Evolution of host use and its ecological consequences in fungivorous ciid beetles

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BACKGROUND

Consumer-resource interactions between trophic levels are ubiquitous and important factors in shaping the diversity of insects. Especially the host-associated organism that lives their life cycle on another organism may be tightly bound by ecological interactions over long evolutionary times. Association between insects and fungi has long history, and fungivory (feeding on mycelia, fruit bodies, or spores of fungi) is observed in variety of taxa. However, There remain a lot of questions on the diversity and complexity of the association of fungi. One of the poorly understood aspects of insect-host fungal association is their evolutionary history. Another fundamental aspect of host fungal use is the specificity in lower taxonomic levels. Furthermore, such difference in host use between species may affect the dynamics and structure of population and ecological communities.

Ciid beetles (Ciidae; Coleoptera) is an ideal system for exploring the specificity, evolution and its ecological consequences of host fungal use. Ciid beetles are abundant in number and depend on the basidiomes of bracket fungi at all stages of their life cycle, and their host use information is relatively well documented among the fungus-feeding insects.

In this thesis, I focus on fungivorous ciid beetles to estimate their host use evolution, examine host specificity at lower taxonomic level, and compare population structure of closely related species with divergent host use patterns. First, I reconstructed the phylogenetic relationships among ciid beetle species using phylogenomics approach and examined host conservatism in host fungal use by ciid beetles. Second, I demonstrated that closely related, congeneric fungivorous ciid species exhibit different host-use patterns for closely related fungal species. Third, I compare population genetic structure among species inhabiting the same landscape to examine the effect of differences in host fungal use on their sensitivity to habitat discontinuity.

METHODS

In Chapter 2, a phylogenetic analysis of ciid was conducted. Ultraconserved elements

(UCEs), mitochondrial and nuclear loci were sequenced and used to reconstruct phylogenetic trees. Ancestral host use was estimated. In Chapter 3, I conduct a taxonomic, phylogenetic and ecological study of *Octotemnus laminifrons* (Ciidae) and its cryptic species using a comprehensive sample across the Japanese archipelago. In Chapter 4, I compare population genetic structure among the three *Octotemnus* species inhabiting the same landscape to test the prediction that ecologically specialized species (specialists; species with narrower host range) are more sensitive to forest discontinuity than generalist species (species with a broader host range). I hypothesized that non-forest areas will act more strongly as a barrier for specialist species than for generalist species and that compared to the simple IBD model, IBR scenarios will better explain the population structure of the specialist species when they do not differ in their dispersal abilities. I used microsatellite data and performed resistance surface optimization and applied the estimation of effective migration surfaces (EEMS) model to landscape population genetic structure of individual species. I evaluated the dispersal ability of focal species using morphological data.

RESULTS

In chapter 2, Phylogenetic analysis and ancestral state reconstruction of eight "host-use groups" showed strong host conservatism in their evolutionary history, indicating certain factors restricting host shift across different fungal taxa. In chapter 3, I found that the ciid beetles previously identified as one species actually comprise four species, and demonstrated that these closely related species exhibit different host-use patterns for closely related fungal species. This finding represents one of few cases demonstrating within-genus discrimination of host fungi by fungivorous insects. In Chapter 4, I compared the spatial genetic structure of closely related species that I described in chapter 3 and showed that levels of response to habitat discontinuity vary among species, which can be explained by differences in flight morphology and host specialization.

DISCUSSION

Results of this study revealed the high degree of host conservatism (Chapter 2) and specificity (Chapter 3) in fungus-feeding ciid beetles. These observations are inconsistent with previous view that the ephemeral and patchy nature of fungal resources should promote generalist associations and polyphagy. Although beetles associated with bracket fungi exhibit specific interactions to limited ranges of fungal taxa, compared with insects that associate with ephemeral mushrooms, no studies have described such long-term and taxon-specific association among insects and host fungi to my knowledge. In herbivorous insects, high specificity and its evolutionary conservatism are considered to reflect conserved recognition of and unique adaptation to host plant chemistry and nutrient content, which may restrict transitions between different host taxa. While it is unknown the similar pattern observed in fungus feeding beetles are derived from similar mechanism with those of herbivorous insects, at least it implies the presence of unique adaptation to fungal bodies in these beetles.