in the aquifer, springs, and flowing artesian wells were sampled during the studies. In a few instances, pumped wells were sampled.

Recharge averages more than 616 hm<sup>3</sup> (cubic hectometers). The total amount of water stored in the aquifer is not known. During the period 1934

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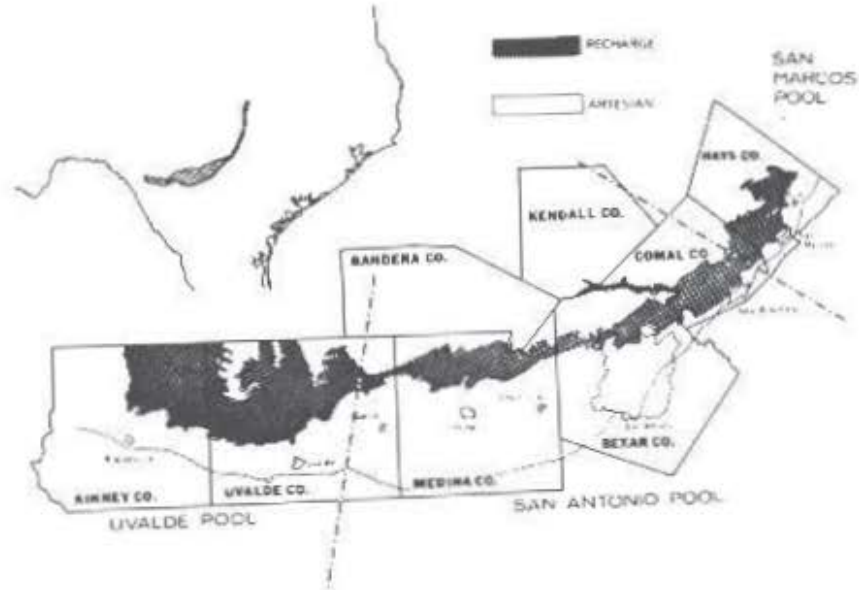


Fig. 1. Edwards Aquifer.

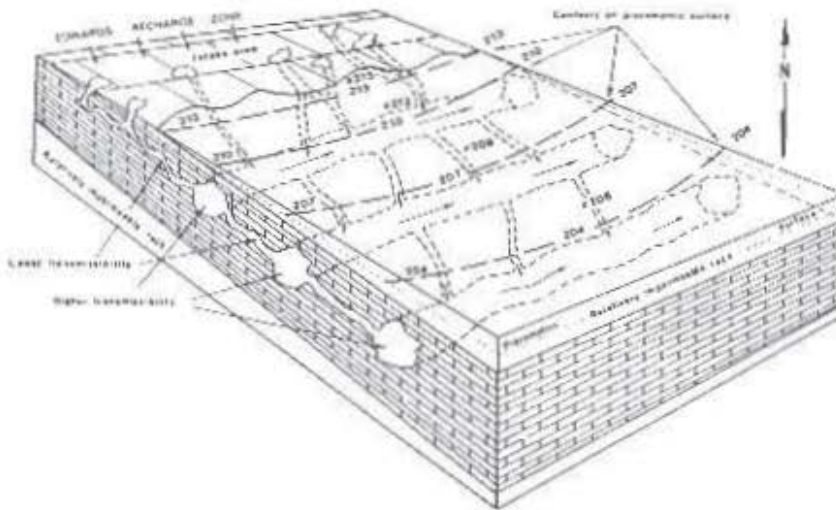


Fig. 2. Hypothetical diagram of flow in the Edward Aquifer.

to 1975, a minimum recharge of 54.25 hm<sup>3</sup> occurred in 1956 and a maximum recharge of 2,096 hm<sup>3</sup> occurred in 1958. In 1971, 501.58 hm<sup>3</sup> were pumped from the aquifer, the highest amount on record (Edwards Underground Water District, 1977). Estimates of water use in the future, due to increased population pressure, indicate that discharge by pumping will exceed recharge and all of the springs will eventually dry (U.S. Department of the Interior, 1973).

The aquifer is divided into three areas hydrologically: the Uvalde Pool, San Antonio (or Central) Pool, and San Marcos Pool. These areas are connected during times when the piezometric levels are high. During periods of severe drought, it can be expected that water in these areas will be separated by some distance. There is some biological evidence that these high points at the base of the aquifer may be factors limiting the distribution of organisms. An example may be the presence of two species of highly adapted cave salamanders *Typhlomolge rathbuni* and *Typhlomolge robusta*, in the San Marcos Pool, (Longley, 1978) and their absence in the San Antonio Pool. Two species of blind catfishes, *Satan eurystomus* (Longley and Karnei, 1978a) and *Trogloglanis pattersoni* (Longley and Karnei, 1978b), are the top of the food chain in the San Antonio pool. All four of these vertebrates occur in the artesian region of the aquifer.

Other aquatic vertebrates that occur in caves of the recharge zone of the aquifer are species of the salamander genus *Eurycea*. These include *Eurycea tridentifera* (Honey Creek Cave Salamander), *Eurycea troglodytes* (Valdina Farms Sinkhole Salamander) now thought to be a hybrid swarm between *E. neotenes* and *E. tridentifera* (Sweet, 1978), *Eurycea latitans* (Cascade Cavern Salamander), and *Eurycea neotenes* (an occasional inhabitant of caves from which springs flow).

The Edwards Aquifer has a wide variety of aquatic invertebrates. The troglobitic species are listed in Table 1. In addition to those mentioned in Table 1, there are several other species which are certainly troglomorphic and may be considered troglobitic by some.

In the San Marcos area, the aquifer is very narrow and the recharge zone is near the entire artesian area. It is easy to visualize local recharge of organic matter as the primary source of energy into the subterranean aquatic system. Numerous caves occur in the recharge zone, near or in stream channels, and they probably account for large amounts of allochthonous debris. In the San Antonio area the aquifer is very wide, and some of the wells yielding aquatic troglobites in southern Bexar County are 32 km from the nearest known recharge area. These same wells are very near (often less than 1.5 km) to the "bad water zone." The wells in the "bad water zone" have high total solids, sulfur compounds, high temperatures, and are also anaerobic. The Edwards formation dips downward to the south. Down dip from the deep wells in Bexar County oil occurs in the Edwards formation. The wells sampled in southern Bexar County were as much as 609 m deep. These same wells are known to produce small amounts of oil. The amount of oil produced seems to increase when the artesian pressure in the aquifer lowers. The blind catfish are found in these wells along with a varied invertebrate fauna. It is unlikely,

Table 1. Troglotic aquatic invertebrate fauna of the Edwards Aquifer.

TAXA	LOCATION
Phylum Platyhelminthes <i>Sphalloplana mohri</i>	Hays Co., Medina Co.
Phylum Mollusca <i>Horatia (Hauffenia) micra</i> Species A (snail) Species B (snail) Species C (snail)	Hays Co., Comal Co. Hays Co. Bexar Co. Bexar Co.
Phylum Annelida Species A (Hirudinea)	Hays Co.
Phylum Arthropoda <i>Candona</i> sp. (ostracod) Species A (ostracod) Cyclops spp. (copepods) <i>Lirceolus smithii</i> (isopod) <i>Cirolanides texensis</i> (isopod)	Medina Co. Hays Co. Hays Co., Bexar Co., Uvalde Co. Hays Co., Uvalde Co. Hays Co., Bexar Co., Uvalde Co., Comal Co.
Cirolanidae (undescribed) (isopod) Stenasellidae (undescribed) (isopod) <i>Monodella texana</i> (Thermosbaenacea) <i>Syngobromus flagellatus</i> (amphipod) <i>Syngobromus russelli</i> (amphipod) <i>Syngobromus pecki</i> (amphipod) <i>Seborgia</i> sp. (amphipod) Plus 8 other amphipod species (1 new family, 4 new genera)* <i>Palaemonetes antrorum</i> (shrimp) <i>Palaemonetes holthuisi</i> <i>Hudeoporus texanus</i> (beetle)	Bexar Co., Uvalde Co. Bexar Co. Hays Co., Bexar Co., Uvalde Co. Hays Co., Bexar Co., Uvalde Co. Hays Co., Comal Co. Comal Co. Hays Co. Hays Co., Bexar Co., Comal Co. Hays Co., Bexar Co. Hays Co. Hays Co.

\* See Hobinger and Longley 1980.

due to distance and hydrology, that organic matter washed into the aquifer in the recharge zone is reaching these deep wells. It should be noted that in the strata above the aquifer in this area there are deposits of oil and peat. Oil is being pumped in this area.

I propose a hypothesis regarding the energy input into the aquatic ecosystem in this part of the aquifer. I contend that the organic matter down dip in the Edwards is continuously migrating up the strata until it contacts the "good Edwards" water. The samples from wells contain large amounts of material that mycologists have described as mycelia from fungi. My concept of the food chain in this system is that saprophytic fungi grow on the fossil organic matter or on bacteria that utilize the organic matter. The fungi serve as food for the smallest invertebrates in the system which are then fed on by the larger invertebrates. The larger invertebrates including amphipods, isopods, decapods (shrimps), and snails are then fed upon by the blind catfishes in the San Antonio area. The toothless blindcat with its sucker mouth proba-

bly feeds on organisms in the bottom sediments and may also use nutrients from organic material in those sediments. The widemouth blindcat is probably an opportunistic feeder eating anything it can get in its mouth including young toothless blindcats. In samples taken from San Antonio wells, the toothless blindcats were twice as abundant as the widemouth blindcats.

The Texas blind salamanders have been observed eating almost all of the available invertebrates in the San Marcos pool of the aquifer. At the present time salamanders are being kept for study at Southwest Texas State University Aquatic Station. Thirty-three preadults and adults are being held in a distribution chamber of the artesian well. They are fed with aquifer invertebrates and apparently eat all that are placed in their holding vessels. In the laboratory, seven juveniles are being held in aquaria at 20-22°C. These young are observed feeding on all invertebrates they can get in their mouths, often including the juvenile stages of shrimps or the smaller species of amphipods.

In the San Marcos Pool of the aquifer, the dytiscid beetle, *Haideoporus texanus*, is found. This form is troglobitic, lacking eyes and pigmentation. This beetle may be another predator in this system since dytiscids often are predaceous. It is relatively rare in samples and also is very small (4.5 mm). Individuals kept in aquaria have been observed feeding on dead shrimp, *Palaeomonetes antrorum*.

The fauna of the Edwards Aquifer consists of at least 35 to 40 species of troglobites, many endemic. Most organisms studied to date have been larger than 500 micrometers. In terms of richness of troglobitic species, this aquifer is apparently either the most diverse or one of the most diverse subterranean aquatic ecosystems in the world.

#### RÉSUMÉ

Des études récentes sur l'Aquifère d'Edwards, système de cavités karstiques du Texas, montrent l'existence d'une communauté de troglobies aquatiques extrêmement diversifiée.

Les prélèvements au niveau des puits et des sources apportent une vision nouvelle de la dynamique de ce système fascinant, qui est sans doute l'écosystème souterrain le plus diversifié connu actuellement dans le monde.

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