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A Review of the Invertebrate Fauna of Volcanic Caves in Western North America

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ABSTRACT

The known invertebrate inhabitants of volcanic caves are listed together with comments on their ecology and distribution. Several highly specialized troglobitic species are present in these caves. The microclimatic similarity of volcanic to limestone caves is discussed. The occupation of temperate volcanic caves was precipitated by changing Pleistocene climatic conditions, just as was the occupation of temperate limestone caves.

INTRODUCTION

Lava tubes and other types of caves in volcanic regions often are not well-regarded as potential sites for biospeleological investigation. Vandel (1965) entirely omitted them from his comprehensive review of biospeleology. He did, however, mention some of the fauna of volcanic caves, such as the crustaceans *Heteromysis cotti* and *Munidopsis polymorpha* from the Canary Islands. Howarth (1972) briefly mentioned the existence of a few troglobites from volcanic regions in other parts of the world and listed appropriate references. Additional data on Japanese lava cave fauna are presented by Uéno (1960, 1970, 1971a, 1971b). Lava cave fauna on the South Korean island of Cheju-do was briefly mentioned by Uéno, Pae, and Nagao (1966). Howarth recently (1972) reported on a remarkable assemblage of cave-adapted arthropods from lava tubes on the oceanic island of Hawaii.

The purpose of this paper is to summarize our knowledge of the invertebrate fauna of the volcanic caves of continental North America, to point out how little is known

about them, and to encourage future research and collecting. The caves included in the following list are lava tubes, caves in lava talus, and those formed as cracks or fissures by lava flow or cooling contractions. To date, knowledge on the invertebrate fauna of volcanic caves in western North America exists only for those in western continental United States. I know of no volcanic caves in Canada or Alaska, though they may exist and may be occupied by invertebrates. Mexico has extensive volcanic areas with volcanic caves. Nothing is known of the fauna in these caves; however, they should offer good potential for future work.

Some data exist only as general observations, such as those gathered by Halliday (1963) and others reported in the newsletters of various caving clubs (e.g.: the *Cascade Caver* and the *Speleograph*). I have not sought out these records, which usually give only common names such as "moths", "spiders", "mosquitos", "collembola", or "harvestmen", because they are not sufficiently trustworthy or lack detailed taxonomic data.

No obligate vertebrates are known to inhabit these volcanic caves. The report of a

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blind fish in Washington by St. Amant (1854) should be regarded as spurious, although a blind fish is known from a Japanese volcanic cave (Uéno, 1970).

FAUNAL LIST

Phylum

Platyhelminthes

Class Turbellaria

Order Tricladida

Family Planariidae

Kenkia rhynchida HYMAN, 1937

This, the only species in the genus, is known only from the type locality, Malheur Cave, Harney County, Oregon. Mitchell (1968) placed the genus in the family used above but noted the need to restudy and redefine the genus, using live and better-fixed material.

Phylum Arthropoda

Class Crustacea

Order Isopoda

Family Trichoniscidae

Trichoniscus nearcticus ARCANGELI,
J. O. Maloney determination

Four males and three females, collected by Hubbs in Malheur Cave, Harney County, Oregon, were reported as an unspecified isopod by Hyman (1937, p. 416) and were deposited in the National Museum of Natural History (Smithsonian) at the time when the University of Michigan crustacean collection was transferred. The species was not found during recent collecting trips to the cave (Benedict, written commun.).

Order Amphipoda

Family Gammaridae

Stygobromus hubbsi SHOEMAKER, 1942

The species is known only from the type locality, Malheur Cave, Harney County, Oregon. Nieland (1971) mentions "sightless life forms" that may be this or another amphipod in a river in Deadhorse

Cave, in southcentral Washington. According to J. R. Holsinger, who is presently revising the genus (written commun.), 14 undescribed subterranean species of the genus *Stygobromus* have been collected from scattered localities west of the continental divide in California, Arizona, Montana, Nevada and Oregon. Thirteen of these species are closely related to *S. hubbsi*. The animals have been collected from lava caves, limestone caves, springs, wells, and deep lakes.

Class Arachnida

Order Pseudoscorpiones

Family Chthoniidae

Apochthonius sp.

The species, from Malheur Cave, Harney County, Oregon, is being described by D. Malcolm and E. Benedict. The genus is widespread throughout much of the United States in forest litter and moss (Chamberlin and Malcolm, 1960); seven cavernicolous species are reported from the eastern United States (Muchmore, 1967).

Family Neobisiidae

Microcreagris columbiana CHAMBERLIN

The species was described from a male with reduced eyes "drawn from a well" at Clatskanie, Oregon. Chamberlin (1962) considered it to be either a soil or a subterranean species, fortuitously recovered from the well. Muchmore (1969) reports the species from Pillar of Fire Cave, 1.5 miles south of Trout Lake, Klickitat County, Washington. Many species in this genus are known from caves in both the eastern and western United States (Muchmore, 1969).

Parobisium charlotteae CHAMBERLIN

This species is known only from "Redmond Lava Cave" in Deschutes County, Oregon. It is a large, blind or nearly blind species considered to be a troglophile (Chamberlin, 1962).

Order Acari

Family Rhagidiidae

Rhagidia sp.

I have taken material in Boy Scout Cave, Craters of the Moon National Monument, Idaho. Several species in the genus occur in caves and seem to be widespread (Elliott and Strandtmann, 1971, and references therein).

Order Opiliones

Family Erebomastriidae

T. S. Briggs determination

Briggs (written commun.) reports an adult female of an undescribed species from Boy Scout Cave, Craters of the Moon National Monument, Butte County, Idaho (collected by S. and J. Peck), and large, pale-yellow, eyeless species from Gwendolyn Cave, Lincoln Co., Idaho and from a cave near Mammoth Cave, also in Lincoln County, Idaho. These are the first examples discovered of blind, fully troglolithic Erebomastriids. They are quite unlike specimens taken in limestone caves in the United States and Europe, which have eyes and relatively short appendages. The Idaho localities provide important links between eastern and western populations of the family. The family name was proposed by Briggs (1969) only recently and may not be generally accepted by other workers.

Family Ischyropsalidae

Taracus malkini

GOODNIGHT and GOODNIGHT

The type locality is Manzanita Lake, Shasta County, California (Goodnight and Goodnight, 1945). Briggs (written commun.) reports the species to be conspicuous on moist walls in Subway Cave, near Manzanita Lake. They have eyes, unpigmented abdomens, and thin, black chelicerae of considerable length. Briggs (written commun.) states that he has found similar *Taracus* in high-elevation limestone caves in the Sierra Nevada Mountains.

Sabacon sp.,

T. S. Briggs determination

Briggs (written commun.) reports a collection from Ape Cave, Skamania County, Washington. Probably, this is an accidental record of an epigeal species, just as is the record of *Sabacon jonesi* from a cave in Alabama (Goodnight and Goodnight, 1942).

Family Travuniidae

T. S. Briggs determination

Briggs (written commun.) reports the recent collection of material from Jug and Nielsens caves, Skamania County, Washington. These are the first New World collections of the family, which is described by Vandel (1965, p. 90) as being cavernicoles of ancient origin. They are, in fact, true "living fossils."

Family Triaenonychidae

T. S. Briggs determination

R. Westcott collected a late instar specimen in Crystal Falls Cave, Clark County, Idaho. As with other cavernicolous members of the family, this specimen has eyes, but its relatively long second tarsi and lack of pigmentation suggest that it is an obligate troglophile. The species most closely resembles juvenile *Cyrtobunus cavicolens* Banks (*Sclerobunus cavicolens* [Banks]), which are depigmented but have large eyes. *C. cavicolens* is found in a limestone cave (Lewis and Clark Caverns) at Limespur, 60 miles W. of Bozeman, in Madison County, Montana (Briggs, 1971, and written commun.).

Order Araneae

Family Linyphiidae

Bathyphantes diasosnemis FAGE

Reported (Ivie, 1969) from Subway Cave, Shasta County, California; otherwise known from caves and epigeal situations in southern Oregon and northern California.

Family **Telemidæ**

Telema sp.

An undescribed species from Subway Cave, Shasta County, California, (data of W. J. Gertsch) shows eye modifications and, possibly, is troglotic. The genus, heretofore thought to comprise a single blind species from caves in the French Pyrenees, is widespread in western North America (our genus *Usofila* is a synonym). Several species are known from caves and from epigeal situations.

Class **Diplopoda**

Order **Chordeumida**

Family **Conotylidae**

Plumatyla humerosa (LOOMIS)

Reported (Shear, 1971) from Indian Wells Ice Cave, Lava Beds National Monument, Siskiyou County, and Sunnyside Mine (type locality), Plumas County, California. I have seen it in other caves (Craig Cave, Frozen River Cave) in Lava Beds National Monument. Immature specimens of *Plumatyla* are known from a number of unspecified mines, limestone caves, and lava tubes (mostly in The Lava Beds) in northern California and adjacent Oregon (Shear, 1971). Shear considers the species to be troglotic because it is unpigmented and because the ocelli are reduced to about 10, in two rows. However, its wide distribution suggests that the species is not an old cave inhabitant. Only one species is known in the genus, but the immature specimens may represent populations of other species. The millipede mentioned by Hubbs (in Hyman, 1937, p. 461) as a true cave species from Malheur Cave, Oregon may be of this genus.

Family **Conotylidae**

Idagone westcotti

BUCKETT and GARDNER, 1967

Known only from Crystal Falls Cave (type locality), Clark County, and Boy Scout Cave, Craters of the Moon Na-

tional Monument, Butte County, Idaho. I have taken it in Boy Scout and Beauty caves, Craters of the Moon. The numerous pigmented ocelli suggest that the species is not an old cave inhabitant. The genus contains only this species. Its familial relationships are discussed by Shear (1969, 1971).

Order **Polydesmida**

Family **Polydesmidae**

Halliday (1963) mentions polydesmid millipeds in Bat and Fish Hatchery caves, Skamania County, Washington.

Class **Collembola**

Order **Arthropleona**

Family **Entomobryidae**

Tomocerus flavescens (TULLBERG),

K. Christiansen determination

This species is a common troglophile and is widespread in North America. I took it in Boy Scout Cave, Idaho. Westcott (1968) mentions undetermined Entomobryids from Idaho caves. There are several troglotic species in this family.

Class **Insecta**

Order **Diplura**

Family **Campodeidae**

Plusiocampa sp.

Species of this genus are known from caves in the eastern United States. I have collected them in Boy Scout Cave, Craters of the Moon, Idaho, and in Craig and Frozen River caves, Lava Beds, California. Westcott (1968) reports them from Idaho and Halliday (1963) mentions them in Dry Creek Cave, Skamania County, Washington.

Order **Grylloblattodea**

Family **Grylloblattidae**

Grylloblatta chandleri KAMP

Reported (Kamp, 1963) from Eagle Lake Ice Cave (type locality), Lassen County, California. These caves are contraction

crevices covered with talus blocks. They are not lava tubes, although some exist nearby. Another species, *G. barberi* Caudell, occurs not far to the south, at the confluence of Butt Creek and the North Fork of Feather River, Plumas County.

Grylloblatta chirurgica GURNEY

Reported by Gurney (1961) from Ape (type locality), Lake, and Nielsens caves, all in Skamania County, Washington. Halliday (1963) mentions what probably is this species in Bat Cave, also in Skamania County.

Grylloblatta gurneyi KAMP

Reported (Kamp, 1963, 1970) from Merrill Ice (type locality), Indian Wells Ice, and Skull caves, all in Lava Beds National Monument, Siskiyou County, California. I have taken it in Frozen River Ice Cave in The Lava Beds, and also have taken what may be this species on snowbanks at high elevations on near-by Mt. Shasta.

Grylloblatta rothi GURNEY

Reported from Edison Ice Cave, near Bend, Oregon (Kamp, 1970). This species typically is subalpine and here occurs sympatrically with an undescribed population.

Grylloblatta sp.

The following caves are known to contain *Grylloblatta*, but the populations either are undescribed or are known only from immature specimens, so that species determination is not possible. The records are those of Kamp, reported by Halliday (1962). **California.** Plumas County: Griffith Ranch Ice Caves (these caves are contraction fissures in lava); Siskiyou County: Jack Jones Ice Cave, Jake Bell caves, Mayfield Ice Cave, Starr Cave (These Siskiyou County populations probably are *G. gurneyi*); Tehama County: Wilson Ice Cave (near Wilson Lake, less than 20 miles NW of a *G. barberi* local-

ity and less than 40 miles SW of a *G. chandleri* locality). **Oregon.** Deschutes County: Edison Ice Cave (Kamp 1970).

Order Coleoptera

Family Leiodidae

Glacivacicola bathyscioides WESTCOTT

Reported (Westcott, 1968; Peck, 1970, 1974) from **Idaho.** Butte County: Boy Scout Cave, Beauty Cave (both in Craters of the Moon National Monument); Clark County: Crystal Falls Cave; Power County: Crystal Ice Caves. This species is highly modified for cave life. Its biology and distributional history are discussed in the above references.

Family Staphylinidae

Subfamily Aleocharinae

Representatives of the subfamily are known from Idaho caves (Westcott, 1968).

Quedius spelaeus HORN

This species is widely distributed across most of the United States and southern Canada. It is a common cave inhabitant, but also is known from non-cave habitats, including mammal burrows. It is known (Halliday, 1963; Smetana, 1971) to occur in lava tubes in **California.** Siskiyou County: Sentinel Cave (Lava Beds Nat. Mon.); Shasta County: Subway Cave. **Idaho.** Clark County: Crystal Falls Cave. **Washington.** Skamania County: Fish Hatchery Cave.

DISCUSSION

Definite ecological classifications can be assigned to some of the above-listed animals. Those animals known definitely to be troglitic, from morphologic features such as reduced or absent eyes and pigment, are the listed species of *Kenkia*, *Stygobromus*, *Erebomastriid* and *Travuniid* harvestmen, and *Glacivacicola*. To this category may also belong the listed species of *Microcreagris*, *Parobisium*, *Apochthonius*, *Rhagidia*, *Telema*, and *Plusiocampa*.

Several of the animals do not show great modification for cave life, but now probably are ecologically confined to caves. These obligate troglaphiles are *Plumatyla*, *Idagone*, the several species of *Grylloblatta* and, perhaps, *Rhagidia* and *Plusiocampa*. Those remaining on the list, the facultative troglaphiles, will also be found in non-cave habitats. These are *Trichoniscus*, the Ischyropsalids and Polydesmids, *Bathypantes*, *Tomocerus*, *Quedius*, and the Aleocharine staphylinids. Only when more taxonomic and ecological data is available can the above species be categorized with more certainty.

Among the terrestrial invertebrate troglaphiles and obligate troglaphiles, at least, the cave occupation seems certainly to have been motivated by a search for cool, moist habitats. Such habitats are those occupied by the species most closely related to the troglaphiles. This conclusion is reinforced by the observation that caves with cooler air and with standing water or ice contain a richer fauna.

The lava plateaus in which the lava-tube caves of western United States occur are mostly located in the Columbia Plateau, in the contiguous semi-arid region of northern California, Oregon, Washington, and southern Idaho. This region today lies within the Upper Sonoran and the Transitional life zones, which are fairly dry and have moderately high summer temperatures. The caves, then, serve as moist, cool microclimatic refuges within a generally dryer and warmer habitat.

Much of the fauna probably came from higher elevations, reaching the caves overland by migration during the cooler and more moist conditions of the last glaciation (Kamp, 1963, 1970; Peck, 1974; Uéno, 1960, 1970, 1971a). As the glacial ice retreated and the warming and drying trends of the present interglacial continued, some of the populations retreated into the suitable environments offered by the caves. This mechanism is certainly true for *Plumatyla* and *Idagone*, and for the species of *Grylloblatta*, all of which show no special

cave modification. The modified species, such as the Erebonastrid and Travuniid harvestman, *Glacivicola*, and other possible troglaphiles, may have occupied caves during earlier interglacials.

It will be seen that most of the localities for the known fauna (Fig. 1) cluster around Craters of the Moon, Idaho; Lava Beds, California; Skamania County, Washington; central Oregon; and Malheur Cave, Oregon. However, it should by no means be assumed that the fauna of these areas is well known. It is hoped that this paper will encourage additional work in these areas, as well as in areas not yet explored biospeleologically.

In conclusion, the volcanic caves of western United States do possess a specialized fauna. Some of this fauna has affinities with the faunas of limestone caves in the United States to the south and east, such as *Stygobromus*, *Apochthonius*, *Microcreagris*, *Rhagidia*, *Bathypantes*, and *Plusiocampa*. However, some of this fauna is unique and is limited to the caves or to the general cave-containing region of the Pacific Northwest. Examples of the latter are *Plumatyla*, *Idagone*, *Grylloblatta* and, especially, the Travuniids and *Glacivicola*. A conclusion which may be drawn from this observation is that, although the caves themselves have histories different from those of caves in limestone regions, their internal environmental conditions have attracted, isolated, and supported faunas in the same way as have those of limestone caves.

SUMMARY

Little is known, at present, about the invertebrate fauna of volcanic caves in the United States. However, there is enough data to show that a specialized fauna exists and that it is unique and significant. Virtually nothing is known about volcanic caves in Canada and Mexico, although a fauna should exist in the latter country. Abundant opportunities exist for enlarging our knowledge by field and laboratory studies of the taxonomy, ecology, distribution, and evolution of this fauna.

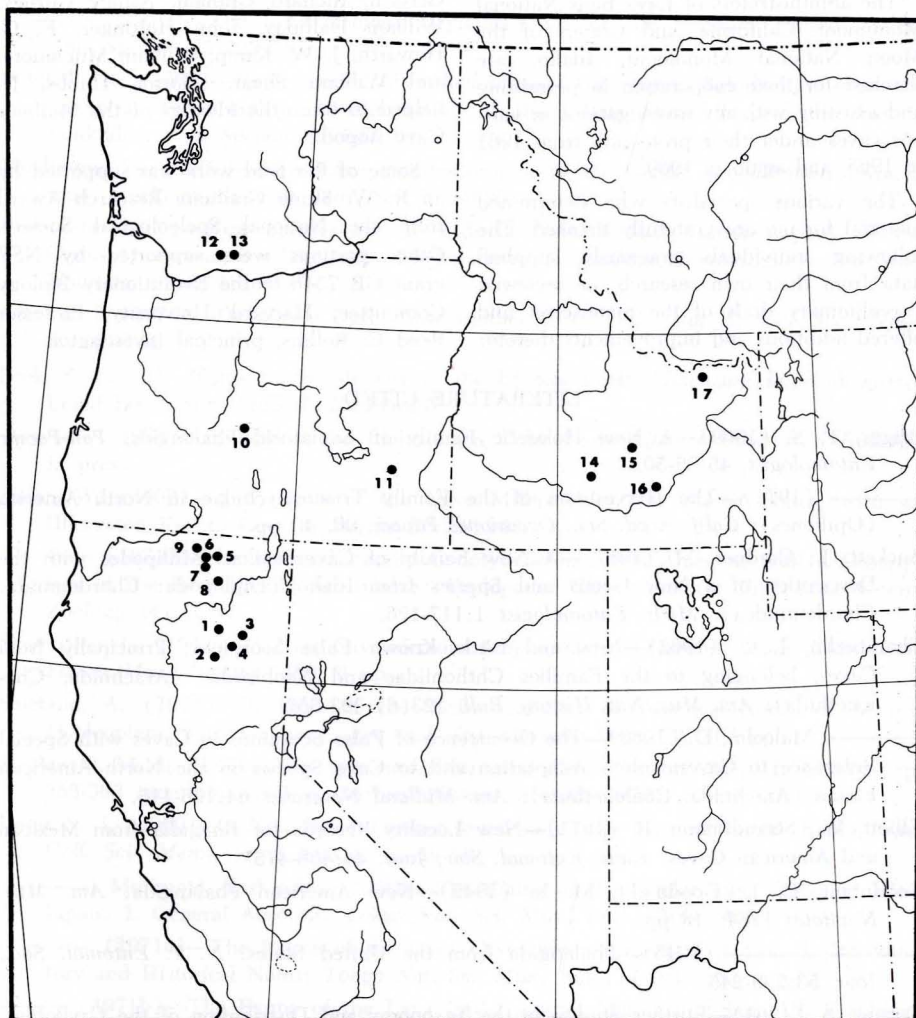


Fig. 1. Locations of volcanic caves in western continental United States from which invertebrates are known. 1. Subway Cave. 2. Wilson Ice Cave. 3. Eagle Lake Ice Cave. 4. Griffith Ranch Ice Caves. 5. Lava Beds National Monument (including Craig, Frozen River, Indian Wells Ice, Merrill Ice, Sentinel, and Skull caves). 6. Jack Jones Ice Cave. 7. Jake Bell Cave. 8. Mayfield Ice Cave. 9. Starr Cave. 10. Deschutes County (Edison Ice Cave and "Redmond Lava Cave"). 11. Malheur Cave. 12. Skamania County (including Ape, Bat, Dry Creek, Fish Hatchery, Jug, Lake, Nielsens, and (?) Deadhorse caves). 13. Pillar of Fire Cave. 14. Lincoln County (Gwendolyn Cave and a cave near Mammoth Cave). 15. Craters of the Moon National Monument (including Boy Scout and Beauty caves). 16. Crystal Ice Cave. 17. Crystal Falls Cave.

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LITERATURE CITED

- Briggs, T. S. (1969)—A New Holarctic Family of Laniatorid Phalangids: *Pan-Pacific Entomologist*, 45:35-50.
- (1971)—The Harvestmen of the Family Triaenonychidae in North America (Opiliones): *Calif. Acad. Sci., Occasional Papers*, 90, 43 pp.
- Buckett, J.; Gardner, M. (1967)—A New Family of Cavernicolous Millipedes with the Description of a New Genus and Species from Idaho (Diplopoda: Chordeumida: Chordeumidea): *Mich. Entomologist* 1:117-126.
- Chamberlin, J. C. (1962)—New and Little Known False Scorpions, Principally from Caves, belonging to the Families Chthoniidae and Neobisiidae (Arachnida, Chelonethida): *Am. Mus. Nat. History, Bull.* 123(6):303-352.
- ; Malcolm, D. (1960)—The Occurrence of False Scorpions in Caves with Special Reference to Cavernicolous Adaptation and to Cave Species in the North American Fauna (Arachnida, Chelonethida): *Am. Midland Naturalist* 64:105-115.
- Elliott, W.; Strandtmann, R. (1971)—New Locality Records for *Rhagidia* from Mexican and American Caves: *Kans. Entomol. Soc., Jour.* 44:468-475.
- Goodnight, C. J.; Goodnight, M. L. (1942)—New American Phalangida: *Am. Mus. Novitates* 1164. 18 pp.
- ; ——— (1945)—Phalangida from the United States: *N. Y. Entomol. Soc., Jour.* 53:239-245
- Gurney, A. (1961)—Further Studies in the Taxonomy and Distribution of the Grylloblattidae (Orthoptera): *Biol. Soc. Wash., Proc.* 74:67-76.
- Halliday, W. R. (1962)—Caves of California: Seattle, Western Speleol. Survey, 194 pp.
- (1963)—Caves of Washington: *Wash. Div. Mines Geol., Inf. Circ.* 40, 132 pp.
- Howarth, F. (1972)—Cavernicoles in Lava Tubes on the Island of Hawaii: *Sci.*, ns 175:325-326.
- Hyman, L. (1937)—Studies on the Morphology, Taxonomy, and Distribution of North American Triclad Turbellaria. VIII. Some Cave Planarians of the United States: *Am. Micros. Soc., Trans.* 56:457-477.
- Ivie, W. (1969)—North American Spiders of the Genus *Bathypantes* (Aranea, Linyphiidae): *Am. Mus. Novitates* 2364, 70 pp.

- Kamp, J. (1963)—New Species of Grylloblattidae with an Interpretation of their Geographical Distribution: *Entomol. Soc. America, Ann.* 56:53-68.
- (1970)—The Cavernicolous Grylloblattodea of the Western United States: *Ann. Spéleol.* 25:223-230.
- Mitchell, R. (1968)—New Species of *Sphalloplana* (Turbellaria; Paludicola) from the Caves of Texas and a Re-examination of the Genus *Speophila* and the Family Kenkiidae: *Ann. Spéleol.* 23:597-620.
- Muchmore, W. (1967)—New Cave Pseudoscorpions of the Genus *Apochthonius* (Arachnida: Chelonethida): *O. Jour. Sci.* 67:89-95.
- (1969)—New Species and Records of Cavernicolous Pseudoscorpions of the Genus *Microcreagris* (Arachnida, Chelonethida, Neobisiidae, Ideobisiinae): *Am Mus. Novitates* 2392, 21 pp.
- Nieland, J. (1971)—Deadhorse Cave, "just another lava tube,": *Nat. Speleol. Soc., News* 29:142-144.
- Peck, S. (1970)—Notes on the Biology of the Eyeless Beetle *Glacicavicola* (Coleoptera; Leiodidae): *Ann. Spéleol.* 25:235-237.
- (1974)—Biology of the Idaho Lava Tube Beetle *Glacicavicola*: *NSS Bulletin*: in press.
- Shear, W. (1969)—A Synopsis of the Cave Millipeds of the United States, with an Illustrated Key to Genera: *Psyche* 76:126-143.
- (1971)—The Milliped Family Conotylidae in North America, with a Description of the New Family Adritylidae (Diplopoda: Chordeumida): *Bull. Mus. Comp. Zoology* 141:55-97.
- Shoemaker, C. (1942)—A New Cavernicolous Amphipod from Oregon: *Mich. Univ., Occ. Papers Mus. Zoölogy*, 466, 6 pp.
- Smetana, A. (1971)—Revision of the Tribe Quediini of America North of Mexico (Coleoptera; Staphylinidae): *Entomol. Soc. Canada, Mem.* 79, 303 pp.
- St. Amant, M. de (1854)—Voyages en Californie et dans l'Oregon: Paris, L. Maisson, pp. 353-363 (reprinted in *Jour. Spelean History* 5:39-42, 1972).
- Uéno, S. -I. (1960)—A New Blind Trechid found in a Lava Cave of Japan: *Kyoto Univ. Coll. Sci., Mem. ser. B Biology* 27:49-58.
- ; Morimoto, Yoshinobu (1970)—The Fauna of the Insular Lava Caves in West Japan. I. General Account: *Tokyo Nat. Sci. Mus., Bull.* 13:443-455.
- (1971a)—The Fauna of the Lava Caves around Mount Fuji-San. I. Introductory and Historical Notes: *Tokyo Nat. Sci. Mus., Bull.* 14:201-216.
- (1971b)—The Fauna of the Lava Caves around Mount Fuji-San. VI. Trechinae (Coleoptera): *Tokyo Nat. Sci. Mus., Bull.* 14:338-350.
- ; Pae, S. K.; Nagao, F. (1966)—Results of the Speleological Survey in South Korea 1966. I. General Account, with Brief Descriptions of the Caves Visited: *Tokyo Nat. Sci. Mus., Bull.* 9:465-499.
- Vandel, A. (1965)—Biospeleology: NYC, Pergamon, 524 pp.
- Westcott, R. (1968)—A New Subfamily of Blind Beetle from Idaho Ice Caves with Notes on its Bionomics and Evolution (Coleoptera: Leiodidae): *Los Angeles County Mus. Nat. History, Contr.* 141, 14 pp.

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Papers discussing any aspect of speleology are considered for publication in *The NSS Bulletin*. We particularly welcome articles describing important caves and cave areas, on the history of caves and of speleology, on problems and techniques of cave conservation, and critical reviews of current literature, in addition to papers on the more traditional subjects of cave geology, geography, fauna, and ecology. The material presented must be original and of lasting interest. Authors should demonstrate the significance of their work to speleological theory and should elucidate the historical antecedents of their interpretations by reference to appropriate literature. Presentations consisting of raw data, only, will not be accepted.

A narrative style of writing is preferred. Fine prose is terse yet free from lacunae, sparkles without dazzling, and achieves splendor without ostentation. Data and interpretations blend effortlessly along a logical continuum so that the reader, having read, neither knows nor cares how many pages he may have turned while following the author's exposition.

As written language must communicate through time as well as across space, neologisms should be introduced only if needed to express new concepts or to record new percepts. This is especially important in an archival journal such as *The NSS Bulletin*. Standard usage, therefore, is required of all authors. For general style, refer to papers in this *Bulletin* and to the following handbooks: "Suggestions to Authors" (U. S. Geological Survey), "Style Manual for Biological Journals" (American Institute of Biological Sciences, Washington, D. C.), and "A Manual of Style" (The University of Chicago Press).

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