Observations on the phenology of ten fungal species in the subtropical forests at Xalapa, Mexico

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The phenology of 9 species of Basidiomycotina and 1 species of Ascomycotina in the subtropical forests of the Botanical Garden at Xalapa is described. Most species had their main fructification period in the rainy season from June to October. For early species the fructification period started in April, whereas for late species this period extended to December. Fructification in August was much lower than that in June–July and September, coinciding with a period of lower precipitation. The entomopathogenic *Cordyceps entomorrhiza* mainly fruited in late autumn, probably in accordance with the biology of its host.

Phenology of fungi, the study of the seasonal occurrence of fruitbodies, has mainly been studied by authors in temperate regions (Eveling *et al.*, 1990; Galán, Ortega & Simón, 1983; Widden, 1981). However, in Mexico this study has scarcely been developed. Guzmán (1958) presented phenological observations on some hallucinogenic species of *Psilocybe* (Fr.) P. Kumm. Guzmán (1973) and Guzmán-Dávalos & Guzmán (1979) discussed phenological patterns in some tropical and temperate fungi. On the basis of a one-year survey Villarreal & Guzmán (1985, 1986*a*, *b*) and Villarreal (1987) made phenological observations on edible fungi from conifer forests of the State of Veracruz and from a subtropical forest close to Xalapa. Recently González-Veláquez & Valenzuela (1993) studied the phenology of some boletes in the State of Mexico. The present contribution deals with phenological observations on 10 species of macromycetes through a 4-year survey.

MATERIALS AND METHODS

Ten common species of macromycetes growing in the forests of the Botanical Garden and the Ecological Park were selected for study of their phenology. The area studied measures 15 ha and is located 3 km to the south of Xalapa in the State of Veracruz (Mexico).

Climatological data were obtained from the Station of Xalapa and from Vivó & Gómez (1946). The area lies at an altitude of 1300–1350 m. The climate is subtropical humid, with a monthly mean temperature of 18 °C and an annual rainfall of 1490 mm. Fig. 1 provides mean monthly temperatures and precipitation from 1980–1990 in Xalapa. The rainy season is from June to September, but it is important to note that there is rain all around the year. Winter season is between November and March and is characterized by fog.

The studied forests are described as subtropical forest or mesophytic forest (Rzedowski, 1978). They are characterized by the presence of *Liquidambar macrophylla* Oersted, *Carpinus caroliniana* Walter, *Cletra mexicana* DC., *Quercus xalapensis* Humb. & Bonpl., *Q. germana* Cham. & Schl., *Q. leiophylla* DC., *Q. laurina* HBK, *Q. sartori* Liebm., and *Nephalea mexicana* (Schl. & Cham.) Tryon, among other trees and shrubs.

Of the ten most frequent and abundant species seven are ectomycorrhizal (*Amanita gemmata* (Fr.) Gillet, *A. virosa* (Lam.) Bertillon, *Lactarius indigo* (Schwein.: Fr.) Fr., *Russula virescens* (Schaeff.) Fr., *Tylopilus balloui* (Peck) Singer, *T. subcellulosus* Singer & García, and *Scleroderma tenerum* Berk. & Cooke), two are parasitic (*Cordyceps entomorrhiza* (Fr.) Link and *Armillaria tabescens* (Scop.: Fr.) Emel), and one is lignicolous saprotrophic (*Oudemansiella canarii* (Jungh.) Höhn.). Representative specimens have been deposited at XAL. Evaluation of phenological patterns was based on monthly surveys from 1987 to 1990. 264 collections were gathered and in addition to these, 136 collections from these forests were taken from

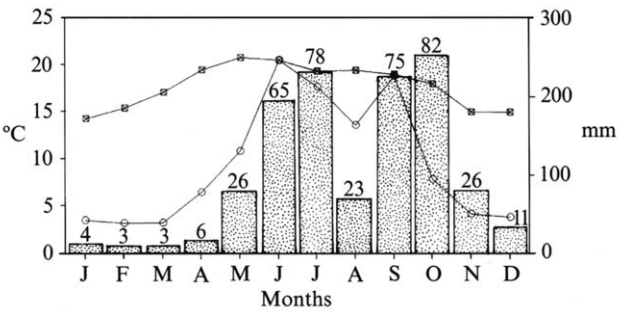

Fig. 1. Average monthly temperature and precipitation (Xalapa Station, 1980–90) and production of the ten species of studied macromycetes (1987–90). ⊠—⊠, temperature; ○—○, precipitation; ⊡, number of collections.

Table 1. Number of collections per month of the ten species studied

	Number of collections by month												Total of collections (n = 400)
	J	F	M	A	M	J	J	A	S	O	N	D	
Oudemansiella canarii	—	—	—	—	4	9	6	1	4	5	1	1	31
Scleroderma tenerum	2	1	1	1	1	2	5	4	4	7	2	2	32
Lactarius indigo	—	—	—	—	2	8	10	3	9	2	1	—	35
Tylopilus balloui	—	—	—	—	1	8	9	—	6	9	3	—	36
Amanita gemmata	—	—	—	—	—	8	12	2	11	3	—	—	36
Russula virescens	—	—	—	2	7	6	8	2	7	5	2	—	39
Tylopilus subcellulosus	—	—	—	—	3	8	9	3	11	6	2	—	42
Armillaria tabescens	2	2	2	2	4	5	7	2	5	9	1	2	43
Amanita virosa	—	—	—	1	2	8	11	3	10	8	4	2	49
Cordyceps entomorrhiza	—	—	—	—	—	1	1	3	10	28	10	4	57

herbarium XAL, gathered during the same period. A total of 400 collections was considered.

RESULTS

All species, with the exception of *Cordyceps entomorrhiza*, had their main fructification period in the rainy season between June and September (Table 1).

Amanita gemmata produced fruitbodies mainly from June to October, with a maximum production in July and September and a very low production in August. *Amanita virosa* also showed maximum production during June–July and September, although fruitbodies could be found from April to December. The other species presented a similar spectrum. Some of these, like *O. canarii*, *A. tabescens*, *A. virosa* and *S. tenerum*, extended the fructification period to December, whereas *R. virescens* was an early species that started fructifications in April. Fruitbodies of *S. tenerum* and *A. tabescens* were found all year round, but had their main period in the rainy season as well. *Cordyceps entomorrhiza*, a parasite of insect larvae, was found between June and December, with a maximum in October. Differences in the production of fungi between years could not be established and the production was more or less the same in each of the four years.

DISCUSSION

Although mycelia are more or less perennial, the development of fruitbodies is conditioned to the environment by a complex of factors, amongst which temperature and rainfall are the most important (Widden, 1981; Wilkins & Harris, 1946; Wilkins & Patrick, 1940). As the temperature allows production of fruitbodies during the whole year, the rainfall pattern is the main determinant of these phenological patterns. The rainy season between June and September yielded about 60% of the observations. Monthly rainfall apparently must exceed 40 mm to permit the production of fruitbodies.

The two peaks in phenology of the ectomycorrhizal species (namely in June–July and in September–October) conformed to a decline in rainfall during August (Fig. 1). The same pattern has been observed in other species from temperate forests in Mexico (Villarreal & Guzmán, 1985, 1986*a*, *b*; Villarreal, 1987). González-Velázquez & Valenzuela (1993), however, noted that in the central part of Mexico 31 species of boletes fruited between June and October, with a maximum in August.

The fruitbodies of *S. tenerum*, gathered during the dry season, probably represented dry fruitbodies that persisted after the rainy season. The phenology of the entomopathogenic fungus *C. entomorrhiza* is probably synchronized with that of its host. It formed fruitbodies only at the end of the rainy season, together with the development of the larvae. We observed the species only on larvae of Lepidoptera, but according to Mains (1958) and Eckblad (1967) the fungus parasitizes larvae of Coleoptera.

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