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Mid-Cretaceous cellular slime mold (Eukarya: Dictyostelia?) in Burmese amber

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ABSTRACT

A cellular slime mould (Eukarya: Dictyostelia?) in mid-Cretaceous Burmese amber is described as *Paleoplastes burmanica* gen. et sp. nov. The specimen consists of a clear, acellular plasmodium containing a central reddish pseudoplasmodium with an aggregation of myxamoebae, from which sorocarps have emerged. The sorocarps produced short chains of small globose to subglobose spores. While the higher taxonomic placement of the specimen remains unknown, the morphological features add to our knowledge of the structure and development of mid-Cretaceous slime moulds

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Introduction

Slime moulds are widespread and often found growing on debris or on trunks of fallen or even upright trees in damp forests. Some species are coprophilous while others occur on plant roots, decaying mushrooms, brewer's yeast and in fish aquaria (Raper 1973). Slime moulds were originally thought to be fungi (Kirk et al. 2004); however, de Bary (1864) showed that they are closer to protozoans (Kudo 1954) and after this was confirmed by molecular studies, they are now classified as Protists (Frederick 1990; Adl et al. 2005; Stephenson 2014).

Slime moulds are quite diverse, and the present study describes a unique eukaryote preserved in Burmese amber, with both vegetative and fructification stages that resemble cellular slime moulds. The fossil shares the following features with the Dictyostelia: uninucleate vegetative amoeboid cells aggregating to form a multicellular pseudoplasmodium from which stalked fruiting bodies (sorocarps) arise (Frederick 1990; Adl et al. 2005).

Materials and methods

The specimen originated from the Noije Bum Summit Site mine in the Hukawng Valley, located southwest of Maingkhwan in Kachin State (26°20'N, 96°36'E) in Myanmar. Based on paleontological evidence the site was dated to the late Albian of the Early Cretaceous (Cruikshank and Ko 2003), placing the age at 97–110 Mya. A more recent study determined the age to be 98.8 ± 0.62 Mya or at the Albian/Cenomanian boundary (Shi et al. 2012). Nuclear magnetic resonance (NMR) spectra and the presence of araucaroid wood fibres in amber samples from the Noije Bum Summit Site indicate an araucarian tree source for the amber (Poinar et al. 2007).

The amber was polished as close as possible to the specimen so that the features could be examined under oil immersion with a light microscope. Observations and photographs were made with a Nikon SMZ-10 R stereoscopic microscope

and a Nikon Optiphot compound microscope with magnifications up to 1000 X. Helicon Focus Pro X64 was used to stack photos for better overall clarity and depth of field.

Results

The fossil is placed in the Domain Eukaryota (Chatton 1925) Whittaker and Margulis, 1978 based on the presence of membrane enclosed nuclei in one or more developmental stages.

Domain: Eukarya
Class: Dictyostelia?
Order: incertae sedis
Family: incertae sedis

Genus *Paleoplastes* gen. nov.

Diagnosis

Plasmodium composed of a protoplast containing a central reddish pseudoplasmodium with an aggregation of myxamoebae. At one end of the pseudoplasmodium are sorocarps bearing small, roundish spores, some of which are in short chains.

Type species

Paleoplastes burmanica gen. et sp. nov.

Diagnosis

as for type genus (monotypic)

***Paleoplastes burmanica* gen. et sp. nov. (Figure 1–5).**

Description

Plasmodium 2.8 mm long and 2.4 mm wide with marginal lobes ranging up to 200 μ m in length and 90 μ m in width

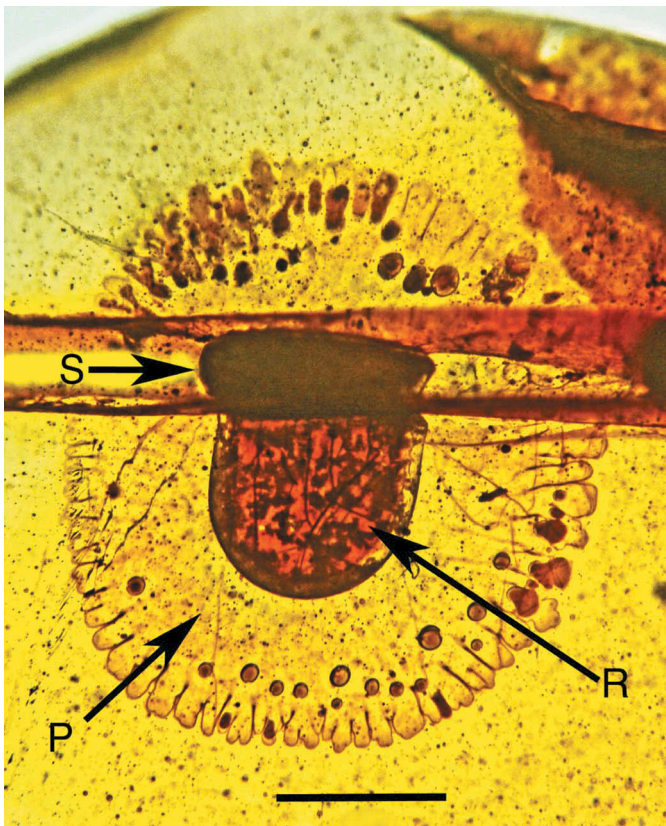


Figure 1. Plasmodium (P) of *Paleoplastes burmanica* gen. et sp. nov. with reddish pseudoplasmodium (R) in centre and area of developing sorocarps (S). Scale bar = 840 μ m.

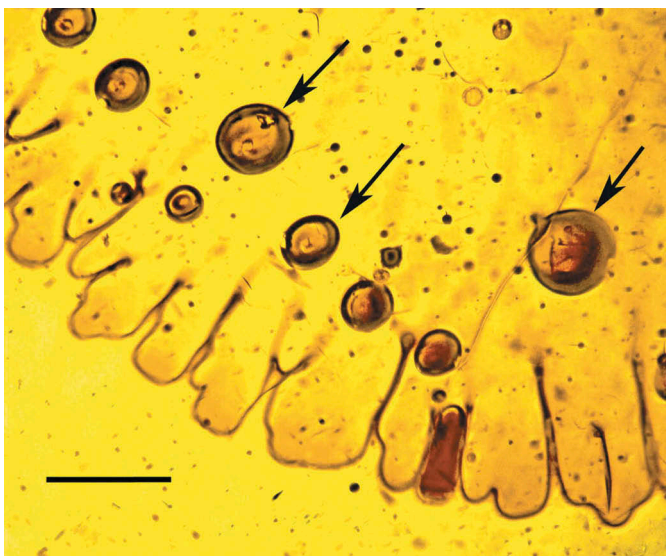


Figure 2. Lobulate edge of plasmodium of *Paleoplastes burmanica* gen. et sp. nov. showing globular vacuoles (arrows). Scale bar = 122 μ m.

(Figures 1 and 2). Central reddish pseudoplasmodium 1.1 mm in length (Figure 1). Myxamoeba in pseudoplasmodium 16 μ m –18 μ m in greatest diameter (Figure 3). Sorocarps develop from pseudoplasmodium (Figures 4 and 5). Terminal portions of sorocarps possess slender or bulbous tips that bear nucleated spores ranging from 8 μ m to 10 μ m in diameter (Figure 5).

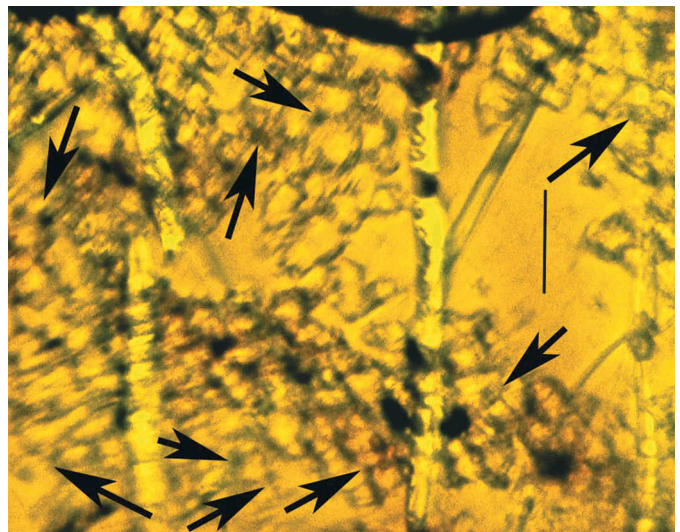


Figure 3. Myxamoebae inside the central reddish area of *Paleoplastes burmanica* gen. et sp. nov. The cells seem to be disintegrating, however nuclei on some are still visible (arrows). Scale bar = 139 μ m.



Figure 4. Sorocarps of *Paleoplastes burmanica* gen. et sp. nov. One on left has a bulbous base with a narrow tip from which a chain of spores has emerged. Three others (arrows) have simple tips. Scale bar = 34 μ m.

Holotype

Accession no. B-PR-23 deposited in the Poinar amber collection maintained at Oregon State University.

Etymology

Generic name from the Greek ‘paleo’ = ancient, and the Greek ‘plastos’ = plasma. Specific epithet indicates place of discovery of the fossil.

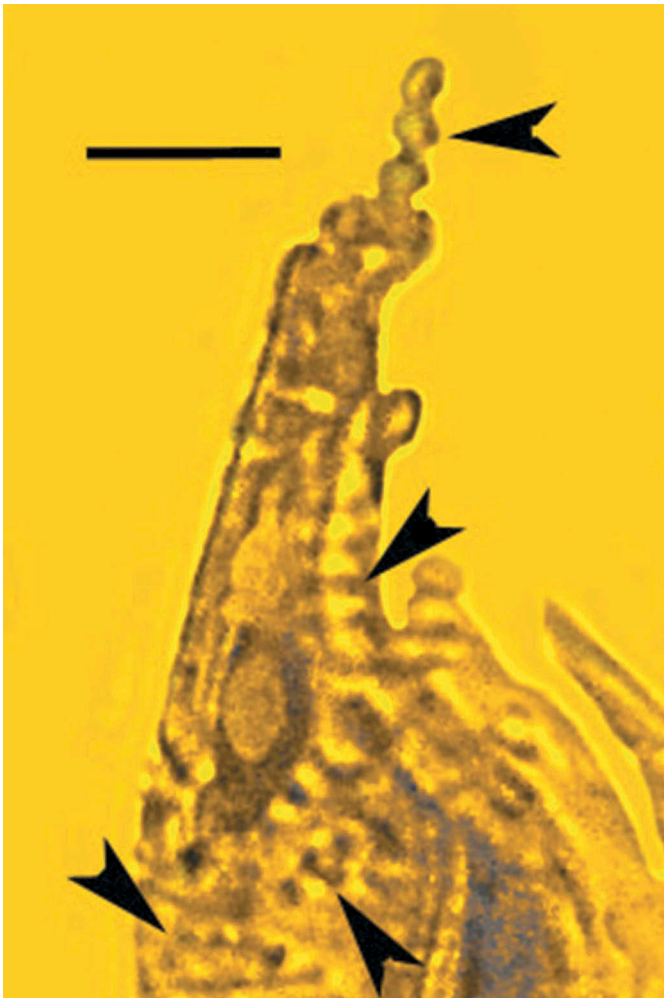


Figure 5. Detail of tips of sorocarps of *Paleoplastes burmanica* gen. et sp. nov. A single chain of spores is being emitted from the left specimen. Arrowheads show developing spores. Scale bar = 17 μ m.

Type locality

Myanmar (Burma), state of Kachin, Noiye Bum Summit Site amber mine in the Hukawng Valley, SW of Maingkhwan (26°20' N, 96°36' E).

Comments

The acellular plasmodium, central reddish pseudoplasmodium and shape of the sorocarps are apomorphic features of *Paleoplastes burmanica* gen. et sp. nov. While the fossil possesses some characters of a cellular slime mould, its systematic placement remains unknown since there are no similar extant or extinct forms for comparison (Taylor et al. 2015).

The origin of the reddish colour of the pseudoplasmodium (Figure 1) could be due to droplets of fluid pigments (Kudo 1954) or coloured myxamoebae. Both pink and red hues are known to occur in myxamoebae and other parts of slime moulds (Nair and Zabka 1966; Raper 1973).

Discussion

Fossil slime moulds are very rare (Frederick 1990; Taylor et al. 2015) and amber appears to be the best source for the preservation of such naked plasmoid organisms (Poinar et al.

1993). The tissues of the entrapped organisms are fixed by various terpenoids and resin acids. Dehydration is accomplished by sugars and terpenes in the resin that replace water, resulting in a type of physical preservation known as inert dehydration. After fixation and dehydration, the resin hardens from polymerisation and cross bonding (Poinar and Hess 1985). However, even though preservation can be quite good, irregularities in the amber matrix can make it difficult to obtain high resolution images when examining minute organisms under high power or oil immersion.

A myxomycete plasmodium was previously reported from mid-Tertiary Dominican amber but no fruiting structure was present for confirmation (Waggoner and Poinar 1992). Some putative myxomycete spores were reported from the Oligo-Miocene La Boca formation in Panama (Graham 1971) and tentative fossil plasmodia were described from a Carboniferous peat bog (Bertrand and Renault 1892). Slime moulds have been described from Baltic amber (Domke 1952; Dörfelt et al. 2003; Dörfelt and Schmidt 2006). None of the above described species are similar to *Paleoplastes burmanica* gen. et sp. nov. While slime mould fossils normally only have portions of their life stages preserved, it is fortunate that both the vegetative and fructification stages of *Paleoplastes* were preserved.

Conclusions

The Burmese amber *Paleoplastes burmanica* gen. et sp. nov. represents an extinct slime mould lineage with unique morphological stages. Such fossils provide a fleeting glimpse of mid-Cretaceous plasmodial eukaryotes and add to our knowledge of the morphological diversity that occurred some 100 Mya.

Disclosure statement

No potential conflict of interest was reported by the authors.

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References

- Adl SM, Simpson AGB, Farmer MA, Andersen RA, Anderson OR, Barta JR, Bowser SS, Brugerolle GU, Fensome RA, Fredericq S, et al. 2005. The new higher level classification of Eukaryotes with emphasis on the taxonomy of Protists. *J Eukaryot Microbiol.* 52:399–451.
- Bary AD. 1864. Die mycetozoen (Schleimpilze). Ein beitrage zur kenntniss der niedersten organismen. Leipzig: Wilhelm Engelmann; p. 132.
- Bertrand CE, Renault B. 1892. Le boghead d'Autun. *C R Acad Sci.* 115:138–141.
- Cruickshank D, Ko K. 2003. Geology of an amber locality in the Hukawng Valley, northern Myanmar. *J Asian Earth Sci.* 21:441–455.
- Chatton E. 1925. *Pansporella perplexa*. *Réflexions sur la biologie et la phylogénie des protozoaires*. *Ann Sci Nat Zool, 10e serie.* 7:1–84.
- Domke W. 1952. Der erste sichere Fund eines Myxomyceten im Baltischen Bernstein (*Stemonitis splendens* Rost fa. Succini fa. nov. foss.). *Mitt Geol Staatinst Hamburg.* 21:154–161.
- Dörfelt H, Schmidt AR. 2006. An archaic slime mould in Baltic amber. *Palaeontology.* 49:1013–1017.
- Dörfelt H, Schmidt AR, Ullmann P, Wunderlich J. 2003. The oldest fossil myxogastroid slime mold. *Mycol Res.* 107:123–126.

- Frederick L. 1990. Phylum plasmodial slime molds, class Myxomycota. In: Margulis L, Corliss JO, Melkonian M, Chapman DJ, editors. *Handbook of Protoctista*. Boston: Jones and Bartlett Publishers; p. 467–483.
- Graham A. 1971. The role of myxomycete spores in palynology (with a brief note on the morphology of certain algal zygospores). *Rev Palaeobot Palynol.* 11:89–99.
- Kirk PM, Cannon PF, David JC, Staplers JA. 2004. *Ainsworth & Bisby's dictionary of the fungi*. 9th ed. Wallingford: CAB International; p. 655.
- Kudo RR. 1954. *Protozoology*. Springfield (Illinois): Charles C. Thomas; p. 966.
- Nair P, Zabka GG. 1966. Pigmentation and sporulation in selected myxomycetes. *Am J Bot.* 53:887–892.
- Poinar GO Jr, Hess R. 1985. Preservative qualities of recent and fossil resins: Electron micrograph studies on tissue preserved in Baltic amber. *J Balt Stud.* 16:222–230.
- Poinar GO Jr, Lambert GJB, Wu Y. 2007. Araucarian source of fossiliferous Burmese amber: spectroscopic and anatomical evidence. *J Bot Res Inst Texas.* 1:449–455.
- Poinar GO Jr, Waggoner BM, Bauer U-C. 1993. Description and paleoecology of a triassic amoeba. *Naturwissenschaften.* 80:566–568.
- Raper KB. 1973. Acrasiomycetes. In: Ainsworth GC, Sparrow FK, Sussman AS, editors. *The fungi: an advanced treatise*. Vol. IVB. New York: Academic Press; p. 9–36.
- Shi G, Grimaldi DA, Harlow GE, Wang J, Wang J, Yang M, Lei W, Li Q, Li X. 2012. Age constraint on Burmese amber based on U-Pb dating of zircons. *Cretaceous Res.* 37:155–163.
- Stephenson SL. 2014. Excavata: Acrasiomycota; Amoebozoa: Dictyosteliomycota, Myxomycota. In: McLaughlin D, Spatafora JW, editors. *Systematics and evolution*, 2nd edition, the Mycota VII, part A. New York: Springer; p. 21–38.
- Taylor TN, Krings M, Taylor EL. 2015. *Fossil fungi*. Amsterdam: Elsevier; p. 382.
- Waggoner BJ, Poinar GO Jr. 1992. A fossil myxomycete plasmidium from Eocene-Oligocene amber of the Dominican republic. *J Protozool.* 39:639–642.