Diplura of Lava Tube Caves

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Abstract

The examination of campodeid diplurans collected from 21 lava tube caves in Washington, Oregon, Idaho, and northern California has revealed seven or eight species belonging to the genus *Haplocampa*. One species may belong to the endogean species *H. rugglesi*, originally described from Mount Rainier. The others are new undescribed species. A morphological study of the cave species was done in an attempt to learn their phylogenetic relationship to each other and to the known endogean and cavernicolous (in limestone caves) species of *Haplocampa*. Lavacicle Cave in Oregon is unusual in that it contains two species of diplurans; in the United States only two other caves (limestone) are known to do so at present. However, this distinction may vanish following the study of some extensive collections of diplurans from lava tube caves in Washington state. Considering their wide occurrence in the lava tube caves of the northwestern United States, it is somewhat surprising that diplurans are so poorly represented in the fauna of volcanic caves elsewhere in the world.

Introduction

Diplurans are small, white, eyeless, wingless hexapods that live under stones, in the soil, and in caves. There are seven taxonomic families recognized for the Order Diplura (Ferguson, 1990), but most of the cave species belong to the family Campodeidae and are characterized by having two long multisegmented cerci (tails) which macroscopically somewhat resemble the antennae (Figure 1). Over 40 species, belonging to 10 genera, of campodeid diplurans are known from caves in the United States (Ferguson, 1981). The species known so far from lava tube caves belong to a single genus, *Haplocampa*.

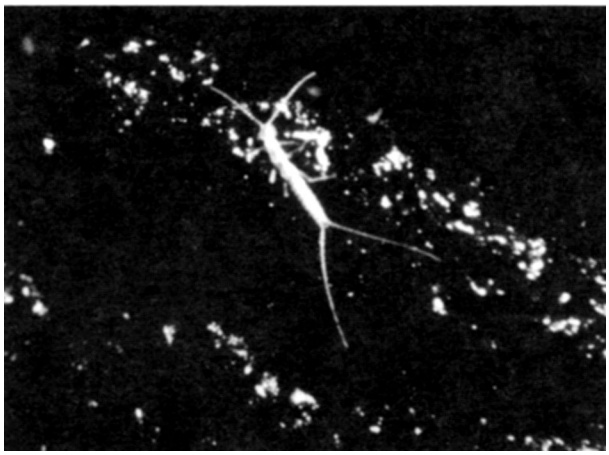

*Figure 1 – Campodeid dipluran (*Haplocampa *sp.) on wet rock, Upper Falls Creek Cave, Washington. (Photo: F.G. Howarth)*

This genus is found in the central and western United States, particularly the northwest, and into Canada. It is represented by endogean (soil-dwelling) forms in northern California, Oregon, Washington, Montana, and Alberta; by cavernicoles in limestone caves in Illinois, Missouri, Utah, Arizona, and Washington; by cavernicoles in lava tubes in Idaho, Washington, Oregon, and California; and by a species from a mine in north central California.

Distribution in the Continental United States

The first dipluran from a lava cave that I was able to examine was collected by Stewart and Jarmila Peck in 1969 at Boy Scout Cave, Craters of the Moon National Monument, Idaho, while Stewart was studying a cave beetle found in the lava tubes there (Peck, 1974). Since then, collections by Frank Howarth, John Holsinger, Rod Crawford, Clyde Senger, and me, aided by Libby Nieland and others, have revealed seven or eight

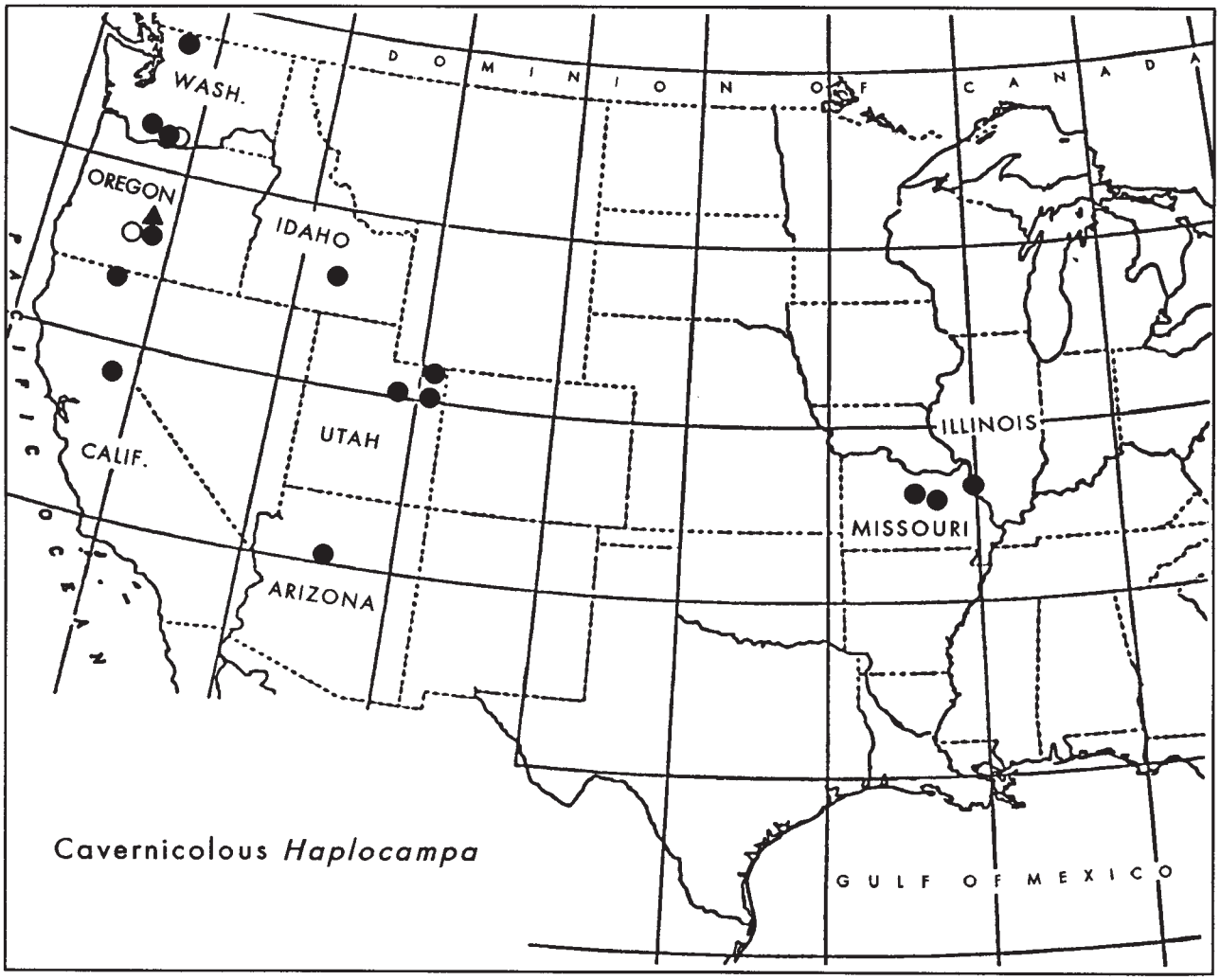

Figure 2—Distribution of cavernicolous campodeid diplurans in the western United States. See text for explanation.

species of campodeid diplurans from 21 lava caves in the states of Idaho, Washington, Oregon, and northern California.

The distribution of species is as follows (see Fig. 2). In Idaho the only collection is the one specimen from Craters of the Moon National Monument mentioned above. Additional attempts to collect more specimens myself in 1972 were unsuccessful. The Idaho form represents a new (undescribed) species of *Haplocampa*.

In the state of Washington, the northernmost solid circle on the map in Figure 2 represents Windy Creek Cave in Skagit County. This is a limestone cave. The species found here is probably *H. chapmani*, an endogean known from nearby Mount Baker. In southern Washington the more westerly solid circle represents a new species found in Ape Cave and others (Dollar and Dime Cave, Little Red River Cave, and Lake Cave) in Skamania County associated with the Mount St Helens lava flows. The easterly solid circle represents another new species from Cheese Cave, Thanks Cave, and Jug Cave in Klickitat County and Dead Horse Cave, New Cave, Big Cave, Dynamited Cave, Ice Rink Cave, Dry Creek Cave, Lower Falls Creek Cave System, and Upper Falls Creek Cave System in Skamania County associated with Mount Adams.

The open circle in southern Washington stands for Snowpatch Cave in Klickitat County. The species found here also appears to inhabit Lava River Cave in south central Oregon, also represented by an open circle symbol. These collected specimens may belong to the endogean species *H. rugglesi*, originally described from Mount Rainier.

The solid circle in northern California indicates the location of Lava Beds National Monument, Siskiyou County, where I found another new species in Merrill Ice Cave in 1982. (More recently, in 1989, Rod Crawford has collected campodeid diplurans there in Catacombs Cave, Fern Cave, Lost Pinnacle Cave, and Merrill Ice Cave as well.) The solid circle in north central California represents Sunnyside Mine in Plumas County, the site of another new species of *Haplocampa*.

The solid circle to the east in Oregon stands for a new species found only in South Ice Cave in Lake County. And the solid triangle indicates Lavacicle Cave, Deschutes County, which is unique in that the cave contains two species of *Haplocampa*. In fact, only two other caves (both in limestone) in the United States are currently known to have two species of campodeids in them. One is Steeles Cave, Monroe County, West Virginia, the other is Panther Creek Cave, Hancock County, Tennessee. Elsewhere in the world this condition of syntopy for cave diplurans is rare also.

The unique situation for Lavacicle Cave may soon change however. Due to intensive sampling of many lava tubes in Washington by Rod Crawford and Clyde Senger (1988) using baited pit fall traps, a large number of specimens (707!) are now available to study. Since then Crawford has collected many more diplurans in California and Washington lava tube caves (personal communication). Now that we know that two (or more ?) species can exist in a single cave, every specimen of these large collections needs to be intensely studied to make species identifications, and not just a representative sample as has been done in the past.

Phylogeny

Referring again to the map in Figure 2, the other solid circles on the map represent limestone caves and possibly four additional species. Just considering the phylogeny of the species known from lava tube caves, based on the morphology of the specimens, the two species found in Ape Cave *et al.* and Cheese Cave *et al.* are very closely related and probably had a common ancestor.

In fact, all of the lava tube diplurans in the northwestern United States show a close affinity to one another and to the surface or endogean species found there. They represent a fairly homogeneous group. In contrast, the *Haplocampa* species in Arizona, Utah, Missouri, and Illinois are distinctly different from one another and from the northwestern forms.

The identification and phylogeny of campodeid diplurans is based largely on the number and distribution of certain large bristles and hairs. Little can be said about the adaptation to living in caves, i.e., becoming a troglobite, by using such features. However, some characteristics which presumably troglobitic diplurans display are: (1) An increase in overall size. *Haplocampa* species, however, are all relatively large bodied forms, even the ones only known as endogeans. (2) Claws with large tergal (dorsal) crests. All known *Haplocampa* species have such claws already. Indeed this is one of the characteristics of the genus. Interestingly, the species from Sunnyside Mine in California has the largest feet of all! (3) Apical segment of the antennae with a cup-like depression at the tip containing five or more complex sensilla (sensory devices). All of the species known only from lava tubes seem to meet this criterion. Therefore, perhaps they are true cavernicoles or troglobites.

To summarize the findings for lava tube caves in the continental United States, seven or eight species of the campodeid genus *Haplocampa* have been identified from 21 lava tube caves, and specimens have been collected from at least 11 more caves in the same region. Also several of the collections consist of large numbers of specimens. Therefore, campodeid diplurans seem to be fairly numerous and common in lava tubes in the continental United States. What about other areas of the world in which lava tubes are found?

Elsewhere

In 1986, when I visited Surtshellir Cave in Iceland, about 100 kilometers northeast of Reykjavík, I found several invertebrates including a couple of species of flies and a rhagidiid mite, but no diplurans. One might suppose that in Iceland it is too cold for such organisms to occur regularly, so what about in the tropics, like in Hawaii? Many lava tube caves are known from the islands, and a fair number of troglobitic arthropods have been found to inhabit the caves there (Howarth, 1983). There is even an endogean campodeid on the island of Oahu, *Litocampa (Cocytocampa) perkinsi* (Silvestri, 1934; Bareth and Condé, 1972); however, none have ever been found in a cave. The somewhat similar primitive thysanuran *Nicoletia* has been found in caves there.

Other volcanic islands in the tropics with lava tubes include the Galapagos Islands, where Peck and Kukalova-Peck (1986) and others (Hernández *et al.*, 1992a) have found *Lepidocampa zeteki* Folsom in caves there. This species is a hardy endogean, not a troglobite, whose setae are modified into scales which probably make it more resistant to desiccation, and therefore, more capable of dispersal than other moisture-loving soil dwellers. It is known from many localities in Central and South America.

Other islands with lava tubes which are being biologically investigated are the Canaries (Hernández *et al.*, 1992b) and the Azores (Borges *et al.*, 1992). They do not specifically mention the presence of campodeid diplurans; however, other cave invertebrates have been found. One could suppose that the geographic isolation of volcanic islands and the resulting chance immigration (sweepstake route of dispersal) of plants and animals, and the relatively young geologic age of many volcanic islands, all reduce the chances of ancestral campodeids reaching the islands and then populating the caves. Yet it has happened in the Galapagos Islands and elsewhere by similar arthropods (but not campodeids).

As for continental areas, such as the Auvergne region of south central France, from my brief look at the area with all of its cinder cones, basaltic lava flows, and long line of volcanos, it would certainly seem that there would be lava tubes associated with this area; yet I am unaware of any cavernicolous diplurans having been identified from there. (The meticulous French zoologists and biospeleologists certainly would have discovered them if they were there.) Therefore, in light of the common occurrence of campodeid diplurans in the northwestern continental United States, and the widespread occurrence of these primitive arthropods in caves in general, it is somewhat surprising that they are not more widely known from lava tube caves elsewhere in the world.

Acknowledgements

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