

## Delving into the Cave Cricket Work by Dr. Kathleen Lavoie

By Kurt Lewis Helf, Ph.D.

Dr. Kathleen Lavoie, along with her collaborators Eugene Studier and Diana Northup, performed some of the early work elucidating the biology and ecology of North American Rhabdophoridae (*Ceuthophilus* spp.) that spend a portion of their life cycle in caves. Kathy and her many collaborators investigated various aspects of *Ceuthophilus* biology and ecology, typically by comparing them with more cave-adapted crickets (e.g., *Hadenoeccus subterraneus*), including their life history, morphology, physiological ecology, habitat use, and foraging behavior. The following biological and ecological information on *Ceuthophilus* spp., based on Kathy Lavoie's research (with her collaborators, including the author), is focused on species from the Mammoth Cave, KY region and Carlsbad Caverns in New Mexico.

### Mammoth Cave area studies

Though *Ceuthophilus* spp. in the Mammoth Cave region utilize the cave environment, compared to the cave-adapted *Hadenoeccus subterraneus*, they are much closer to "typical" surface orthopterans with respect to their evaporative water loss rates, metabolic rates, foraging behavior, and reproduction. *Ceuthophilus stygius* roost just inside cave entrances which they use as a relatively predator-free shelter during the day. In this transitional zone between the surface and cave environments, temperature and relative humidity can be highly variable. However, the relatively thick cuticle of *C. stygius*, enhanced by a shiny layer of waxy lipids, reduces evaporative water loss and so enables them to utilize cave real estate that *H. subterraneus* largely avoids. Though *C. stygius* metabolic rate is higher than that of *H. subterraneus* it is less sensitive to increased temperatures on the surface which also enables it to survive over a wider range of temperatures without increased metabolic demand.

Weight loss studies, the energetic demands of growth and reproduction for an annual species such as *C. stygius*, and its lack of a distensible storage crop like *H. subterraneus*, suggest an interval of 2-3 days between nocturnal foraging bouts on the surface. The foraging exodus of *C. stygius* from the cave entrance to the surface, joined by some fraction of the *H. subterraneus* population, places all the foraging crickets at an increased risk of predation from a range of both invertebrate and vertebrate predators. Increased predation risk from white-footed mice (*Peromyscus leucopus*), a high impact predator based on its size, metabolic rate, and hunting behavior, that aggregates around cave entrances, is supported by mark-recapture data obtained from live trapping grids centered on two cave entrances in Mammoth Cave National Park.

While *Ceuthophilus* spp. invertebrate predators and parasites have a relatively low impact per individual they nonetheless may have a significant negative effect on their populations. Among *C. stygius* examined for parasitic hairworms (*Chordodes morgani*), females were parasitized more frequently than males (N=65, 16.9% and N=70, 2.9%, respectively). Annually reproducing *C. stygius* are found to contain mature gonads only in late summer and fall. Based on dissection data horsehair worm biomass increased slowly during the spring and summer and more significantly increased in late summer and fall when their host crickets' gonads were maturing. Tellingly, six non-parasitized individuals contained an average of 25.5 ova/female whereas nine individuals parasitized by hairworms contained an average of 2.2 ova/female; seven parasitized individuals contained no ova at all.

### New Mexico area studies

In the southwestern United States only *Ceuthophilus* spp. are found using cave habitats. In the Carlsbad Cavern region of New Mexico, *Ceuthophilus* spp. region of New Mexico appearance suggests a range from least cave-adapted *Ceuthophilus carlsbadensis*, the intermediate species *Ceuthophilus conicaudus* with a few morphological adaptations to cave life, to the highly adapted, exclusive cave dweller

*Ceuthophilus longipes*, found in the more remote, food-limited areas of the cave. The first two species have the robust morphology typical of surface dwelling *Ceuthophilus* whereas *C. longipes* bears a striking (but not surprising) resemblance to *H. subterraneus*. An “index of attenuation,” based on the statistically significant relationship between the weight of a crop-empty cavernicolous cricket and its cubed hind femur length, can be used to rank the relative level of cave adaptation among species where low values indicate a high level of cave adaptation. The index of attenuation values for *C. carlsbadensis* and *C. conicaudus* (i.e., .1879 and .1546, respectively) support their apparent lower level of cave adaptation relative to highly cave-adapted *C. longipes* (i.e., .0602). Fecundity studies of female *C. carlsbadensis* and *C. longipes* showed both species carried eggs throughout the year but that *C. longipes* carried significantly fewer but larger eggs (N = 74, # eggs = 0-60, mean = 6.34/individual, mean egg length = 2.89 mm; N = 43, # eggs = 0-4, mean = 0.67/individual, mean egg length = 3.22 mm, respectively); these characteristic of the latter are observed across all highly cave-adapted taxa.

A bioenergetic study of these species showed *C. carlsbadensis* lost weight most rapidly and *C. conicaudus* and *C. longipes* had similar weight loss rates but no real difference in predicted intervals between foraging intervals among all three. However, the same study showed *C. longipes* may maintain greater fat stores and, given it does not forage on the surface and its habitat is mostly remote, food poor cave sites it may be constantly foraging to keep its fat stores in reserve for drought conditions. *C. conicaudus* is known to forage in large numbers on the surface where it is subject to predation by a suite of vertebrate and invertebrate predators such as ringtails and scorpions. Intriguingly, there is evidence *C. conicaudus* foraging activity on the surface is reduced during moonlit nights when predation risk is higher due to increased scorpion activity. It is clear much investigation remains to be done to elucidate the ecological relationships among these fascinating animals.