

Cuticular Hydrocarbon Research¹

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We have been studying existing taxonomies of forest insects that are based on morphological, genetic and/or behavioral characteristics to evaluate the utility of cuticular (surface) hydrocarbons as taxonomic characters (Haverty and others 1988, 1989, Page and others 1990a, 1990b). Cuticular hydrocarbons are relatively stable metabolic end products that appear to be genetically fixed. Because the insects studied so far synthesize all or most of their hydrocarbon components, hydrocarbon composition and taxonomic grouping should be related. Ideally, we would use these chemical characters much as classical taxonomists use morphology, behavior or genetics, i.e., to sort the groups of insects on the basis of surface chemical characters first, rather than after groups have already been sorted on the basis of existing (nonchemical) character criteria. However, by comparing our taxonomic separations on the basis of cuticular hydrocarbons with existing taxonomic divisions based on other characteristics, we are broadening the data base of cuticular hydrocarbons as potential taxonomic characters for forest insects.

We initially started our studies on the dampwood termites, *Zootermopsis*, while trying to understand a synonymy of two species of scolytid cone beetles, *Conophthorus ponderosae* and *C. lambertianae*. Since these beetles have few useful diagnostic morphological characters, we decided to examine cuticular hydrocarbons as taxonomic characters. To test our understanding of the current methodology, we repeated the results of Blomquist and others (1979) on *Z. angusticollis*. Our initial investigation produced hydrocarbon profiles that differed from those they had published. Had we made an error in methodology? Was their hypothesis about species and caste-specific hydrocarbons correct? Had we observed population or colony variation unreported by them?

On the basis of morphological characters, our termite specimens were identified as *Z. nevadensis*, not *Z. angusticollis*. Blomquist (personal communication) suggested that both our laboratories reevaluate our termite collections using identical methods and gas chromatography parameters. Surprisingly, Blomquist's and our laboratory data were identical to those in our first trial but different than his published data. Had we discovered a sibling species? Additional collections and analyses led us to identify an "extra" hydrocarbon phenotype of *Zootermopsis* and to find a morphological character for unequivocal identification of the three described species of *Zootermopsis* (Thome and Haverty 1989). We have separated all species of the dampwood termite by hydrocarbon pheno-

types. Two phenotypes within a species were so different that we used these data as a basis for proposing two subspecies, *Z. nevadensis nevadensis* and *Z. nevadensis nuttingi*.

Confident that we were capable of proceeding with our original purpose involving cone beetles, we embarked on studies of *Conophthorus* spp. and [testing hypothesis on] select species of forest insects. We conducted a study to determine the degree of similarity or diversity or both among eight of the 15 described species of *Conophthorus* (Page and others 1990a). From these species we identified 140 hydrocarbons occurring as individual and isomeric mixtures. Many hydrocarbons were species specific. We discovered that the relatedness of hydrocarbon profiles for each species parallels existing morphological keys. These data support the synonymy of *C. monticolae* with *C. ponderosae*. *Conophthorus* from sugar pine could comprise a sibling species. Hydrocarbon mixtures of two eastern species, *C. resinosae* and *C. banksianae*, are identical, supporting the suspicion that *C. banksianae* may not be a valid species. Closely related pinyon cone beetles, *C. cembroides* and *C. edulis*, have similar combinations of hydrocarbons except for a unique and abundant alkene (C27:1) in *C. edulis* and two dimethylalkanes in *C. cembroides*.

To date we have published the only studies on the cuticular hydrocarbons of scolytid beetles (Page and others 1990a, 1990b). We examined four species of *Dendroctonus* that comprise two sibling species and one pair of morphologically similar species (Page and others 1990b). Each of these four species has an abundance of information on behavioral classifications (i.e., location and patterns of larval and adult galleries), host associations, and taxonomic classification based on host-finding and mating behaviors, pheromone chemistry, and classical morphological traits. The mountain pine beetle and Jeffrey pine beetle are sibling species and are difficult to separate on the basis of morphological characters. The western pine beetle can be distinguished from its close relative, the southern pine beetle, by a few morphological characters, such as larger body size, and on the basis of geographical distribution. We were able to ascertain that the cuticular hydrocarbon mixtures in these four species are species specific. The hydrocarbon patterns of the sibling species corroborate their similarity, yet a few hydrocarbon components are unique enough to allow separation. Western pine beetle and southern pine beetle have hydrocarbon mixtures that are not qualitatively identical. However, they are similar enough to each other to confirm that these species are closely related, as suggested by electrophoresis analyses.

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