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Tasmanian myxomycetes and associated invertebrates in a drying climate

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Abstract: Fifteen years of photographing myxomycetes and associated invertebrates in northern Tasmania has captured beetles (Coleoptera), springtails (Collembola), flies (Diptera), snails (Gastropoda) and ants (Hymenoptera) feeding on plasmodia and spores. The frequency of these observations in Northern Tasmania and reported elsewhere confirms that myxomycetes provide an important food source for many animals. The woody debris where many of these interactions occur are likely to become less able to support myxomycetes and associated invertebrates in a rapidly changing climate.

Keywords: climate change, ecology, endemism, saproxylic

Introduction

Myxomycetes are ancient organisms. Myxomycologist Dr. Steve Stephenson called them “living fossils” and speculates that they could have been present in the coal forests of the Carboniferous when dinosaurs roamed the land 360 million years ago (Stephenson 2025). Recent papers based on molecular data confirm that this was likely, with a report on the evolutionary relationships between the major lineages of the supergroup Amoebozoa, which includes myxomycetes, dating their origin to the Mesoproterozoic Period, 1250-1624 million years ago (Tekle et al. 2022). However, because of the small size and fragile nature of myxomycetes, there is no physical evidence from this time. The earliest known fossil of a myxomycete is a well-preserved specimen in the extant genus *Stemonitis* that was found in amber from Myanmar that dates to the Cretaceous Period 100 million years ago (Rikkinen et al. 2019). Animals associated with myxomycetes also have long evolutionary histories. The crown age of the superfamily Neanuroidea (Collembola), which includes families of slime mold-eating collembola (springtails), dates to the Cretaceous Period 86–72 million years ago (Stevens and D’Haese 2025). The coevolution of myxomycetes and cryptic slime mold beetles in the family Sphindidae began to diversify in the mid-Cretaceous Period 99 million years ago (Li et al. 2021).

Given the long evolutionary history of myxomycetes and invertebrates, and their shared habitats, the interactions between them are likely to be more common and important than documentation suggests.

The small size and opportunistic occurrence of most myxomycetes, and the cryptic nature and small size of most associated invertebrates means they are easy to overlook. Furthermore, the focus of entomologists is not the same as that of most myxomycologists who consider any "contamination" undesirable. Until relatively recently, many of the interactions have been documented by myxomycologists rather than by entomologists. Myxomycologist Bruce Ing (1967) listed invertebrates feeding on myxomycetes, including nematodes (Nematoda), woodlice (Isopoda), millipedes (Diplopoda), springtails (Collembola), beetles (Coleoptera) and flies (Diptera). Beetle-myxomycete associations have been documented in the North America by Stephenson et al. (1994), and in Ukraine by mycologists Dudka and Romanenko (2000). In 1980, entomologists Lawrence and Newton documented the beetles associated with the fruiting bodies of slime molds (Lawrence and Newton 1980) and a more recent paper discussed the early evolution of the mid-Cretaceous Sphindidae family, also known as cryptic slime mold beetles (Li et al. 2021).

In the paper "How will climate change affect the feeding biology of Collembola" (Saunders et al. 2023), which describes collembolans' preferred food of saprotrophic and mycorrhizal fungi, there is no mention of myxomycetes being eaten. However, Yano and Nakamori (2024) discuss collembolan and myxomycete co-existence on dead trees in Japan and spore eating and dispersal by collembola. A comprehensive paper that discusses myxomycete interactions with other taxonomic groups in forest ecosystems mostly in the northern hemisphere, includes invertebrate consumers and vectors such as beetles, mites, flies, tardigrades, collembola and woodlice (Pawlowicz 2025). There is an early account of collembola feeding on plasmodia and developing fruiting bodies in Australia (Greenslade 1991). Tasmanian entomologist Lynne Forster's website (Forster website) describes a beetle, *Neopelatops* sp. feeding on *Stemonitis* sp.

In 2010 I started photographing and collecting myxomycetes at Black Sugarloaf, Birralee in Northern Tasmania. I also photographed any associated invertebrates including collembola (springtails), beetles, flies, snails, and ants, interactions that mostly occur within or close to moist decaying woody vegetation. I speculate on the impact of the drying climate on the invertebrate species documented, and the myxomycetes associated with the woody debris on which these saproxylic animals depend.

Study site

Myxomycetes and associated invertebrates have been photographed and or collected opportunistically at Black Sugarloaf, Birralee in northern Tasmania, Australia (41°23′28″S 146°48′29.2° Elev.: 388 m), during regular—usually daily—walks. The vegetation community varies according to topography and microclimate, with the regularly searched area classified "*Eucalyptus obliqua* forest with broad-leaved shrubs" (Kitchener and Harris 2013). The canopy comprises *Eucalyptus obliqua* and *Acacia melanoxylon*, with sub-canopy and understory trees *Pomaderris apetala*, *Banksia marginata* and *Bedfordia salicina*, ground ferns *Blechnum nudum* and *Polystichum proliferum* and the tree fern *Dicksonia antarctica*. Large decaying logs and stumps covered in mosses, liverworts and lichens that either fell naturally or are the result of timber harvesting in the early days of British settlement in Tasmania in 1850s, and subsequently in the 1950s, are frequent in the forest (Fig. 1A, B and D). There are copious quantities of bark, leaves and fallen branches on the forest floor (Fig. 1C). There is no recent evidence of fire on the study site. There is limited human disturbance where the myxomycetes proliferate and the area is protected by a perpetual conservation covenant.

Figure 1. Scenes along "Big Tree Track". A. The holotype of *Tasmaniomyxa umbilicata* was collected from this log. B. "Big Tree" stump and associated fallen log. C. Leaf litter and fallen logs are left *in situ*. D. "Upper gully mossy log".

Methods

In early 2010 I started photographing myxomycetes in the field, and was particularly interested in the associated invertebrates, especially the collembola (springtails) feeding on plasmodia or developing fruiting bodies (Fig. 5 A–L**).** I was encouraged to record these interactions by Australian collembolan researcher, Dr Penelope Greenslade, because the diet of some species is not often observed. More recently, I sent photographs and specimens of beetles and flies to Dr. Lynne Forster, who also encouraged my interest in myxomycete-invertebrate associations.

(It should be noted that the names of the myxomycetes found at Black Sugarloaf have been identified using mostly northern hemisphere texts. It is likely that the names will change when the myxomycetes in Australia are more comprehensively studied.)

Slime Mold Beetles (Coleoptera)

Beetles are the most commonly recorded insects that associate with myxomycetes in the temperate forests of the Northern Hemisphere (Stephenson and Stempen 1994; Pawlowicz 2025), and it is likely to be the same in the Southern Hemisphere. Lawrence and Newton (1980) discussed myxomycete fruiting bodies as a food source for adult beetles, along with larval feeding mechanisms and possible host preferences. They summarize known myxomycete specialists in the different beetle families, from the

"primitive" Sphindidae, in which all genera and species feed on myxomycetes, to Leiodidae, Scaphidiidae, Eucinetidae, Clambidae, and Latridiidae, whose members are either obligatory or facultatively feeders on myxomycetes. Stephenson et al. (1994) added 633 new records of beetle–slime mold associations in North America, and Dudka and Romanenko (2006) documented five beetle species in the Latridiidae family that interact with myxomycetes in Ukraine. The authors speculated on the obligatory nature of the beetles they observed.

Recent research on beetles found in amber in Myanmar provide evidence that basal crown slime mold beetles in the family Sphindidae, began to diversify by the mid-Cretaceous when they co-evolved with myxomycetes (Li et al. 2021). These sphindid beetles, also known as cryptic slime mold beetles, are described as "obligately tied to slime molds throughout their lives", but their diversity and abundance remain mostly undocumented. A 2021 report that there were only nine genera and 66 extant species of sphindids, omitted a study that found that more than one hundred undescribed species had been identified in a single genus *Aspidiphorus*, which suggests the Sphindidae is much more species rich than current records indicate (Li et al. 2021). Britton (1979) lists all known species of beetle in Australia, and although they were known to occur in the country at the time, it does not include any records of Sphindidae. By 2021 there were 67 described species of Sphindidae in Australia including two in Tasmania, *Aspidiphorus humeralis* and *Notosphindus slateri*, (Fig. 2F) neither of which is regarded as endemic (Grove 2021). *Notosphindus slateri* was collected in Tasmania in 1980 and described in 1991, and despite the variable size and body coloration in specimens from Tasmania and southeastern Australia, the authors regarded all specimens as con-specific (McHugh and Wheeler 1991). However, all 291 records of *A. humeralis* and 68 records of *N. slateri* on the Atlas of Living Australia (ALA) are from Tasmania, which suggests otherwise (Atlas of Living Australia 2026 a and b). Given the geographical separation and island endemism, it seems likely that there are many more sphindid species in Australia than current documentation reveals.

Slime mold-feeding beetles are between 1-3 mm long and their association with myxomycetes seems to benefit both groups. The beetles get nutrients from the spores, probably in the form of cellulose from the spore walls, which in myxomycetes are often heavily reinforced, and possibly also from calcium carbonate in the hypothallus, capillitium, peridium or stalks (Lawrence and Newton 1980). In return, while beetles are feeding, cavities in their mandibles (mycetangia), and their pitted and/or hairy bodies trap spores, which assist dispersal. Laboratory trials show spores of *Fuligo septica* adhering to and germinating from the elytra of *Enicmus* spp. (Pawlowicz 2025). In eastern Ukraine, the gut contents of some of the collected beetles had slime mold spores which were germinated successfully, and one species, *Latridius hirsutus* completed its lifecycle within the aethalia of *Fuligo intermedia* (Dudka and Romanenko 2006).

Beetles are recorded in association with such a diversity of large and small myxomycetes (Stephenson et al. 2007, Lawrence and Newton 1980, Pawlowicz 2025), that it seems unlikely that they favor particular species. However, Dudka and Romanenko (2006) list the features of the myxomycetes they observed, which include 1. abundant spores in large simple sporophores or large aethalia, 2. long period of sporophore development, 3. long lasting sporophores, 4. abundance, 5. development on woody substrates, and 6. spores with spiny, warted or net-like walls. Climate and local ambient conditions were not mentioned by either Dudka and Romanenko (2006) or Stephenson et al. (2007), but the listed dates of the beetle–myxomycete associations were from June to early September, with most in July and August, which coincides with summer in the northern hemisphere when temperatures are within the tolerance level of beetles. Some of the Northern Hemisphere myxomycetes that are listed include *Stemonitis* spp., *Fuligo* spp., *Tubifera ferruginosa*, *Tubifera* spp., *Arcyria* spp., *Lycogala* spp., *Reticularia lycoperdon*,

Comatricha spp., *Leocarpus fragilis*, *Mucilago crustacea* (now *Didymium spongiosum*), and *Trichia decipiens* (now *Hemitrichia decipiens*) (Lawrence and Newton 1980; Pawlowicz 2025).

Figure 2. Beetles on myxomycetes at Black Sugarloaf. A. *Aspidiphorus* sp. on *Oligonema affine*. B. *Enicmus* sp. on developing *Stemonitis* sp. C. Latridiinae breeding in *Fuligo septica*, D. *Enicmus notialis* on *Stemonitis* sp. E. *Enicmus foviatus* on *Fuligo septica*. F. *Notosphindus slateri* on *Lycogala* sp. G. *Enicmus* sp. in *Paradiachea caespitosa*. H. Leiodidae sp. burrowing in developing *P. caespitosa*. I. Net-winged beetle larva (Lycidae) on *Fuligo septica*.

My observations at Black Sugarloaf suggest that most beetles do not target particular species. Some of my records have involved relatively large taxa that appear in the warmer months with features listed by Dudka and Romanenko including *Stemonitis* spp. (Fig. 2B and D), *Fuligo septica* (Fig. 2C, E and I) and *Paradiachea caespitosa* (Fig. 2G and H) (see Lloyd 2020 p.115). As well as observations in the field, I find beetles in collected specimens, such as the *Aspidiphorus* sp. on *Oligonema affine* (Fig. 2A) that

wandered into view when I was checking the specimen under the microscope. Interestingly, although sphindid slime mold beetles do not seem to preferentially feed on particular species of myxomycete, *N. slateri* is only the second sphindid beetle species recorded in association with a *Lycogala*. *Sphindus dubius* in the northern hemisphere has been collected repeatedly from *Lycogala* "epidendrum" (McHugh and Wheeler 1991). Two of the four observations of *N. slateri* on iNaturalist are clearly associated with *Lycogala* spp. (iNaturalist 2026a).

Paradiachea caespitosa (Fig. 3) has the features listed by Dudka and Romanenko (2006). Its large, creamy-white plasmodium can cover areas larger than 150 x 150 mm. It matures over several days (Fig. 3A–E) and forms large, closely-packed, sessile, cylindrical to clavate, 1.5 mm tall sporocarps on woody substrates (Fig. 3F). The majority of my records occur on or near "Big Tree" stump and the associated log (Fig. 1B), but it sometimes appears at the base of a living *Eucalyptus obliqua*. I have records dating back to 2010, with several collections made in some years and sometimes two appearances in succession on the same substrate. All collections have been made after rainy periods in summer, mostly November and December. The species was not observed in 2014 or 2015, which marks the beginning of a decade of dryer than normal conditions in northern Tasmania (Lloyd 2025), nor was it observed in the summer of 2025/2026 which was the hottest year on record in Australia, with above average temperatures and below average rainfall in Tasmania (Bureau of Meteorology 2026a). The myxomycetes attractive to beetles (e.g., *Stemonitis* spp., *F. septica*, and *P. caespitosa*) mostly occur in summer at Black Sugarloaf. However, their appearance depends on there being simultaneous wet weather conducive to the production of fruiting bodies, conditions that are becoming less reliable with the drying climate.

There are very few records of feeding on plasmodia, possibly because plasmodia are usually active within woody substrates and rarely appear on the surface. Lawrence and Newton (1980) consider circumstantial evidence that indicates plasmodia could be as common a food source as fruiting bodies. Saproxylic beetles also remain within the moist habitats of decaying wood so interactions are unlikely to be seen. My first observation of beetle larvae feeding on a plasmodium was on the trunk of a tall double-trunked *Eucalyptus ovata* in a shaded gully in mid-winter 2025 (Fig. 4A). A tiered bracket fungus had formed in the crevice on one of the trunks, and a plasmodium was actively feeding on the fungus (Fig. 4B.) During the rainy weather that persisted from 8–25 July, the plasmodium spread and covered every surface of each tier of the fungus and extended up to 50 mm beyond. Beetle larvae were feeding in the low light conditions beneath the fungal tiers, and were only visible with a headlamp and camera flash (Fig. 4C). The vigor of the plasmodium and its association with a polypore fungus suggested *Badhamia utricularis*, a known fungivore. However, the fruiting bodies resemble an aberrant form of *Physarum flavicomum*, another myxomycete known to feed on fungi.

Collembola (springtails)

Collembola (springtails) is a diverse group of hexapods dating back 412 million years (Sanchez-Garcia and Engel 2016). They occur in all habitats across the globe and are regarded as generalist feeders of decaying plant material, fungi, bacteria and other microorganisms (Greenslade 2002). Ing (1967) describes them as "frequently a nuisance in moist chamber cultures of bark" and speculates that because nymphal and adult stages feed avidly on small myxomycetes that occur on bark, the bark-inhabiting springtails may habitually use slime molds as a food source. He reported springtails feeding on *Comatricha typhoides* (currently *Stemonitopsis typhina*) and *Cribraria piriformis*.

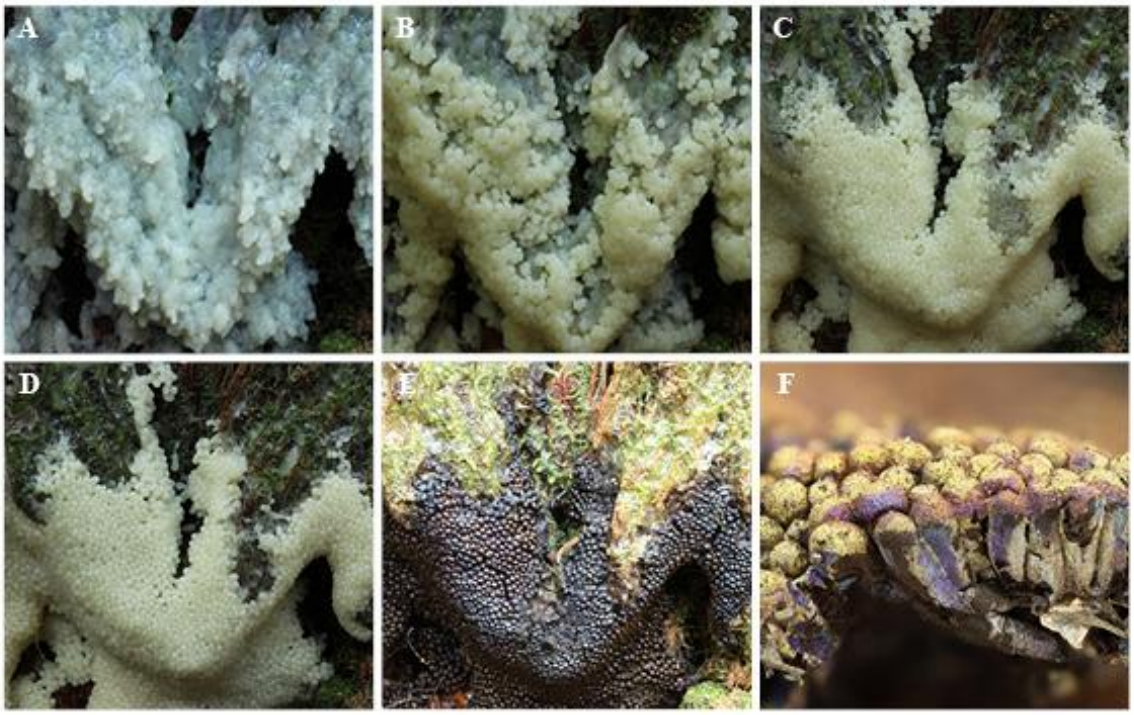

Figure 3. *Paradiachea caespitosa* developing at the base of the trunk of a live *Eucalyptus obliqua*. A. Plasmodium 15 Nov. 2017 0721. B. 1201. C. 1446. D. 1714. E. 16 Nov 0723. F. Mature sporocarps.

Figure 4. A. *Eucalyptus ovata* with crevice marked with vertical red line. B. Plasmodium covered the tiered polypore fungus and the tree trunk. C. Beetle larvae feeding on plasmodium.

Recent studies in the Northern Hemisphere using isotopic signatures of collembolan diets and feeding choice experiments whereby animals are given the choice between different foods (fungi, bacteria and algae) indicate that soil fungi, predominantly saprotrophic fungi, are their major food source, and within mycorrhizal groups, feeding on arbuscular mycorrhizal fungi (AMF) is preferred over ectomycorrhizal fungi (EMF), because feeding on EMF requires higher specialization of their mouthparts to enable sucking; no feeding on myxomycetes was reported (Saunders et al. 2023). Yano and Nakamori (2024) studied collembolan and myxomycete co-existence on dead trees in Japan and discuss spore eating and dispersal by collembola. Greenslade (2002) studying collembola in Australia speculates that because

animals kept for over four months in captivity did not feed on provided microorganisms (e.g., fungi, yeasts and bacteria) and no eggs were seen, they might be specialist feeders on something else. Studies of the alimentary canals of the Neanurinae, a predominantly northern hemisphere clade known to feed on slime molds, failed to discern any identifiable contents. This is because semi-liquid substances such as plasmodia or young fruiting bodies of myxomycetes are unlikely to leave a trace in examined animals (Greenslade 2002). Sanders et al. (2023) call for the use of emerging technologies such as stable isotope analysis to quantify diets more accurately.

Collembola can be divided into two groups based on their mouthparts. One group has a mandible with toothed molar plate and has relatively unspecialized feeding habits, and will feed on decaying plant material, fungi, algae and bacteria. The other group (including families such as the Neanuridae to which the Uchidanurinae belong), has a simpler mandible without a toothed molar plate and has more specialized feeding habits. Greenslade (2002) speculated that some species in the second group may feed exclusively on slime molds.

The first two collembola that were described from Australia, *Megalanura tasmaniae* and *Acanthanura dendyi*, were described from Tasmanian specimens in 1899 (Greenslade 1991). They belong to the Uchidanurinae family (but see below), a distinctive group of collembola that can reach 17 mm in length and be adorned with brightly colored digitations (Stevens and D'Haese 2025). A third species, *Womersleymeria bicornis* was subsequently described from Tasmania in 1940, but despite the genera *Megalanura* and *Acanthanura* likely to be species rich in southeastern Australia, no additional species have been described since then (Stevens and D'Haese 2025). In 1992 two *Acanthanura* sp. cf. *dendyi* individuals were recorded feeding on a yellow plasmodium on the lower side of a well-rotted log in a tall wet eucalypt forest in southern Tasmania. In 2001 there were two observations of *Womersleymeria* sp. bicornis group recorded in Victoria, southeastern Australia: on 29 July two individuals were observed feeding on developing fruiting bodies, possibly *Arcyria* sp., on a rotting log, and on 5 August ten individuals were observed in the same location. All records were made during the day when conditions were overcast and humid (Greenslade 2002).

The classification of collembola is changing as rapidly as it is for myxomycetes. Not long before I started this article, the species mentioned above (i.e., *Acanthanura* and related genera in Australia, *Megalanura* and *Womersleymeria*) as well as the New Zealand genus *Holocanthella* were included in the family Uchidanurinae. It was dissolved in late 2025 with the genera now in the subfamily Acanthanurinae (Stevens and D'Haese 2025). Interestingly, the animals in this subfamily are found mostly in temperate south-east Australia, including Tasmania, and New Zealand, which coincides with the distribution referred to as "eastern temperate Gondwanan" to describe the occurrence of myxomycetes including *Lamproderma gracile*, the basal taxon *Tasmaniomyxa umbilicata*, and *Alwisia repens* (Lloyd et al. 2024).

Animals in the newly described subfamily Acanthanurinae are confined to moist habitats, and live mostly in or under decaying logs usually covered in bryophytes, where they occupy spaces between bryophytes or bark and the wood, or in areas with a deep litter layer (Greenslade 2002). The crown age (i.e. the age of the most recent common ancestor) of the Superfamily Neanuroidea which encompasses the subfamily Acanthanurinae, supported by fossil evidence from Canadian amber, began in the mid-cretaceous ~86–72 million years ago when the cooler and wetter climate at the time would have suited these animals (Stevens and D'Haese 2025). As the climate changed and gradually dried, the animals were able to persist in areas that retain suitable habitats of decaying logs or deep forest litter. Greenslade (1991)

notes it is unlikely that *W. bicornis*, which was collected in the 1930s in the Dandenong Ranges east of Melbourne, Victoria, still occurs there because of considerable modification of the habitat for urban development. It is likely that other places where these animals once occurred have also been lost through land clearing, fire, or other modifications of their habitat. At Black Sugarloaf, suitable large decaying logs are frequent in the forest, but the climate has dried noticeably in the past five years. Some logs have lost the shade of the leafy, evergreen subcanopy tree *Pomaderris apetala*, because it is particularly vulnerable to strong winds, which have increased in strength and frequency. This is contributing to some important habitat niches in the forest to become less able to support moisture-dependent species (Fig. 1 A and D).

The most commonly observed collembola at Black Sugarloaf is an undescribed *Acanthanura* sp. in the newly described Acanthanurinae subfamily (Fig. 5, A–L). It is relatively large (up to 8 mm long) and has a darkly pigmented body and seven or eight ocelli (eyes), which suggest diurnal habits; nocturnal animals are usually non-pigmented and have reduced ocelli (Greenslade 2002). However, diurnal activity away from the moist interior of a rotting log or protective bark, increases their vulnerability to desiccation and predation (Greenslade 2002). *Acanthanura* sp. at Black Sugarloaf have been observed during pre-dawn walks by torch light, and during the day in shaded moist situations. They have been observed on a range of different species including the plasmodium of *Badhamia utricularis* (Fig. 5A), Tubifera tomentosa (Fig. 5B), *Alwisia lloydiae* (Fig. 5C), Cribraria sp. (Fig. 5D), *Oligonema verrucosum* (Fig. 5E), *Tubifera coralloides* (Fig. 5F), *Stemonitis* sp. (Fig. 5G), *Heterotrichia* sp. (Fig. 5H), and developing sporocarps of *Physarum viride* (Fig. 5I). On 19 May 2026 I had the opportunity to observe and photograph several *Acanthanura* sp. feeding on sporocarps developing on a windthrown “stringybark” eucalypt (*Eucalyptus obliqua*) that fell in September 2024. Compared to the substrates the collembola usually inhabit, the fallen tree showed relatively little sign of decay. However, the nature of the fibrous bark, which is 24 mm thick in places, provides countless micro niches where the animals sought shelter. The three animals (Fig. 5J) were feeding at 800, the solitary animal (Fig. 5K) was feeding in dappled light at 1327, and on both occasions the animals were almost motionless as they fed on the developing sporocarps. The *Acanthanura* sp. (Fig. 5L) was one of several I observed scurrying across large patches of *Arcyria* sp. on the log, without stopping to feed; presumably the capillitial threads within the sporangia had developed enough to be unsuitable for their feeding method.

Other species of collembola observed feeding on myxomycetes include *Entomobrya termitophila clarki* on developing fruiting bodies (Fig. 6A), *Ceratrimeria* sp. on *Elaeomyxa cerifera* (Fig. 6B), *Ceratrimeria* sp. on *Lycogala* sp. (Fig. 6C), *Acanthanura* sp. and *Ceratrimeria* sp. on developing *Diderma* sp. (Fig. 6D), *Ceratrimeria* sp. and *Pseudochorutes* sp. feeding on *Ceratiomyxa fruticulosa* (Fig. 6E), *Acanthanura* sp. and *Pseudochorutes* sp. feeding on *Dictydiaethalium* sp. (Fig. 6F). *Ceratrimeria* spp. belong to the Uchidanurinae family and are probably also obligate feeders on plasmodia; *Pseudochorutes* sp. has a generalist diet.

Unlike the beetle–myxomycete association where there seems to be a mutualistic association, collembola feeding on the developing fruiting bodies are unlikely to cause damage or affect their development. The developing *Stemonitis* sp. that was being eaten by the *Acanthanura* sp. (Fig. 5G), showed only minimal damage on several adjoining sporangia.

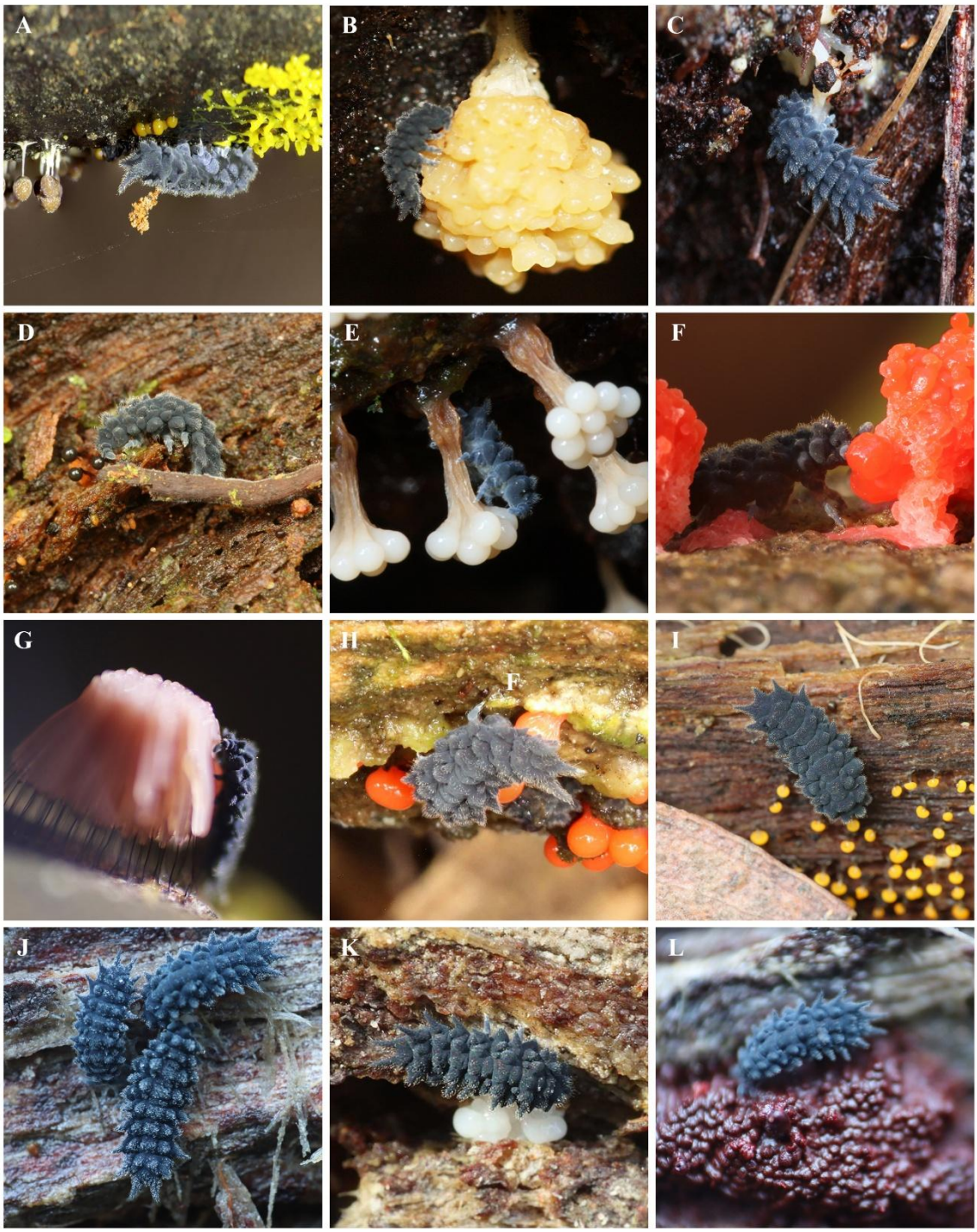

Figure 5. *Acanthanura* sp. observed on myxomycetes. A. Plasmodium of *Badhamia utricularis*. B. *Tubifera tomentosa*. C. *Alwisia lloydiae*. D. *Cribraria* sp. E. *Oligonema verrucosum*. F. *Tubifera coralloides*. G. *Stemonitis* sp. H. *Heterotrichia* sp. I. *Physarum viride*. J. Three *Acanthanura*. K. Developing sporocarps. L. *Acanthanura* sp. scurrying across mature *Arcyria* sp.

Figure 6. Collembola on myxomycetes. A. *Entomobrya termitophila clarki* on developing fruiting bodies. B. *Ceratrimeria* sp. feeding on developing *Elaeomyxa cerifera*., C. *Ceratrimeria* sp. on *Lycogala* sp. D. *Acanthanura* sp. and *Ceratrimeria* sp. feeding on developing *Diderma* sp. E. *Ceratrimeria* sp. and *Pseudochorutes* sp. feeding on *Ceratiomyxa fruticulosa*. F. *Acanthanura* sp. and *Pseudochorutes* sp. feeding on *Dictydiaethalium* sp.

Flies

There are several fly families known to associate with myxomycetes, including the Mycetophilidae, (fungus gnats), Sciaridae and Drosophilidae (Stephenson and Stempen 1994). The larval stage of the Mycetophilidae, also known as fungus gnats, are worm-like insects regarded as fungivorous or saprophagous, and feed on decaying plasmodia, fungi and decaying vegetation, although some species seem to be restricted to breed only within myxomycetes (Stephenson and Stempen 1994; Ing 1967). Dipteran larvae have been observed developing within large *Reticularia* spp. and *Tubifera* spp. and deposit adhering spores to other substrates (Powlowitz 2025).

Flies have been photographed opportunistically on several myxomycete genera including *Plecia dimidiata* on *Lycogala* sp. (Fig. 7A), fungus gnat *Pyrtaula* sp. on *Tubifera tomentosa* (Fig. 7B), dark-winged fungus gnat Sciaridae on developing *Stemonitis* sp. (Fig. 7C), non-biting midge *Tanytarsus* sp. on *Fuligo septica* (Fig. 7D), Dolichopodidae on *F. septica* (Fig. 7E), and larvae in *Tubifera glareata* (Fig. 7F). The flies that landed on the myxomycetes do not necessarily indicate an association. However, the larvae of fungus gnats (Mycetophilidae), also known as web spinners have been observed in numerous collected specimens. As with the beetle observations, the myxomycetes are large and the flies active in the warmer months, from November to January. One exception is the larvae on *T. glareata* (Fig. 7F), which appeared in April.

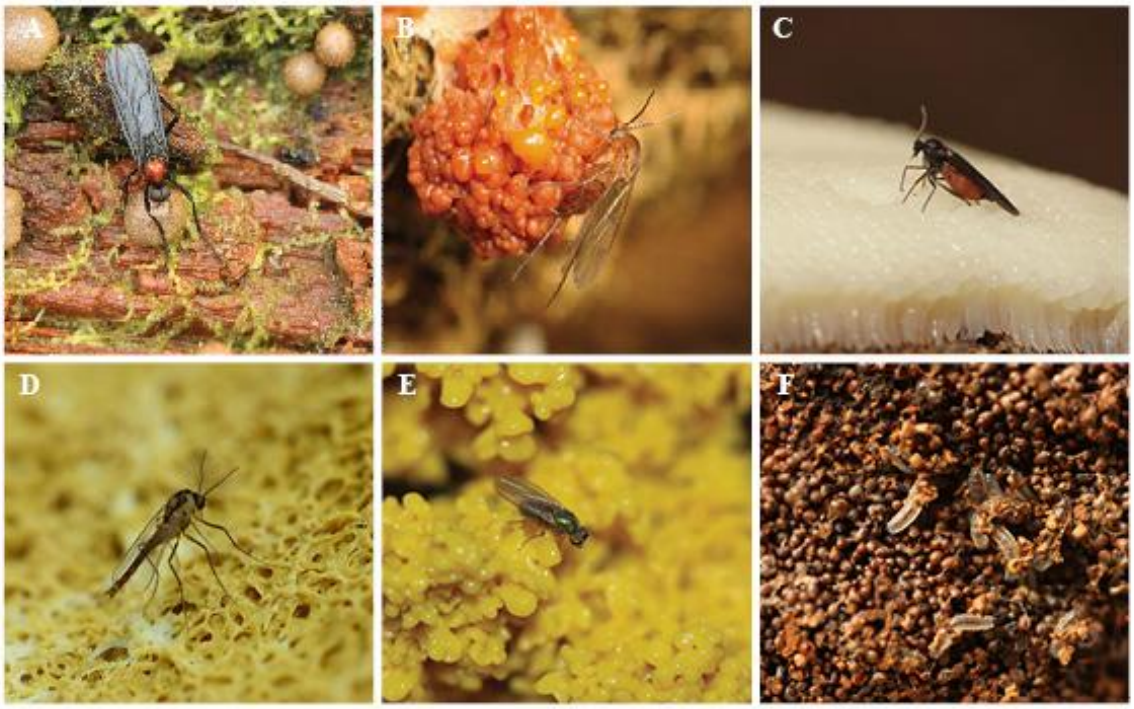

Figure 7. Flies on myxomycetes. A. *Plecia dimidiata* on *Lycogala* sp. B. Fungus gnat *Pyrtaula* sp. on *Tubifera tomentosa*. C. Dark-winged fungus gnat Sciaridae on *Stemonitis* sp. D. Non-biting midge *Tanytarsus* sp. on *Fuligo septica*. E. Dolichopodidae on *Fuligo septica*. F. larvae in *Tubifera glareata*.

Ants on Lycogala

On 23 January 2026, bright orange *Lycogala* sp. appeared on a paperbark *Melaleuca ericifolia* log. This in itself was surprising as conditions were dry with only the occasional *Fuligo septica* appearing. I returned an hour later to take a photograph with my phone camera to upload the observation to iNaturalist, (2026b) but as the ants were showing an interest in the *Lycogala*, I returned with my Canon EOS 90D with 100 mm macro lens plus Raynox magnifier mounted on a tripod to get a better record of the interaction.

At first the ants seemed cautious about the intruder in their midst, reluctantly approaching the five closely appressed aethalia, which somewhat resembled an orange caterpillar but without defensive hairs or spines (Fig. 8A and B). Some of the ants seemed to peck at the edge of the *Lycogala* with their mandibles, rarely venturing on to the "body", and still seemingly cautious of this likely unfamiliar organism. Before long, one of the ants breached the peridium and started withdrawing the orange liquid developing spore mass. It was difficult to conclude if the ants were attacking or feeding on the intruder, maybe both? Once some of the ants had extracted some of the liquid spore mass, other ants did likewise.

My observation on iNaturalist received an immediate identification, the ants belong to the genus *Anonychomyrma*, a genus of ants of cool-temperate Gondwanan origin, believed to have originated in Australia approximately 30 million years ago from an ancestor shared with southern South America through a land connection via Antarctica (Leahy et al. 2020). They nest either in the soil, or in living or

dead wood. In this case they were nesting in a fallen but slightly elevated paperbark *Melaleuca ericifolia* log. The 8 mm long mainly predatory ants had formed trails to and from a large borer hole further along the trunk in their search for food, which also includes plant juices.

Figure 8. A. and B. A*nonychomyrma* sp. on *Lycogala* sp., C. *Formica* sp. feeding on *Lycogala* sp. at Burnham Beeches Nature Reserve, South Buckingshire, U.K. Image ©Barry Webb (used with permission).

I posted my photos on Instagram and the highly acclaimed myxomycete photographer, Barry Webb, replied with the comment "ants have a taste for *Lycogala* here too [in the UK]". He described frequently observing feeding by wood ants (*Formica* sp.) on *Lycogala* sp. at Burnham Beeches Nature Reserve, South Buckingshire, U.K. (personal communication) (Fig. 8B).

Chance encounters

Numerous small white eggs are often seen in collections of various species, e.g. *Stemonitis* sp. (Fig. 9A), Tasmanian endemic snail *Stenacarpha hamiltoni* eating *Reticularia tasmanica* (Fig. 9B), amphipod on developing *Diderma* sp. (Fig. 9C), nematode woven through the peridial net of *Cribraria* sp. (Fig. 9D), spermatophores (probably collembolan) on *Alwisia lloydiae* (Fig. 9E), spider (Family Araneidae) on *Badhamia utricularis* (Fig. 9F).

The changing climate

Tasmania has a cool temperate maritime climate with average daily summer temperatures between 17 and 23°C and winter daily temperatures between 3 and 11°C. Rain usually falls in every month, with a peak in June and July (Lloyd 2025).

During the first several years after I started to document myxomycetes at Black Sugarloaf in 2010, rainfall was plentiful and reasonably predictable, with a corresponding predictability of the appearance of myxomycetes. The "autumn break", that is, rainfall in April, May and June, stimulated litter dwelling species and many were collected on fallen leaves and on the crown of tree ferns *Dicksonia antarctica*.

During subsequent years, when the autumn break has been less predictable or non-existent, these species are either absent, or occur in much reduced numbers.

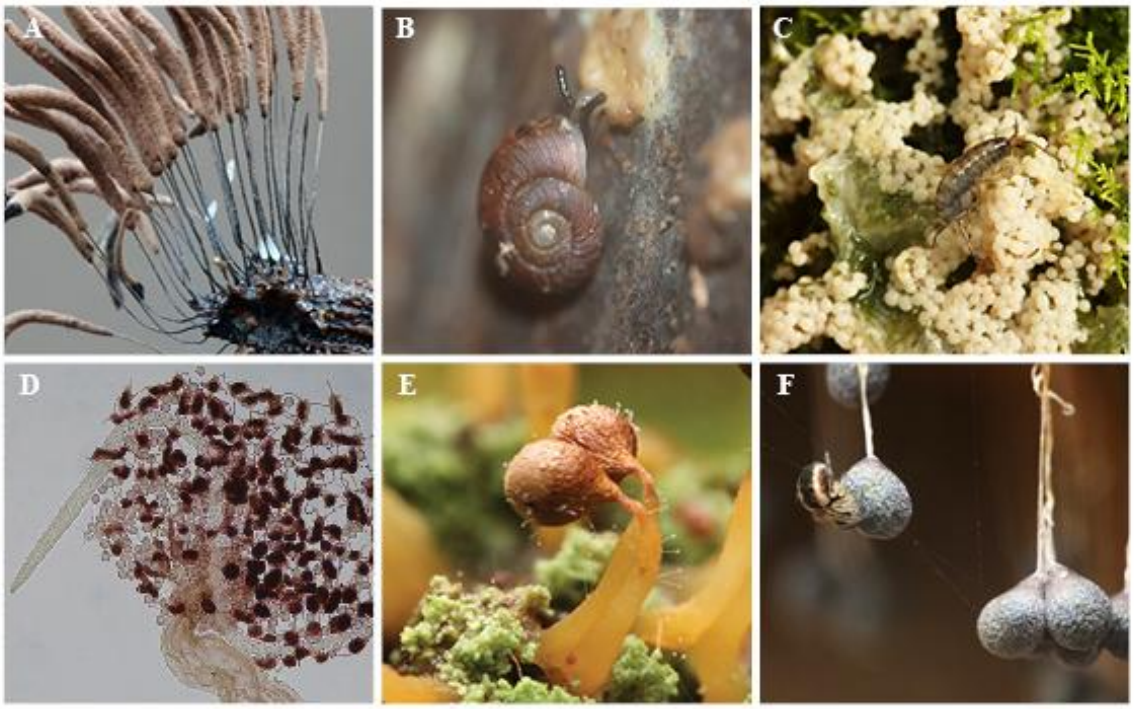

Figure 9. Chance encounters of invertebrates and myxomycetes. A. *Stemonitis* sp. with eggs. B. endemic land snail *Stenocarpha hamiltoni* on *Reticularia tasmanica*. C. Amphipod on developing *Diderma* sp. D. Nematode woven through the peridial net of *Cribraria* sp. E. Spermatophores (probably collembolan) on developing *Alwisia lloydiae*. F. Spider (Family Araneidae) on *Badhamia utricularis*.

Historical maps on the Australian Bureau of Meteorology website graphically illustrate how the climate has changed in northern Tasmania since 2010 when I started searching for myxomycetes. There was average and above average rainfall in 2010, 2011, 2012 and 2013, but average, below average and very much below average in the decade from 2014 until 2025, except for 2016, which was the only 'above average' rainfall for the decade. (Bureau of Meteorology 2026b)

When I started looking for myxos, I had no idea that I would still be studying them 16 years later. I also could not have anticipated that conditions would change so conspicuously. Had I known this maybe I would have kept meticulous records of rainfall and temperature.

Just one log

"Upper gully mossy log" (Fig. 1D) is covered in mosses liverworts and lichens and over the past 15 years it has supported more than 24 species of myxomycete. They include *Alwisia lloydiae*, *A. repens*, *Ceratiomyxa fruticulosa*, *Cribraria cancellata*, *C. ferruginea*, *C. mirabilis*, *C. macrocarpa*, *Comatricha*

sp., *C. brachypus*, *C. pulchella*, *Fuligo septica*, *Stemonitis inconspicua*, *Lamproderma* "versicolor", *Stemonitis fusca*, *Stemonitopsis gracilis*, *Lamproderma* "lutruwita", *Elaeomyxa cerifera*, *Oligonema affine*, *O. verrucosum*, *Tubifera glareata*, *T. tomentosa*, T. *vanderheuliae*, *Trichia erecta*, *T. botrytis* complex, and it is the "type log" of a yet to be described stalked *Calomyxa*.

The log lies across an ephemeral waterway, which flows only after protracted rainy periods. Until 2023, it was shaded for most of the day by several tall evergreen subcanopy trees, which fell leaving the log much more exposed. The bryophytes have gradually dried and 'clumped', and the habit of the local marsupials to use the log as a runway is dislodging the bryophytes, leading to more drying.

Conclusion

Opportunistic studies and observations without collected animals are limited in scope. However, the frequency of chance observations of invertebrate–myxomycete interactions at a small study site rich in myxomycetes in northern Tasmania, suggests they are common. The bioinclusions in amber of myxomycetes, beetles, and collembola indicates that extant animals are little changed from their Cretaceous ancestors, which suggests myxomycete–invertebrate associations have been continuing for millions of years. The decaying woody substrates where these interactions occur are threatened by land clearing, urbanisation, and forestry activities The drying climate and what impact it will have on the saproxylic animals and the myxomycetes on which they depend is difficult to assess without more observations in the coming years.

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