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Observations of the impact of bushfire on a community of myxomycetes

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Abstract

In this study, we examined the impacts of a bushfire on a community of myxomycetes (also known as plasmodial slime moulds or myxogastrids) in north-eastern New South Wales, Australia. Using the moist chamber culture technique, we prepared 40 moist chamber cultures from four different substrates. We collected the same four types of substrates on either side of a fire line approximately six months post-fire in order to assess what impact fire had on the myxomycete communities. Sixty percent of moist chamber cultures yielded evidence (plasmodia or fruiting bodies) of myxomycetes representing eleven species in eight genera. But only 40% of samples from the burned site were positive for myxomycetes, and only one species produced fruiting bodies. In contrast, 80% of samples from the unburned site were positive, and all eleven species were recorded. These data suggest that fire reduced the abundance and diversity of the myxomycete community at our site.

Introduction

Myxomycetes (plasmodial slime molds or myxogastrids) are a group of eumycetozoans associated with dead plant material in terrestrial ecosystems, where they feed upon bacteria and other microbes (Martin & Alexopoulos 1969). Myxomycetes are particularly common in forests where they occur in association with substrates such as the outer bark of living trees, coarse woody debris, woody twigs, dead leaves, and other types of organic debris (Stephenson and Stempen 1994). There are approximately 1,200 species of myxomycetes worldwide (Lado 1995-2022), and more than 300 of these are known to occur in Australia (Stephenson 2021). The primary factors that determine the distribution of myxomycetes are temperature, moisture, and the availability of substrates that support the populations of microbes upon which they feed (Stephenson 1988, 1989).

Fire is a major disturbance factor in Australia. Mataix-Solera et al. (2009) reported that intense fires that produce high temperatures could completely sterilize the soil microbiome. This would likely also be the case for the microbiota (including myxomycetes) associated with organic substrates. There have been only a few studies that have examined the effects of fire on myxomycetes. In central Alaska, Novozhilov et al. (2007) compared communities of myxomycetes associated with bark and litter in a series of burned and unburned sites. They reported that the numbers of species recovered from burned and unburned substrates were similar. Adamonytė et al. (2016) examined the effects of crown fire and surface fire on the myxomycetes associated with pine plantations in Lithuania. Their study extended over three years and showed that both types of fire have a major impact on myxomycetes communities: myxomycetes in plantations subjected to fire and those which were not proved to be equally diverse but were quantitatively very different with respect to the species present. Stephenson et al. (2021) assessed the impact of fire intensity on the communities of myxomycetes associated with three substrates (the bark of living trees, woody twigs, and forest floor leaf litter) in the Great Smoky Mountains National Park, United States of America. Samples from areas of forest characterized by lower intensity burns yielded more myxomycetes than samples from areas of forest subjected to higher intensity burns. Their data suggested that following a burn, bark and twigs were recolonized by myxomycetes more quickly than forest floor leaf litter. In another study by Shchepin et al. (2019), the diversity of the dark-spored group of myxomycetes in forest ground litter and soil was assessed in four study plots across a fire chronosequence in the Nizhne-Svirskiy Nature Reserve (northwestern portion of Russia) by using a metabarcoding approach. They reported that the history of fire disturbances and the season of sampling influenced the composition of the communities of myxomycetes present.

The results from these four previous studies on myxomycetes and fire indicate that fire can be a major disruption for myxomycetes communities. However, these organisms have the capability to recolonize the substrates from which they were eliminated by fire. There has been limited research on fire ecology in relation to myxomycetes, and we are not aware of any previous research of these associations in Australia. This lack of research prompted us to conduct the present study.

Materials and methods

Samples were collected near Dundurribin, New South Wales (30° 10’ 09” S 152° 28’ 13” E). The general study area is characterized by an eucalypt-tree fern forest with a maximum canopy height of about 16 m, an incomplete understory, and a sparse ground layer of herbaceous plants. The specific site investigated was part of the Bee’s Nest Fire which burned through this site on 12 September 2019, and was part of the Black Summer Fires (**Figure 1**). This specific fire burned through an area of approximately 100,000 hectares. Our samples were collected on 22 March 2020, approximately six months after the fire. Samples were collected from either side of a bulldozed trail that was used to stop one section of the fire front. This enables comparisons within the same habitat since one side got burned and the other did not. Samples were collected less than 20 meters apart, directly opposite each other along the fire break. The second author was present when the

Figure 1. An illustration of the site where substrate samples were collected. **a.** This photo was taken on the night of 12 September 2019 as fire fighters fought the blaze at the site where samples were collected. **b.** The site where samples were collected on the burned side of the containment line six months after the fire. **c.** The site on the unburned side of the containment line six months after the fire. All photos © Todd F. Elliott.

fire burned this site and observed it to be an intense blaze, but the fire moved through quickly enough that it did not severely impact the trees and did not burn into the canopy.

Four types of samples were collected from the burned and unburned sites consisting of (1) the outer bark of *Eucalyptus campanulata*, (2) portions of the petiole and "bark" of *Dicksonia antarctica*, (3) woody twigs on the forest floor, and (4) mixed ground litter. All samples were placed in labeled paper bags in the field and sent to the Eumycetozoan Laboratory at the University of Arkansas and processed in the manner described by Stephenson & Stempen (1994). In brief, portions of each sample were placed in plastic Petri dishes lined with filter paper with enough material to cover the bottom of the dish. Water was added to each dish, the lid was added, and these moist chamber cultures were set aside for approximately 24 hours. Then the pH was determined for each culture using a portable pH meter equipped with a flat surface electrode, and then excess water was poured off. Cultures were examined on a weekly basis for three months using a stereomicroscope. Water was added when necessary to maintain moist conditions. Specimens of myxomycetes were removed along with a small portion of their substrate, allowed to air-dry, and then placed in small pasteboard boxes for permanent storage. All specimens cited herein are now deposited in the mycological herbarium (UARK) of the University of Arkansas.

Results

Sixty percent of the 40 moist chamber cultures prepared with the samples collected in the present study yielded evidence (either fruiting bodies or plasmodia) of myxomycetes. Samples from the unburned site were much more productive (80% positive) than samples from the burned site (40% positive). Eleven species in seven genera were recorded, but the fruiting bodies of only a single species were recovered from samples collected on the burned site. In contrast, all eleven species appeared on samples collected on the unburned site. *Arcyria cinerea* (specimens appeared in ten cultures), *Trichia botrytis* (six cultures), *Clastoderma pachypus* (four cultures), *Cribraria microcarpa* (four cultures), and *Cribraria minutissima* (four cultures) were the most common species. Five species were represented by only a single specimen.

Samples of burned *Eucalyptus campanulata* bark and burned *Dicksonia antarctica* produced no evidence of myxomycetes. Still, plasmodia did appear on 100% of samples of burned twigs and 60% of samples of ground litter. However, a plasmodium developed into fruiting bodies in only a single instance (one sample of burned twigs).

The mean pH of all moist chamber cultures prepared with samples from the burned site was 3.9 (range = 3.7 to 4.9), the same value (3.9) recorded for all samples from the unburned site. However, the range of values (3.7 to 6.7) was wider for the latter site. Mean pH values recorded for the four sets of unburned samples displayed little variation (4.6 to 4.9), but differences existed when some of these values were compared with those recorded for burned samples. Samples of burned *Dicksonia* (mean = 6.1; 5.6 to 6.7) versus unburned *Dicksonia* (mean = 4.9; range 4.8 to 4.9), burned twigs (mean = 6.2; range 5.3 to 5.8) versus unburned twigs (mean = 4.6; range 4.3 to 4.8), and burned ground litter (mean = 6.0; range 5.7 to 6.3) versus unburned ground litter (mean = 4.8; 4.7 to 4.9) were less acidic post-burn. In contrast, samples of burned bark (mean = 3.9; range 3.7 to 4.0) were about the same as unburned bark (mean = 4.0; range 3.7 to 4.0).

Annotated checklist of species

All species of myxomycetes recorded in the present study are listed alphabetically by genus and then species. The nomenclature used follows Lado (2005–2022). Information is provided on the total number of collections and the substrate(s) yielding the species in question. Note: BB = burned bark, BD = burned *Dicksonia*, BG = burned ground litter, BT = burned twigs, UB = unburned bark, UD = unburned Dicksonia, UG = unburned ground litter, and UT = unburned twigs. Numbers in brackets are collection numbers of the first author. Note that "bark" refers to the bark of *Eucalyptus campanulata* and "Dicksonia" refers to *D. antaractica*.

Arcyria cinerea (Bull.) Pers.

SPECIMENS: Ten (1 UB, 3 UD, 4 UG, 2 UT), pH 3.8 to 4.9 [34598, 34651]
COMMENTS: Martin & Alexopoulos (1969) considered this species to be cosmopolitan, and it is common throughout Australia (Stephenson 2021).

Arcyria pomiforis (Leers) Rostaf.

SPECIMENS: Two (2 UD), pH 4.8 and 4.9 [34663]
COMMENTS: Martin & Alexopoulos (1969) listed this species from scattered localities throughout the world. In Australia it is known from most states and territories but does not appear to be common (Stephenson 2021).

Clastoderma pachypus Nann.-Bremek.

SPECIMENS: Four (4 UB), pH 3.7 to 4.0 [34510]
COMMENTS: Martin and Alexopoulos (1969) did not provide any distribution data for this species, which had been described by Nannenga-Bremekamp (1968) just a year earlier, but it is not common. *Clastoderma pachypus* is known from only a few localities in Australia (Stephenson 2021). The species was abundant in the four cultures in which it appeared.

Comatricha laxa Rostaf.

SPECIMENS: Three (UB 1, UT 2), pH 3.8 to 4.5 [34641]
COMMENTS: Martin & Alexopoulos (1969) listed only one specific and three general localities for *Comaticha laxa*, but the species is probably cosmopolitan (Ing 1999). It is known from scattered localities throughout Australia but does not appear to be common (Stephenson 2021).

Comatricha nigra (Pers. ex J.F. Gmel.) J. Schröt.

SPECIMENS: One specimen (UT 1), pH 4.5 [34642]
COMMENTS: This species was considered to be cosmopolitan by Martin and Alexopoulos (1969). It is known from scattered localities throughout Australia but seems to be relatively uncommon (Stephenson 2021).

Cribraria microcarpa (Schrad.) Pers.

SPECIMENS: Four (UB 1, UG 2, UT 1), pH 3.8 to 4.3 [34642]
COMMENTS: Martin & Alexopoulos (1969) listed *Cribraria microcarpa* as widely distributed in Europe and North America, with scattered reports from elsewhere in the world. However, Ing (1999) later suggested that it is probably cosmopolitan, and the first author concurs. This species is known from a few scattered localities in Australia (Stephenson 2021) but may have been overlooked because of its small size.

Cribraria minutissima Schwein.

SPECIMENS: Four (UB 4), pH 3.7 to 4.0 [34601]
COMMENTS: When Martin & Alexopoulos (1969) published their monograph, the concept of this species also encompassed what is now recognized as *Cribraria confusa* Nann.-Bremek. & Y. Yamam. However, Keller et al. (1988) determined that the latter should be recognized as distinct. Because earlier records could refer to either species, the distribution records listed by Martin & Alexopoulos (1969) are likely to be somewhat problematic. Nevertheless, what is certainly *C. minutissima* has been reported from a number of localities throughout the world. There are only a few records of the species in Australia (Stephenson 2021).

Echinostelium minutum de Bary

SPECIMENS: One (UD 1), pH 4.8 [34648]
COMMENTS: This species is known from virtually every temperate locality for which data on myxomycetes exist, both in Australia and throughout the world (Stephenson 2021). However, it is uncommon in tropical forests and deserts. It is surprising that we found the species only once in this study.

Physarum decipiens M.A. Curtis

SPECIMENS: One (UG 1), pH 4.7 [34657]
COMMENTS: Martin & Alexopoulos (1969) listed this species from scattered localities throughout the world but indicated that it was uncommon. There are only a few records from Australia (Stephenson 2021). This is a new record for New South Wales.

Trichia botrytis (J.F. Gmel.) Pers.

SPECIMENS: Six (UD 2, UG 2, UT 1, BT 1), pH 4.5 to 4.8 [34643, 34658]
COMMENTS: Martin & Alexopoulos (1969) listed this species from temperate regions of North America and Europe along with scattered localities throughout the remainder of the world. There are only a few records of *T. botrytis* from Australia (Stephenson 2021).

Trichia munda (Lister) Meyl.

SPECIMENS: One (UG 1), pH 4.8 [34644]
COMMENTS: Martin & Alexopoulos (1969) did not provide locality data for this species, which they did not recognize as distinct from *Trichia botrytis*. However, the sporangia of the former are much smaller (<1.0 mm tall in *T. munda* versus1.5–2.0 mm tall in *T. botrytis*) and the tips of the elaters are different (short tips in *T. munda* versus long, tapering tips in *T. botrytis*) (Ing 1999). There are very few records of *T. munda* from Australia (Stephenson 2021).

Discussion

The data obtained in the present study clearly indicate that fire had a detrimental impact on the communities of myxomycetes present at our study site. However, some substrates appear to be less affected by fire than others. For example, cultures prepared with burned *Eucalyptus campanulata* bark and burned *Dicksonia antarctica* yielded no evidence of myxomycetes, but unburned samples of these same two substrates were quite productive. Unburned *E. campanulata* bark and *D. antarctica* yielded four species and ten specimens. The bark surface of a tree serves as a "spore trap" for the spores of myxomycetes, which are largely dispersed by wind. Both *E. campanulata* bark and *D. antarctica* have a relatively smooth bark and thus might be expected to trap fewer spores than trees with rough bark. Unburned ground litter was even more productive, yielding six species and twelve specimens. Ground litter traps moisture, which would make it a more favorable subtrate myxomycetes. Unburned twigs were more-or-less intermediate for the number of specimens (eight) but more productive for number of species (five). Twigs possess features of both litter (i.e., a thin bank is present and they occur on the ground in association with litter, so these data would not seem unexpected.

The overall lack of productivity of all burned samples presumably reflects the fact that the substrates involved did not "recover" quickly enough from the fire to be recolonized by myxomycetes by the time the samples were collected. However, if one assumes that fire totally eliminated myxomycetes from the substrates considered in the present study, then some substrates were more quickly colonized than others. Fruiting bodies of a single species appeared in one sample of burned twigs, but plasmodia were present in the remaining four cultures. Three of the five cultures of burned ground litter produced plasmodia, but none of these ever fruited. The time in which it takes for the microbial community to recolonize an area after fire varies and could be a facter (Xiang et al. 2014, Li et al. 2019, Bouskill et al. 2022). It is possible that the population levels of the microbes (primarily bacteria) upon which the trophic stages in the myxomycete life cycle feed were not yet high enough six months post-fire for the development of fruiting bodies to occur in

the cultures in which only plasmodia appeared. It is also possible that a number of unidentified factors including changes in the chemical and physical features of the substrate due to burning could be involved. This has been suggested in a number of previous studies of myxomycetes (Novozhilov et al. 2017). It would have been interesting to collect and process another set of samples of the same four substrates after a longer post-fire interval than the one used in the present study.

The number of species recorded in the present study was lower than anticipated, based on the results obtained in other recent studies (e.g., Stephenson et al. 2020, White et al. 2020) of myxomycetes in Australia. This suggests that the forest community from which our samples were collected is not characterized by a diverse community of myxomycetes although the number of cultures and substrates collected in this study differs from Stephenson et al. (2020) and White et al. (2020). If such is the case, it might be worthwhile to repeat the study in a forest known to support a more diverse community of myxomycetes. This study will hopefully inspire future more intensive studies of the ecological impact of fire on myxomycetes in Australia and other regions.

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