Bark Beetle Genetics

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1. Previous work
A. Protein electrophoresis the basic technique for most work.
B. Genetic variability has been characterized.
C. Population differences demonstrated and analyzed.
D. Genetic population structure assessed.
E. Basic molecular systematics explored; phylogenetic trees developed.
F. T. to attempt to link protein loci to phenotypic characters such as behavior.

2. Our work at University of Georgia
A. Starch gel electrophoresis of Dendroctonus and Ips populations, in terms of genetic variability, population structure, and population differences.
B. mtDNA studies, using restriction site analysis and DNA sequencing.
   (1) Cloned part of mitochondrial DNA
   (2) Completed restriction site analysis of SPB populations
   (3) Begin sequencing of some mtDNA segments

3. Work to be done
A. Long-term study to follow genetic variability and population structure in relation to population cycles of SPB. Electrophoresis and perhaps restriction mapping of genes.
B. Studies using mtDNA as molecular markers of population history in relation to geographic location—phylogeography.
C. Molecular systematics of bark beetle taxa such as Dendroctonus species, using mtDNA and nuclear loci. Restriction mapping and sequencing of PCR-amplified sequences techniques here.

Isozyme Studies of Bark Beetle Population Genetics and Systematics

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Electrophoretic analysis was used extensively in the 1970’s to estimate genetic relationships among populations, species, and closely related genera of many different plants and animals, including many insect genera. Some of the first electrophoretic work on bark beetles was done by Anderson and others (1979), Anderson and others (1983), Florence and Kuhluy (1981), Florence and others (1982), and Namkoong and others (1979). These studies demonstrated that bark beetles are highly polymorphic and amenable to population studies using this technique. The first isozyme study of the mountain pine beetle (Dendroctonus ponderosae) (Stock and Gunther 1979) showed differentiation among geographically separated populations. A subsequent study of MBP from four locations (Stock and Amman 1980) suggested that there might also be genetic differences at individual gene loci between MBP from lodgepole and ponderosa pines, and greater overall heterozygosity in beetles from ponderosa pine. Some preliminary data also showed differences between beetles emerging from trees with thin and thick phloem and between early- and late-emerging beetles from the same tree.

Inferences that could be made from these observations of differences related to host species were, however, confounded by geographic distance among sites. Sturtevant (1980) and Sturgeon and Milton (1986) studied sympatric groups of MBP attacking different hosts in mixed pine stands and found significant differences related to host tree species. Further evidence of differentiation of MBP by host was found in a comparison of isozyme frequencies of MBP collected from lodgepole and ponderosa pines at a single site in Utah (Stock and Amman 1980). Deviations in genotype frequency from Hardy-Weinberg (random mating) expectations occurred when isozyme data from all beetles were pooled (Wahlund effect); frequencies were much closer to random mating expectations when separate analyses were conducted for beetles from each of the host species.

Once again, greater heterozygosity was observed in beetles from ponderosa pine. Overall, beetles from thin-phloem lodgepole were more heterozygous than those from thick phloem, though these differences were not detected in beetles from ponderosa pine.

Heterozygosity and Environmental Stress

Males were more differentiated than females among sites and numbers of emerging males more variable in thin-phloem than in thick-phloem stands. Sturgeon and Amman (1985), males emerging from thin-phloem lodgepole pine were found to be more heterozygous and more variable from tree to tree, and fewer and more variable males (relative to females) emerged from this phloem. We suggested that genetic diversity of MBP (as measured by average heterozygosity) might increase in response to increased severity of environmental conditions (i.e., stress), a response observed in numerous other organisms by other workers (e.g., Samish and Soule 1983). Male MBP are generally thought to be more sensitive to microenvironmental conditions than females, and therefore would be expected to have greater genetic diversity if a generalized population-level response to increased selective pressures was an increased level of heterozygosity. Further evidence to support this hypothesis was provided by a study of isozyme variation observed over six consecutive generations of MBP laboratory-reared in thick and thin phloem; heterozygosity increased in both groups over the generations, but more rapidly in the beetles in thin phloem (Amman and Stock unpublished).

In Ips pinis (Gast and Stock unpublished), genetic diversity was significantly higher in overwintered than in non-overwintered beetles. However, Langor and Spence (1991) observed changes in gene frequencies but no consistent increase in heterozygosity in MBP with overwintering. These authors attribute the genetic differentiation they observed to differential survival in the host, rather than to differential host preference of beetle genotypes. Thus, one might see, as did Gast and Stock (unpublished), greater differences between beetles that have lived for a longer time in different hosts or in the same host species under more severe environmental conditions. Other evidence supports this hypothesis. For example, Gast (1987) reported that overwintered I. pinis responding to pheromone were significantly more heterozygous than overwintered beetles responding to host volatiles. Heterozygosity levels in host-responding, pheromone-responding, and non-responding beetles that had not overwintered were very similar across response categories.

Time of collection can therefore have an important influence on the type of genetic variation observed and interpretations that can be made from it. Langor and Spence (1991) and the work of Gast (1980) suggest that laboratory rearing of beetles collected from logs cut before winter reduces the differential selective influence of host tree species. This possibility could help explain the fact that Sturgeon (1980) and Sturgeon and Milton (1986) found genetic differences between MBP and