European Journal of Taxonomy 900: 138–147
https://doi.org/10.5852/ejt.2023.900.2307
ISSN 2118-9773
www.europeanjournaloftaxonomy.eu
2023 · Wood T.S. *et al.*

This work is licensed under a Creative Commons Attribution License (CC BY 4.0).

Research article

urn:lsid:zoobank.org:pub:3C651457-5780-4C15-B2F0-710068B648D9

Bryozoan statoblasts from lake sediments in Madagascar, including two new species

Timothy S. WOOD [1], Lilian Eva UNGER [2,*] & Laurence RASOAMIHAINGO [3]

[1] Department of Biological Sciences, Wright State University, Dayton, Ohio, OH 45435, USA.
[1] Department of Life Sciences, Natural History Museum, Cromwell Road, London, SW7 5BD, UK.
[2] Environmental Change Research Centre, Department of Geography, University College London, Gower Street, London, WC1E 6BT, UK.
[3] Ecole Doctorale de Biodiversité et Environments Tropicaux, Université de Toliara, Route de L'Université, Toliara 601, Madagascar.

[*] Corresponding author: lilian.unger.16@ucl.ac.uk
[1] Email: tim.wood@bryotechnologies.com
[3] Email: mihlaurence@gmail.com

[1] urn:lsid:zoobank.org:author:2357250B-DDED-4DFA-809C-B92FD04076FE
[2] urn:lsid:zoobank.org:author:B20212BE-E99B-4987-8D12-7252A9EBDC72
[3] urn:lsid:zoobank.org:author:9F26FFED-0776-420B-83CA-D9A104EF342A

Abstract. Madagascar is a freshwater biodiversity hotspot, yet the current understanding of freshwater bryozoan diversity is limited. Using a dissecting microscope, bryozoan statoblasts were collected during macrofossil analysis of a sediment core, which was taken from Lake Sofia, Madagascar, in 2019. There was a peak in the abundance of statoblasts prior to 1900, with 67 statoblast valves found at 45.5 cm and a decline in more recent sediments. A subsample of 14 specimens was examined under a scanning electron microscope to determine species identification. One of the species found was *Plumatella kinesis*. Two new species, *Plumatella tsimiheta* sp. nov. and *Plumatella sofiae* sp. nov. were also found and described. These results show the potential of lake sedimentary bryozoan remains for categorising species presence and distribution. Although poor preservation was a limitation for identification, there is still value in having a historical record of past biodiversity, especially when species may no longer be extant. This study highlights the need for further research to better understand the status of these species and other potential new species of bryozoan in Madagascar.

Keywords. Bryozoa, Phylactolaemata, palaeoecology, palaeolimnology, *Plumatella*.

Wood T.S., Unger L.E. & Rasoamihaingo L. 2023. Bryozoan statoblasts from lake sediments in Madagascar, including two new species. *European Journal of Taxonomy* 900: 138–137.
https://doi.org/10.5852/ejt.2023.900.2307

Introduction

Bryozoans in the class Phylactolaemata Allman, 1856 occur exclusively in fresh water. They are commonly found in lakes, ponds, and rivers where they attach to almost any submerged surface (Wood & Okamura

2005). A characteristic feature of phylactolaemate bryozoans is the asexual production of small capsules, called statoblasts, that germinate to form new individuals, usually following a period of dormancy. Some statoblasts are buoyant upon their release into the water and are known as floatoblasts. Others are attached to the substratum as sessoblasts. Both types have a pair of sclerotized valves which are commonly preserved in lake sediments, and their morphology is often used for species identification. These characteristics mean that statoblast remains found in lake sediment cores can significantly aid the determination of bryozoan species presence and distribution, as demonstrated for *Lophopus crystallinus* Pallas, 1768 in the UK (Hill *et al.* 2007).

Madagascar is a freshwater biodiversity hotspot, but assessment of its wetlands shows widespread habitat degradation (Benstead *et al.* 2003; Bamford *et al.* 2017). Lake Sofia (14°35′04″ S, 49°00′30″ E) is a shallow lake and Ramsar site, in the Sofia Region of Northwest Madagascar (Pruvot & de Roland 2021). Including the extensive surrounding marsh system, the 16.5 km^2 site supports several endemic bird species of conservation importance, but there is significant pressure from human disturbance (Bamford *et al.* 2017; Pruvot & de Roland 2021). Here we report on the statoblasts found in a lake sediment core taken from Lake Sofia (Fig. 1).

These are the results from one of a suite of analyses which have been conducted on this core, which will later be published in full. The wider project aims to use palaeolimnology in lakes related to a critically endangered duck, the Madagascar Pochard, to inform conservation and restoration work being done by the Wildfowl and Wetlands Trust. The separate publication of this record aims to highlight the value of statoblasts remains in lake sediment cores, as a record of historical bryozoan biodiversity, and to demonstrate their potential contribution to published freshwater bryozoan research, especially from underrepresented regions such as Madagascar.

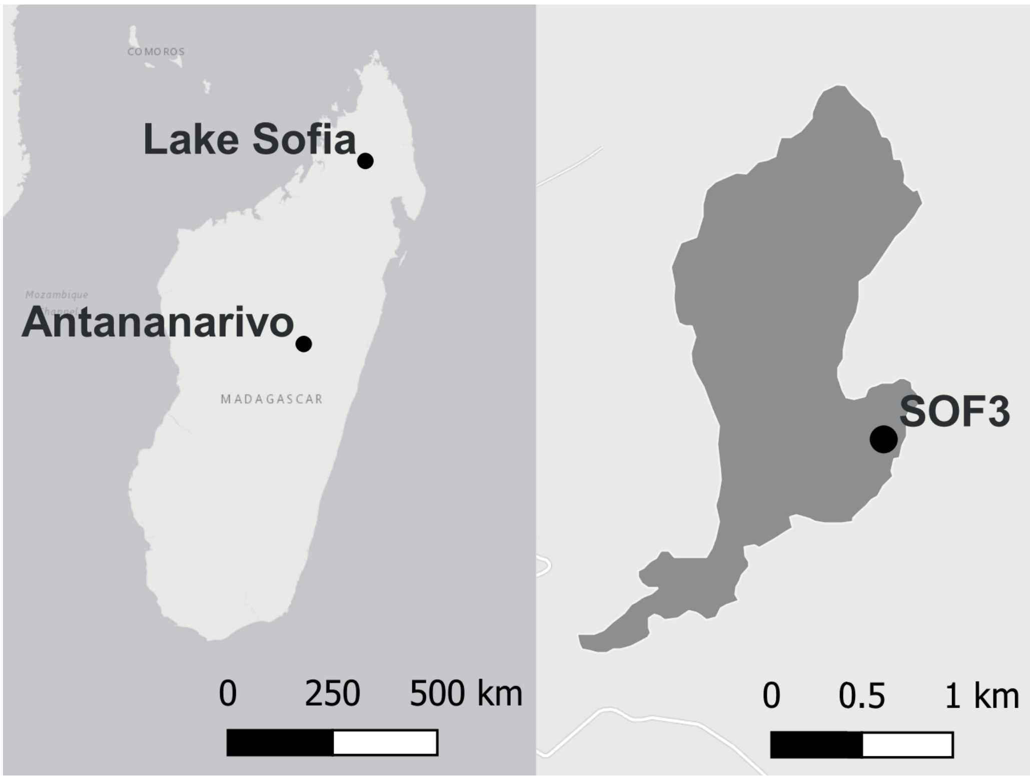

Fig. 1. Map (left) showing the location of Lake Sofia within Madagascar, in relation to the capital city of Antananarivo, and (right) showing the location of the SOF3 core within Lake Sofia.

Material and methods

In September 2019, a 'Big-Ben' wide-bore (14 cm) piston corer (Patmore *et al.* 2014) was used to take the SOF3 sediment core from a 1.5 m water depth. The SOF3 core was extruded and sliced into 1-cm sections on site. Each section was transferred into a Whirl-Pak™ bag, flown to the UK and stored in a University College London cold store. The core was dated radiometrically, analyzing the sediment for ^{210}Pb, ^{226}Ra, ^{137}Cs and ^{241}Am in the Environmental Radiometric Facility at University College London by direct gamma assay (Appleby *et al.* 1986). Sixteen samples at 5 cm intervals were analyzed for macrofossils according to standard methods (Birks 2001). For each sample, 30 cm^3 of sediment was sieved through a 250 µm and 125 µm sieve and the remaining material was examined under a dissecting microscope, with all bryozoan statoblast valves picked out and stored.

Selected statoblasts were used for species identification by scanning electron microscopy (SEM). The isolated statoblasts included whole floatoblasts, floatoblast valves, and at least one sessoblast. They were first rehydrated in deionized water to restore their original shape and size. They were then cleaned in 2 ml Eppendorf containers with a 0.1 M solution of sodium hexametaphosphate and vibrated at 60 Hz for 3 minutes (Wood 2001). When necessary, whole statoblasts were further treated with a 2 M NaOH solution to separate the valves. Measurements were made from enlarged, calibrated photographs of valves in water. For scanning electron microscopy at the Natural History Museum in London, the valves were dried, then transferred to aluminum stubs, but not sputter coated as this is not necessary at low magnifications. The scanning electron microscope was an FEI Quanta 650 FEG used in low vacuum mode.

Holotype material examined for comparative purposes included *Plumatella dhritiae* Wood, 2022, Specimen No. P1190/1 at the Zoological Survey of India in Kolkata, India; *Plumatella kisalensis* Wood, 2018, Specimen No. 61 at the Royal Museum of Central Africa at Tervuren, Belgium; and *Plumatella patagonica* Wiebach, 1974, Specimen No. 291 at the Zoologisches Museum, Hamburg, Germany.

Results

A stratigraphic plot displaying the total number of the pooled plumatellid statoblast valves found in this core is shown in Fig. 2. There is a clear increase and subsequent decline in statoblast abundance at this site over time, with a peak of 67 valves at 45.5 cm, just below the earliest ^{210}Pb date of 1898 at 39.5 cm.

The identification of a subsample of 14 selected statoblast valves, from various sample depths, determined that there were three species present: one is a known species and two are new species (Table 1). The condition of several of the remains was too poor for adequate identification.

The following is a systematic account of the three species found.

Class Phylactolaemata Allman, 1856
Order Plumatellida Allman, 1856
Family Plumatellidae Allman 1856
Genus *Plumatella* Lamarck, 1816

Plumatella tsimiheta sp. nov.
urn:lsid:zoobank.org:act:BD3A02EE-5785-45B7-A3DB-E939BE6A59FB
Fig. 3

Diagnosis

Floatoblasts unusually long and narrow, the outer dimensions similar to *Plumatella dhritiae* Wood, 2022; fenestra tubercles well formed and densely crowded, spilling onto the annulus in a manner resembling *P. patagonica* Wiebach, 1974.

Table 1. The resulting identifications of a subsample of 14 Phylactolaemata bryozoan remains, from different depths in the SOF3 lake sediment core, from Lake Sofia, Madagascar.

Depth (cm)	Identity	No of individuals
30.5	*Plumatella kisalensis* Wood, 2018	2
	Plumatella sofiae sp. nov.	1
	Unidentifiable	1
40.5	*Plumatella sofiae* sp. nov.	3
	Plumatella tsimiheta sp. nov.	2
	Unidentifiable	3
80.5	*Plumatella sofiae* sp. nov.	1
	Unidentifiable	1

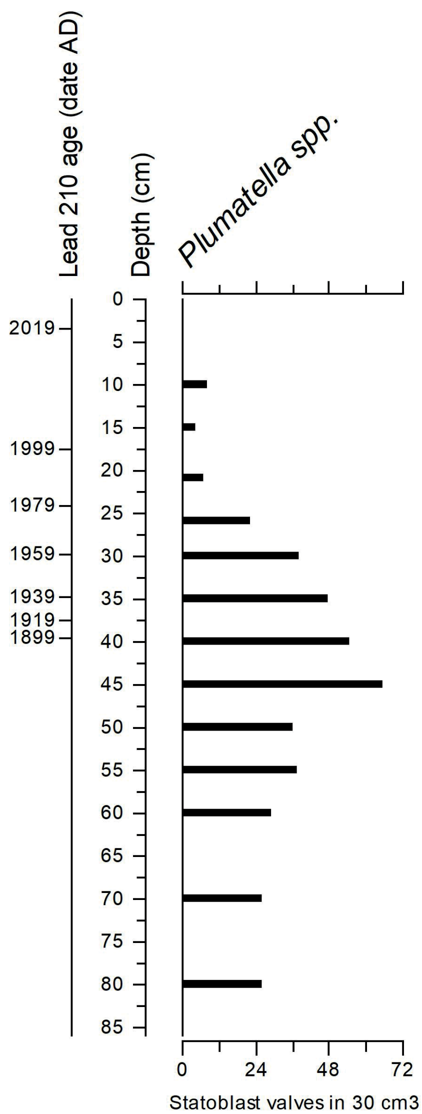

Fig. 2. A stratigraphic graph displaying the total number of plumatellid bryozoan statoblast valves found in the SOF3 wide diameter core from Lake Sofia, Madagascar. Each bar represents the number of valves found in 30 cm^3 of sediment.

Etymology

The species name is a tribute to the local ethnic group, the Tsimihety, who inhabit much of the northern Madagascar.

Material examined

Holotype

MADAGASCAR • Statoblast valves; Mahajanga Province, Sofia Region, Bealanana District, Marotolana Village, Lake Sofia; 14°35′04″ S, 49º00′30″ E; Sep. 2019; L. Unger leg.; NHMUK 2023.1.17.1, slide collection.

Description

Floatoblast 51–535 µm long (Fig. 3a) with an average of 530 µm and 245–255 µm wide with an average of 253 µm (n = 3), length : width averaging 2.16; capsule measuring 360 µm by 215 µm; dorsal valve nearly flat, with fenestra encroaching on underlying capsule only at the poles (Fig. 3a, arrows); ventral valve convex, with fenestra matching capsule outline; fenestra tubercles small, densely crowded and highly convex, merging indistinctly with annular cells surrounding the fenestrae; other annular cells mostly defined by low mounds; suture appearing as crenulated margin around entire floatoblast (Fig. 3b).

Remarks

While the floatoblast outer dimensions resemble those of *Plumatella dhritiae* Wood, 2022, in that species the dorsal fenestra encroaches uniformly on all sides of the capsule, fenestra tubercles are well spaced, and the outer margin is smooth. Floatoblast tubercles in *P. tsimiheta* sp. nov. resemble those of *P. patagonica* Wiebach, 1974 in their size, density, and distribution (Fig. 3c). However, in that species the floatoblast is over 750 µm in length and more broadly oval.

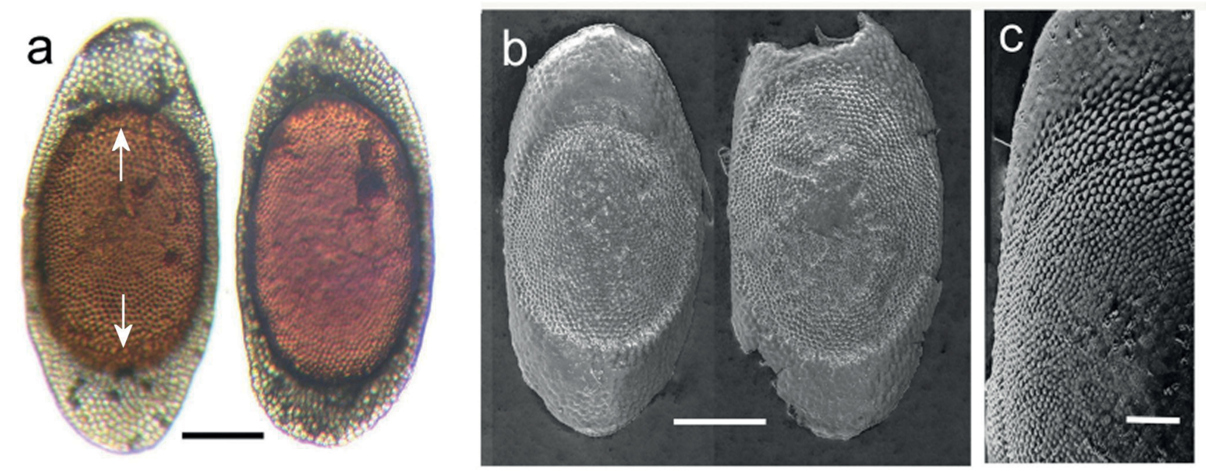

Fig. 3. Floatoblasts related to *Plumatella tsimiheta* sp. nov. **a**. Unpaired valves, dorsal on left with arrows showing annulus encroachment over the capsule, image of ventral valve (right) electronically composed to show two planes in focus. **b**. SEM micrograph showing floatoblast surface details on dorsal (left) and ventral (right) valves. **c**. SEM view of a portion of floatoblast in *P. patagonica* Wiebach, 1974 showing similar tuberculation. Scale bars: a–b = 100 µm; c = 50 µm.

Plumatella sofiae sp. nov.
urn:lsid:zoobank.org:act:84847FC0-B38F-4548-B9AE-EB3FB8A28B99
Fig. 4

Diagnosis

Floatoblast large, average length > 500 µm, average length : width 1.79; fenestra tubercles small and well spaced; suture minutely toothed and projecting beyond the outer margin.

Etymology

The species name is derived from the region of Sofia in northern Madagascar where these statoblasts were collected.

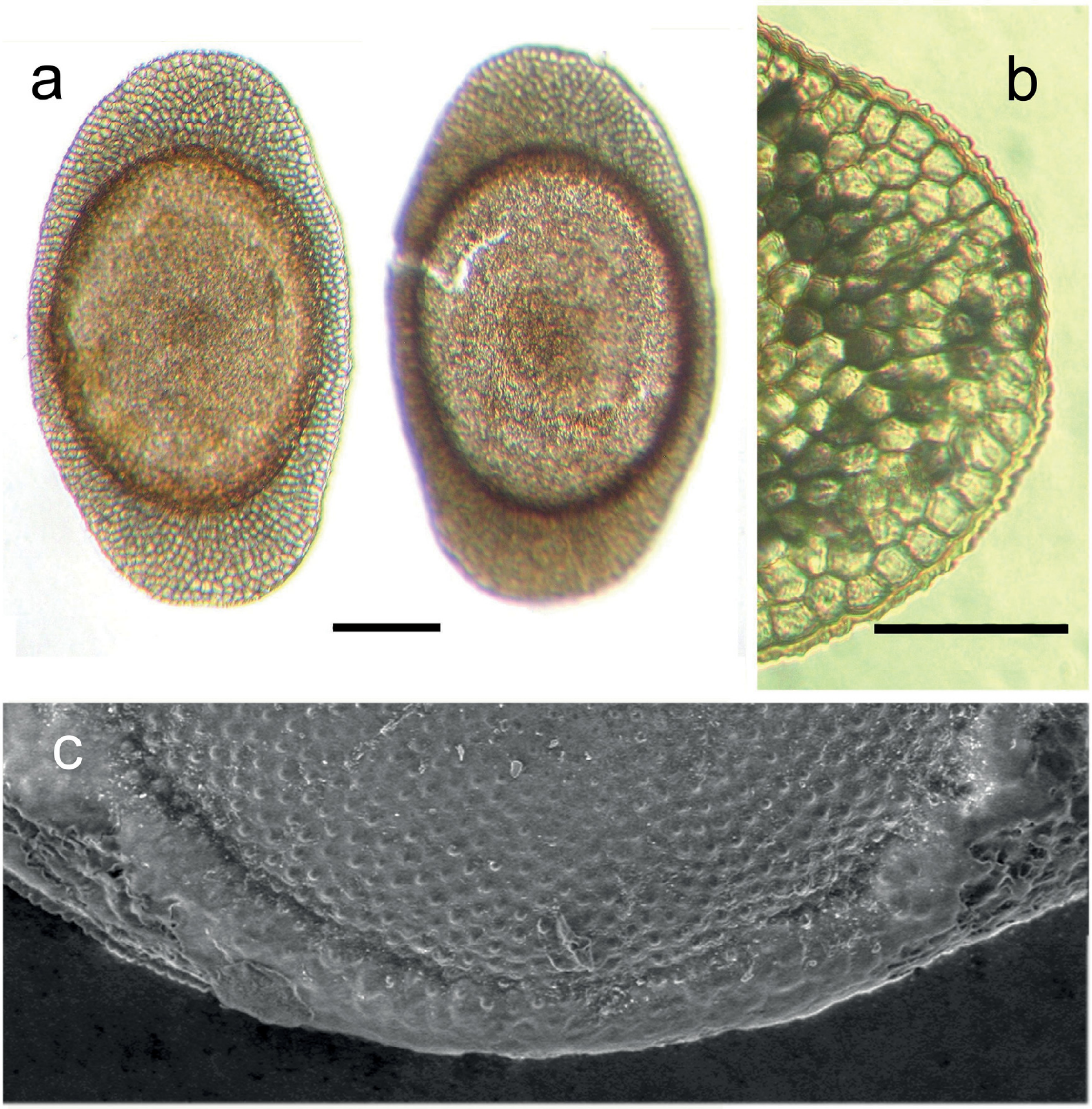

Fig. 4. Floatoblasts of *Plumatella sofiae* sp. nov. **a**. Paired floatoblast valves, dorsal on left, ventral on right. **b**. One end of ventral valve showing toothed margin. **c**. SEM of a portion of the ventral valve showing tuberculation. Scale bars: a = 100 µm; b–c = 50 µm.

Material examined

Holotype

MADAGASCAR • Statoblast valves; Mahajanga Province, Sofia Region, Bealanana District, Marotolana Village, Lake Sofia; 14°35′04″ S, 49º00′30″ E; Sep. 2019; L. Unger leg.; NHMUK 2023.1.17.2, slide collection.

Description

Floatoblasts broadly oval and rounded at the poles, somewhat variable in shape and size (Fig. 4a), length 474–573 µm with average of 529 µm, width 252–326 µm with average of 296 µm (n = 4), length : width averaging 1.79; ventral valve more convex than dorsal one; dorsal fenestra slightly oblong to nearly round, encroaching on all sides of the underlying capsule; ventral fenestra matching outline of capsule; tubercles uniformly small and uncrowded on both fenestrae; annulus about three times wider at poles than along sides; suture projecting slightly beyond annulus, giving outer margin slightly serrated appearance (Fig 4b–c).

Remarks

Most of the statoblasts of this species were intact, but a persistent layer of silt or clay particles obscured many of the surface details.

Plumatella kisalensis Wood, 2020
Fig. 5

Stolella indica Wiebach, 1964: 22–25, text-figs 16–21, pls 8–10 (not Annandale 1909: 279–280).

Material examined

MADAGASCAR • Statoblast valves; Mahajanga Province, Sofia Region, Bealanana District, Marotolana Village, Lake Sofia; 14°35′04″ S, 49º00′30″ E; Sep. 2019; L. Unger leg.; NHMUK 2023.1.17.3, slide collection.

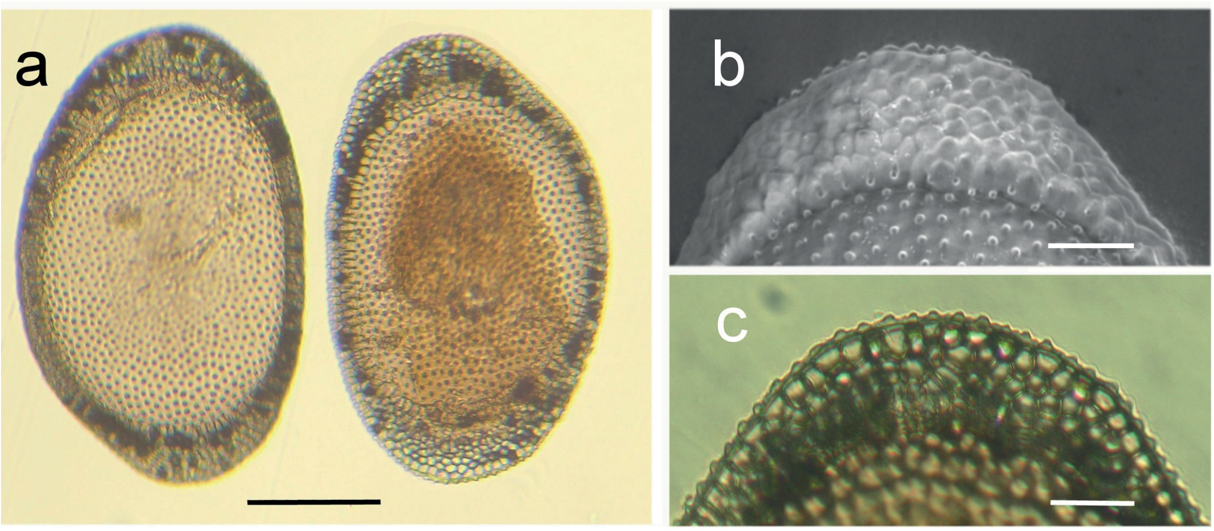

Fig. 5. Floatoblasts of *Plumatella kisalensis* Wood, 2018. **a**. Paired valves, dorsal on left, ventral on right. **b**. SEM image of one end of ventral valve showing tuberculation. **c**. One end of ventral valve showing toothed margin. Scale bars: a = 100 µm; b–c = 50 µm.

Description

Floatoblast small: 330 µm long, 214 µm wide, both valves about equally convex; dorsal fenestra unusually large in proportion to overall dimensions, measuring 250 µm by 182 µm, ventral fenestra slightly larger (Fig. 5a); tubercles small, bead-like, and well spaced; small, rounded knobs project from suture around entire periphery, giving a distinctly toothed appearance (Fig. 5b–c).

Remarks

Since only a single statoblast was available, there is no range in size to report. *Plumatella kisalensis* was first described from material collected at three sites in what is now the Democratic Republic of Congo (Wood 2020). The single floatoblast examined from Lake Sofia sediments is considerably smaller than those of the type material, which average 476 µm in length (Wood 2020). Statoblast size among plumatellid bryozoans is often strikingly variable, even from the same colony. All other features of the floatoblast match the holotype.

Discussion

The high number of statoblast valves found preserved in this lake sediment core confirms the potential of sediments for bryozoan species sampling and determining community change over time. This is unsurprising as species in the genus *Plumatella* are notoriously prolific producers of statoblasts (Francis 2001). This approach could be used to greatly increase the understanding of bryozoan species presence and distribution in Madagascar. Preservation quality does affect identification potential, illustrated by the frequency of valves being too degraded or damaged to identify. The decline in the abundance of plumatellid statoblasts in this core indicates that these species may be declining at Lake Sofia. Additional sediment core records from across the lake would confirm whether this is a general or localised trend. If these two new species are endemic to Madagascar, further study of their current status and distribution is urgently needed to ensure their protection. The sampling of modern bryozoan colonies at Lake Sofia and other lakes in Madagascar, will be important to address these issues and provide further details of these new species, such as colony morphology. There is also a number of existing lake sediment cores from Madagascar that could be examined for bryozoan remains to further contribute to bryozoan research in Madagascar and potentially lead to the identification of more new species. There is increasing evidence for bryozoan dispersal by waterbirds (Okamura *et al.* 2019), therefore water bird conservation at this site may benefit the bryozoan species present.

Acknowledgements

We wish to thank everyone who helped during fieldwork to collect the SOF3 sediment core including Ian Patmore, Solomiarintsoa Nidealysoa Razafindrabe, and Rovaniaina Nidealysoa Rakotondraibe. We want to thank the many members of WWT (Wildfowl and Wetlands Trust) staff in the UK and Madagascar who helped to make the fieldwork possible. In particular thanks to Harison Andriambelo for helping to obtain the research and export permits required for this work and the government in Madagascar for granting them (research permit number: N° 220/18/MEEF/SG/DGF/DSAP/SCB.Re). We thank the Chief of Fonkontany Marotolana, the Mayor of the Marotolana Commune and the Mandroso, Santatra Sofia and Marofamara Fikambanana Fitantanana Matsabory Sofia (FFMS) VOI (Vondron'Olona eny Ifotony) managers for giving us permission to conduct this research on Lake Sofia. We thank Handong Yang for the core dating, Beth Okamura for hosting the SEM work and NERC for funding this research (grant number: NE/R007357/1).

References

Allman G.J. 1856. A monograph of the fresh-water Polyzoa, including all the known species, both British and foreign. *Ray Society* 28: 1–119. https://doi.org/10.5962/bhl.title.9143

Annandale N. 1909. Preliminary note on a new genus of Phylactolaematous polyzoa. *Records of the Zoological Survey of India* 3: 279–280. https://doi.org/10.26515/rzsi/v3/i3/1909/163283

Appleby P.G., Nolan P.J., Gifford D.W., Godfrey M.J., Oldfield F., Anderson N.J. & Battarbee R.W. 1986. ^{210}Pb dating by low background gamma counting. *Hydrobiologia* 143: 21–27. https://doi.org/10.1007/BF00026640

Bamford A.J., Razafindrajao F., Young R.P. & Hilton G.M. 2017. Profound and pervasive degradation of Madagascar's freshwater wetlands and links with biodiversity. *PLOS One* 12 (8): e0182673. https://doi.org/10.1371/journal.pone.0182673

Benstead J.P., De Rham P.H., Gattolliat J.-L., Gibon F.-M., Loiselle P.V., Sartori M., Sparks J.S. & Stiassny M.L. 2003. Conserving Madagascar's freshwater biodiversity. *BioScience* 53 (11): 1101–1111. https://doi.org/10.1641/0006-3568(2003)053[1101:CMFB]2.0.CO;2

Birks H.H. 2001. Plant macrofossils. *In*: Smol J.P., Birks H.J.B., Last W.M., Bradley R.S. & Alverson K. (eds) *Tracking Environmental Change Using Lake Sediments: Volume 3: Terrestrial, Algal, and Siliceous Indicators*: 49–74. Springer Netherlands, Dordrecht. https://doi.org/10.1007/0-306-47668-1_4

Francis D.R. 2001. Bryozoan statoblasts. *In*: Smol J.P., Birks H.J.B. & Last W.M. (eds) *Tracking Environmental Change Using Lake Sediments: Volume 4: Zoological Indicators*: 105–123. Springer Netherlands, Dordrecht. https://doi.org/10.1007/0-306-47671-1_6

Hill S.L.L., Sayer C.D., Hammond P.M., Rimmer V.K., Davidson T.A., Hoare D.J., Burgess A. & Okamura B. 2007. Are rare species rare or just overlooked? Assessing the distribution of the freshwater bryozoan, *Lophopus crystallinus*. *Biological Conservation* 135 (2): 223–234. https://doi.org/10.1016/j.biocon.2006.10.023

Lamarck J.B.P.A. 1815. *Histoire naturelle des Animaux sans Vertèbres... précédée d'une Introduction offrant la Détermination des Caracteres essentiels de l'Animal, sa Distinction du végétal et des autres Corps naturels, enfin, l'Exposition des Principes fondamentaux de la Zoologie.* Verdière, Libraire, Paris. https://doi.org/10.5962/bhl.title.12712

Okamura B., Hartikainen H. & Trew J. 2019. Waterbird-mediated dispersal and freshwater biodiversity: general insights from bryozoans. *Frontiers in Ecology and Evolution* 7. https://doi.org/10.3389/fevo.2019.00029

Patmore I.R., Sayer C.D., Goldsmith B., Davidson T.A., Rawcliffe R. & Salgado J. 2014. Big Ben: a new wide-bore piston corer for multi-proxy palaeolimnology. *Journal of Paleolimnology* 51 (1): 79–86. https://doi.org/10.1007/s10933-013-9756-0

Pruvot Y.Z. & de Roland L.A.R. 2021. Food habits of the Malagasy Pond Heron (*Ardeola idae*) during the breeding season in northern Madagascar. *Journal of Heron Biology and Conservation* 6 (1): 2.

Wiebach F. 1964. Untersuchungen an Süsswasser-Bryozoen aus Zentralafrika. *Annals de la Musée royal de l'Afrique centrale* 129: 1–42.

Wood T.S. 2001. *Plumatella mukaii*, a new phylactolaemate bryozoan from Asia and South America. *Hydrobiologia* 445 (1): 51–56. https://doi.org/10.1023/A:1017526418685

Wood T.S. 2020. Review of freshwater Bryozoa (Phylactolaemata) of Central Africa with descriptions of two new species. *Zootaxa* 4820 (3): 581–600. https://doi.org/10.11646/zootaxa.4820.3.11

Wood T.S. 2022. Phylactolaemate bryozoans at the Zoological Survey of India and a taxonomic key to Indian Phylactolaemata. *Zootaxa* 5200 (5): 401–435. https://doi.org/10.11646/zootaxa.5200.5.1

Wood T. & Okamura B. 2005. *The Freshwater Bryozoans of Britain, Ireland, and Continental Europe. Scientific Publication No, 63*. Freshwater Biology Association of the United Kingdom, Swansholme, UK.

Manuscript received: 14 November 2022
Manuscript accepted: 17 April 2023
Published on: 31 October 2023
Topic editors: Tony Robillard, Magalie Castelin
Desk editor: Radka Rosenbaumová

Printed versions of all papers are also deposited in the libraries of the institutes that are members of the *EJT* consortium: Muséum national d’histoire naturelle, Paris, France; Meise Botanic Garden, Belgium; Royal Museum for Central Africa, Tervuren, Belgium; Royal Belgian Institute of Natural Sciences, Brussels, Belgium; Natural History Museum of Denmark, Copenhagen, Denmark; Naturalis Biodiversity Center, Leiden, the Netherlands; Museo Nacional de Ciencias Naturales-CSIC, Madrid, Spain; Leibniz Institute for the Analysis of Biodiversity Change, Bonn – Hamburg, Germany; National Museum of the Czech Republic, Prague, Czech Republic.