The Rufford Foundation
Final Report

Congratulations on the completion of your project that was supported by The Rufford Foundation.

We ask all grant recipients to complete a Final Report Form that helps us to gauge the success of our grant giving. The Final Report must be sent in **word format** and not PDF format or any other format. We understand that projects often do not follow the predicted course but knowledge of your experiences is valuable to us and others who may be undertaking similar work. Please be as honest as you can in answering the questions – remember that negative experiences are just as valuable as positive ones if they help others to learn from them.

Please complete the form in English and be as clear and concise as you can. Please note that the information may be edited for clarity. We will ask for further information if required. If you have any other materials produced by the project, particularly a few relevant photographs, please send these to us separately.

Please submit your final report to jane@rufford.org.

Thank you for your help.

Josh Cole, Grants Director

Grant Recipient Details	
Your name	Alexandra Zieritz
Project title	Diversity, distribution and conservation status of Brunei's freshwater mussels
RSG reference	23152-1
Reporting period	14 Nov 2017 – 13 Nov 2018
Amount of grant	£4954
Your email address	Alexandra.zieritz@nottingham.edu.my
Date of this report	14 Nov 2018

1. Please indicate the level of achievement of the project's original objectives and include any relevant comments on factors affecting this.

Objective	Not achieved	Partially achieved	Fully achieved	Comments
Determine the diversity, distribution, environmental requirements and population characteristics of freshwater mussels in Brunei			X	As detailed below, no freshwater mussels were found in Brunei and our surveys indicated that mussels may have never been present in this country.
Identify the most vulnerable mussel species, major threats to Brunei's freshwater mussel fauna and suitable sites for conservation efforts in different regions of Brunei			X	Although no freshwater mussel populations could be located in Brunei, we did succeed in obtaining the first records of *Ctenodesma borneensis* and *Pseudodon walpolei* for approximately 60 and 100 years, respectively. Historical records indicate that these two species are endemic to (northern) Borneo, and used to be relatively common in the area. However, the species have dramatically declined, as after extensive surveying of the area over the past 3 years, we were able to confirm presence of these species only at a single site each in a patch of primary rainforest.
Build local expertise in freshwater malacology and ecology, and ensure the continuation of our efforts towards protection of Brunei's freshwater mussel fauna after completion of the project by closely collaborating with local scientists and involving at least one field-assistant in all stages of			X	Fieldwork was conducted in collaboration between Alexandra Zieritz (Nottingham Malaysia), Hussein Taha (University of Brunei Darussalam) and Khairul Adha Rahim (University of Malaysia Sarawak), with Prof. Dr Hjh Zohrah Binti Hj Sulaiman (Universiti Teknologi Brunei) providing guidance on fieldwork in Brunei. In addition, Manuel Lopes-Lima (IUCN, Portugal) and John Pfeiffer (University of Florida) kindly

the project.				contributed their expertise on freshwater mussel surveys free of charge by participating in Expedition 1 and 2, respectively, and covering their own flight costs. AZ gave a public presentation at the University of Brunei.
Raise awareness by disseminating outputs and results to the media, NGOs, schools, universities, museums and governmental authorities. Good communication and a close partnership with authorities will be crucial for the development and implementation of Action Plans, which is planned after completion of this project.	X			We have only just completed data collection, so data dissemination has not yet started for this project. However, please see our detailed plans for this in the text below.

2. Please explain any unforeseen difficulties that arose during the project and how these were tackled (if relevant).

No unforeseen difficulties arose during this project. However, in the course of the first expedition of this project (8 days in March 2018), we found that the abundance and spread of crocodiles in Brunei was more severe than expected, and prevented us from surveying many of the planned sites for mussels efficiently. We therefore had to adjust our study design by focusing data collection in Brunei on small streams, and interviewing local communities residing near rivers about the presence of mussels. In total, only 14 sites in Brunei could be surveyed by hand and net, but additionally, interviews were conducted at another 30 sites across the country with a total of about 100 local people from various ethnicities (including indigenous) and ages. No mussels were found at any of the surveyed sites and none of the interviewees recalled that freshwater mussels had ever been present in any rivers or streams of Brunei. Based on our experience in Malaysia, local knowledge on freshwater fauna is generally highly reliable, and was confirmed in Brunei by the fact that most of the interviewees knew about the presence/absence of snails and prawns in rivers and streams of their area.

Considering that museum records of freshwater mussels for Brunei date back about 100 years or more, combined with the fact that Limbang Division (todays Sarawak) was lost from Brunei to Malaysia only in 1890, this may suggest that historical records from "Brunei" in fact stem from the river basins of Limbang. In the second expedition of this project, conducted over 8 days in July 2018, we therefore expanded our data

collection to the river basins of Limbang, including the Limbang, Trusan and Merapok basins. A total of 29 sites were surveyed, and interviews conducted at another 10 sites. Native freshwater mussels were found at one site in a comparatively untouched rainforest stream in the upper Limbang basin (Sg. Kemadi), accessible only by foot (~1.5 hour hike) and with a local guide (Lun Bawang tribe) (see Fig. 1a for map of the area). The species found was *Ctenodesma borneensis* as identified by morphology and COI sequencing. This find represents the first record of this species and Bornean endemic freshwater mussels in general for about 60 years. Historical records, of which approximately 10 are available to our knowledge, indicate that this species is endemic to northern Borneo with a native distribution from Mempawah, Kalimantan (type locality), to Sandakan, Sabah (location of latest record by N.S. Haile, probably from around 1960). In addition, we found the first record of the non-native *Sinanodonta woodiana* in Limbang, which is widespread in Sabah but has so far been reported in Sarawak only from one location in the Suai basin near Miri (Zieritz et al., 2018).

In the final stage of the project, we surveyed sites in the upper Kanowit river in Sarawak's Sibu and Sarikei Divisions over 4 days in November 2018. Our previous work in the region and correspondence with the local Iban community suggested that this region, which still retains some patches of untouched rainforest, holds one of the healthiest native freshwater mussel populations in northern Borneo and exhibits the highest probability of still retaining populations of one of northern Borneo's endemic mussel species.

3. Briefly describe the three most important outcomes of your project.

(1) Our findings indicate that it is unlikely that freshwater mussels are present in Brunei today and that possibly, historical museum records from "Brunei" might actually originate from Limbang Division, which was part of Brunei until the late 19th century.

(2) Deforestation and land-use change to predominantly oil palm plantations, which accelerated dramatically from the 1960s, have diminished endemic freshwater mussel populations in northern Borneo. Only one native species remains present in fairly healthy numbers, i.e. *Rectidens sumatrensis*, which is also native to Peninsular Malaysia, Sumatra and Java, and therefore not endemic to Borneo.

(3) The endemic northern Bornean species, in particular *Ctenodesma borneensis*, *Pseudodon walpolei*, *P. crassus* and *Pressidens exanthematicus*, have not been found by scientists for many decades. However, our project was successful in providing the first record of *C. borneensis* in a forest stream in the upper Limbang basin, for about 60 years. Only three specimens could be found over several hours of searching, indicating that the species is present in only low densities. In addition, we provide the first anecdotal record of *P. walpolei* for many decades from a tributary of the Kanowit River, as supported by several members of the local Iban tribe, who state that the species is very rare and declining in numbers (see Fig. 1b for a map of the site). Our own surveys at this site conducted during unfavourably high water levels, were unfortunately unsuccessful in finding this species so far. However, we did find dense populations of another native species, *R. sumatrensis*, in this stream, indicating that

habitat conditions for freshwater mussels are favourable in this area. We are planning to visit the site again during low water levels in 2019, and are staying in close contact with the Iban community who will keep looking out for this mussel and inform us as soon as they have collected a specimen again.

4. Briefly describe the involvement of local communities and how they have benefitted from the project (if relevant).

Throughout the project we hired a number of local people for transportation, guides and accommodation. In fact, only due to the knowledge of the indigenous communities, we were able to locate as well as reach the populations of the Bornean endemic freshwater mussel species. As explained in detail in point 9 below, in the next step of this project, we will push for legal protection of the two patches of rainforest surrounding the Limbang and Kanowit tributaries with extant *C. borneensis* and *P. walpolei* populations, respectively. These primary rainforests, as well as the streams and their fauna are vital for the survival of the local indigenous communities.

5. Are there any plans to continue this work?

Yes, please see point 9 for details.

6. How do you plan to share the results of your work with others?

Firstly, results of this project will be used to update the national and global assessment of freshwater mussel species from northern Borneo, i.e. *Ctenodesma borneensis*, *Pressidens exanthematicus*, *Pseudodon crassus*, *Pseudodon walpolei* and *Rectidens sumatrensis*. National assessments will be published in an updated version of the "Handbook and National Red List of the Freshwater Mussels of Malaysia" with the new title of "Handbook and National Red List of the Freshwater Mussels of Malaysia and Brunei" (see current version at http://www.nationalredlist.org/handbook-and-national-red-list-of-freshwater-mussels-of-malaysia/).

Secondly, results of this project, including data on environmental parameters, will be published in Ellipsaria, the Newsletter of the Freshwater Mollusk Biology and Conservation published quarterly and available online at https://molluskconservation.org/Ellipsaria-archive.html. We will also prepare an article for the Malaysian Naturalist, the Newsletter of the Malaysian Nature Society.

Thirdly, COI, ND1 and 28S sequences of *C. borneensis*, *R. sumatrensis* and *S. woodiana* specimens collected in the course of this project will be included in two scientific papers on: (1) the phylogenetic position and habitat requirements of *C. borneensis*; and (2) the population genetics and phylogeography of *R. sumatrensis*, targeting mid- to high-impact journals such as Biodiversity and Conservation.

Fourthly, results will be shared orally in scientific conferences and talks.

Finally, please see point 9 for our plans on how we plan to directly communicate result to the local and international authorities and NGOs.

7. Timescale: Over what period was The Rufford Foundation grant used? How does this compare to the anticipated or actual length of the project?

Fieldwork was completed in the course of three expeditions, amounting to a total of 20 days, of which 15 were full fieldwork days. This is in accordance with the originally proposed fieldwork plan.
Expedition 1: 25/3-1/4, 8 days, 7 nights, Brunei
Expedition 2: 7-14/7, 8 days, 7 nights, Brunei and Limbang State (Sarawak)
Expedition 3: 9-12/11, 4 days, 3 nights, Sibu and Kanowit-area (Sarawak)

8. Budget: Please provide a breakdown of budgeted versus actual expenditure and the reasons for any differences. All figures should be in £ sterling, indicating the local exchange rate used.

Item	Budgeted Amount	Actual Amount	Difference	Comments
Flights & transport to/from airport	172	702	530	Overspending due to splitting 1 expedition into 3 separate expeditions in order to cover a wider geographic area as originally planned (i.e. Including former Brunei states of Limbang and Lawas, as well as 3 nights in Sibu)
Field transport	1482	902	-580	We saved costs by using the personal car of Dr. Hussein for fieldwork in Brunei and parts of Limbang rather than renting.
Accommodation	1596	736	-860	Underspending due to finding cheaper accommodation as expected, sometimes sharing 1 room among 4-5 participants, and spending 1 night in the forest for free.
Subsistence	570	953	383	Overspending due to higher number of participants as originally planned (i.e. Manuel Lopes-Lima and John Pfeiffer joining Expedition 1 and 2, respectively).
Consumables	342	410	68	
Salaries	342	610	268	Overspending due to higher workload as expected, including repetition of some PCRs due to poor quality of samples that got overheated during the expedition.

Services (sequencing, ion analysis, courier)	399	542	143	Slight overspending due to additional sequencing of ND1 gene for population genetic analyses.
Equipment	51	98	47	Additionally bought a rake to enable sampling from boat.

Exchange rates used:
- MYR to GBP: 1:0.19 based on amount received in MYR on AZ's Malaysian Bank account (MYR 25,979).
- BND to MYR: 1:3.03 based on exchange rate received in Malaysia.

9. Looking ahead, what do you feel are the important next steps?

(1) Revise global and national conservation status assessment of *Ctenodesma borneensis* (currently global "not evaluated", national "Vulnerable") and *Pseudodon walpolei* (currently global "not evaluated", national "Near Threatened") to endangered or possibly even critically endangered. This is now possible as we have surveyed a total of 118 sites (72 in our previous project and 46 in the current project) across all major river basins of northern Borneo east and including the Rajang basin, with each species having been reported only from a single site each. Loss of the species' extent of occurrence are now estimated to be close to 100%.

(2) Provide hard evidence of the presence of *P. walpolei* in the Kanowit tributary by collecting one or two specimens of the species from the site for molecular analysis either through our local Iban contact (we left the necessary equipment, including ethanol with him for this purpose) and/or by revisiting the site during low water levels around April 2019. The record of this species in the Kanowit tributary is so far based on anecdotal evidence, albeit confirmed independently by several members of the local Iban community and can therefore, based on our previous experience, be considered highly reliable.

(3) Lobby for the protection of the patches of primary rainforest in the areas surrounding the tributaries where *C. borneensis* and *P. walpolei* were found, respectively. As can be seen in Fig. 1a and b, logging activities are ongoing in the areas upstream of both sites. According to the local indigenous communities, logging activities have been ongoing for the past 30 years or so and have led to deteriorating habitat conditions of their rivers, in particular, increasing sedimentation, which in turn has led to a decrease in presence of aquatic fauna, such as fish, mussels and prawns. These patches of rainforest and the rivers and biodiversity within it (see red areas in Fig. 1) are now severely threatened by expanding logging activities, which the local communities are trying to fight. Once the IUCN status of *C. borneensis* and *P. walpolei* have been revised and hard evidence has been collected for the presence of *P. walpolei* (i.e. specimens collected), we will contact international and national NGOs (e.g. the Rainforest Trust, Malaysian Nature Society) as well as the local government (Fisheries Department) to make the case for protection of these patches of rainforest for the sake of not only the endemic mussel fauna but also the local indigenous communities.

(4) Survey the Kanowit tributaries where *P. walpolei* has been reported from for other freshwater fauna, including fish, crabs, snails and prawns. If other rare or endemic species are found, this will hopefully help our case for protecting this patch of primary rainforest.

(5) Continue our survey work for endemic Bornean freshwater mussel species to identify further sites of particular conservation importance. In northern Borneo, the upper reaches of the Limbang basin in the Gunung Buda and southern part of the Gunung Mulu National Parks deserve particular attention, but fieldwork in these areas will be expensive and particularly difficult to organise as they can only be reached and navigated by longboat. Furthermore, the river basins west of the Rajang basin, including Kuching and Samarahan River, should be surveyed, but safe access is particularly difficult here due to the abundance of crocodiles. In the long-term, we are planning to develop protocols for environmental DNA studies in these crocodile-infested tropical rivers, which would help to at least gather initial data on the general presence/absence of freshwater mussels.

10. Did you use The Rufford Foundation logo in any materials produced in relation to this project? Did The Rufford Foundation receive any publicity during the course of your work?

So far, the logo of the Rufford Foundation was used in Alexandra Zieritz's presentation of the project given at the University of Brunei Darussalam in March 2018, ahead of the first expedition, as well as at another presentation at the National University of Singapore in July 2018. We are also planning (pending permission of the Rufford Foundation) to use the logo in our updated version of the Handbook and National Red List of the Freshwater Mussels of Malaysia and Brunei (see current version at http://www.nationalredlist.org/handbook-and-national-red-list-of-freshwater-mussels-of-malaysia/).

11. Please provide a full list of all the members of your team and briefly what was their role in the project.

Dr. Alexandra Zieritz (Nottingham Malaysia): Project lead, coordinated participants, developed routes of expeditions and survey design. Took part in all fieldwork activities. Conducted water quality (nutrients, ions) and molecular analyses.

Dr. Hussein Hj Taha (University of Brunei Darussalam): Organised permits, fieldwork, accommodation and sample processing in Brunei. Provided his personal car and acted as driver during fieldwork in Brunei and those parts of Limbang Division where 4WD was not required.

Prof. Dr Hjh Zohrah Binti Hj Sulaiman (Universiti Teknologi Brunei) provided guidance on fieldwork in Brunei.

Dr. Khairul Adha Rahim (University of Malaysia Sarawak): Participated in all field expeditions. Provided in situ-water quality measurement equipment (pH, conductivity

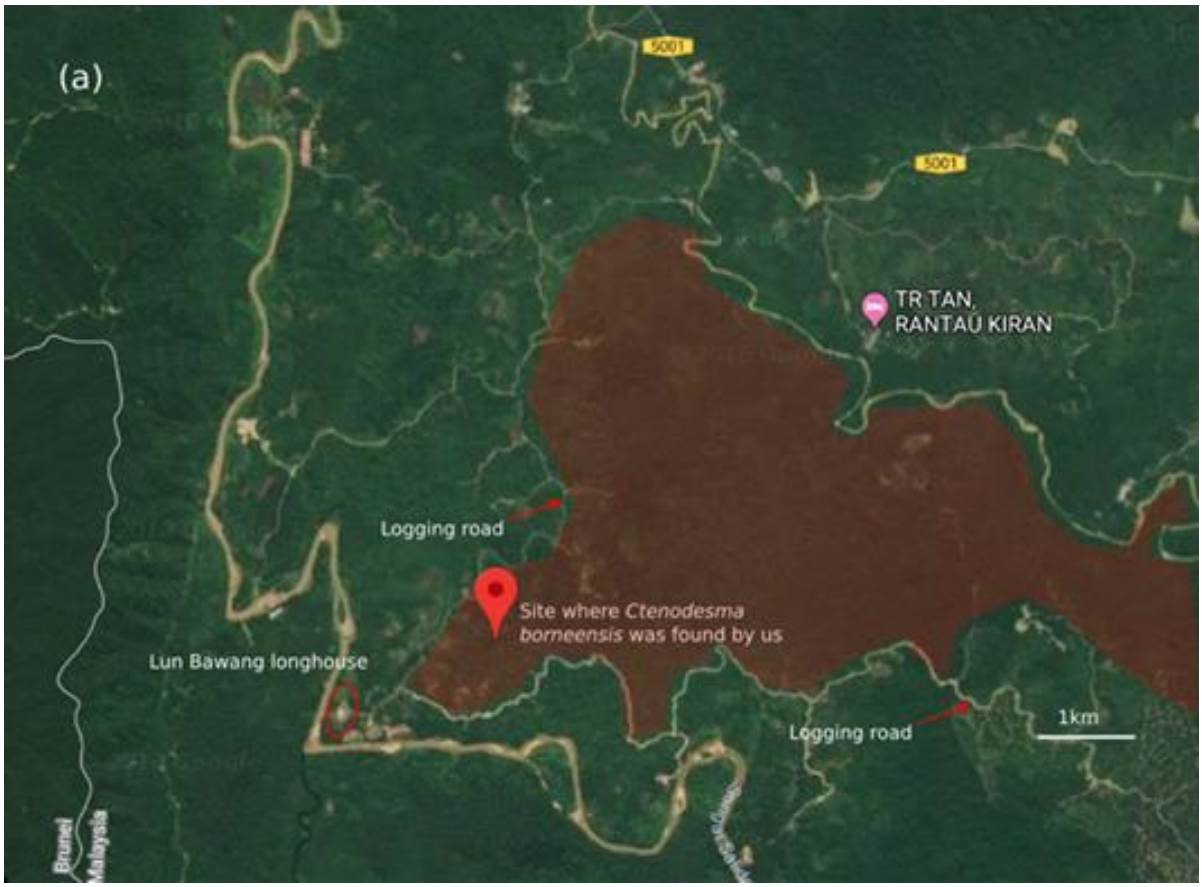
etc.) and grab sampler for expeditions. Organised permits, accommodation and local contacts (drivers, field guides) in Limbang and Sibu.

Manuel Lopes-Lima (IUCN, University of Porto): Participated in Expedition 1, providing additional expertise on freshwater mussel sampling. Covered his flight costs from Portugal through other funds.

John Pfeiffer (University of Florida): Participated in Expedition 2, providing additional expertise on freshwater mussel sampling. Covered his flight costs from the USA through other funds.

12. Any other comments?

We would be very interested to receive feedback by the Rufford Foundation staff on our plans regarding lobbying for the protection of an area of rainforest. It would also be interested to hear whether the Foundation would encourage us to apply for further funding for our work on freshwater mussels in Borneo.



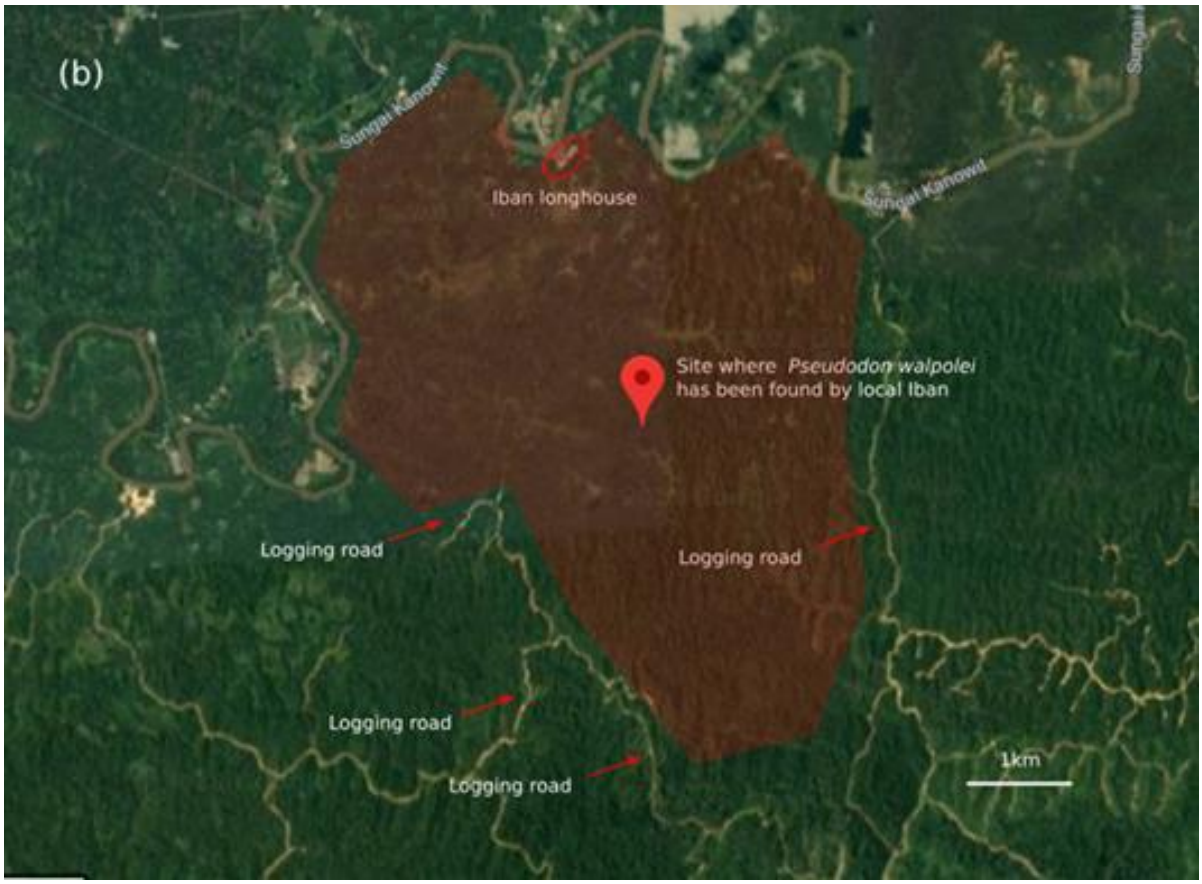
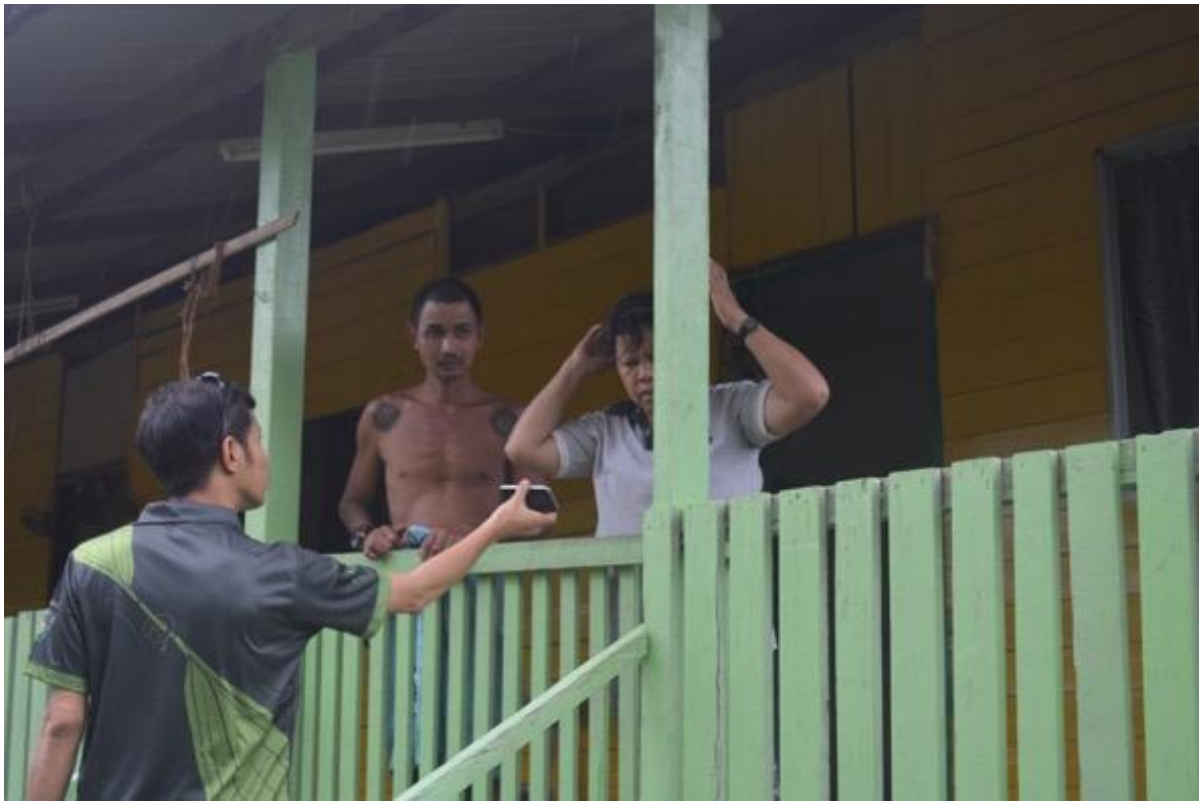
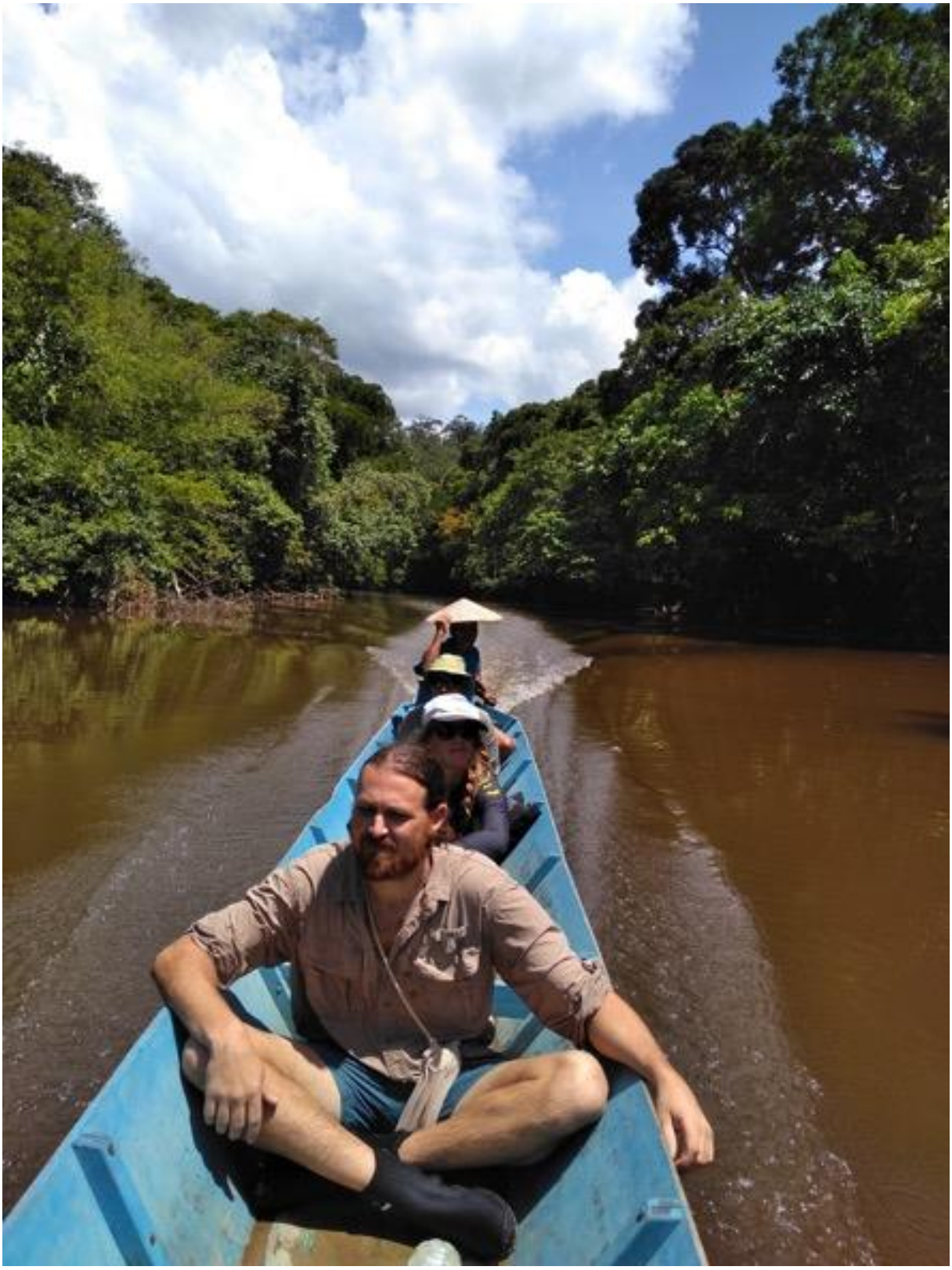


Figure 1. *Map depicting the only sites where (a)* Ctenodesma borneensis *and (b)* Pseudodon walpolei *have been reported in the last 60-100 years, respectively. Also shown are logging roads upstream of these sites, and proposed areas of conservation (in red), covering approximately 25km^2 each.*

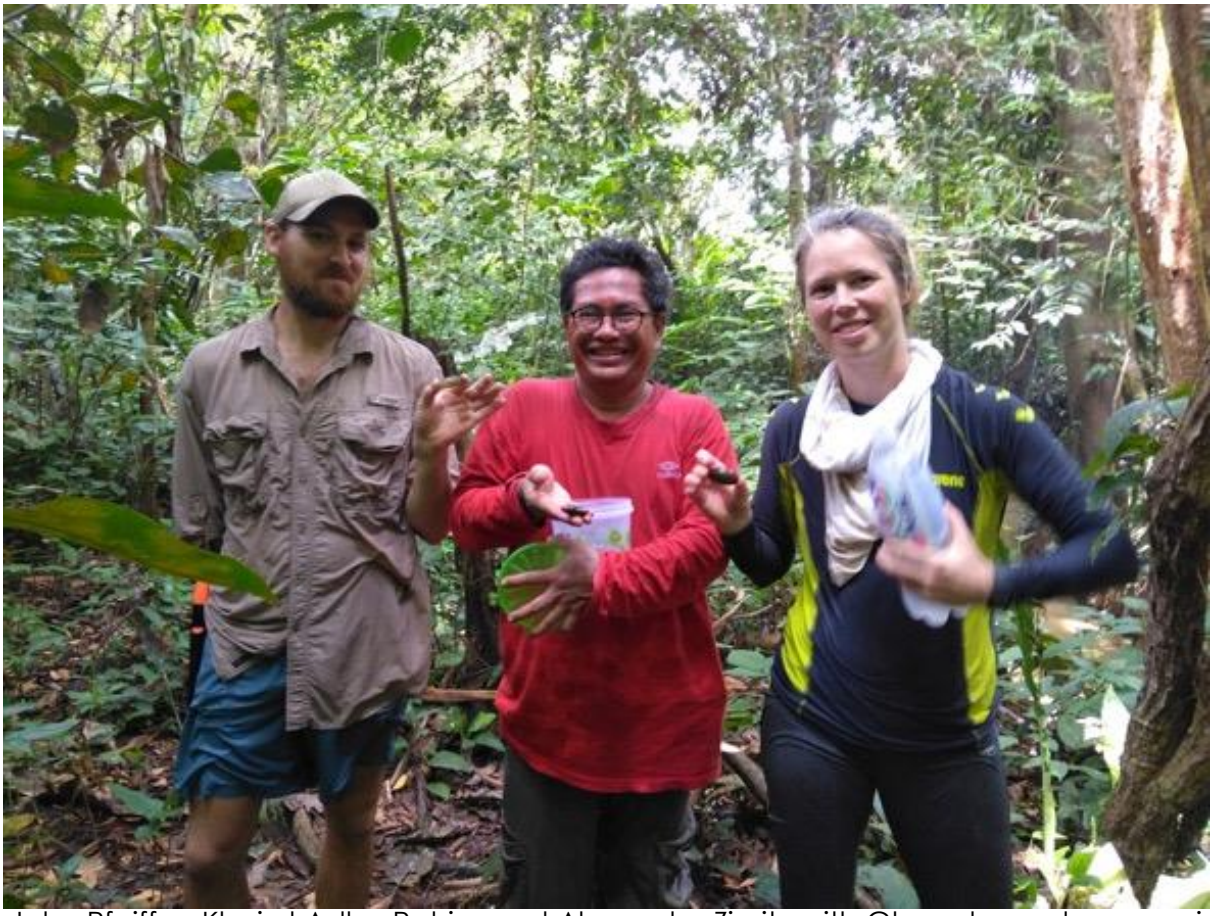
Manuel Lopes-Lima, Alexandra Zieritz, Prof. Hjh Zohrah Binti Hj Sulaiman, Khairul Adha Rahim and Hussein Taha after enjoying a lunch meeting in Bandar Seri Bewagan.



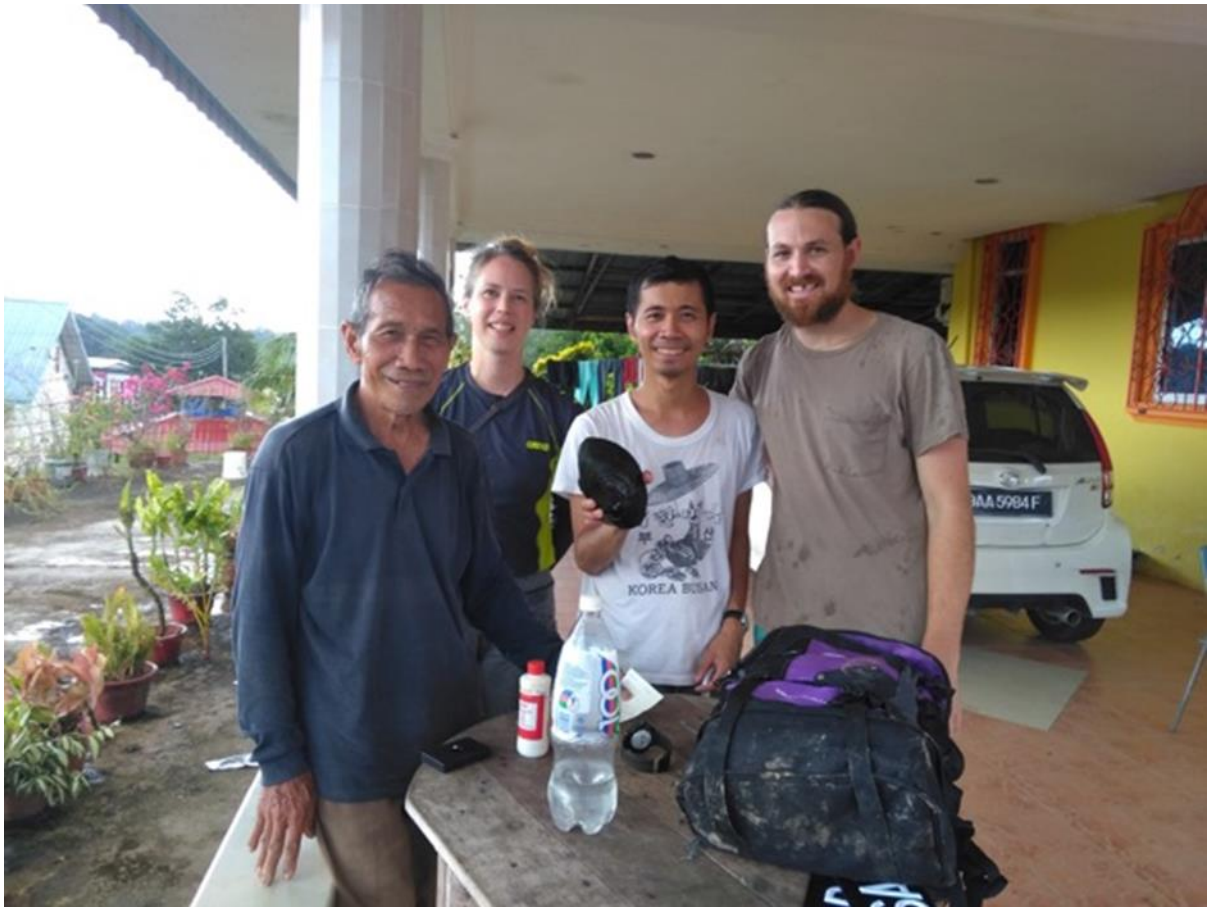
Hussein Taha interviewing local Lun Bawang people in Brunei about the presence of freshwater mussels in their area.



John Pfeiffer, Alexandra Zieritz, Hussein Taha's hat and local boatman on the Limbang river.

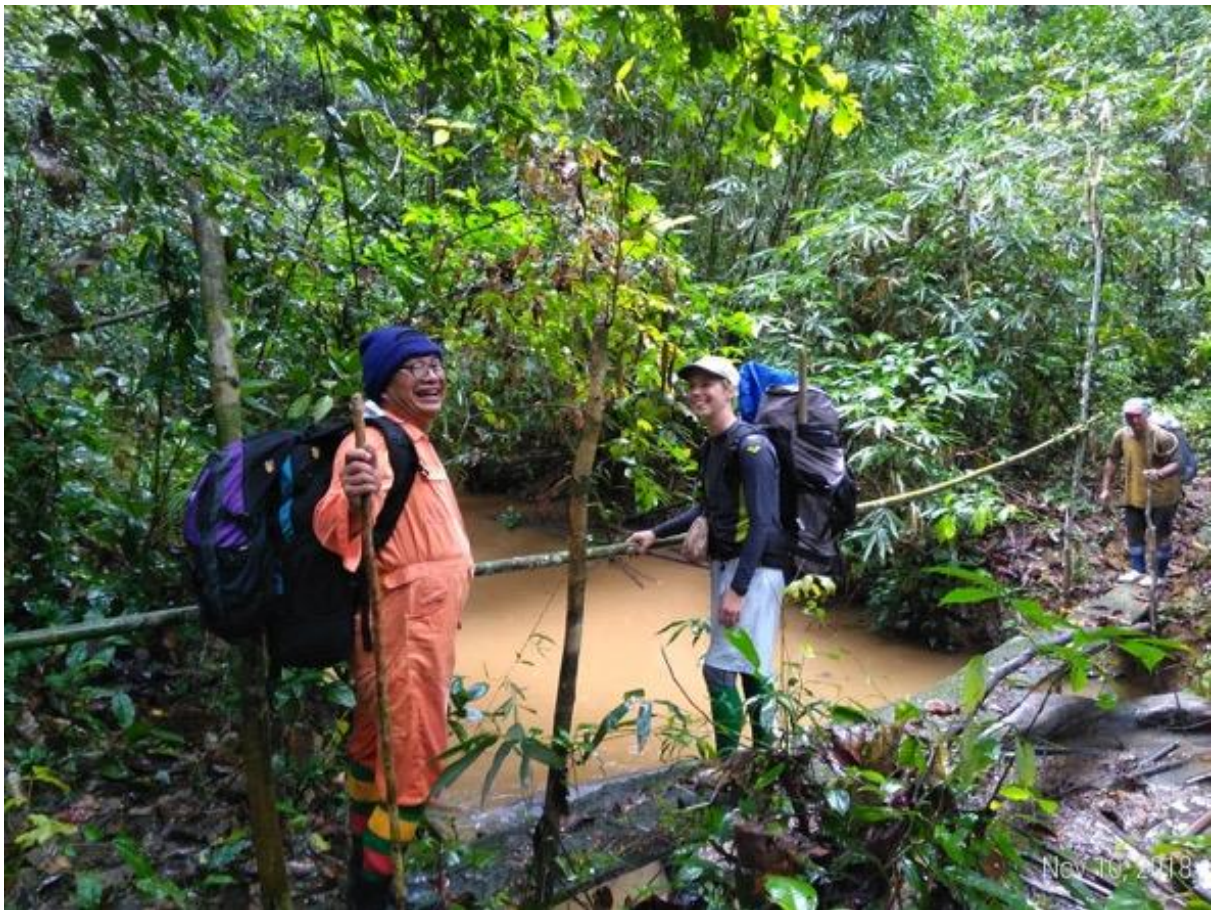


John Pfeiffer, Khairul Adha Rahim and Alexandra Zieritz with Ctenodesma borneensis from a Limbang river tributary.

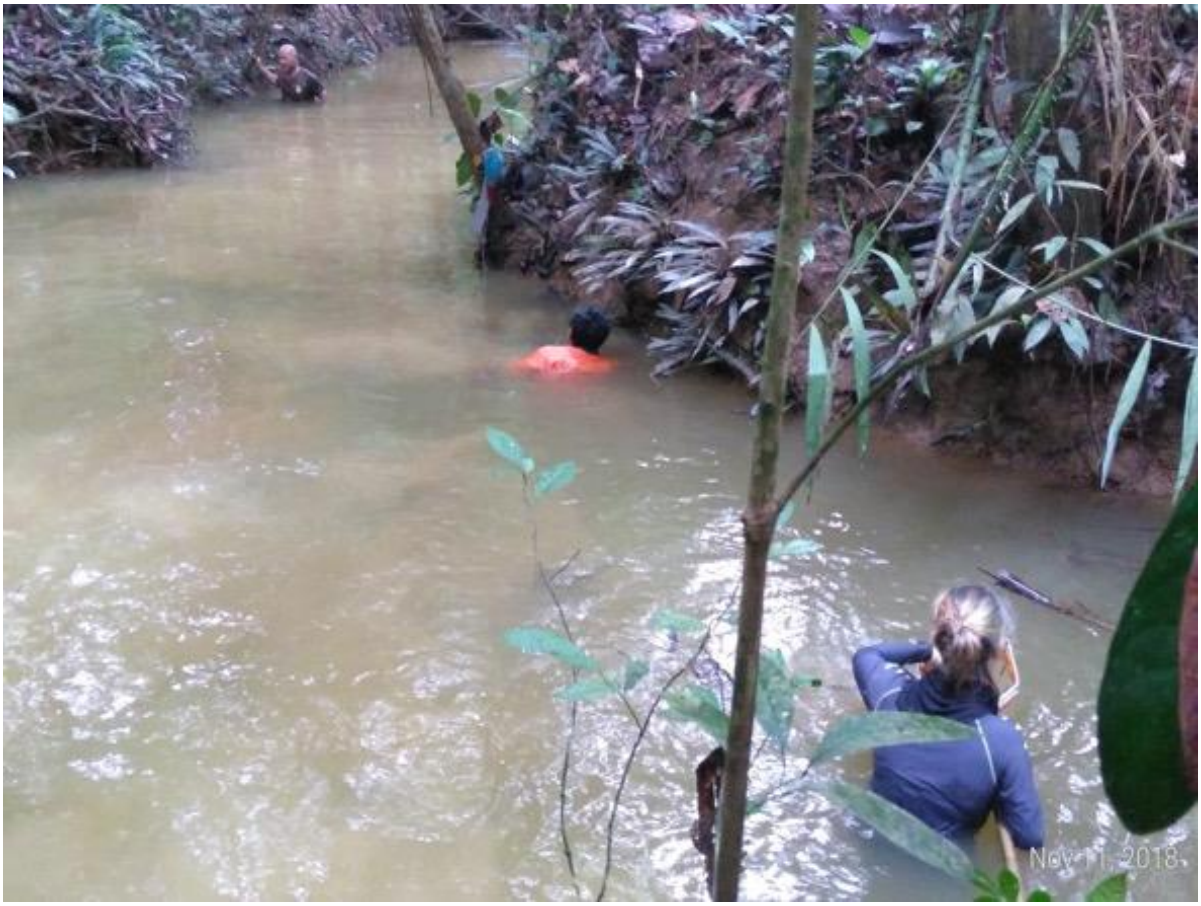


Mr Acob, Alexandra Zieritz, Hussein Taha and John Pfeiffer with Sinanodonta woodiana collected from Mr Acob's pond in Lawas district, Sarawak.

The three Ctenodesma borneensis specimens collected from a Limbang tributary, now deposited at the museum of the Universiti of Malaysia Sarawak (Unimas)



Khairul Adha Rahim, Alexandra Zieritz and our Iban guide on the way to jungle camp.



Sampling at site where *Pseudodon walpolei* has been reported.