

Terrestrial Isopods (Crustacea: Isopoda: Philosciidae)



Adult female of *Oliarus polyphemus*



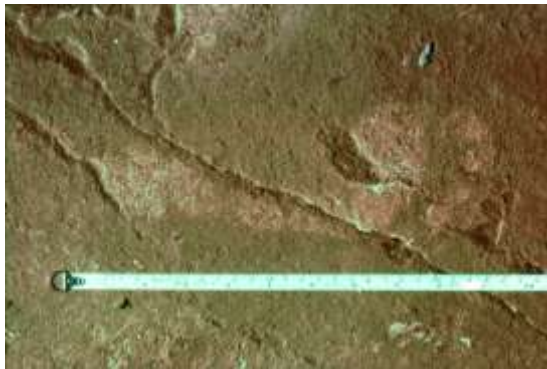
The amphipod *Niphyargus pectencoronatae*



The amphipod *Hadzia fragilis*



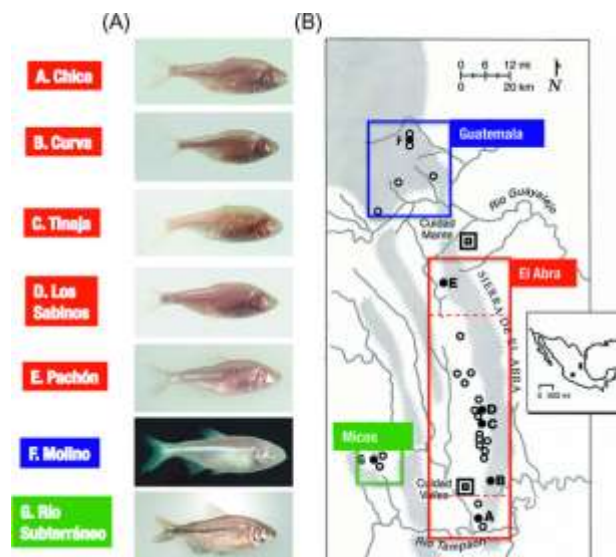
Torch of dried weed stalks (*Gerardia* sp., false foxglove) with inner-bark tie, in situ on the floor of Indian Avenue, Salts Cave, Mammoth Cave National Park, Kentucky. Cave Research Foundation photo by Pete Lindsley. Used with permission.



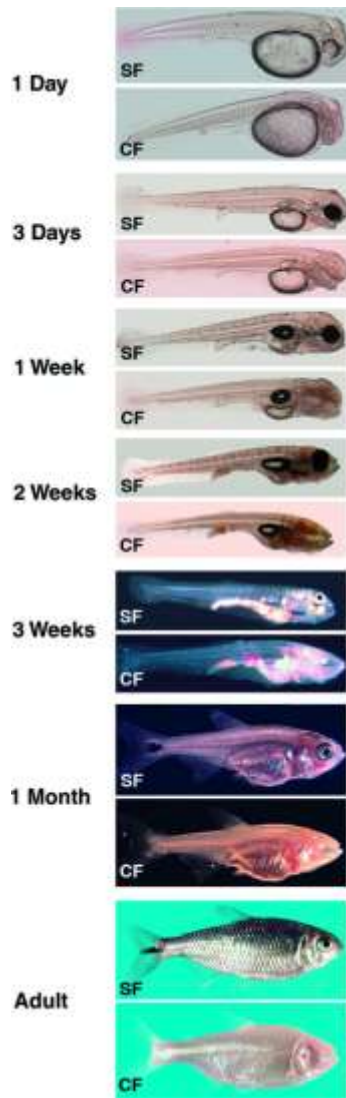
(A) Outline of a prehistoric caver's foot in the dust covering a breakdown boulder in Indian Avenue, Salts Cave, Mammoth Cave National Park, Kentucky. (B) Imprint of a prehistoric caver's foot in mud floor of the Upper Crouchway, Unknown Cave, Mammoth Cave National Park, Kentucky. Cave Research Foundation



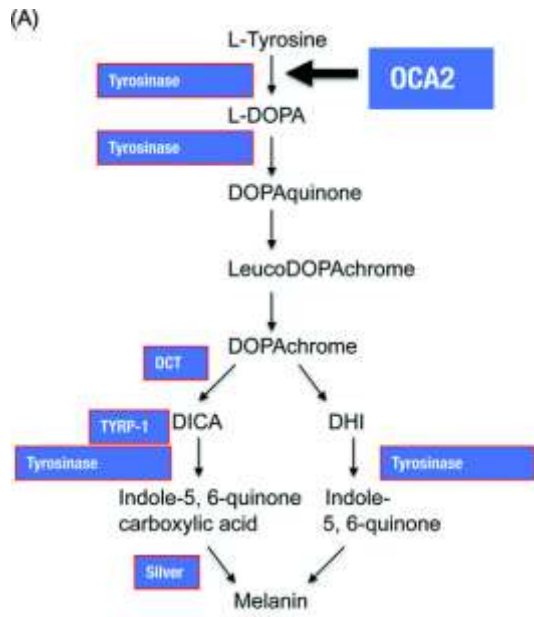
Troglophormic and surface populations of *Asellus aquaticus* are easy to distinguish.



Astyanax mexicanus cavefish populations in northeastern Mexico. (A) Photographs of cavefish populations named on the left and located according to letters on the map. (B) Map showing the distribution of 29 cavefish populations in Tamaulipas and San Luis Potosí, Mexico. Each sphere represents one cavefish population. Filled spheres labeled with a letter represent populations shown and named on the left. Boxes indicate the location of independently evolved Guatemala (blue box), El Abra (red box), and Micos (green box) cavefish populations. Dashed lines representing zones of cavefish populations that may have evolved some troglomorphic features separately subdivide the El Abra box. Inset: Outline map of Mexico showing northeastern region in B as a rectangle and a filled sphere indicating the location of the Granadas cavefish population in Guerrero.



Astyanax mexicanus surface fish (SF) and Pachocavefish (CF) shown from top to bottom at selected developmental stages and as adults.



(A) Melanin biosynthetic pathway showing substrates and positions of enzyme and Oca2 function.
 (B) Albino Pachocavefish embryo provided with exogenous L-DOPA substrate rescues melanin-containing pigment cell precursors (TPC).

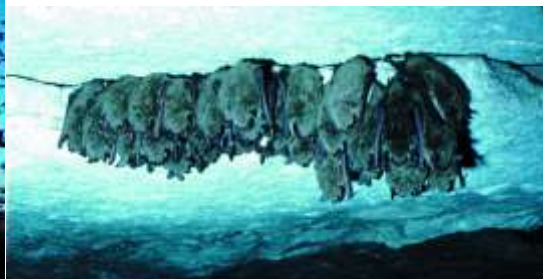
BATS



Townsend's big-eared bat (*Corynorhinus townsendii*).



Emerging Brazilian free-tailed bats (*Tadarida brasiliensis*) from a maternity cave in south-central Texas



Hibernating cave bats (*Myotis velifer*) in a gypsum cave in south-central Kansas

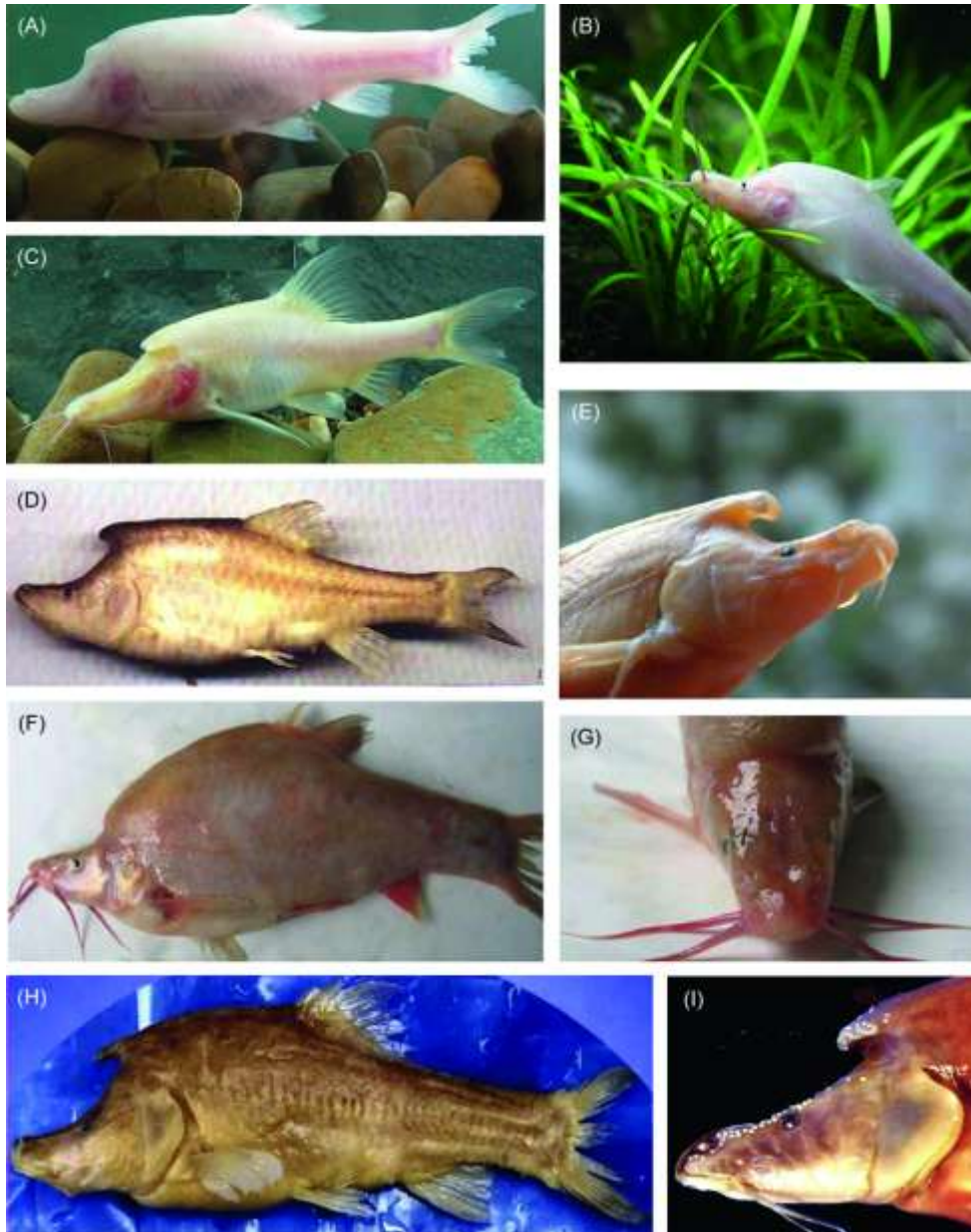
BETLES



Leptodirus hochenwartii (Schmidt, 1832)



A comparison between the general morphologies of (A) adult *S. grahami*, (B) *S. hyalinus*, and (C) *S. brevibarbatus*. Scale bars 51 cm



Examples of the different species of *Sinocyclocheilus*. (A) *S. tianlinensis*; (B) *S. microphthalmus*; (C) *S. furcodorsalis*; (D) *S. broadihornes*; (E) *S. tileihornes*; (F) *S. hugeibarbus*; (G) enlarged image of *S. hugeibarbus* head; (H) *S. rhinoceros*; (I) enlarged image of *S. rhinoceros* head.



Dorsal view of the remipede, *Micropacter yagerae*

Koenemann, Iliffe, and van der Ham, from Old Blue Hill Cave, Caicos Island, Bahamas



A candonid ostracod (subclass Podocopa)



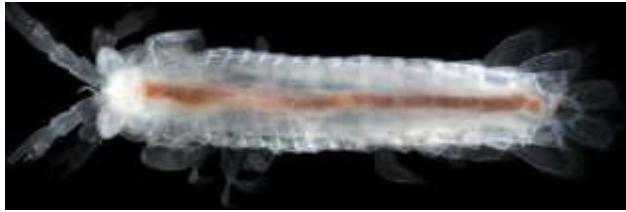
The stygobiotic leptostracan, *Speonebalia cannoni*
Bowman, Yager, and Iliffe from Providenciales, Caicos Islands



The parabathynellid syncarid, *Hexabathynella* spp.



The anaspidean syncarid, *Anaspides tasmaniae*
Thomson, from Tasmania.



The speleogriphacean, *Mangkurtu katjarra* Poore and Humphreys, from groundwater in limestone in the upper Fortescue River in Western Australia.



The stygobiotic mictacean, *Mictocaris halope* Bowman and Iliffe, from a cave in Bermuda.



The stygobiotic stenopodid, *Macromaxillocaris bahamaensis* Alvarez, Iliffe, and Villalobos, from an anchihaline cave in the Bahamas.



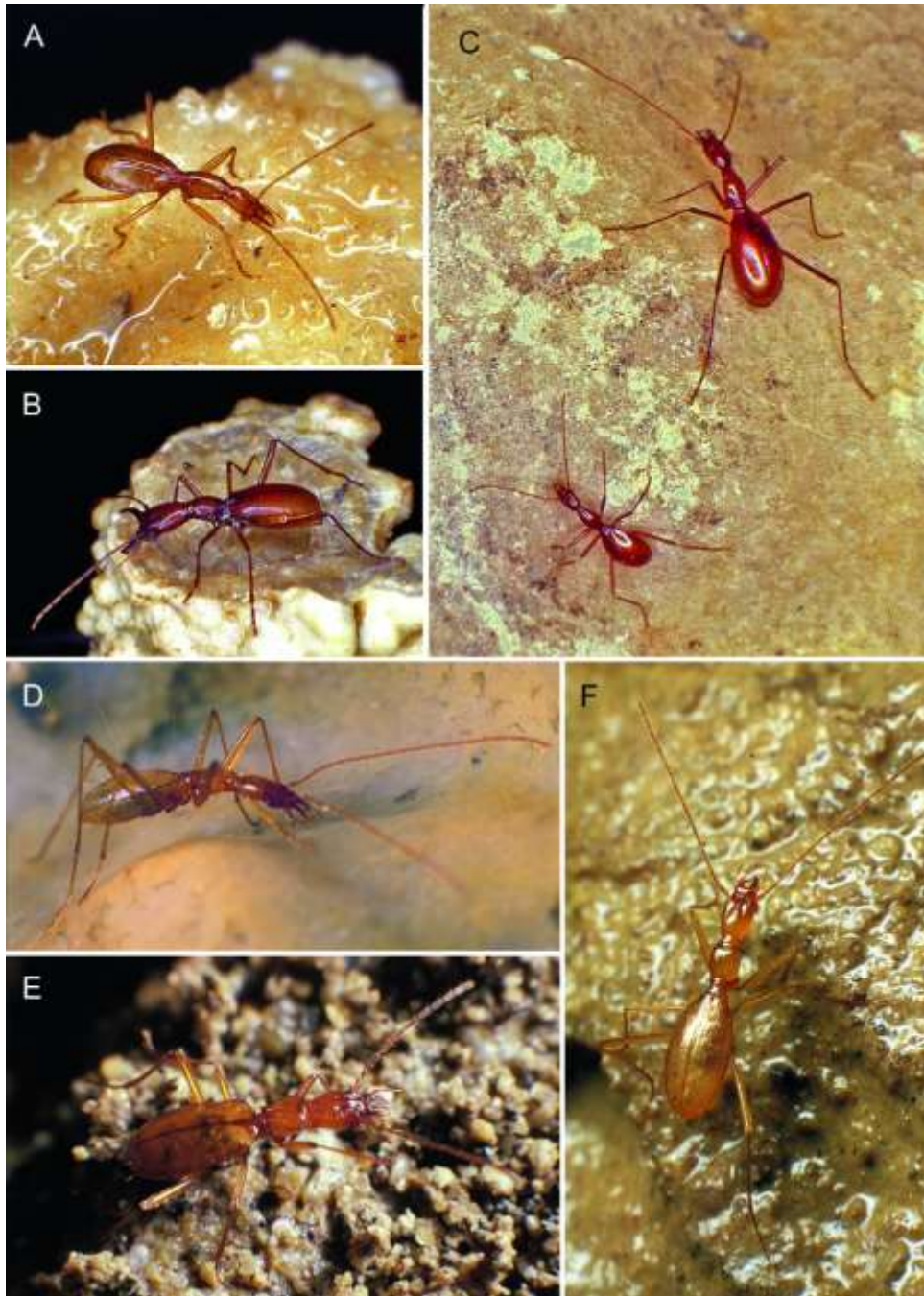
Subterranean animals:

- (A) *Limbodessus eberhardi* (Dytiscidae), one of 100 species of blind diving beetles from calcrete aquifers in the Australian arid zone;
- (B) unnamed blind philosciid isopod;
- (C) *Ngamarlangia luisae* (Gryllidae: Nemobiinae) from Cape Range, the only troglobitic cricket in Australia;
- (D) head of *Ophisternon candidum* (Synbranchiformes), one of two Australian cavefish;
- (E) *Draculoides vinei* (Schizomida), one of seven species of microwhip scorpions known from Cape Range;
- (F) the phreatoicidean isopod *Phreatoicoides gracilis*;
- (G) *Mangkurtu mityula* (Spelaeogriphacea), a subterranean family that is known from only four species, two in Australia, and Africa and Brazil;
- (H) *Pygolabis humphreysi*, from Ethel Gorge calcrete, belongs to a family of flabelliferan isopods, the Tainisopidae, known only from groundwater

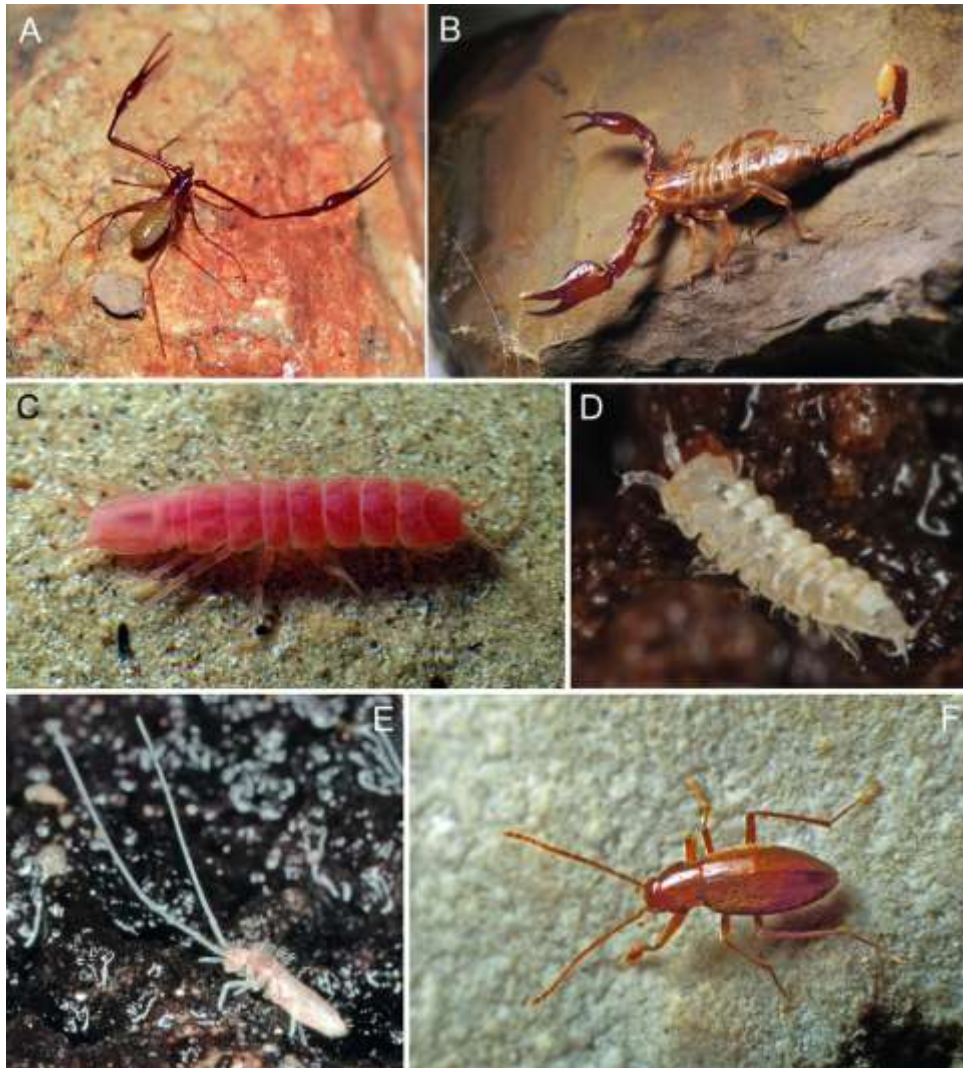
in the Kimberley and Pilbara regions of Western Australia. Photographs (B_E) Douglas Elford, Western Australian Museum; (A and G) William Humphreys, former from a painting by Elyse O'Grady; and (F and H) GDF Wilson, Australian Museum



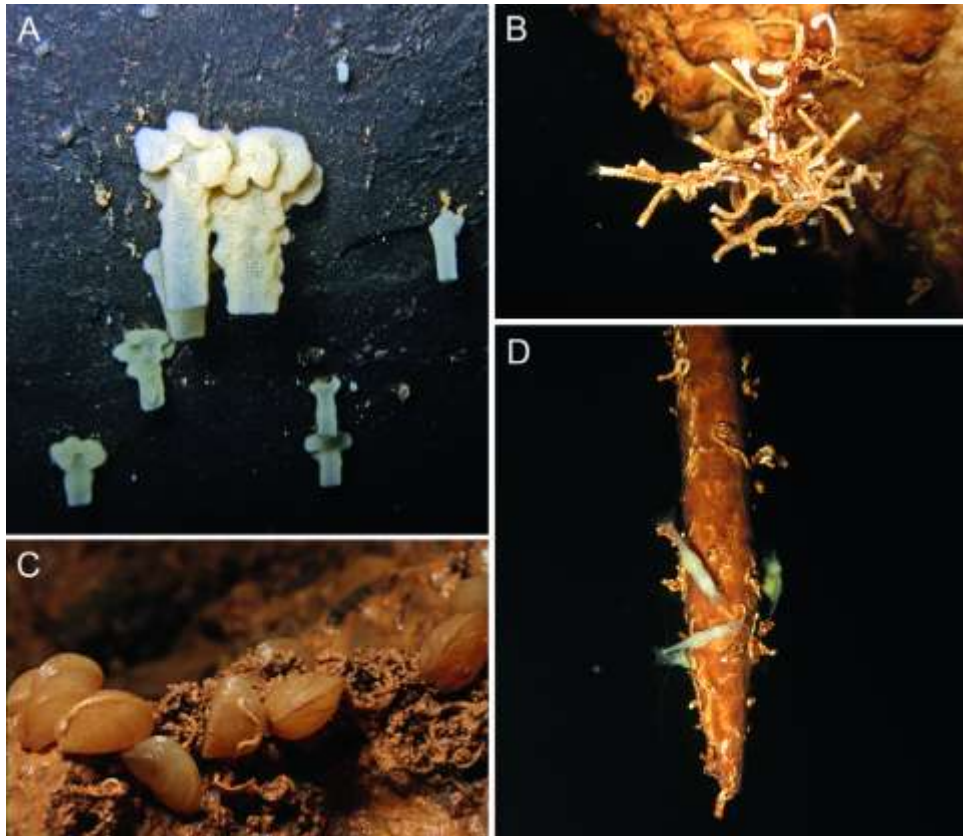
Stygal animals from Australian anchihaline waters. (A) *Milyeringa veritas* (Eleotridae); (B) *Halosbaena tulki* (order Thermosbaenacea); (C) *Stygiocaris stylifera* (Decapoda: Atyidae); (D) *Danielopolina kornickeri* (Ostracoda: Thaumatoocyprididae). Photographs (A) and (B) by Douglas Elford; (C) and (D) by William Humphreys; both of the Western Australian Museum



Troglomorphic Trechinae (Carabidae) of Western Europe. (A) *Lessinodytes pivai* from Italian Alps; (B) *Italaphaenops dimaioides* from Italian Alps, the largest cave Trechinae in the world; (C) *Sardaphaenops supramontanus grafittii* and *Sardaphaenops adelphus* from Sardinia; (D) *Aphaenops pluto* from French Pyrenees; (E) *Trichaphaenops obesus* from French Alps; (F) *Aphaenops cerberus* from French Pyrenees.



Some remarkable subterranean species of Europe. (A) *Titanobochica magna*, a recently described, highly troglomorphic pseudoscorpion from Portugal; (B) *Belisarius xambeui*, a relictual troglomorphic scorpion of Catalonia, only representative in Europe of the family Troglotayosicidae; (C) *Stenasellus virei hussoni*, a frequent stygobiont of central Pyrenees (Isopoda); (D) *Thaumatoniscellus speluncae* from Croatian caves, one of the two species of *Thaumatoniscellus* in the monotypic subfamily Thaumatoniscellinae (Isopoda); (E) *Verhoeffiella longicornis*, a highly troglomorphic Entomobryidae Collembola from Croatia; (F) *Trocharanis mestrei* from Pyrenees, a troglomorphic beetle of the monospecific genus *Trocharanis*.



Some remarkable stygobionts of the Dinaric karst in Croatia. (A) *Eunapius subterraneus*, the only subterranean freshwater sponge in the world; (B) *Marifugia cavatica*, the only freshwater serpulid in the world (Polychaeta); (C) *Congeria kusceri*, the only stygobiotic bivalve in the world, and *Marifugia cavatica*; (D) *Trogloniscus anophthalmus* (Decapoda Atyidae) and *Marifugia cavatica* on a stalactite

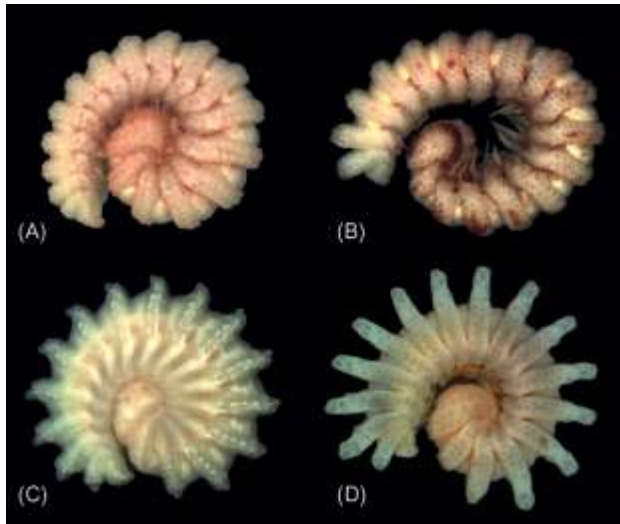




Some representatives of the Dinaric subterranean fauna. (A) *Typhlogammarus mrazeki* (Amphipoda), (B) *Machaerites spelaeus* (Coleoptera: Pselaphidae), (C) *Monolistra monstrosa* (Isopoda: Sphaeromatidae), (D) *Niphargus orcinus* (Amphipoda: Niphargidae), (E) *Zospeum kusceri* (Gastropoda: Carychiidae), (F) *Leptodirus hochenwartii* (Coleoptera: Cholevidae), (G) *Synurella ambulans* (Amphipoda: Crangonyctidae), (H) *Delaya bureschi* (Oligochaeta: Haplotaxidae), (I) *Stalita taenaria* (Araneae: Dysderidae), (J) *Lanzaia vjetrenicae* (Gastropoda: Hydrobioidea).



Sulaplex ensifer Naruse, Ng, and Guinot, 2008 from a cave of Muna island (Sulawesi)



Radiation of the millipede genus *Eutrichodesmus*, illustrated by four recently described species from Vietnamese caves (Golovatch et al., 2009): (A) *Eutrichodesmus regularis*; (B) *E. armatocaudatus*; (C) *E. asteroides*; (D) *E. aster*



Nocticolidae cockroach from Saripa Cave in Maros (Sulawesi).



Swiftlets. Left: young, Ngalau Indah near Lintau Buo (Sumatra) (Photograph by Louis Deharveng). Right: female in its nest, Santo (Vanuatu)



Heteropoda sp. eating a giant cave cockroach *Miroblatta baai* Grandcolas (Bai Cave, Kalimantan)



Vietbocap canhi Lourenço and Pham (Pseudochactidae), a blind scorpion discovered in 2010 from a cave in the Phong Nha-Ke Bang National Park (Vietnam)



(A) A live, adult specimen of *Gammarus minus* from a spring population, 7-mm body length.
(B) Specimen from a troglomorphic cave population, 10-mm body length. Notice the difference in eye size, antennae length, and body coloration



Close-up of a frugivorous bat guano pile, showing a *Maxcheres pseudoscorpion* and the large number of seeds with adhered digested material.



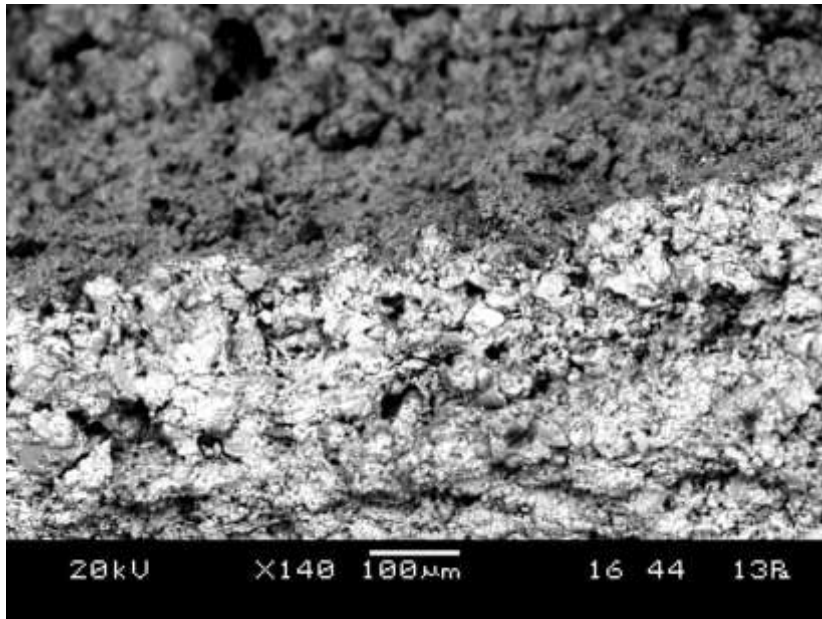
Overview of a somewhat old and dry hematophagous bat guano pile.



Close-up of a carnivorous bat guano pile, showing a large concentration of cholevine larvae (at least two species of the genus *Dissochaetus*).



A large concentration of *Acherontides eleonora* collembolans, with some scattered mites. Close-up of the region pointed out where the white spots indicate the presence of these animals.



Lampenflora encrusted in flowstone. Contact between flowstone and algae coating. Image was taken with low vacuum scanning electron microscope 5500 LV JEOL (back scattered electron image).



Entomopathogenic fungi on *Triphosa dubitata*; moth B2.5 cm long, Planinska Jama, Slovenia. (B) Fungi growing on organic debris; acorn cap for scale, approximately 2 cm across, Sandy Cave, Kentucky. (C) Algae, cyanobacteria, and other phototrophic organisms growing in the entrance zone.



(A) Gold and white actinomycete colonies forming in the upper portion of a cave passage, approximately 1 m across, that is not submerged by rising water, Planinska Jama, Slovenia. (B) Close-up of the colonies from (A); water droplets condense on the hydrophobic surfaces of the colonies. (C) White actinomycete colonies with condensation, Cascade Cave, Kentucky. (D) Clay vermiculations on limestone cave wall, being covered in gypsum, Frasassi Caves, Italy.

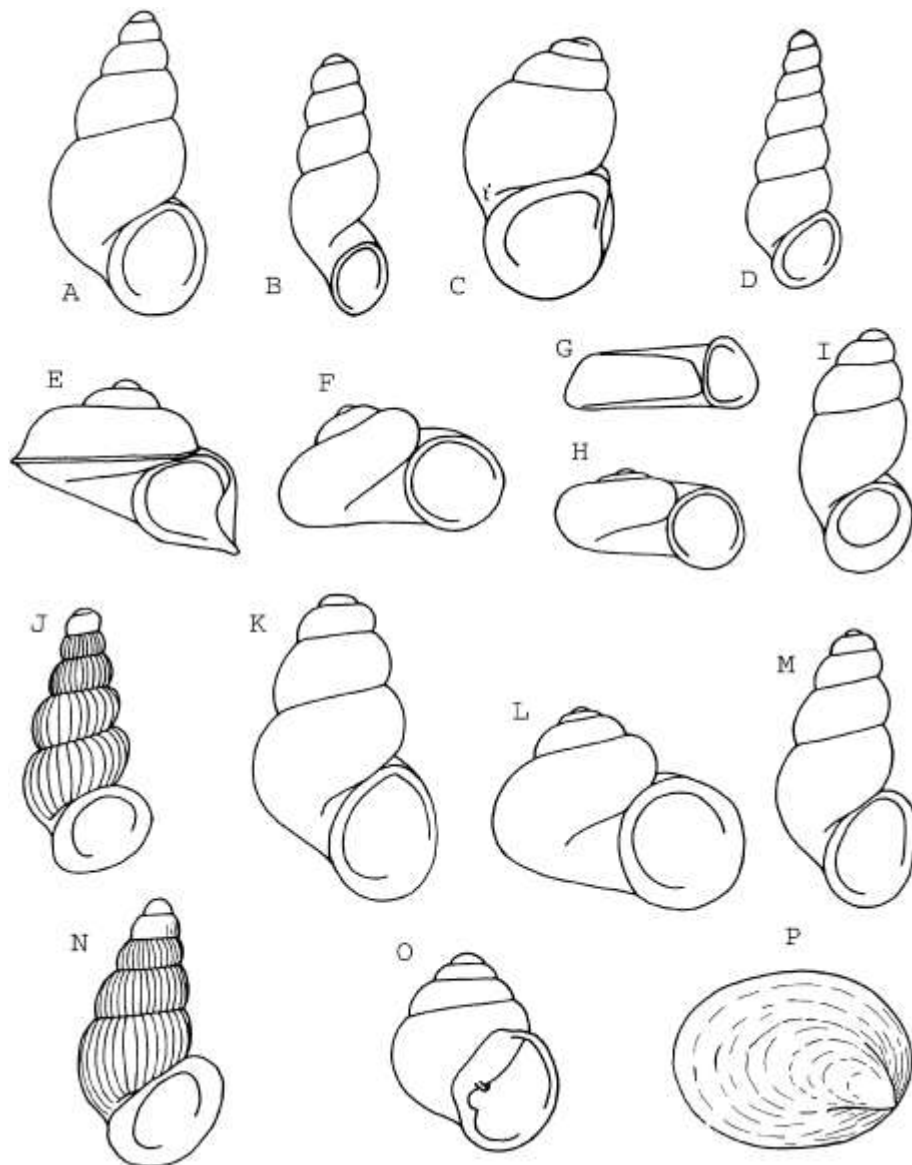


(A) Floating microbial mats in Movile Cave, Romania; PVC grids are 10 cm² x 310 cm. (B) White filamentous microbial mats in the Frasassi Caves, Italy. (C) White mats in Lower Kane Cave, Wyoming. (D) Cave-wall biofilms on gypsum with condensation droplets with pH 2, Lower Kane Cave, Wyoming. Scale bar is 5 cm.

CAVE MOLLUSKS

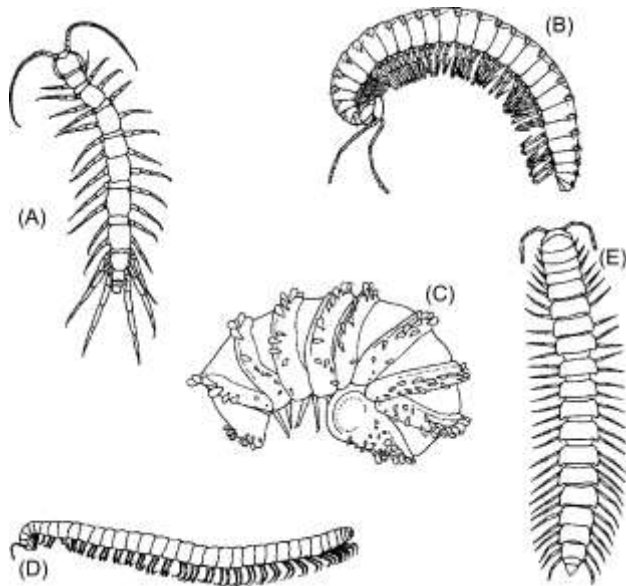


The hydrobiid snail *Marstoniopsis croatica*



A sampling of stygobiotic mollusks from caves in the Dinaric Mountains.

- (A) *Anagastina hadouphylax*, 4mm; (B) *Bagalivia karamani*, 1.7 mm;
 (C) *Belgrandiella kusceri*, 2.4mm;
 (D) *Cilgia dalmatica*, 1.8 mm; (E) *Dalmatella sketi*, 2.2mm;
 (F) *Erythropomatiana erythropomatia*, 1.5 mm;
 (G) *Hadziella ephippiostoma*, 1.6mm; (H) *Hauffenia tellinii*, 1.8mm;
 (I) *Istriana mirnae*, 2 mm;
 (J) *Lanzaia vjetrenicae*, 1.8mm; (K) *Marstoniopsis croatica*, 3mm;
 (L) *Neohoratia subpiscinalis*, 2.4 mm;
 (M) *Paladilhiopsis robiciana*, 4mm; (N) *Plagigeyeria mostarensis*, 3.3mm;
 (O) *Zoospeum exiguum*, 1.6 mm; (P) *Arcoloxus tetensi*, 4.5 mm.



Illustrations of troglomorphic myriapods: (A) centipede—Lithobiomorpha, *Lithobius anophthalmus*; (B) millipede—Chordeumatida, undescribed species from China; (C) millipede—Glomerida, *Trachysphaera orientalis*; (D) millipede—Julida, *Antrocoreeana arcuata*; (E) millipede—Polydesmida, *Epanerchodus fontium*.

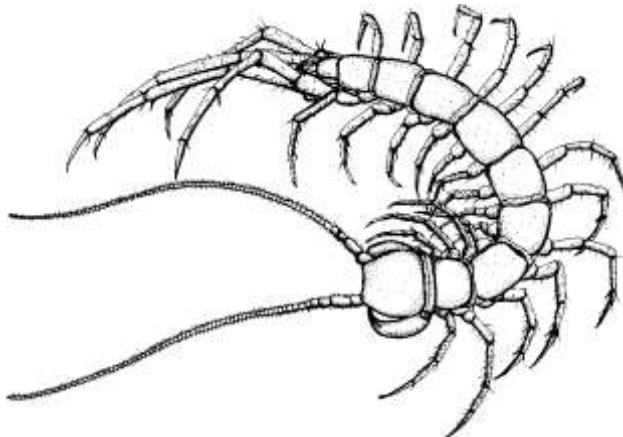
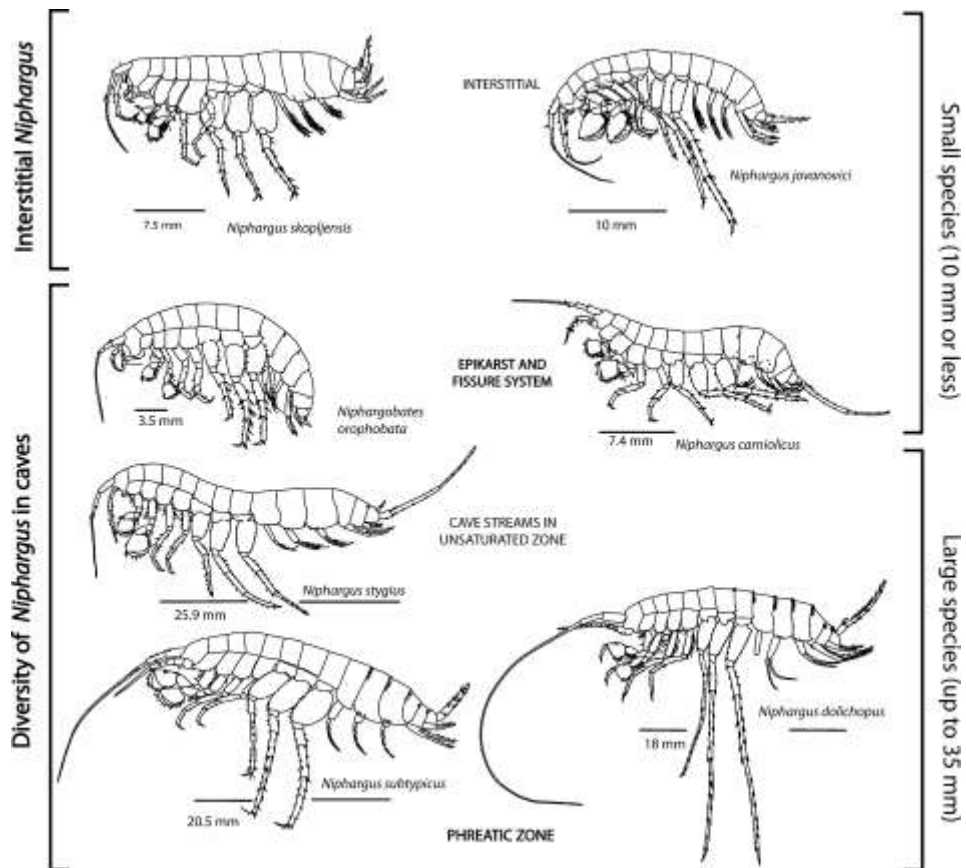


Illustration of the cave centipede *Lithobius matulicii* from Vjetrenica Jama in Bosnia and Herzegovina



Morphological diversity of *Niphargus*: size, shape, and proportions. Species are not drawn to scale: size proportions are indicated by scale bars. Note that size minimally contributes to diversity of interstitial species, which is in stark contrast to the cave species



Microbial mantles, icicle morphology. The gelatinous biofilm can be seen with its encapsulated calcite crystals reflecting light from the flash gun. In the top right corner, above the mantles, the limestone bedrock is etched.



Giant short-faced bear forelimbs in Big Bear Cave, MO, U.S.A.



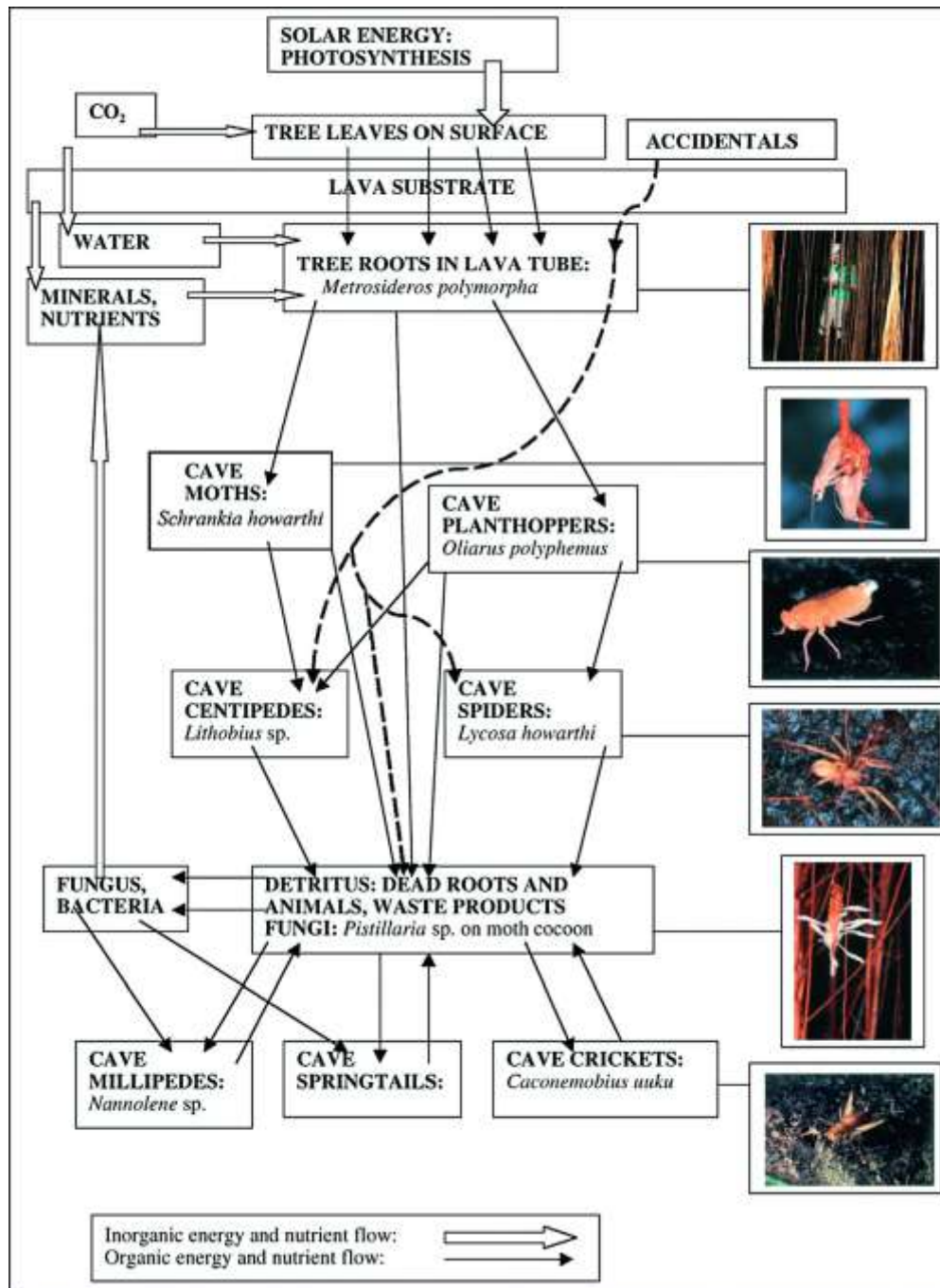
Extinct Pleistocene Harrington's mountain goat with preserved horn sheaths from a Grand Canyon Cave, AZ, U.S.A.



Somali cave fish: *Barbopsis devecchii* and *Phreatichthys andruzzii*



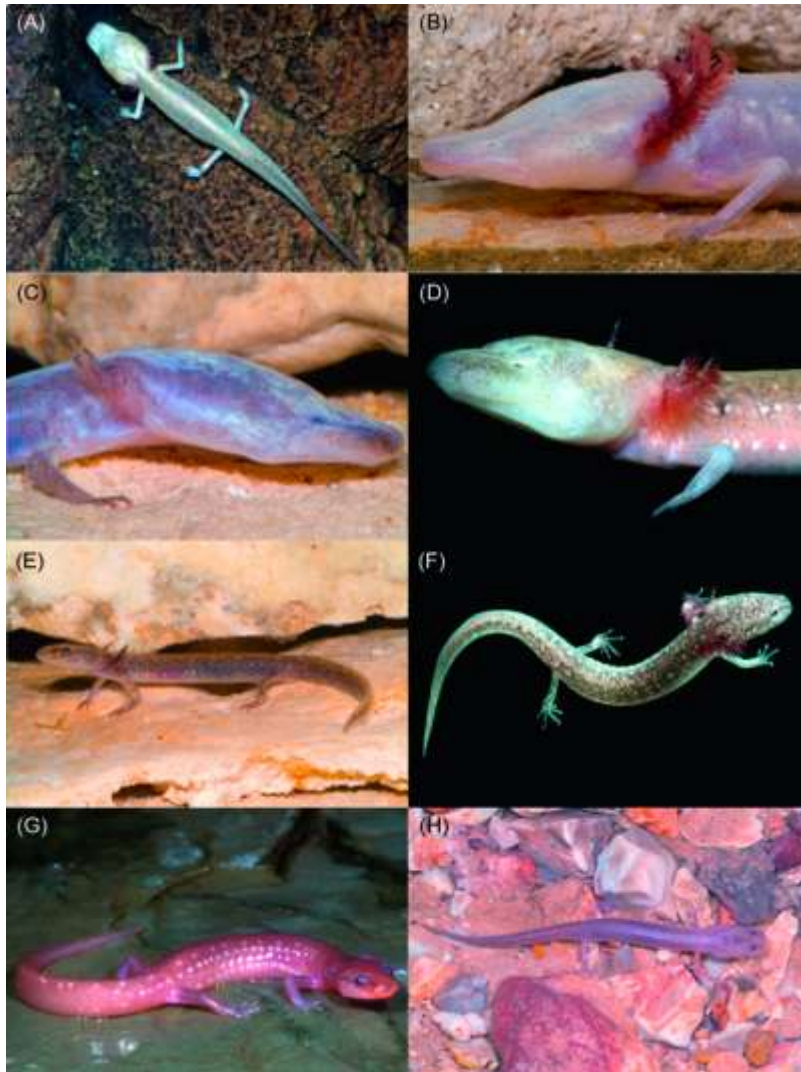
Lava tube passage with tree roots



Cave root food web



The olm (*Proteus anguinus*). (A) Described in 1768, this blind salamander was the first scientifically documented cave-dwelling animal, but its existence had already been known long before. Its earliest representation may be a Venetian stone carving from the tenth or eleventh century. (B) A rare, pigmented individual with eyes, from southeastern Slovenia. This unique population was discovered toward the end of the twentieth century. (C) Female protecting her clutch of eggs from predation by conspecifics



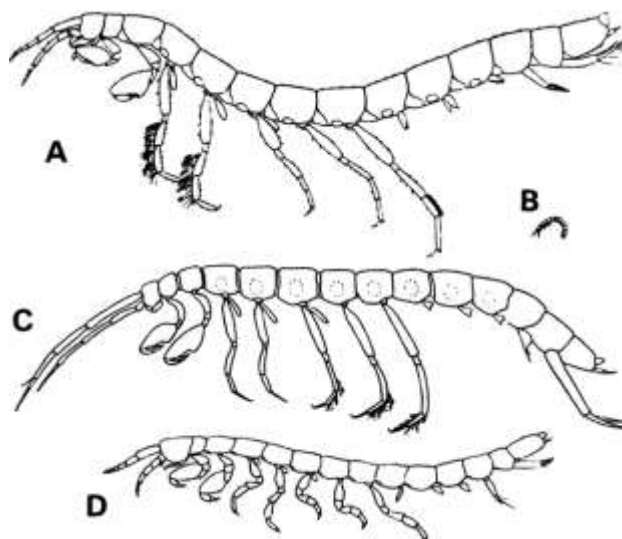
Brook salamanders (*Eurycea*). Troglomorphic *E. rathbuni* (A) and (B), *E. waterlooensis* (C), and *E. tridentifera* (D) from the Edwards Plateau have degenerate eyes and reduced pigmentation compared to spring-dwelling populations of *E. sosorum* (E) and *E. latitans* (F). Adult (G) and larva (H) of *Eurycea spelaea* from the Ozark Plateau. This species is the only troglomorphic brook salamander to readily undergo metamorphosis in nature.



A few salamanders frequently found in caves. In eastern North America, *Eurycea lucifuga* (A) and *E. longicauda* (B) frequently inhabit the same cave. (C) *Plethodon petraeus* is associated with karst and caves on Pigeon Mountain in Georgia. (D) *Pseudotriton ruber* also frequently uses caves for reproduction (Miller et al., 2008). (E) This undescribed species of *Paramesotriton* inhabits pools in the twilight zone of caves in China. Photos (A)-(C) by D. Fenolio; (D)-(E)



Spring salamanders (*Gyrinophilus*). Metamorphosed adults of *G. palleucus* (A) and left in (B) are pale and have smaller, degenerate eyes compared to the troglophile *G. porphyriticus* (right in (B)). The larvae of *G. subterraneus* (C), *G. palleucus palleucus* (D), *G. palleucus necturoides* (E), and *G. gulolineatus* (F) have small but functional eyes. In addition, the numerous neuromast mechanoreceptors on the head and flanks enable them to detect vibrations in the water.



Diagrams of stygobiotic ingolfiellid amphipods.
(A) *Trogloleleupia leleupi* (12_20 mm) from a cave; (B) *Ingolfiella* sp. (,1 mm) from interstitial habitats, shown at same scale as (A); (C) *Trogloleleupia opisthodus* (24_28 mm) from a cave; and (D) *Ingolfiella petkovskii* (1 mm) from an interstitial habitat. Note the relatively short appendages of *I. petkovskii* as well as its small size



Concentration of cave crickets, *Ceuthophilus stygius*, on the ceiling of Dogwood Cave, Hart County, Kentucky, U.S.A



Alacran tartarus from Sotano de San Agustin, Oaxaca, Mexico



Paraphrynus chacmool from Actun Ziz, Yucatan, Mexico



Tartarocreagris infernalis from Electro-Mag Cave, Williamson County, TX, U.S.A.



Pseudocellus osorioi from Sotano del Tigre, San Luis Potosi, Mexico



Texella reyesi from Electro-Mag Cave, Williamson County, TX, U.S.A



Bundles of bacterial filaments in Cueva de Villa Luz, Mexico. The droplets are dilute sulfuric acid with pH as low as zero



The Martino's vole (*Dinaromys bogdanovi*), subadult female



The fairy shrimp (Anostraca), *Chirocephalus croaticus*, a rare species limited to temporary karst waters

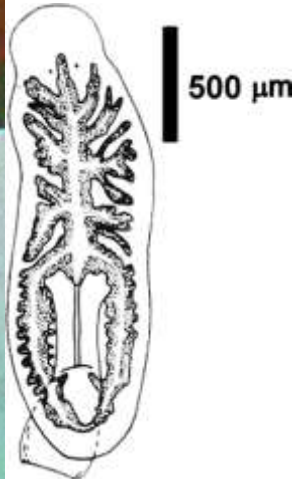


Hibernating little brown myotis (*Myotis lucifugus*) infected with a putative fungal pathogen, *Geomyces destructans*, associated with white-nose syndrome.

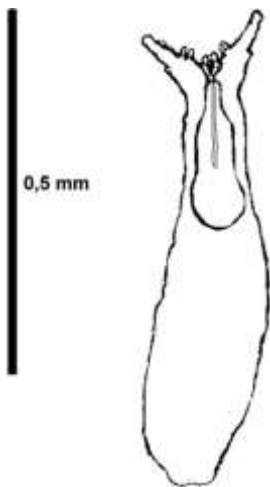


Wings of little brown myotis (*Myotis lucifugus*) unaffected by and affected by white-nose syndrome captured in early spring from a maternity colony.

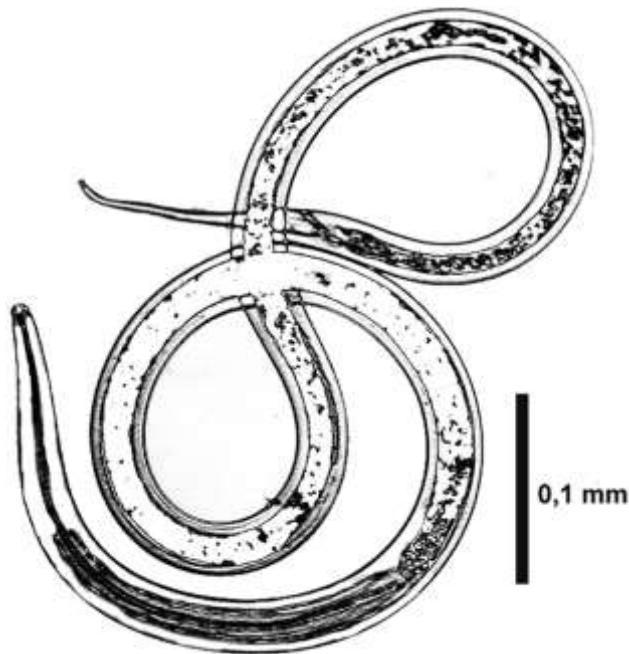
- (A) Undamaged wing (wing-damage index 0);
 - (B) wing showing moderate scarring and spotting (wing-damage index 11);
 - (C) wing showing severe scarring and necrosis (wing-damage index 3).
- Wing-damage index after



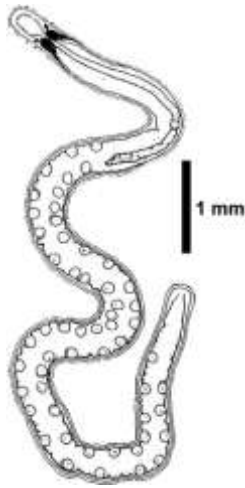
Dinizia sanctaehelena (Tricladida) The Temnocephalid, an external parasite of crustaceans.



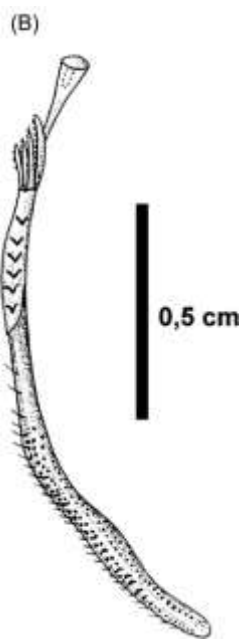
roglocaridicola capreolaria (Temnocephalida)



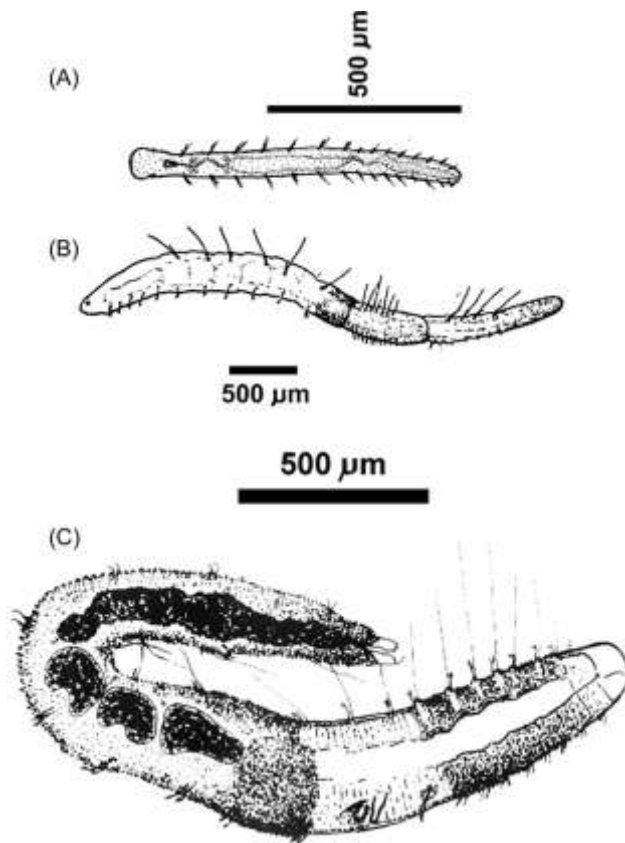
Dorylaimus sp. (Nematoda)



Ototyphonemertes sp. (Nemertina)



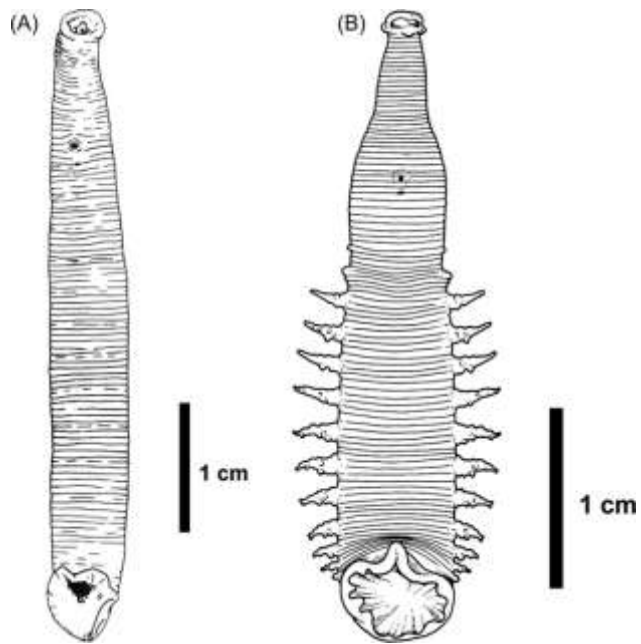
Marifugia cavatica (Polychaeta): (A) Anterior part of the body (B) Habitus of a female individual



Representatives of cave oligochaetes: (A) *Aeolosoma* sp. (B) *Nais* sp.; (C) *Haber turquini*



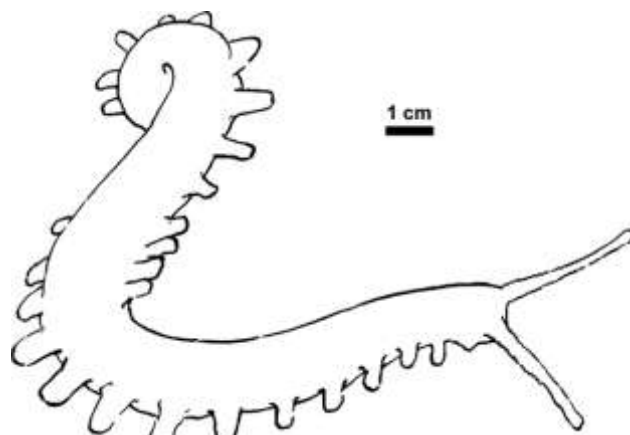
Gianius aqueductalis (Oligochaeta), anterior segments



Representatives of cave leeches:

(A) *Dina* sp.

(B) *Croatobranchus mestrovi*, ventral side



Speleoperipatus speleus (Onychophora)