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Boletacea (Agaricales): Latitudinal biodiversity and biological interactions in Costa Rica and Colombia

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Abstract: Numbers of taxa of Boletaceae appear to decrease from North America southward to South America. Because the majority of members of this family are obligately ectomycorrhizal, this decrease appears to be linked to the fewer ectotrophic phanerogamic associates in Latin America. However, *Quercus*, *Colombobalanus*, and *Alnus* in montane Costa Rica and Colombia do form associations with Boletaceae. A comparison of the bolete mycotas of the Americas indicates that the genera of boletes in Costa Rica and Colombia are more similar to North American genera and there appears to be a trend towards high endemism at the species level.

Key words: Fungi, Boletaceae, Costa Rica, Colombia, *Quercus*, diversity, endemism.

The published record of Boletaceae in Costa Rica and Colombia has been compiled primarily by Singer, Gómez, and Halling within the last 25 years (Singer 1970, 1973, Gómez and Singer 1984, Singer and Gómez 1984, Halling 1989, 1993, Singer, *et al.* 1990a, 1990b, 1991, 1992). Compared to the known Colombian taxa, Costa Rican representatives are better understood because of more intensive sampling efforts by Singer and collaborators and therefore appear to be more diverse at the species level. Because of the propensity for taxa of Boletaceae to form ectomycorrhizae, distribution is primarily restricted to montane elevations in isolated tracts of *Quercus*, *Colombobalanus*, and *Alnus*. However, some genera such as *Gyrodon*, *Phlebopus*, and *Xerocomus* may be facultatively ectomycorrhizal, and can occur in lowland forests away from traditional ectomycorrhizal hosts (Singer, *et al.* 1983, Singer 1986, Singer and Araujo 1986). The relationships of most neotropical Boletaceae, at least those that form ectomycorrhizae, appear to be with the north temperate mycota. Even though there are species in the neotropical montane forests of Costa Rica and Colombia in common with the north temperate zone, a high degree of endemism exists at the species level. Both Colombia and Costa Rica are geographically situated at the crossroads of an event that has been called the Great American Biotic Interchange (Stehli and Webb 1985). At this intersection there has been a mixing of temperate and tropical elements during the last 5-10 million years, as a result of tectonic and Pleistocene events (Raven and Axelrod 1974, Rich and Rich 1983). This has allowed the successful establishment of some temperate biota at tropical latitudes. In the case study presented here, there are 12 species of *Quercus* in Costa Rica (Burger 1977) and one species in Colombia in addition to the fagaceous *Colombobalanus excelsus* (Lozano *et al.*) Nixon and Crepet (1989). Also, there is one species of *Alnus*.

TABLE 1

Generic distribution of Boletaceae in the Americas

Subfamily *Genus*	North America	Costa Rica Colombia	Lesser Antilles	Tropical South America	Temperate South America
Gyroporoideae					
Gyroporus	+	+	+	+	+
Gyrodontoideae					
Paragyrodon	+				
Phlebopus		+	+	+	
Gyrodon	+	+	+	+	
Meiorganum	+	+			
Suilloideae					
Boletinus	+				
Suillus	+				
Xerocomoideae					
Xerocomus	+	+	+	+	
Phylloporus	+	+	+	+	
Boletoideae					
Chalciporus	+	+	+	+	
Pulveroboletus	+	+	+	+	
Boletus	+	+			+
Boletellus	+	+	+	+	
Leccinum	+	+			
Xanthoconium	+	+			
Veloporphyrellus	+	+			
Porphyrellus	+	+			
Tylopilus	+	+		+	
Fistulinella	+	+	+	+	
Austroboletus	+	+		+	
Gastroboletus	+				+
Strobilomycetoideae					
Strobilomyces	+	+		+	

These trees of Laurasian origin (Kappelle, *et al.* 1992 and citations therein) have migrated to these tropical localities with their obligate bolete symbionts.

For purposes of this paper, the Western Hemisphere has been arbitrarily divided into five regions: North America, Costa Rica and Colombia (southern neotropical *Quercus* forests), Lesser Antilles, tropical South America (excluding the southern neotropical *Quercus* forests), and temperate South America. Reports of Boletaceae from these regions are based on the following: North America (Both 1993), the Lesser Antilles (Pegler 1983), tropical South America (Singer 1960, Dennis 1970, Singer *et al.* 1983), Costa Rica and Colombia (references cited above and my unpublished observations), temperate South America (Singer 1958. 1964, Horak 1977, Garrido 1988).

In a list of the known distribution of bolete genera in the Americas (Table 1), generic similarity decreases from North America toward the south. Because of the absence of native populations of Pinaceae south of Nicaragua, there is a complete lack of native Suilloideae. However, *Suillus luteus* (L.:Fr.) S. F. Gray has been introduced with exotic pines planted in

plantations. On the other hand, *Phlebopus* appears to be restricted to Latin America.

The Simpson Coefficient of Similarity has been used routinely in zoology for measuring taxonomic resemblance between two samples when there may be a discrepancy in sample size (Simpson 1960). Because of the small sample size of ectomycorrhizal boletes in Latin America, the Simpson Coefficient is utilized here to compare bolete mycotas. This coefficient is based on the following formula: $C/N_1 \times 100$, where C is the number of taxa (at a specified taxonomic level) in common between the two samples being compared, and N_1 is the total number of taxa (at the same taxonomic level) present in the smaller sample. If we employ this equation, we see that the generic similarity between North America and Costa Rica and Colombia is 87.5% (14/16 × 100). Examples of comparisons at the species level in some genera indicate that with our current inventory of taxa, the specific similarity between North America and Colombia and Costa Rica is less in *Gyrodon* (1/3 × 100 = 33%), *Leccinum* (2/5 × 100 = 40%), *Tylopilus* (3/15 × 100 = 20%), and *Boletus* (8/21 × 100 = 38%). Clearly the sample size is low, but I would hypothesize that with further surveys and inventories, the numbers of taxa for comparison would increase, but a major alteration in the trends would not be seen here.

Some examples of taxa with a broad distribution include *Boletellus ananas* (Curt.) Murr., *Pulveroboletus ravenelii* (Berk. & Curt.) Murr., *Boletus atkinsonianus* (Murr.) Sacc. & Trot. and *Leccinum rugosiceps* (Pk.) Singer with distribution in Costa Rica and Colombia as well as North America. At present, *Boletus separans* Pk., originally described from eastern North America, has been collected in southern Colombia but is unknown as yet from Costa Rica. Conversely, *Boletus frostii* Russell was described from eastern North America and has been collected as far south as the northern Cordillera Talamanca in Costa Rica but is not known from Colombia.

On the other hand, examples of local endemics might include, among others, *Leccinum andinum* Halling, *L. griseoides* nom. prov., *Tylopilus cartagoensis* Wolfe and Bougher, *T. obscurus* Halling, and *B. flavoniger* nom. prov. Obviously, the current distribution of these taxa reflects the paucity of sampling, as *L. andinum* was only known previously from Colombia (Halling 1989).

At present, 26 boletes from Colombia and 55 from Costa Rica have been identified. Some of these occur in both places and some are contaxic with entities from North America. I suspect that continued inventory will support the hypothesis that a high generic similarity is shared with North America, and that a high degree of endemism is apparent at the specific level.

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RESUMEN

El número de táxones de Boletaceae parece disminuir conforme se va al sur, desde América del Norte hasta América del Sur. Ya que la mayoría de los miembros de esta familia son obligatoriamente ectomicorrízicos, este patrón parece asociarse con la menor cantidad de fanerógamas ectotróficas asociadas en la América Latina. Sin embargo, *Quercus*, *Colombobalanus* y *Alnus* en las partes montañosas de Costa Rica y Colombia sí forman asociaciones con hongos boletáceos. Una comparación de hongos boletos de las Américas indica que los géneros costarricenses y colombianos son más similares a los géneros norteamericanos y parece haber una tendencia hacia un alto endemismo al nivel de especie.

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