



# Factors driving changes in freshwater mussel (Bivalvia, Unionida) diversity and distribution in Peninsular Malaysia

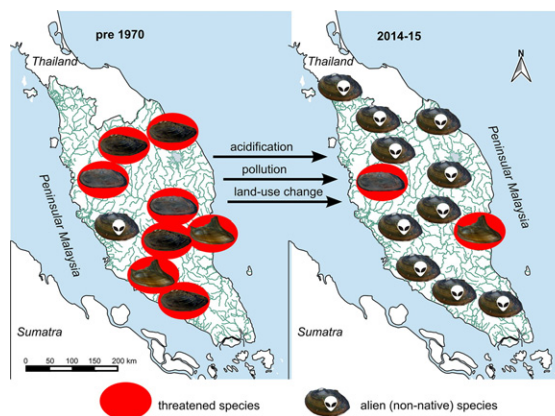
Alexandra Zieritz <sup>a,\*</sup>, Manuel Lopes-Lima <sup>b</sup>, Arthur E. Bogan <sup>c</sup>, Ronaldo Sousa <sup>d</sup>, Samuel Walton <sup>e</sup>, Khairul Adha A. Rahim <sup>f</sup>, John-James Wilson <sup>g,h</sup>, Pei-Yin Ng <sup>g,h</sup>, Elsa Froufe <sup>b</sup>, Suzanne McGowan <sup>a,i</sup>

<sup>a</sup> School of Geography, University of Nottingham Malaysia Campus, Jalan Broga, 43500 Semenyih, Malaysia  
<sup>b</sup> CIIMAR/CIMAR - Interdisciplinary Centre of Marine and Environmental Research, University of Porto, Rua dos Bragas 289, 4050-123 Porto, Portugal  
<sup>c</sup> Research Laboratory, North Carolina State Museum of Natural Sciences, 1671 Gold Star Drive, Raleigh, NC 27607, USA  
<sup>d</sup> CBMA - Centre of Molecular and Environmental Biology, Department of Biology, University of Minho, Braga, Portugal  
<sup>e</sup> Universiti Malaysia Terengganu, Kenyir Research Institute, 21030 Kuala Terengganu, Malaysia  
<sup>f</sup> Department of Aquatic Science, Faculty of Resource Science & Technology, Universiti Malaysia Sarawak, 94300 Kota Samarahan, Sarawak, Malaysia  
<sup>g</sup> Museum of Zoology, Institute of Biological Sciences, Faculty of Science, University of Malaya, 50603 Kuala Lumpur, Malaysia  
<sup>h</sup> Ecology and Biodiversity Program, Institute of Biological Sciences, Faculty of Science, University of Malaya, 50603 Kuala Lumpur, Malaysia  
<sup>i</sup> School of Geography, University Park, University of Nottingham, Nottingham, NG72RD, UK

## HIGHLIGHTS

- We conducted the first assessment of freshwater mussels in Peninsular Malaysia.
- We found ten species, two of which had not been previously recorded.
- Three species are acutely threatened due to restricted and declining distributions.
- Main threats to this fauna are human-induced acidification and eutrophication.
- We recommend establishing riparian buffers and improving waste water treatment.

## GRAPHICAL ABSTRACT



## ARTICLE INFO

**Article history:**  
 Received 27 April 2016  
 Received in revised form 14 July 2016  
 Accepted 14 July 2016  
 Available online 26 July 2016

Editor: D. Barcelo

**Keywords:**  
 Acidification  
 DNA barcoding

## ABSTRACT

Freshwater mussels (Bivalvia, Unionida) fulfil important ecosystem functions and are one of the most threatened freshwater taxa globally. Knowledge of freshwater mussel diversity, distribution and ecology in Peninsular Malaysia is extremely poor, and the conservation status of half of the species presumed to occur in the region has yet to be assessed. We conducted the first comprehensive assessment of Peninsular Malaysia's freshwater mussels based on species presence/absence and environmental data collected from 155 sites spanning all major river catchments and diverse habitat types. Through an integrative morphological-molecular approach we recognised nine native and one widespread non-native species, i.e. *Sinanodonta woodiana*. Two species, i.e. *Pilsbryoconcha compressa* and *Pseudodon cambodjensis*, had not been previously recorded from Malaysia, which is likely a result of morphological misidentifications of historical records. Due to their restriction to single river catchments and declining distributions, *Hyriopsis bialata*, possibly endemic to Peninsular Malaysia, *Ensidents*

\* Corresponding author at: School of Geography, Faculty of Science, University of Nottingham Malaysia Campus, Jalan Broga, 43500 Semenyih, Malaysia.  
 E-mail address: [Alexandra.zieritz@nottingham.edu.my](mailto:Alexandra.zieritz@nottingham.edu.my) (A. Zieritz).