Cavernicolous invertebrates of Cave Gulch, Santa Cruz County, California.

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INTRODUCTION

The importance of the cavernicole fauna of the Santa Cruz region has long been recognized. The isolation of this karst, being the only sizable exposure in the Coast Ranges, as well as its proximity to spreading urbanization, has certainly contributed to the attention it has received. The first systematic study of this biota, conducted over 4 decades ago, was by Graham, who later published a series of papers on the general biology of several species (Graham, 1963, 1966, 1967, 1968a, 1968b). Starting in the late 1960's, Briggs and his students, including myself, began exploring these caves and focused on the opilionids and other arachnids, which contributed to some taxonomic studies (Briggs, 1968, 1971, Ubick & Briggs, 1989). In 1979, Rudolph and his team surveyed the caves and incorporated the results into an unpublished manuscript on the cave fauna of California (Rudolph et al, MS). As plans developed to deforest the Cave Gulch area, in the late 1980's, Briggs and I conducted additional surveys and updated the species list (Briggs & Ubick, 1988). The present work includes data from all of the above studies along with two recent surveys conducted during July and December 2001.

THE CAVES

The Cave Gulch caves (Appendix 1) occur in metamorphosed limestone which lies on the Salinian Block, west of the San Andreas Fault. As they are located at relatively low elevations, between 100-170 m, they were subjected to periodic inundation during the late Tertiary and early Quaternary. These inundations were caused by changes in sea levels which resulted in a series of marine terraces. The caves are located on one of these, the Blackrock Terrace, which is believed to be about 1 million years old. Thus, it is only after this date, as the sea level dropped, that the caves would have been formed, dissolved out of the limestone, and subsequently populated by organisms (Tinsley, 1985).

The relative ages of the caves have been estimated by their elevations from the canyon floor. As both IXL and Bat Caves are located highest on the canyon walls, they are believed to be the oldest. Similarly, Dolloff and Empire Caves, located closest to the stream channel, are considered the youngest, with Stump and Stearns Caves being of intermediate age (Rogers, 1983).

Human interaction with these caves has been poorly recorded. The best known is Empire Cave, which was first mentioned in 1872. Little has been recorded of the others except that IXL and Dolloff were both discovered in the 1950's (Halliday, 1962).

CAVE BIOLOGY

Cavernicoles may be classified into categories based on their degree of

cave adaptation. These range from the troglobites, those most strongly modified and dependent upon caves, to the casual epigean visitors. The following classification is summarized from Barr (1963).

Troglobite (TB)-an obligate cavernicole. Troglobites exhibit a high degree of anatomic modification, troglomorphy, including total depigmentation, extreme elongation of appendages, loss of body rugosity, and loss of eyes.

Phreatobite (PB)-an organism which is restricted to underground sources of water. These are modified in the same way as troglobites.

Troglophile (TP)-a facultative cavernicole which can complete its life cycle in a cave but may also live in ecologically similar epigean situations. Troglophiles may show moderate troglomorphy, such as slight depigmentation and elongation of appendages.

Trogloxene (TX)-an organism which frequents caves but is unable to complete its life cycle there. Trogloxenes do not exhibit cave modification.

Epigean (EP)-these are surface organisms whose presence in caves is accidental.

It should be noted that classifying cave organisms into these ecological categories is often rather tentative given the patchy knowledge of their life cycles. This is certainly true for the Cave Gulch species, which have received only limited attention. In fact, the only ecological studies conducted so far are those by Graham, who published his observations on the staphylinids (1963), crane flies (1966), Meta dolloff (1967, as Pseudometa biologica), and Triphosa haesitata (1968a, 1968b). Apart from these papers, some biological information is presented in taxonomic studies, as by Holsinger (1974: Stygobromus mackenziei), Muchmore and Cokendolpher (1995: Fissilicreagris imperialis), and Ubick and Briggs (1989: Calicina serpentinea). Needless to say, the basic biology of the majority of the species remains a largely unexplored territory.

Despite the relative youth of the Cave Gulch caves, they contain a rich fauna of over 70 invertebrate species. Six of these are apparent endemics as they have not been recorded outside of this cave system. Four show marked adaptation to cave life and are classified as troglobites, with the aquatic species also referred to as phreatobites. They are the blind pseudoscorpions, Neochthonius imperialis Muchmore and Fissilicreagris imperialis (Muchmore), an aquatic amphipod, Stygobromus mackenziei Holsinger, and an as yet undescribed aquatic isopod, Calasellus n. sp. The remaining two endemics are both troglophiles, the spider Meta dolloff Levi and an undescribed fulgoroid roothopper, Cixius n. sp., which despite showing no cave adaptations are nonetheless restricted to these caves. Apart from these species, the fauna includes some 20 troglophiles, 10 trogloxenes, and over 30 epigean species.

CAVE MANAGEMENT AND MONITORING

Management of the cave fauna needs to take into account and minimize the various stresses resulting from human activities. These are discussed in some detail by Elliott (2000) who groups them into several categories. The first, hydrological modification, is human impact on the water table in karst areas which may result in either drying or flooding of caves. Second are land developments which may tear open and expose caves, as through quarrying and road construction, or seal them off completely. Third, alteration of the nutrient flow into caves, either reducing the flow, as by use of inappropriate gates, or accelerating it, as by the introduction of organic matter. Fourth, the effect of exotic and pest species. Fifth, the effect of chemical pollution in caves. Sixth, the impact of killing, over-collecting, and disturbing the fauna. Finally, the impact of isolation of caves resulting from the urbanization of the surrounding environment.

Of these potential stresses, most are not relevant to the caves in Cave Gulch, assuming that the region continues to remain in the relatively unaltered state as regards its hydrology, topography, and biotic community. Three issues, however, may be of some concern here. 1.-Cave gates. If caves are to be gated, the gates need to be so constructed as to allow free movement to bats and other organisms and to permit unaltered flow of organic matter into the cave. 2.-Cave clean-ups. Although cave clean-ups have become a regular occurrence in Cave Gulch, especially in Empire Cave, they should be exercised with some caution. As reported by Adamson (1982), an overzealous clean-up can actually harm the cave faunas by removing bits of organic matter, decaying wood and leaves, which have become incorporated into the cave's food chain. 3.-Chemical contamination. At least some caves in the area, like Empire Cave, are regularly used by students for partying. Apart from filling the cave with non-organic debris, these gatherings occasionally or often result in the construction of fires which are clearly harmful to the biota.

METHODS

The present surveys were conducted over a three-day period. On 27 and 28 July 2001 all six caves were surveyed and on 14 December 2001, about a month after the start of the rainy season, Bat, Empire, and Stump Caves were revisited. The surveying consisted of noting the presence, approximate abundance, and distribution of organisms in the caves. Collections were made of representatives of the species encountered. These were later curated, identified, and, where needed, sent to specialists. The survey team consisted of T. Hyland, T. Sasaki, D. Snyder, S. Ubick, and myself. Photographs of the organisms were taken on the July survey, by J. Ledford.

The arrangement of the species is phylogenetic to the ordinal level, alphabetical from the family down. The currently valid scientific names are given, along with the synonyms which have appeared in the cave references. In cases where a full species name is not known it is given as “sp.”; or “n. sp.” if the species is known to be new but has not yet been described.

The diagnosis gives only enough description of the taxa to help separate them from others found in Cave Gulch. Lengths refer to the total body lengths of the adults. Full descriptions of the taxa can be found in the primary references.

Information of the biology is likewise minimal but enough to get a sense of the species’ niches and ecological classifications.

The distribution includes records from the six Cave Gulch caves and a summary, where known, of the species’ total ranges. Type localities are indicated for the five species described from these caves. Distributional records from recent surveys are included and so indicated in the species table.

The references, although not exhaustive, include the most important taxonomic works, ecological studies of the species, papers giving distributional information, and those from which figures were extracted, including electronic sources. In the many cases where illustrations for the Cave Gulch species were not available, a morphologically similar representative taxon has been substituted. Similarly, where habitus images were unavailable, the figures given are of the relevant diagnostic parts. The reference "Ubick, 2001 survey" refers to taxa which were encountered on the recent surveys.

RESULTS

As pointed out by Pape (1998), biological inventories of caves are usually restricted by time constraints and thus do not reveal a complete overview of the fauna. This is certainly evident in the inventories conducted in Cave Gulch over the past decades, which recorded a total of 49 species. The present surveys, representing three days of collecting, have added 23 species, or an increase of nearly 50% (see Appendices 2 and 3). This is clearly a significant addition to the faunal list and suggests that a full inventory of the species is far from complete.

Additionally, the present survey did not find 14 species previously recorded. This points to another characteristic of cave faunas: the presence of some species at low abundances. An ongoing monitoring of these caves would thus appear to be critical for a full understanding of the species composition.

Apart from an inventory of species, a monitoring program conducted over a period of years and across the seasons would reveal variations in abundance which can not be ascertained through isolated sampling of the fauna. As such protocols have not been generally established, I would propose a monitoring

program that samples the caves during both wet and dry seasons and continues for at least a few-year period.

SPECIES LIST

PHYLUM ANNELIDA
CLASS CLITELLATA
ORDER OPISTHOPHORA
Family Lumbricidae

Lumbricus sp. (determination tentative) (Ap. 4, Pl. 1)
Diagnosis.-This is the only earthworm recorded from the caves.
Biology.-Burrows through loose soil.
Distribution.-CA: Santa Cruz Co.: Dolloff Cave, IXL Cave. The genus is widely distributed.
References.- Briggs & Ubick, 1988; Ubick, 2001 survey.

PHYLUM MOLLUSCA
CLASS GASTROPODA
ORDER STYLOMMATOPHORA

"**slugs and snails**"
Diagnosis.-
Biology.-(EP).
Distribution.-CA: Santa Cruz Co.: Empire Cave.
Reference.-Graham, 1968a.

slugs (Ap. 5, Fig. 1)
Diagnosis.-
Biology.-(EP).
Distribution.-CA: Santa Cruz Co.: Empire Cave, Stearns Cave, Stump Cave.
Reference.-Ubick, 2001 survey.

snails
Diagnosis.-
Biology.-(EP).
Distribution.-CA: Santa Cruz Co.: Bat Cave, Empire Cave, Stearns Cave, Stump Cave.
Reference.-Ubick, 2001 survey.

Family Haplotrematidae

Haplotrema minimum (Ancey) (Ap. 4, Pl. 1)
Diagnosis.-
Biology.-(EP).
Distribution.-CA: Santa Cruz Co.: Empire Cave.
References.- Briggs & Ubick, 1988; Graham, 1968a.

Family Zonitidae

Pristiloma sp. nr. **nicholsoni** Baker (Ap. 4, Pl. 1)

Diagnosis.-
Biology.-(EP).
Distribution.-CA: Santa Cruz Co.: IXL Cave.
Reference.- Briggs & Ubick, 1988.

PHYLUM ARTHROPODA
CLASS CRUSTACEA
ORDER ISOPODA
Family Asellidae

Calasellus n. sp. (Ap. 4, Pl. 1)

Diagnosis.-(9-10 mm). This is the only aquatic isopod known from the Santa Cruz caves.
Biology.-(PB). This undescribed species is aquatic and occurs in cave pools present during the rainy season.
Distribution.-CA: Santa Cruz Co.: Empire Cave. Not known from any other localities.
References.- Borror et al, 1989; Briggs & Ubick, 1988; Ubick, 2001 survey.

Family Trichoniscidae

Brackenridgia sp. (Ap. 4, Pl. 1; Ap. 5, Fig. 2)

Diagnosis.-(4-6 mm). This is the only terrestrial isopod known from the Santa Cruz caves.
Biology.-(?TP). This white isopod is found under rocks and at decaying wood and other plant debris on the cave floor.
Distribution.-CA: Santa Cruz Co.: Dolloff Cave, Empire Cave, IXL Cave, Stump Cave.
Reference.- Mitchell & Reddell, 1971; Ubick, 2001 survey.

ORDER AMPHIPODA
Family Gammaridae

Stygobromus mackenziei Holsinger (Ap. 4, Pl. 1)

Diagnosis.-(4-6 mm). This is the only amphipod known from the Santa Cruz caves.
Biology.-(PB). This phreatobitic species is known from cave pools.
Distribution.-CA: Santa Cruz Co.: Empire Cave (Type Locality). Not known from any other localities.
Reference.-Holsinger, 1974; Ubick, 2001 survey.

CLASS ARACHNIDA

Biology.-With few exceptions, arachnids are predators and require living prey. Of the taxa dealt with here, only Leiobunum, which is a facultative scavenger, may be classified as an omnivore.

ORDER ARANEAE
Family Anyphaenidae

Anyphaena sp. (Ap. 4, Pl. 2)
Diagnosis.-(4-6 mm). This pale spider has two paramedian dark bands on the carapace and does not build webs but is a wandering hunter.
Biology.-(EP). This is an epigean species which normally occurs on foliage.
Distribution.-CA: Santa Cruz Co.: Empire Cave. The genus is widespread and common throughout California and has not previously been recorded in caves.
References.-Kaston, 1978; Platnick, 1974; Ubick, 2001 survey.

Family Cybaeidae

Cybaeus sp. (Ap. 4, Pl. 2)
Diagnosis.-(5-8 mm). These dark spiders have white markings on the abdomen, which is posteriorly rounded.
Biology.-(EP). This is an epigean species which may occur at cave entrances. The spiders generally build small retreats under rocks.
Distribution.-CA: Santa Cruz Co.: Empire Cave, Stearns Cave, Stump Cave. The genus is widespread and common throughout California and is occasionally found in caves.
References.-Chamberlin & Ivie, 1932; Ubick, 2001 survey.

Family Hahniidae

Calymmaria sp. (Ap. 4, Pl. 2, Ap. 5, Fig. 3-5)
Diagnosis.-(4-8 mm). The conical web, long legs, and color pattern distinguish this species from other spiders.
Biology.-(EP). This is an epigean species which may occur at cave entrances.
Distribution.-CA: Santa Cruz Co.: Bat Cave, Dolloff Cave, Empire Cave, IXL Cave, Stearns Cave, Stump Cave. The genus is widespread and common throughout California and is occasionally found in caves.
References.-Briggs & Ubick, 1988; Chamberlin & Ivie, 1937; Ubick, 2001 survey.

Family Linyphiidae

Diagnosis.-Linyphiid spiders may be recognized by the form of their snare, which is typically a small sheet web, on which they move on the undersurface. The species are difficult to separate with ease as the best characters are minute features of the genitalia.

Arcuphantes sp. (Ap. 4, Pl. 3)
Diagnosis.-(3-4 mm). This is a dark species in which females have a long spine-like epigynum.
Biology.-(EP).
Distribution.-CA: Santa Cruz Co.: Stearns Cave. Common in closed canopy forests throughout California.
References.-Chamberlin & Ivie, 1943; Ubick, 2001 survey; Yaginuma, 1968.

Bathyphantes alameda Ivie (Ap. 4, Pl. 3)

Diagnosis.-(3 mm). This species has distinct black and white markings on the abdomen.
Biology.-(TP).
Distribution.-CA: Santa Cruz Co.: Bat Cave, Empire Cave. Known from epigean and cave habitats along the coastal ranges of central California north to Canada.
References.-Ivie, 1969; Ubick, 2001 survey.

Bathyphantes orica Ivie (Ap. 4, Pl. 3)
(B. orea, of Briggs & Ubick, 1988 and Rudolph et al, MS, is a misspelling)
Diagnosis.-(2.5 mm). This is similar to B. alameda but is smaller and has less distinct abdominal markings.
Biology.-(TP).
Distribution.-CA: Santa Cruz Co.: Dolloff Cave, Stump Cave. Known from epigean and cave habitats along the coast ranges, from central California north to Canada.
References.-Briggs & Ubick, 1988; Ivie, 1969; Ubick, 2001 survey.

Oaphantes pallidulus Banks (Ap. 4, Pl. 3)
Diagnosis.-(2.5 mm). This species may be recognized by its yellowish-gray color and absence of abdominal markings.
Biology.-(EP).
Distribution.-CA: Santa Cruz Co.: Dolloff Cave, Stump Cave. Known from coastal epigean habitats of California, from San Francisco to Los Angeles.
References.- Briggs & Ubick, 1988; Chamberlin & Ivie, 1943; Ubick, 2001 survey.

Family Nesticidae

Nesticus silvestrii Fage (Ap. 4, Pl. 4; Ap. 5, Fig. 6-7)
Diagnosis.-(3-4 mm). Apart from genitalic characters, nesticid spiders are most easily recognized by their pallid, yellowish color and the form of the web, an aerial cobweb with vertical sticky lines.
Biology.-(TP). These spiders make their webs in cave crevices and under rocks and logs.
Distribution.-CA: Santa Cruz Co.: Bat Cave, Dolloff Cave, Empire Cave, IXL Cave, Stump Cave. Occurs from central California north to Canada, in both cave and epigean habitats.
References.-Gertsch, 1984; Kaston, 1978; Ubick, 2001 survey.

Family Telemidae

Usofila n. sp. (Ap. 4, Pl. 4)
(also referred to as Telema sp.)
Diagnosis.-(1-2 mm). This tiny spider is the only 6-eyed species known from the Santa Cruz caves.
Biology.-(TP). This spider builds small sheet webs under rocks and in irregularities along the walls of caves.
Distribution.-CA: Santa Cruz Co.: Dolloff Cave, Empire Cave, IXL Cave, Stump

Cave. This genus, represented by numerous species, is known from both cave and epigean habitats of California.
References.-Briggs & Ubick, 1988; Comstock, 1940; Ubick, 2001 survey.

Family Tengellidae

Titiotus n. sp. (Ap. 4, Pl. 4; Ap. 5, Fig. 8)
(previously referred to as Liocranoides sp.)
Diagnosis.-(10-15 mm). This spider is easily recognized by its large size and strong ventral spination of the front legs.
Biology.-(TP). These are wandering hunters which do not build webs but crawl about on cave surfaces. Eggsacs are spherical balls, roughly 1 cm in diameter, which are suspended from cave ceilings.
Distribution.-CA: Santa Cruz Co.: Bat Cave, IXL Cave. This genus occurs throughout the mountainous parts of California, in both cave and epigean habitats.
References.-Briggs & Ubick, 1988; Ubick, 2001 survey.

Family Tetragnathidae

Meta dolloff Levi (Ap. 4, Pl. 5; Ap. 5, Fig. 9-10)
(Pseudometa biologica of Graham 1967 and Pimoa n. sp. of Briggs & Ubick, 1988, and Rudolph et al, MS, are misidentifications).
Diagnosis.-(10-15 mm). This is the largest web-building spider known from the Santa Cruz Caves.
Biology.-(TP). These spiders live in large, vertically-oriented orb webs which are typically placed at the entrance and twilight regions of caves.
Distribution.-CA: Santa Cruz Co.: Bat Cave, Dolloff Cave, Empire Cave (Type Locality), IXL Cave, Stearns Cave, Stump Cave. Not known from any other localities.
References.-Briggs & Ubick, 1988; Graham, 1967, 1968a; Levi 1980; Ubick, 2001 survey.

Family Theridiidae

Theridion sp. (Ap. 4, Pl. 5)
Diagnosis.-(3-4 mm). Theridion can be separated from most other spiders by their globose abdomen and tarsal comb on Leg IV.
Biology.-(EP). These spiders stay in cobwebs which they construct in irregularities of the walls in cave entrances.
Distribution.-CA: Santa Cruz Co.: Bat Cave. This genus contains numerous species and is common throughout California.
References.-Briggs & Ubick, 1988; Kaston, 1978.

Thymoites pallidus (Emerton) (Ap. 4, Pl. 5)
(The earlier record of Theridion might actually refer to this species as the two genera may be easily confused. No specimens from the earlier surveys are available and no Theridion were encountered in this recent survey of Bat Cave.)
Diagnosis.-(2-3) mm). These spiders are similar to but smaller and paler than

most Theridion.
Biology.-(TP). These spiders are usually found at rock undersurfaces and in forest litter. Although this species has not previously been recorded from caves, other members of the genus are occasional cavernicoles.
Distribution.-CA: Santa Cruz Co.: Bat Cave. This species occurs throughout the southern United States.
References.-Levi, 1957; Ubick, 2001 survey.

ORDER CHELONETHI
Family Chthoniidae

Neochthonius imperialis Muchmore (Ap. 4, Pl. 6)
Diagnosis.-(1.5 mm). Of the two pseudoscorpions, this species is smaller, has shorter palpi, and has enlarged chelicerae.
Biology.-(TB). This troglobitic species is found under rocks and wood in the dark to twilight zones of the cave.
Distribution.-CA: Santa Cruz Co.: Empire Cave (Type Locality). Not known from any other localities.
References.-Muchmore, 1996; Weygoldt, 1969.

Family Neobisiidae

Fissilicreagris imperialis (Muchmore) (Ap. 4, Pl. 6; Ap. 5, Fig. 17-18)
(previously included in Microcreagris)
Diagnosis.-(2.5-3.5 mm). Of the two pseudoscorpions, this species is larger and has longer palpi and smaller chelicerae.
Biology.-(TB). This species shares the habitat preference of the preceding.
Distribution.-CA: Santa Cruz Co.: Bat Cave, Dolloff Cave, Empire Cave (Type Locality), IXL Cave (probably), Stump Cave. Not known from any other localities.
References.-Muchmore & Cokendolpher, 1995; Ubick, 2001 survey.

ORDER OPILIONES
Family Nemastomatidae

Ortholasma rugosum Banks (Ap. 4, Pl. 7; Ap. 5, Fig. 14)
Diagnosis.-(3-5 mm). This species is easily distinguished from other harvestmen with moderate leg length by its flattened body, rugose sculpturing, and lacy anterior expansion of the eyemound.
Biology.-(EP). Found in closed canopy forest biomes beneath rocks and wood debris, this species has not previously been recorded from caves, although other members of the genus have.
Distribution.-CA: Santa Cruz Co.: Dolloff Cave, Empire Cave, Stearns Cave. Known from coastal California, from Mendocino to San Benito Counties.
References.-Shear & Gruber, 1983; Ubick, 2001 survey.

Family Phalangodidae

Calicina serpentinea (Briggs & Hom) (Ap. 4, Pl. 6)
Diagnosis.-(1.5 mm). This species can be separated from other harvestmen by its small size, short legs, and pale yellow coloration.

Biology.-(EP). Found in mesic areas beneath rocks in both forest and grassland biomes. This is the first record of the species from caves.
Distribution.-CA: Santa Cruz Co.: Bob's Secret Cave (near Bat Cave). Known from coastal California, from Santa Clara to San Benito Counties.
Reference.-Ubick & Briggs, 1989.

Sitalcina californica (Banks) (Ap. 4, Pl. 6; Ap. 5, Fig. 11)
Diagnosis.-(2 mm). This species can be separated from other harvestmen by the combination of their short legs, reddish-orange color, and 2 claws on the hind tarsi.
Biology.-(TP). Found in mesic areas, generally on and beneath rocks and wood where they probably feed on collembolans.
Distribution.-CA: Santa Cruz Co.: Bat Cave, Empire Cave, IXL Cave, Stearns Cave, Stump Cave. Known from coastal California, from Sonoma to San Luis Obispo Counties.
References.-Briggs, 1968; Briggs & Ubick, 1988; Ubick, 2001 survey.

Family Sabaconidae

Sabacon briggsi Shear (Ap. 4, Pl. 7; Ap. 5, Fig. 13)
Diagnosis.-(5 mm). This harvestman is most easily distinguished from others by its moderate leg length, shorter chelicerae, and especially its robust hairy palpi.
Biology.-(EP). Occurs under rocks and ground litter in forest biomes and occasionally in caves.
Distribution.-CA: Santa Cruz Co.: Empire Cave. This species is restricted to coastal California from Marin to Santa Cruz Counties.
References.-Shear, 1975; Ubick, 2001 survey.

Taracus sp (Ap. 4, Pl. 7)
Diagnosis.-(5 mm). This harvestman has legs of moderate length and is most easily distinguished from others by its long chelicerae, often longer than the body. The chelicerae are black in adults and grayish-white in juveniles.
Biology.-(TP). These harvestmen are restricted to caves and mesic forest habitats and are believed to feed on snails.
Distribution.-CA: Santa Cruz Co.: Stearns Cave. This genus occurs in the mountainous areas of central California north to Canada.
References.-Briggs & Ubick, 1988; Comstock, 1940.

Family Sclerosomatidae

Leiobunum exilipes (Wood) (Ap. 4, Pl. 7; Ap. 5, Fig. 15-16)
Diagnosis.-(7-10 mm). This large species is easily distinguished from other opilionids by its extremely long legs which span several centimeters.
Biology.-(TX). As a trogloxene, this species spends only a part of its life cycle in caves. It is often quite abundant and may form dense aggregates which are commonly referred to as 'cave hair'.
Distribution.-CA: Santa Cruz Co.: Bat Cave, Dolloff Cave, Empire Cave, IXL Cave, Stearns Cave, Stump Cave. Known from California north to Canada and

east to Montana.
References.- Briggs & Ubick, 1988; Davis, 1934; Graham, 1968a; Levi et al, 1968; Martens, 1978; Ubick, 2001 survey.

Family Triaenonychidae

Zuma acuta Goodnight & Goodnight (Ap. 4, Pl. 6; Ap. 5, Fig. 12)
Diagnosis.-(2 mm). This short-legged species is similar to Sitalcina but has paler brown pigmentation and a single claw on its hind tarsi.
Biology.-(TP). Occurs in mesic areas on and under rocks and wood debris.
Distribution.-CA: Santa Cruz Co.: Dolloff Cave, Empire Cave, Stump Cave. Known from forest habitats in coastal California, from San Mateo to Monterey Counties.
References.-Briggs, 1971; Ubick, 2001 survey.

ORDER ACARI
SUBORDER PARASITIFORMES

undetermined (Ap. 4, Pl. 7)
Diagnosis.-(1 mm). This is the only mite recorded from these caves.
Biology.-(EP?). A single specimen was collected on the ceiling of the entrance room in the midst of a cluster of psocopterans, Psyllipsocus ramburii.
Distribution.-CA: Santa Cruz Co.: Bat Cave. Full range not known.
Reference.-Ubick, 2001 survey.

"MYRIAPODA"
CLASS DIPLOPODA

Biology.-Millipedes are scavengers and are found in the vicinity of decaying organic material.

ORDER CHORDEUMATIDA

Family Striariidae

Striaria sp. (Ap. 4, Pl. 8; Ap. 5, Fig. 21-22)
Diagnosis.-These small to medium sized troglophiles have tuberculate body keels.
Biology.-(TP).
Distribution.-CA: Santa Cruz Co.: Dolloff Cave, Empire Cave, IXL Cave, Stearns Cave, Stump Cave. Total distribution not known.
References.- Briggs & Ubick, 1988; Ubick, 2001 survey.

ORDER POLYDESMIDA

undetermined (Ap. 4, Pl. 8)
Diagnosis.-These medium to large millipedes have body rings with lateral keels.
Biology.-(TP?).
Distribution.-CA: Santa Cruz Co.: Bat Cave, Dolloff Cave, Empire Cave, IXL Cave, Stearns Cave, Stump Cave. Polydesmids are found throughout California.
Reference.- Briggs & Ubick, 1988.

ORDER SPIROBOLIDA

undetermined (Ap. 4, Pl. 8; Ap. 5, Fig. 20)
Diagnosis.-(10 cm) These giant millipedes have a cylindrical body with smooth rings.
Biology.-(EP).
Distribution.-CA: Santa Cruz Co.: Bat Cave, Empire Cave. Found throughout California.
References.- Levi, 1968; Ubick, 2001 survey.

CLASS CHILOPODA

Biology.-(EP). Centipedes are predators found beneath rocks and wood debris and in loose soils.

ORDER GEOPHILOMORPHA

Family Geophilidae

undetermined (Ap. 4, Pl. 9)
Diagnosis.-(>25 mm) Geophilid centipedes have long slender bodies with 31 to 177 pairs of legs.
Distribution.- CA: Santa Cruz Co.: Dolloff Cave, Empire Cave, IXL Cave. Found throughout California.
References.- Briggs & Ubick, 1988; Cloudsley-Thompson, 1968; Ubick, 2001 survey.

ORDER LITHOBIOMORPHA

undetermined (Ap. 4, Pl. 9)
Diagnosis.-(10-14 mm) Lithobiomorph centipedes are slender bodied with only 15 pairs of legs.
Distribution.- CA: Santa Cruz Co.: Stearns Cave, Stump Cave. Found throughout California.
References.- Levi, 1968; Ubick, 2001 survey.

ORDER SCOLOPENDROMORPHA

undetermined (Ap. 4, Pl. 9; Ap. 5, Fig. 19)
Diagnosis.-(>30 mm) Scolopendromorph centipedes are thick bodied and have 21 to 23 pairs of legs.
Distribution.- CA: Santa Cruz Co.: Empire Cave. Found throughout California.
References.- Levi, 1968; Ubick, 2001 survey.

CLASS SYMPHYLA

Family Scutigerellidae

Scutigerella sp. (Ap. 4, Pl. 9)
Diagnosis.-(5-6 mm) This is the only symphylan known from these caves.
Biology.-(TP). Symphylans are detritovores living interstitially and in ground litter. Although frequently encountered in caves, this is the first record from the Santa Cruz caves.

Distribution.- CA: Santa Cruz Co.: Empire Cave. Probably found throughout California.
References.- Cloudsley-Thompson, 1968; Scheller, 1986; Ubick, 2001 survey.

CLASS INSECTA
ORDER COLLEMBOLA

Note.-The several as yet undetermined collembolans collected during the 2001 survey from all the caves except Dolloff probably belong to the following species.

Family Entomobryidae

Diagnosis.-The four species representing this family have elongated abdomens and slightly elbowed antennae. Christiansen & Bellinger (1980) give keys for species determinations.
Biology.-(TP). These entomobryids are all troglophiles and occur in caves and cave-like habitats. In caves they are commonly found on moist decomposing wood and other plant material.

Sinella (Sinella) baca Christiansen & Bellinger (Ap. 4, Pl. 10)
Diagnosis.-(3 mm).
Distribution.-CA: Santa Cruz Co.: Bat Cave, Empire Cave (Type Locality), Stearns Cave, Stump Cave. Also known from several localities in northern California.
References.- Briggs & Ubick, 1988; Christiansen & Bellinger, 1980.

Sinella (Sinella) sexoculata (Schott) (Ap. 4, Pl. 10)
Diagnosis.-(2 mm).
Distribution.-CA: Santa Cruz Co.: Stearns Cave, Stump Cave. Also known from several localities from central California to Washington.
References.- Briggs & Ubick, 1988; Christiansen & Bellinger, 1980.

Tomocerus (Plutomurus) californicus Folsom (Ap. 4, Pl. 10)
Diagnosis.-(3.5 mm).
Distribution.-CA: Santa Cruz Co.: Bat Cave, Dolloff Cave, Empire Cave, IXL Cave, Stearns Cave. Also known from several localities from central California into Oregon.
References.- Briggs & Ubick, 1988; Christiansen & Bellinger, 1980.

Tomocerus (Plutomurus) wilkeyi Christiansen (Ap. 4, Pl. 10)
Diagnosis.-(4 mm).
Distribution.-CA: Santa Cruz Co.: Bat Cave, Empire Cave, Stearns Cave, Stump Cave. Also known from several localities from California into Oregon and Utah.
References.- Briggs & Ubick, 1988; Christiansen & Bellinger, 1980.

undetermined
Distribution.-CA: Santa Cruz Co.: Bat Cave, Empire Cave, IXL Cave, Stearns Cave, Stump Cave.

Reference.-Ubick, 2001 survey.

Family Sminthuridae

Dicyrtoma *(*Ptenothrix*)* maculosa (Schott) (Ap. 4, Pl. 10)

Diagnosis.-(3 mm). The species representing this family has a globular abdomen and distinctly elbowed antennae.
Biology.-(EP)-This sminthurid is an epigean species and its occurrence in caves is accidental.
Distribution.-CA: Santa Cruz Co.: Empire Cave, Stump Cave. Also known from several epigean localities from California to Canada.
References.- Briggs & Ubick, 1988; Christiansen & Bellinger, 1980.

ORDER DIPLURA

Family Japygidae

undetermined (Ap. 4, Pl. 10)

Diagnosis.-(about 10 mm). Japygids are easily recognized by their creamy color and dark abdominal forceps.
Biology.-(TP). These predaceous diplura require high humidity and occur in protected habitats, under rocks, and in decaying vegetation.
Distribution.-CA: Santa Cruz Co.: Dolloff Cave. Japygids are widely distributed in both cave and epigean habitats.
References.- Briggs & Ubick, 1988; CSIRO, 1970.

ORDER ARCHAEOGNATHA

Family Machilidae

undetermined (Ap. 4, Pl. 10)

Diagnosis.-(about 10 mm). Machilids are easily recognized by their dark color, cylindrical body, and long abdominal cerci.
Biology.-(EP). These detritovores are commonly found in leaf litter and hop when disturbed.
Distribution.-CA: Santa Cruz Co.: Bat Cave. Machilids are widely distributed in epigean habitats. This is the first cave record from this region.
References.- CSIRO, 1970; Ubick, 2001 survey.

ORDER ORTHOPTERA

Family Rhaphidophoridae

Ceuthophilus sp. nr. **inyo** Hubbell (Ap. 4, Pl. 11; Ap. 5, Fig. 23)

Diagnosis.-(about 10 mm). These cave crickets are easily recognized by the curved wingless body and long hind legs.
Biology.-(TX). These plant feeders are found crawling on cave walls and on and under detritus.
Distribution.-CA: Santa Cruz Co.: Bat Cave, Empire Cave, Stearns Cave. This genus is widely distributed.
References.-Briggs & Ubick, 1988; Daly et al, 1978; Ubick, 2001 survey.

ORDER PSOCOPTERA

Family Psyllipsocidae

Psyllipsocus ramburii Selys (Ap. 4, Pl. 11)

(P. ramburi of Rudolph et al, MS and Briggs & Ubick, 1988, is a misspelling)

Diagnosis.-(2 mm). This is the only book louse known from these caves and is dimorphic, occurring in both short and long winged forms.

Biology.-(TP). This species prefers humid conditions and is believed to be omnivorous, especially favoring moulds. Males are unknown and the species probably reproduces parthenogenetically.

Distribution.-CA: Santa Cruz Co.: Bat Cave. Widely distributed across Europe and North America.

References.- Briggs & Ubick, 1988; Gurney, 1943; Ubick, 2001 survey.

ORDER HOMOPTERA

Family Achilidae

undetermined (Ap. 4, Pl. 11)

Diagnosis.-(3 mm). This hopper differs from a cixiid by having a narrower body and wings which overlap apically.

Biology.-(EP). The presence of this plant feeder in the cave is probably accidental.

Distribution.- CA: Santa Cruz Co.: Bat Cave. Not known from other localities.

References.-Ubick, 2001 survey.

Family Cixiidae

Cixius n. sp. (Ap. 4, Pl. 11; Ap. 5, Fig. 24-26)

Diagnosis.-(3 mm). This hopper differs from an achilid by having a broader body and wings which do not overlap apically.

Biology.-(TP). Both adults and nymphs of this species feed on roots which penetrate caves.

Distribution.- CA: Santa Cruz Co.: Bat Cave, Dolloff Cave, Empire Cave, IXL Cave, Stump Cave. Not known from other localities.

References.-Briggs & Ubick, 1988; Fennah, 1973; Kramer, 1981; Ubick, 2001 survey.

ORDER MEGALOPTERA

Family Corydalidae

undetermined (Ap. 4, Pl. 11)

(previous references to Corydalus sp. are in error)

Diagnosis.-(over 5 cm). These dobsonflies are most easily recognized by their large size.

Biology.-(EP). The larvae of these insects develop in intermittent streams. Adults seek out dark places for shelter and may occasionally enter caves.

Distribution.- CA: Santa Cruz Co: Dolloff Cave. Widespread in California.

References.- Borror et al, 1989; Briggs & Ubick, 1988.

ORDER COLEOPTERA

Family Carabidae

Diagnosis.-Carabids are dark colored, flattened beetles easily recognized by the combination of filiform antennae and the 1st abdominal segment bisected by the hind coxae.
Biology.-All are predaceous and occur on the ground or beneath ground litter.

Anillodes sp (Ap. 4, Pl. 12)
Diagnosis.-(2 mm). This tiny carabid is a light brown color.
Biology.-(TP?).
Distribution.- CA: Santa Cruz Co: Dolloff Cave.
Reference.- Briggs & Ubick, 1988.

Bembidion iridescens LeConte (Ap. 4, Pl. 12; Ap. 5, Fig. 27)
Diagnosis.-(4 mm). This medium-sized carabid is dark brown in color.
Biology.-(TP).
Distribution.- CA: Santa Cruz Co: Dolloff Cave, Empire Cave.
References.- Briggs & Ubick, 1988; Ubick, 2001 survey.

Promecognathus sp. (Ap. 4, Pl. 12)
Diagnosis.-(5-8 mm). This carabid has a narrowed elongate head and mandibles.
Biology.-(EP).
Distribution.- CA: Santa Cruz Co: Bat Cave. The genus is widespread along the west coast, from California to Canada.
References.- Hatch, 1953; Ubick, 2001 survey.

Pterostichus (**Hypherpes**) spp (Ap. 4, Pl. 12)
Diagnosis.-(10-15 mm). Most Pterostichus are large and black in color.
Biology.-(EP?).
Distribution.- CA: Santa Cruz Co: Bat Cave, Empire Cave, IXL Cave.
References.- Briggs & Ubick, 1988; White, 1983.

Scaphinotus sp (Ap. 4, Pl. 12)
Diagnosis.-(6-10 mm). This carabid is easily recognized by its narrow head and thorax.
Biology.-(EP). Scaphinotus is a snail-eating carabid.
Distribution.- CA: Santa Cruz Co: Stearns Cave.
References.- Ubick, 2001 survey; White, 1983.

Trechus ovipennis californicus Motschultsky (Ap. 4, Pl. 12)
Diagnosis.-(4 mm). This medium-sized carabid is chestnut brown in color.
Biology.-(TX?)
Distribution.- CA: Santa Cruz Co: Empire Cave.
References.- Briggs & Ubick, 1988.

Trechus sp. (**vandykei** group) (Ap. 5, Fig. 28)
Diagnosis.-

Biology.-(TX?)
Distribution.- CA: Santa Cruz Co: Empire Cave, Dolloff Cave.
Reference.- Briggs & Ubick, 1988; Ubick, 2001 survey.

Family Curculionidae

undetermined (Ap. 4, Pl. 12)
Diagnosis.-(3-8 mm) Curculionids (weevils) are easily recognized by their mouthparts elongated into a snout.
Biology.-(EP). These beetles occur in a variety of habitats. The cave specimens were collected beneath rocks.
Distribution.- CA: Santa Cruz Co: Empire Cave, Stump Cave. The family occurs throughout California.
References.- Ubick, 2001 survey; White, 1983.

Family Elateridae

Limonius sp. (larvae only) (Ap. 4, Pl. 12)
Diagnosis.-(10 mm) This is the only click beetle recorded from the caves.
Biology.-(EP). These elaterids are phytophagous and are associated with decomposing wood.
Distribution.- CA: Santa Cruz Co: Bat Cave. This is a widespread genus.
References.- Briggs & Ubick, 1988; Peterson, 1960; White, 1983.

Family Pselaphidae

undetermined (Ap. 4, Pl. 12)
Diagnosis.-(2 mm) Pselaphids resemble rove beetles in having short elytra but differ in having a stocky oval body and clubbed antennae.
Biology.-(EP). These beetles are most commonly encountered under rocks and in leaf litter.
Distribution.- CA: Santa Cruz Co: Stearns Cave. The family occurs throughout California.
References.- Ubick, 2001 survey; White, 1983.

Family Staphylinidae

Aleocharinae (Ap. 4, Pl. 12)
Diagnosis.-(5-10 mm). Rove beetles are easily recognized by their elongated body and short elytra.
Biology.-(TX?). Most staphylinids are predaceous and occur on the ground, under rocks, and around decomposing organic matter.
Distribution.- CA: Santa Cruz Co: Dolloff Cave, Empire Cave. Aleocharines occur throughout California.
References.-Graham, 1963; Ubick, 2001 survey; White, 1983.

Family Tenebrionidae

Diagnosis.- Tenebrionids (darkling beetles) are slow-moving black beetles with the distinctive tarsal formula of 5-5-4.
Biology.-(EP). Tenebrionids feed on plant matter and are often associated with

decaying wood,

Eleodes sp. (Ap. 4, Pl. 12)
Distribution.- CA: Santa Cruz Co: Bat Cave. This genus is widespread and common in California.
References.- Briggs & Ubick, 1988; Ubick, 2001 survey; White, 1983.

Eleodes parvicollis Escholtz
Distribution.- CA: Santa Cruz Co: Bat Cave.
Reference.-Briggs & Ubick, 1988.

ORDER DIPTERA

Family Culicidae

undetermined (Ap. 4, Pl. 13)
Diagnosis.-(6 mm). Mosquitos are easily recognized by their long legs and elongated piercing mouthparts.
Biology.-(EP). Larvae develop in water, adult males feed on plant juices and females on tetrapod blood.
Distribution.- CA: Santa Cruz Co: Bat Cave, Stearns Cave. This family occurs throughout California.
References.- Borror et al, 1989; Ubick, 2001 survey.

Family Muscidae

undetermined (Ap. 4, Pl. 13)
Diagnosis.-(7 mm). Muscids may be recognized by the hairy terminal segment of the antenna (arista) and characteristic wing venation.
Biology.-(EP). These flies generally occur at decomposing organic matter.
Distribution.- CA: Santa Cruz Co: Bat Cave. This family occurs throughout California.
References.- Cole, 1969; Ubick, 2001 survey.

Family Mycetophilidae

undetermined (Ap. 4, Pl. 13; Ap. 5, Fig. 29)
Diagnosis.-(5-7 mm). Mycetophilids may be recognized by their elongated coxae.
Biology.-(TX?). This species may be a trogloxene or perhaps a troglophile. Members of this family feed on fungus growing in soil and decaying vegetation
Distribution.- CA: Santa Cruz Co: Empire Cave, Stearns Cave. This family occurs throughout California.
References.- Cole, 1969; Graham, 1967; Ubick, 2001 survey.

Family Phoridae

undetermined (Ap. 4, Pl. 13)
Diagnosis.-(1.5 mm). Phorids are small humpbacked flies with strongly reduced wing venation.
Biology.-(EP). Members of this family feed on decomposing organic matter.

Distribution.- CA: Santa Cruz Co: IXL Cave, Stump Cave. This family occurs throughout California.
References.- Cole, 1969; Ubick, 2001 survey.

Family Piophilidae

undetermined (Ap. 4, Pl. 13)
Diagnosis.-(4-5 mm). Pioplilids may be recognized by their long arista and details of the wing venation.
Biology.-(EP). Members of this family feed on decomposing organic matter.
Distribution.- CA: Santa Cruz Co: Empire Cave, Stump Cave. This family occurs throughout California.
References.- Cole, 1969; Ubick, 2001 survey.

Family Sciaridae

undetermined (Ap. 4, Pl. 13)
Diagnosis.-(2-4 mm). These are similar to mycetophilids but are smaller and have less pronounced coxae.
Biology.-(TX?). This species may be a trogloxene or perhaps a troglophile. Members of this family feed on fungus.
Distribution.- CA: Santa Cruz Co: Dolloff Cave, Empire Cave, IXL Cave. This family occurs throughout California.
References.- Cole, 1969; Graham, 1967; Ubick, 2001 survey.

Family Sphaeroceridae

Leptocera sp. (Ap. 4, Pl. 13)
Diagnosis.-(3 mm). These small flies are recognized by their characteristic wing venation.
Biology.-(EP). These flies generally breed in decaying organic matter.
Distribution.- CA: Santa Cruz Co: Empire Cave. This genus occurs throughout California.
References.- Cole, 1969; Ubick, 2001 survey.

Family Tipulidae

Diagnosis.-These are the common crane flies known from the Santa Cruz caves. They lack ocelli.
Biology.- (TX) The adults of these species are seasonal trogloxenes, occuring in caves only during the dry season, and are found flying and resting on walls of the entrance and twilight portions of caves.

Dicranoptycha sp. nr. **occidentalis** Alexander (Ap. 4, Pl. 14)
Diagnosis.-(7-9 mm). This smaller species has yellowish, transparent wings.
Distribution.- CA: Santa Cruz Co: Empire Cave. Also known from other cave and epigean localities in California.
References.-Graham, 1966; Young, 1987.

Limonia (Limonia) maculicosta sciophila (Osten Sacken)

(previosly known as Limonia nubeculosa sciophila) (Ap. 4, Pl. 14; Ap. 5, Fig. 30)
Diagnosis.-(9-11 mm). This larger species has mottled wings.
Distribution.-CA: Santa Cruz Co: Bat Cave, Dolloff Cave, Empire Cave, IXL Cave, Stump Cave. Also known from other cave and epigean localities in California.
References.-Graham, 1966; Ubick, 2001 survey.

Family Trichoceridae

Trichocera sp. (Ap. 4, Pl. 14)
Diagnosis.-(7-9 mm). These crane flies have ocelli and transparent wings.
Biology.-(EP). The biology of trichocerids is similar to that of the common crane flies.
Distribution.- CA: Santa Cruz Co: Bat Cave. Occurs throughout California.
References.-Cole, 1969; Ubick, 2001 survey.

ORDER LEPIDOPTERA

undetermined
Diagnosis.-(5-7 mm).
Biology.- (EP).
Distribution.- CA: Santa Cruz Co: Bat Cave; Stearns Cave.
References.-Ubick, 2001 survey.

Family Geometridae

Triphosa haesitata Guenee (Ap. 4, Pl. 14; Ap. 5, Fig. 31-32)
Diagnosis.-(15 mm). This is the only moth recorded from these caves.
Biology.-(TX). Only adults of this species occur in caves, principally in entrance and twilight portions, where they rest with outstretched wings on the cave walls.
Distribution.-CA: Santa Cruz Co.: Bat Cave, Empire Cave, Dolloff Cave, IXL Cave, Stearns Cave. Also known from numerous epigean and cave localities in California and Nevada.
References.-Graham, 1968a, 1968b; Ubick, 2001 survey.

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Appendix 1

The Cave Gulch Caves

1.--Map showing the location of the caves in Cave Gulch.

2.--Photographs of the caves taken during the July 2001 survey

Appendix 2

Copies of the original field notes of the 2001 surveys.

Appendix 3

Spreadsheet of the species' distribution in Cave Gulch.

Legend:

Column 1 lists the higher classification of the organisms, from phylum to family, arranged as in text.

Columns 2 and 3 give the genus and species along with the common names of the higher categories (included parenthetically).

Column 4 indicates the ecological classification of the organisms: EP=epigean; PB=phreatobite; TB=troglobite; TP=troglophile; TX=trogloxene.

Columns 5 through 10 list the caves, from N to S: emp=Empire; dol=Dolloff; stm=Stump; ixl=IXL; bat=Bat; str=Stearns.

Symbols: TL=type locality of species; c=species collected during the 2001 survey; s=species seen but not collected during that survey; x=previously published records.

Appendix 4

Illustrations of Cave Gulch invertebrates.

Plate 1.—Annelida, Mollusca, Crustacea

Plate 2.—Araneae: Anyphaenidae, Cybaeidae, Hahniidae

Plate 3.—Araneae: Linyphiidae

Plate 4.—Araneae: Nesticidae, Telemidae, Tengellidae

Plate 5.—Araneae: Tetragnathidae, Theridiidae

Plate 6.—Chelonethi, Opiliones: P halangodidae, Triaenonychidae

Plate 7.—Opiliones: Nemastomatidae, Sabaconidae, Sclerosomatidae. Acari

Plate 8.—Diplopoda

Plate 9.—Chilopoda, Symphyla

Plate 10.—Collembola, Diplura, Archaeognatha

Plate 11.—Orthoptera, Psocoptera, Homoptera, Megaloptera

Plate 12.—Coleoptera

Plate 13.—Diptera: Culicidae, Mycetophilidae, Phoridae, Piophilidae, Sciaridae

Plate 14.—Diptera: Tipulidae, Trichoceridae. Lepidoptera

Appendix 5

Photographs (by J. Ledford) of Cave Gulch invertebrates taken during the July 2001 survey. (Cave where organism encountered indicated parenthetically.)

Plate 1
1.--slug (Stump)
2.--Brackenridgia (Empire)
3.--Calymmaria (Stearns)
4.--Calymmaria in web (Empire)
5.--Calymmaria webs (Dolloff)

Plate 2
6.--Nesticus silvestrii with eggsac (Empire)
7.--Nesticus silvestrii with eggsac (IXL)
8.--Titiotus (Bat)
9.--Meta dolloff with eggsac (Dolloff)
10.--Meta dolloff web (Empire)

Plate 3
11.--Sitalcina californica (Stearns)
12.--Zuma acuta (Empire)
13.--Sabacon briggsi (Empire)
14.--Ortholasma rugosum (Dolloff)
15.--Leiobunum exilipes (Empire)
16.--Leiobunum cluster, "cave hair" (Stearns)

Plate 4
17.--Fissilicreagris imperialis (Empire)
18.--Fissilicreagris imperialis (Empire)
19.--scolopendromorph centipede (Empire)
20.--spirobolid millipede (Bat)
21.--Striaria (IXL)
22.--Striaria (IXL)

Plate 5
23.--Ceuthophilus (Empire)
24.--Cixius nymph (Empire)
25.--Cixius adult (Empire)
26.--Cixius adult (Stump)
27.--Bembidion (Empire)
28.--Trechus (Empire)

Plate 6
29.--mycetophilid (Empire)
30.--Limonia (Empire)
31.--Triphosa (Stump)
32.--Triphosa cluster (Empire)