

the Kauai cave wolf spider in 1971 (Bousfield and Howarth 1976). Because of the unusual attributes of a highly reduced pincher-like condition of the first gnathopod (thoracic appendage) of the amphipod, and the second gnathopod being mitten-like in both sexes, this taxon is placed in its own unique genus (*Spelaeorchestia*) within the family Talitridae (Bousfield and Howarth 1976). This species is also distinctive in its lack of eye facets and pigmentation, and extremely elongate, spiny, post-cephalic appendages. Adult cave amphipods are 7 to 10 mm (0.25 to 0.4 in) in length with a slender, laterally compressed body and a hyaline (nearly transparent) cuticle, giving it a shiny, translucent appearance. The second pair of antenna are slender and elongate, with the flagellum (slender outer part of the antenna) only slightly longer than the peduncle (narrow stalk attaching to the body). Peraeopods (abdominal walking legs) are very elongate, with slender, attenuated claws. All pleopods (swimming legs) are reduced, with branches vestigial or lacking. Uropods (tail-like appendages) 1 and 2 have well-developed pre-peduncles, and brood plates in the mature female are vestigial or entirely absent (Bousfield and Howarth 1976).

The Kauai cave amphipod is a detritivore and has been observed feeding on the roots of *Pithecellobium dulce* (Manila tamarind) and *Ficus* sp. (fig), rotting roots, sticks, branches, and other plant material washed into, or otherwise carried into, the caves, as well as the fecal material of other arthropods. In large cave passages, most individuals are found in association with roots or rotting plant debris. When disturbed, this cave amphipod typically moves slowly away rather than jumping like other amphipods. Nothing is known of the reproductive biology of this amphipod, but the vestigial brood plates of the female suggest they give birth to a small number of large offspring (Poulson and White 1969; Bousfield and Howarth 1976).

Cave Habitat

Cave habitats have a high degree of zonation which plays a major role in the distribution of cave-dwelling organisms. Howarth and Stone (1990) recognize five distinct zones, not all of which are always present within any one cave. The first zone, the "entrance zone," typically receives large amounts of solar radiation and is often vegetated with surface plants. Within the second zone, the "twilight zone," ambient light levels decrease as one moves away from the entrance and photosynthesizing plants that may be present in the entrance

decline. The third zone is referred to as the "transition zone." The transition zone lacks light penetration from the entrance, but other outside factors still greatly influence the cave habitat (e.g., ample air movement and daily temperature fluctuations). All of the above described zones (entrance, twilight, and transition) are typically influenced by surface conditions, daily cycles of warming and cooling, surface humidity, and a fair degree of air exchange occurring between these zones and surface habitats over relatively short periods of time (daily). The fourth cave zone, the "dark zone," typically exhibits a sharp climatological change from the three previously described zones. The dark zone largely lacks daily air exchange with the surface and the three previously described zones. The relatively constant conditions encountered in the dark zone are often the result of a narrowing cave passage or low ceiling(s) that serve as physical barriers that restrict air exchange with other cave zones, or may be due to an up-slope orientation into a dead-end passage that traps warm, moist air. While the dark zone may undergo drastic changes in temperature and relative humidity, this more often is associated with seasonal rather than diurnal changes in air temperature. As a result of this, dark zones are seasonally stable in their micro-climatic conditions, remaining warm and humid during warm seasons. The final recognized cave zone is that of the "stagnant" zone (Howarth and Stone 1990). This zone lies deeper than the dark zone, receiving significantly less air exchange. As a consequence, the composition of gasses within this last zone is often largely controlled by the decomposition of organic matter and maintains high concentrations of carbon dioxide and low concentrations of oxygen. While considered inhospitable by human standards, field observations have indicated that obligate cave-dwelling species are highly tolerant of these conditions and many may, in fact, thrive in the stagnant air zone of caves (Howarth and Stone 1990).

Cave habitats almost always contain small voids, cracks, and passages (mesocaverns) that cannot be accessed by researchers (Howarth 1983b), but remain readily accessible (or preferred) by small troglobites (obligate cave-dwelling animals). Although such voids and cracks can occur in any zone and possess characteristics of each of the five zones, they frequently represent areas of reduced air flow and consequently are most similar to the dark and stagnant air zones. Passages

and mesocaverns in limestone caves can form or be destroyed at almost anytime in the life of the cave, depending on the chemical characteristics of the rock and normal geologic processes. Limestone caves often become larger over time as acidic waters from the surface dissolve away the calcium carbonate bedrock. Since water flow enlarges and creates caves in limestone by solution, subterranean voids do not fill through erosion. If any do, the water quickly finds a different path and enlarges a new void. Limestone caves grow deeper as the water table sinks and the surface over the caves dissolves away. Limestone caves improve with age because, although individual voids and passages may be short-lived, limestone caves continuously reform so that habitat can remain suitable for very long time spans. Caves derived from lava tube systems are fundamentally different from limestone in that basalt is not as readily soluble. Hence, lava tube passages and mesocaverns do not typically dissolve away and become larger (formed), but are subject to filling with sediments (destroyed).

The tendency for Hawaiian basalt to shrink and crack upon cooling results in younger lava flows having an abundance of mesocaverns throughout their structure that may serve as habitat or as corridors between habitats. However, the cave-building process typically stops some time after cave and crack formation, and is replaced by the cave-filling processes as weathering and sedimentation begin filling in mesocaverns and passages. On younger islands, the abundance of mesocaverns may allow cave animals to move among and between larger, adjacent lava tubes (Berger *et al.* 1981; Howarth 1991). However, because these smaller voids become filled with erosional sediment in older flows like the Koloa Volcanics, and as a result of surface disturbance (Mueller-Dombois and Howarth 1981; Adam Asquith, Service, *in litt.*, 1994a), it is less likely that the Kauai cave animals can readily move among separate lava tubes or other cave systems.

Cave ecosystems are typically regarded as being food limited, and in most caves, the resident food-web communities require food input which is derived from surface systems based upon a photo-autotrophic (*i.e.*, photosynthesizing plants) food base (Culver 1986). Nutrients may enter caves via subterranean streams or other surface runoff; as guano from bats, birds, rodents, or other cave visitors or residents; or from plant roots that penetrate the cave (Culver 1986). Of these methods, roots from surface plants